

**UNIVERSITY OF ÇUKUROVA  
INSTITUTE OF NATURAL AND APPLIED SCIENCE**

**MSc THESIS**

**Süleyman YILMAZ**

**SYSTEM DESIGN, IMPLEMENTATION AND AUTOMATION FOR  
ENERGY CONSERVATION IN OIL PRODUCTION AND BOILER  
PROCESSES**

**DEPARTMENT OF ELECTRICAL ELECTRONICS ENGINEERING**

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**INSTITUTE OF NATURAL AND APPLIED SCIENCES**

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## **ABSTRACT**

### **MSc.THESIS**

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|----------------------------------------------------------------------------------------------------------------------------|
| <b>SYSTEM DESIGN, IMPLEMENTATION AND AUTOMATION FOR<br/>ENERGY CONSERVATION IN OIL PRODUCTION AND BOILER<br/>PROCESSES</b> |
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With the growth of technology, automation control systems (PLC) and process monitoring (SCADA) systems improved. The improvement of control and process monitoring helped in improving energy efficiency, process quality, continuity of quality and security.

Industries which include heating or cooling process has energy conservation potential. Especially if manufactured product needs both heating and cooling process, then energy conservation potential is inevitable and higher . By founding robust, reliable and comprehensive automation control, energy conservation is achieved much. Also, product quality and system safety can be increased.

In this thesis study, in MARSAN Plants which produces vegetable oil in ADANA, energy conservation is provided by integrating electrical, mechanical and control units, between two plants. Operation practise of study reveals good control and economic performance index. Significant economic benefits are supplied. Also, quality parameters of production is significantly healed.

**Keywords:** Energy Efficiency, Boiler, Heating-Cooling, Automation Control, Energy Saving,

## ÖZ

### YÜKSEK LİSANS TEZİ

#### SIVI YAĞ ÜRETİMİ VE KAZAN PROSESLERİNDE ENERJİ VERİMLİLİĞİ İÇİN SİSTEM TASARIMI, UYGULAMASI VE OTOMASYONU

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ELEKTRİK ELEKTRONİK MÜHENDİSLİĞİ ANABİLİM DALI

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Teknolojinin ilerlemesi ile birlikte otomasyon kontrol sistemleri (PLC) ve proses izleme (SCADA) sistemleri de gelişmiştir. Kontrol sistemlerinin ve proses izlenebilirliğin gelişmesi; enerji verimliliği, proses kaliteleri, kalitenin sürekliliği, emniyet ve diğer pek çok noktalarda büyük faydalar sağlamıştır.

Isıtma veya soğutma prosesi olan işletmeler enerji verimliliği potansiyeline sahiptir. Özellikle üretilen mamül hem ısıtma hem de soğutma prosesine ihtiyaç duyuyorsa, enerji verimliliği potansiyeli yüksek ve kaçınılmazdır. Sağlam, güvenilir ve geniş kapsamlı düşünülmüş otomasyon kontrolü kurularak enerji verimliliği sağlanabilir. Aynı zamanda ürün kalitesi ve sistem güvenliği artırılabilir.

Bu tez çalışmasında, ADANA’da bitkisel yağ üreten MARSAN tesislerinde, ısı ihtiyacı olan kazan prosesiyle, soğutma ihtiyacı olan deodorize prosesi arasında mekanik, elektrik ve kontrol sistemlerinin entegrasyonu yoluyla enerji verimliliği sağlanmıştır. Tez sonucunda enerji verimliliği sağlanırken diğer yandan her iki proseste de kalite parametreleri eski sisteme göre daha iyi değerlere çıkması sağlanmıştır.

**Anahtar Kelimeler :**Enerji Verimliliği, Kazan, Isıtma – Soğutma, Otomasyon Kontrol, Eneji Tasarrufu

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Suleyman YILMAZ

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## LIST OF SYMBOLS

|            |                          |
|------------|--------------------------|
| $f$        | : Frequency              |
| $h$        | : Hour                   |
| $E$        | : Energy                 |
| $t$        | : ton                    |
| $v$        | : Speed                  |
| $Q$        | : Energy                 |
| $I$        | : Current                |
| $A$        | : Area                   |
| $L$        | : Length                 |
| $m$        | : Mass                   |
| $P$        | : Power                  |
| $\Delta t$ | : Temperature Difference |
| $F$        | : Farad                  |
| $KW$       | : kilowatt               |
| $mA$       | : Milli amper            |
| $psi$      | : pressure               |
| $V_{dc}$   | : DC Voltage             |
| $V_{Ac}$   | : AC voltage             |
| $P$        | : Power                  |
| $T$        | : Temperature            |
| $V$        | : Voltage                |



## LIST OF ABBREVIATIONS

|         |                                                               |
|---------|---------------------------------------------------------------|
| GPC     | : Generalized Predictive Control                              |
| MPC     | : Model Predictive Control                                    |
| TOE     | : Ton Oil Equivalence                                         |
| IEA     | : International Energy Agency                                 |
| CHP     | : CombinedHeatandPower                                        |
| ETKB    | : Republic of Turkey Ministry of Energy and Natural Resources |
| HPPs    | : HydropowerPlants                                            |
| TPPs    | : ThermalPowerPlants                                          |
| BOT     | : Build-Operate-Transfer                                      |
| BOO     | : Build-Own-Operate                                           |
| R&D     | : Researchand Development                                     |
| ECD     | : Energy Conservation Division                                |
| EİE     | : Electrical Power Resources Survey Administration            |
| NECC    | : National Energy Conservation Center                         |
| RMB     | : Ren Min Bi                                                  |
| BTHBNTL | : Beijing Tian Hong Bao Neng Thermal Ltd                      |
| ANFIS   | : Adaptive Neuro-Fuzzy Inference System                       |
| DC      | : Direct Current                                              |
| PLC     | : Programming Logic Controller                                |
| IGBT    | : Insulated Gate Bipolar Transistor                           |
| MOSFET  | : Metal OxideSemiconductorFieldEffect Transistor              |
| FB      | : Function Block                                              |
| FC      | : Function Control                                            |
| OB      | : Organization Block                                          |
| DB      | : Data Block                                                  |
| Kbps    | : Kilo Bit per Second                                         |
| Mbps    | : Mega Bitper Second                                          |

|       |                                                                                              |
|-------|----------------------------------------------------------------------------------------------|
| PID   | : Proportional-Integral-Derivative (Controller)                                              |
| MPI   | : Multi Point Interface                                                                      |
| SCADA | : Supervisory Control and Data Acquisition                                                   |
| I/O   | : InputandOutput                                                                             |
| HL    | : High Level                                                                                 |
| LL    | : Low Level                                                                                  |
| PC    | : Personel Computer                                                                          |
| PPI   | : Point To Point Interface                                                                   |
| EE    | : Energy Efficieny                                                                           |
| SFC   | : Sequential Function Control                                                                |
| AI    | : Analog Input                                                                               |
| AO    | : Analog Output                                                                              |
| EU    | : European Union                                                                             |
| HE    | : Heat Exchanger                                                                             |
| TEIAS | : Turkish Electricity Transmission Company                                                   |
| EIE   | : General Directorate Of Electrical Power Resources Survey And<br>Development Administration |
| ETKB  | : RebuplicOf Turkey Ministry Of Energy And Natural Resources                                 |
| IEA   | : International Energy Agency                                                                |
| TUREB | : Turkish Wind Energy Association                                                            |
| MENR  | : Ministryof EnergyandNatural Resources                                                      |
| R&G   | : ResearchingandDevelopment                                                                  |
| DSI   | : Directorate-General of StateHydraulic Works                                                |
| EUAS  | : Electricity Generation Company,                                                            |
| TEDAS | : Turkish Electricity Distribution Company                                                   |

|           |                                 |
|-----------|---------------------------------|
| DPT       | : State Planning Organization   |
| TPAO      | : Turkish Petroleum Company     |
| BOTAS     | : Turkish Pipeline Corporation  |
| TKI       | : Turkish Coal Enterprises      |
| TTK       | : Turkish Hard Coal Enterprises |
| <i>DC</i> | : Direct Current                |
| <i>AC</i> | : Alternating Current           |



## 1. INTRODUCTION

It is clearly known that energy is the basic fundamental of development not only economically but also socially and has a great effect for the improvement of life standards. And also for a continuous development, energy must be served in steady and high quality.

The reserves of fossil fuels which currently respond to the major part of world energy requirements are running out very fast. Because it is forecasted that reserves of some fossil fuels like oil and natural gas will come to an end in the second half of this century, exploiting all energy resources in an efficient manner has great importance. Throughout the world where the energy demand grows continuously but the resources decrease gradually, many types of programs are implemented to provide efficient energy use ( Kavak, 2005).

First energy efficiency and conservation strategies, started and developed in 1970s as response to oil crises and oil prices in the world. Especially; Japan, USA and some other countries which has rich industry. In 1980s, energy efficiency concept, has become an inevitable part of energy and development policy, and found a widespread application area. But when it comes to energy sources, the basic energy sources; fossil fuels, such as petroleum, coal and natural gas are incredibly diminishing with a lot of enviromental problems and this situation is triggering the use of energy in an efficient way.

Energy efficiency can be described as the use of different energy forms such as steam, pressurized air, electricity and gas with new technology and making improvements to gain all these energy types to reprocess without decreasing the quality in ecnomically and socially (Hayakawa et al, 1999).

Automation plays an increasingly important role in the world economy and in daily experience. Engineers strive to combine automated devices with mathematical and organizational tools to generate complex systems for a rapidly expanding range of applications and human activities.

Process automation involves using computer technology and software engineering to help power plants and factories in industries as diverse as paper, mining, cement and food operate more efficiently and safely.

The automation system ensures that appropriate parameters are measured, operational situations analyzed, more profitable opportunities explored and control actions calculated and taken, plant personnel kept informed and their knowledge and capabilities exploited, abnormal situations identified and addressed, and business processes integrated. Automation is of course too important but architecture of automation is more important. The components and devices of the automation system perform functions that are essential for safe and efficient process operation, but it is the system architecture—the logical organization of the components and associated infrastructure—that often dictates choices of components and determines key system performance features such as reliability, product quality, throughput, scalability, and cost. The system architecture also dictates how well applications are integrated, deployed and supported throughout their life-cycles, and in what manner the application functionality is delivered. Major themes for a system architecture are thus (1) to devise infrastructures, services, components, and their organizational schemes for best delivering the automation functions including advanced application capabilities; and (2) to integrate—to cohesively combine seemingly disparate components into an effective and consistent whole. It's the architecture that makes a system more than the sum of its parts (Samad et al, 2007).

Various studies are applied on boiler systems for energy saving or for improving efficiency or safety by automation.

Example study is applied on Chain Grate Boiler, which is same type with MARSAN A.Ş boiler, owned by Beijing Tian Hong Bao Neng Thermal Ltd, a large enterprise in heat supply service in Beijing in China. Normally, degree of automation is too low in that type of boilers. Manual control of auxiliary equipments of boiler are very difficult and mistakes can be made easily. Also good quality can not be realized at production. For advanced control system at chain grate boiler thermal plant, North China Electric Power University is entrusted for designing comprehensive automation system. Advanced Foundation Fieldbus technology is

applied in the control system of chain grate boiler to improve the automation degree and production efficiency. The operation of automation control system greatly improves the safety and economic, lightens the labor intensity of operators, promotes modern production of enterprise. According to the economic benefit certificate provided by BTHBNTL(Beijing Tian Hong Bao Neng Thermal Ltd), it is up to 300 million RMB(Ren Min Bi) in cost cut and benefit increment. Notable economic benefit is created for economy development in Beijing ( Geng et al, 2007).

In another study for performance improvement, an effective model of the second-left-hand de-superheater of ‘Shazand’ power plant, located in Arak, a city at the center of Iran, with the capacity of 4\_325MW is developed based on adaptive neuro-fuzzy inference system (ANFIS) technique. De-superheater outlet steam temperature control of this power plant is maintained by a 10-year-old PID controller. The performance of the de-superheater, with the existing system, does not show high-quality set-point tracking ability. By retuning of the existent controller and re-designing a more efficient control strategy, performance of system is improved (Ghaffari et al, 2007).

Another study is based on combustion control systems. The investigation is mainly performed on the combustion system of industrial boiler at an oil refinery plant. In that application, the controller of boiler consumption is an old controller system which is controlled as PI control system type. With new control technique, combustion quality compared with old control technique( with reach time to set point, excess air ratio and other parameters has been compared) has been healed significantly. Excess air ratio decreased from 6.6% to 2.2%. Also boiler efficiency increased from 82.05% to 83.43%. This result shows that, by improvement of technology, boiler efficiency increased and other parameters are kept at optimum level (Nazaruddin et al, 2008).

Another study for performance optimization is monitoring boiler parameters and by some evaluations and comparison with reference process. These evaluations are repeated at regular time intervals using data readily available from on-line instrumentation. The objective of performance monitoring is continuous evaluation of degradation i.e. decrease in performance of the steam boiler. These data enable

additional information which is helpful in problem identification, improvement of plant performance and making economic decisions about maintenance schedule. All these actions are aimed towards optimization of boiler performance. Every performance monitoring system involves comparison between current (measured) and expected parameters of performance. The procedure to calculate expected performance of a steam boiler is to start with the expected performances at the reference operating conditions and then use a model to predict the change in boiler performance when it is operated at conditions different from the reference operating conditions ( Buljubašić et al, 2008).

And also there is another study for online monitoring. By recording, monitoring and evaluating measured datas; some predictions are possible. And with those predictions, some control systems can be designed. In this study, many parameters are recorded and monitored. With evaluations of recorded datas, unburned carbon content of fly ash is monitored on-line in pulverized utility boilers. In turbines, conjectural exhausted steam enthalpy is monitored on-line. Also, real time calculation of net standard coal consumption rate carried out according to the data from the data acquisition system (DAS) as on-line monitoring. The efficiency and accuracy of this system is compared with other control systems. The feasibility of the proposed method is demonstrated in two pulverized coal-fired units in a power plant ( Cai et al, 2009).

As safety control of boilers, there are some studies on literature. As we know, the drum level is an important variable to be controlled such that it is within the pre-specified safety limits. In practice, this is a difficult control task due to the existence of constraints on the amount of feedwater flow dictated by the pump rating, parameter uncertainties, and modeling inaccuracies. To overcome these difficulties, different automation cotrol systems are developed. One study is a cascade control structure, in which both the inner loop and the outer one consist of generalized predictive control (GPC), for boiler drum level control is presented. GPC has several of the desired attributes of model predictive control (MPC). The objectives for two loops are to maintain drum level at constant load and to reject measured and unmeasured disturbances of the flow system. GPC, has been applied in a 75-MW

boiler unit in China for half a year and the performance of the system is very good (Xu et al, 2005).

Also in some studies, use of waste heat is investigated. One of them is told below.

In one study, investigation of the potential for cascade use of waste heat among energy intensive industries has been done in Japan. Those industries are: iron & steel, cement, paper & pulp and ethylene. Regional energy saving potential by heat cascading was evaluated in the actual local industrial structure in Japan. As result; Cascading between high temperature waste heat supply of ethylene and middle & low temperature heat and electricity demand of paper & pulp can provide high energy saving. Oil consumption of steam boilers for the energy balance in a combination can be reduced by more than about 90% by optimizing the industrial structure. Also in this study, it is demonstrated that heat transmission loss is unavoidable. This model is used at any other country and also used in same factory which consist of plants which needs different energy intensity (Hayakawa et al, 1999).

In recent years Turkey has just started to make important studies in energy efficiency but it is a fact that this issue is not clearly understood by the groups which has an important role in energy. According to the statistical signs, Turkey is spending much more energy and has a bad average compared with other countries in the world. And also it is understood from the statistical signs that Turkey has a critical place to compete with other industries in international markets is not able to use energy in an efficient way.

In this thesis, it is aimed to make an integrated system between deodorization unit that needs cooling and boiler unit that needs heat to work in an efficient way and gain energy. Energy efficiency, these two units and their control automations with logic parameters are also covered in this project.

Synchronization and integration are the most important steps in a control system representation. Because water is a must for the boiler unit to generate steam. If boiler does not get water properly, pipes in boiler will be empty and there may be leaks in the surface of pipes with the effect of heat. In addition to that if there is no

water in boiler, water in pipes will be evaporated and so pressure in boiler will increase up to 60 bars. In this situation if water is fed to boiler, it may cause an explosion in boiler unit. For those reasons, it is important to feed required water to boiler in a steady way. But required water for the boiler unit and required steam for departments in plant can be easily changed with consumptions.

On the other hand, for deodorization unit to cool the oil until desired temperature, cooling water must be fed properly. In deodorization unit each oil which must be deodorized has a different retention time in deodorization unit. Those retention times can be a value between 17 minutes and 28 minutes. If boiler unit stops when it gets required water, then it can halt the booster pump which regulates the water for the boiler unit and as a result, production in plant can be halted. For these reasons, an integral control system must be prepared according to those datas which also provide an efficient way and a reliable working conditions.

Firstly, to control and integrate two different systems, needed datas such as condense tank level, condense tank and buffer tank minimum - maximum level points, returned water temperature, cold water flow rate, oil temperature etc. have been defined. Then, control components such as pump, level transmitter, water level switches, valves, flowmeter, pt100 etc. have been defined. For control of two different process parameters and achieve synchronization of two processes, siemens S7 315 2DP CPU (programmable logic controller) is used. For control of new designed system, a control panel is installed in boiler plant. In control panel, CPU, signal cards, pump driver, power and signal control components have been installed. To monitor and control of new designed system, a SCADA program has been written and SCADA program has been installed in boiler operator room. Also, signal cards have been added in deodorization control system for data transfer between deodorization control system and new designed system. New program blocks have been added into deodorization plant process controller(PLC). For deodorization plant operator monitoring, new SCADA page has been added into deodorization SCADA system.

The content of the thesis is arranged as follows:

After this introduction chapter, chapter 2 presents an overview of energy, development for energy efficiency studies on energy in the world and in Turkey

In chapter three, liquid oil process and its steps are presented

In chapter four, boiler types, running principle of boilers and Marsan A.Ş boiler type is presented.

In chapter five, design and implementation of the thesis is presented. Feasibility of the study is explained. Old deodorization cooling system and old boiler condense level control system is explained. New project design is presented in detail including control principles, flow charts, hardware configurations.

In chapter six, process control system is presented. Generally Automation, PLC, SCADA, communication types are presented. New control system is presented including PLC, SCADA, and communication sides.

In chapter seven, thesis results are presented. Cost savings are calculated and other benefits of thesis are explained.

In chapter eight, a general view to the thesis is presented and the important conclusions of this study are explained.



## 2. ENERGY

### 2.1 Energy And Energy Efficiency

It is clearly known that energy is the basic fundamental of development not only economically but also socially and has a great effect for the improvement of life standarts.

The link between continuous improvement and energy has been mainly thought as the service of energy in a reliable way to the consumers and also the relationship between energy and invesment has been evaluated as well. On the other hand, there has been a steady decrease in the natural energy sources such as coal, crude petroleum and natural gas with a steady increase in environmental problems. The above mentioned problems reveal the use of energy in an economical way and energy efficiency while including the solution of continuous improvement in that frame.

The usage rate of fossil fuels that meet the current energy demand of world for right now is rapidly increasing. Especially there is great increase for the developing countries. But there is not a parallel increase in the fossil fuel reserves. Even if the current usage rate of petroleum stays steady, it is clear that these sources will diminish in near future. Also compared with petroleum natural gas has a greater life but it is possible to say same conclusions like petroleum.

Instead of rapidly diminishing petroleum fuels, new searches are made in both alternative energy source fields and efficiency without affecting the current comfort. These trends are mainly evaluated in the energy efficiency issue.

Energy efficiency encompasses all the critical points related with energy production, distribution and consumption. On the one hand the current consumption conditions are investigated to determine the optimum parameters and on the other hand new strategies are produced and conducted to do the same work with consuming less energy.

Energy efficiency can be described as the use of different energy forms such as steam, pressurized air, electricity, gas with new technology and making

improvements to gain all these energy types to reprocess without decreasing the quality in economically and socially.

In the world, especially in developed countries, there are a lot of new techniques and researches based on considerable budgets that aims to use energy in a more sensible way. These programmes may be classified in different groups such as public programmes which serve education, governmental programmes that make legal arrangements, civil programmes that aim to announce the situation of energy to whole world and programmes that are improved by universities, sponsored by government based on technology.

In recent years Turkey has just started to make important studies in energy efficiency but it is a fact that this issue is not clearly understood by the groups which has an important role in energy. According to the statistical signs, Turkey is spending much more energy and has a bad average compared with other countries in the world. And also it is understood from the statistical signs that Turkey that has a critical place to compete with other industries in international markets is not able to use energy in an efficient way (Kavak, 2005).

## **2.2. Energy Density**

Energy density is the main indicator of energy efficiency. Energy density is the ratio between the consumption of energy per gross domestic product and used in the whole world.

Table 2.1 shows energy density of some countries on the world.

Table 2.1 Energy density at some countries on the world (Kavak, 2005).

| Countries         | Population<br>(Million) | Energy<br>Consumption<br>(MTOE) | Energy<br>Density(TOE/1000\$) |
|-------------------|-------------------------|---------------------------------|-------------------------------|
| USA               | 285,9                   | 2281,4                          | 0,25                          |
| GERMANY           | 82,3                    | 351,1                           | 0,13                          |
| ARGENTINA         | 37,5                    | 57,6                            | 0,21                          |
| AUSTRALIA         | 19,5                    | 115,6                           | 0,25                          |
| UNITED<br>KINGDOM | 58,8                    | 235,2                           | 0,18                          |
| BRAZIL            | 172,4                   | 185,1                           | 0,23                          |
| FRANCE            | 60,9                    | 265,6                           | 0,15                          |
| INDIA             | 1032,4                  | 531,5                           | 1,08                          |
| ISRAEL            | 6,4                     | 21,2                            | 0,20                          |
| SWEDEN            | 8,9                     | 51,1                            | 0,17                          |
| ITALY             | 57,9                    | 172                             | 0,14                          |
| JAPAN             | 127,2                   | 520,7                           | 0,09                          |
| CANADA            | 31,1                    | 248,2                           | 0,35                          |
| MEXICO            | 99,1                    | 152,3                           | 0,41                          |
| RUSSIA            | 144,8                   | 621,4                           | 1,65                          |
| GREECE            | 11                      | 28,7                            | 0,20                          |
| TURKEY            | 68,6                    | 72,5                            | 0,38                          |

TOE (ton oil equivalence) which is consumed for product which costs 1000\$, is preferred as energy density in international articles. Here, TOE is used for expression of different units such as kg, m<sup>3</sup>, ton which are used for different energy source units, in same unit. 1 TOE corresponds to energy which got when burned 1 ton of oil. And this value corresponds to approximately 10<sup>7</sup> Kcal, 41,8x10<sup>9</sup> joule and 11,6x10<sup>3</sup> kWh.

So, it means that if the energy density of a country is low, it indicates that the energy, consumed to produce a product is low as well and this situation results in energy efficiency.

The development degree of a country can be monitored with two indicators.

The first indicator is the energy consumption per capita and the other one is energy density. The great amount of energy consumption per capita reflects the comfort level of society and the good economic activity. Similarly, the less level of energy density represents the good production and more economic value added

production. So the determinant and identifier criteria of a developed country is the low level of energy density and the great level of energy consumption per capita.

Table 2.2 shows energy consumption per capita at some countries on the world.

Table 2.2 Energy consumption per capita of some countries on the world (Kavak, 2005).

| Countries         | Population<br>(Million) | Energy<br>Consumption<br>(MTOE) | Energy<br>Consumption Per<br>Capita |
|-------------------|-------------------------|---------------------------------|-------------------------------------|
| USA               | 285,9                   | 2281,4                          | 7.979                               |
| GERMANY           | 82,3                    | 351,1                           | 4.264                               |
| ARGENTINA         | 37,5                    | 57,6                            | 1.536                               |
| AUSTRALIA         | 19,5                    | 115,6                           | 5.939                               |
| UNITED<br>KINGDOM | 58,8                    | 235,2                           | 4.000                               |
| BRAZIL            | 172,4                   | 185,1                           | 1.074                               |
| FRANCE            | 60,9                    | 265,6                           | 4.360                               |
| INDIA             | 1032,4                  | 531,5                           | 515                                 |
| ISRAEL            | 6,4                     | 21,2                            | 3.332                               |
| SWEDEN            | 8,9                     | 51,1                            | 5.736                               |
| ITALY             | 57,9                    | 172                             | 2.969                               |
| JAPAN             | 127,2                   | 520,7                           | 4.093                               |
| CANADA            | 31,1                    | 248,2                           | 7.985                               |
| MEXICO            | 99,1                    | 152,3                           | 1.536                               |
| RUSSIA            | 144,8                   | 621,4                           | 4.293                               |
| GREECE            | 11                      | 28,7                            | 2.619                               |
| TURKEY            | 68,6                    | 72,5                            | 1.056                               |

### 2.3 The Actions Oriented To Improve The Energy Efficiency

It is possible to make and conduct a lot of researches in different fields to improve the energy efficiency. In this chapter, especially, the applications that have a significant importance in energy balance and their possible advantages are issued.

Researches that aim to improve the energy efficiency can be classified as;

1. Energy efficiency in buildings,
2. Energy efficiency in power stations,
3. Energy efficiency in transportation,
4. Energy efficiency in industry,

### **2.3.1 Energy Efficiency In Buildings**

One-third of energy consumption of countries that are the members of International Energy Agency (IEA) is taking place in normal and commercial buildings. Residential states and commercial buildings have a lower share, nearly 11 % compared with transportation and industry. But still their share in European Union is at least 40 % and 60 % in IEA. A considerable number of countries – members of IEA- spend their energy for the central –heating as well as water-heating.

Energy efficiency in buildings can be separated in two groups;

1. Heat,
2. Electricity,

It has been already proved with studies done that a considerable amount of savings can be made with precautions related with energy efficiency. To optimize the heat exchange between inlet and outlet environment, to design the chimneys that provide a steady and balanced flow through to atmosphere, to design the facility pipes that do not allow water to freeze, to choose the optimum boiler and the isolation can be classified as the main parameters of savings of energy. Isolation that provides a thermal resistance by lowering the heat transfer coefficient is the core point of energy efficiency in buildings.

To decrease the heat loss from the outer space of buildings by lowering the heat transfer coefficient is accepted as a standart in many countries. Additionally the foam insulation is one of the most important research in that field.

The control sytems which arrange themselves automatically according to heating - cooling needs and also super isolated wall systems and window panes are the most important issues that a lot of researches are made on the world.

For energy efficiency in buildings, the precautions related with electricity can be summarized as below;

- Lighting installation can be improved by being sensitive to daylight and controlled with sensors & photocells,
- Suitable materials determined by legal standarts can be used,
- Designing a compensation system for the building electricity energy ,
- Motion detection devices can be used in suitable buildings,
- Computer controlled automatic systems can be used in special buildings,

### **2.3.2 Energy Efficiency In Power Stations**

The inner energy consumption of power stations is the energy which is used for their needs to produce energy. The cooling water system, waste and purification water system, exhaust gas system can be given as the major components of this consumption. These sytems may use the 6-7 % of total production. On the other hand in hydroelectric power plants the consumption is too low compared with general power plants.

Some modifications are needed to improve the energy efficiency in hydroelectric power stations. In thermal power plants; new technologies are used to improve the energy efficiency, suitable fuel materials for boilers and control of pumps can be given as the key points of energy saving (Kavak, 2005).

### **2.3.3 Energy Efficiency In Transportation**

According to the Statistical Review of World Energy-2004 (BP), the current petroleum reserve in the whole world is 1,147,800 barrel and the daily consumption is 78,11 barrel. These datas indicate that reserves will diminish in 40 years even if there is no increase in the current consumption.

It is clearly known that there will be a bit increase in the consumption of petroleum in transportation. On the other hand, there is an estimation that there will be a decrease or halt according to the new technologies in transportation.

### **2.3.4 Energy Efficiency In Industry**

It is an acceptable supposition that the crisis experienced in 70's and the price rise is the main factor triggering the energy efficiency policies. Furthermore the competition in industry causes new opportunities to decrease the production cost by heading new projects to save energy.

Despite the above explained fact, it is impossible to say that the new projects are based on profit but it is clear that these projects are supported by government and include really detailed performance and operation.

Starting in late 1970, the energy efficiency issue is focused in industry in many western countries. It can be explained as;

- The investment made to decrease the energy consumption can get the payback time shorter in industry compared with the public.
- Energy saving precautions have a significant role in the modernization and business competition as well as in industry.
- Calculation the energy cost in industry is an understandable issue compared with other fields.

In industry, the precautions to save the energy can be summarized as:

1. To improve the energy accounting in industries, a lot of practices can be done in the management, operation and maintenance departments.
2. The simple investments like insulation and control systems that can reach the payback time less than in one year.
3. Complex and big investments such as adaptation of new technologies and high tech machines.
4. New industrial processes (Kavak, 2005).

### **2.4. Energy Efficiency In The World**

The first energy efficiency strategies were developed and implemented as a result of cost increase and crisis in petroleum by Japan and some western industrialized countries in 1970. After then in 1980, energy efficiency

concepts&strategies became the core point of energy efficiency and development policies with a better field of application.

Compared with other countries; policies, incentives, precautions and current projects in Japan and U.S.A related with energy efficiency have a great difference than other countries in the world.

The Energy Conservation Center in Japan is turning the world's attention to the energy efficiency issue by making great projects and orientating the other countries to implement active policies. As a result of that the energy efficiency precautions have a great importance in Japan.

Compared datas, published by the Energy Efficiency Conservation Center, leads the world to conduct the best energy efficiency projects.

On the other hand, in Europe, developed countries have a great role in different fields, in the meaning of energy efficiency. In addition to that, according to the European Union laws and regulations, insistent precautions should be considered to make a common purpose and field. The institutes which have been responsible for the energy efficiency and environment policies of 25 European Union countries have a great role to establish ODYSSEE that aims to make a common field and precautions since 1992.

Another important project conducted in Europe for the energy efficiency is SAVE program. This program aims to implement energy efficiency issue for different fields by making both local and regional projects, giving informations to keep the society, advised with the current actions and operations. After the first SAVE program-started in 1991 and completed in 1995- SAVE II program is developed for the next five years by the decision of 96/737/EC. In 2000, by the decision of 647/2000/EC this program is reorganized as a sub-program of Energy Frame Program (Kavak, 2005).

#### **2.4.1 Energy Efficiency Applications Of Industry In The World**

Especially Europe, Japan, USA and all developed countries made a significant progress in the energy efficiency issue starting in late 1970.

An important improvement – definitely 18 %- was made in industry of 15 countries in Europe between 1990 and 2001.

The differences in calculations between European Union countries lead ODYSSEE to reintroduce a new database in 1995 because of percentage of distribution for calculations and to orientate these countries to use this database.

The improvements in the energy efficiency of industrial plants have been monitored not only in the european union but also in Japan. The production industry in Japan has 30 % improvement in last twenty years. The other improvements for the countries, the member of IEA, are similar with Japan.

The unit energy which is used to produce a single product is continuously decreasing in IEA. The analysis of the absolute energy required in different industrial processes are possible to describe the best applications for energy savings. A lot of members of IEA have conducted some programs to compete with other programs and projects in the world wide projects. In the projects, the best programs were implemented with the supervision of energy efficiency. Beside, a lot of countries signed long term contracts.

One of the most important action used and resulted in achievement in the energy efficiency is energy efficiency survey and study. These survey and studies are rewarded with tax reduction (abatement) or subsidy fund by some countries.

To generalize the use of a new technology named cogeneration plants which can produce electricity and heat simultaneously, has a great importance for both large scale production plants and junior plants. Cogeneration systems - also called combined heat and power or CHP systems - generate both heat and power. These systems consist of an engine/generator unit and heat exchangers for the utilization of waste heat. As a result of both heat and electricity need of plants make a great demand for the cogeneration systems.

The signed contracts and performance orientated agreements, between industrial plants and governments and also information meetings which are arranged by recognized organizations are the other remarkable examples of energy efficiency programs (Kavak, 2005).

### 2.5 Energy Overview of Turkey

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports. Figure 2.1 shows primary energy resource production according to Republic of Turkey Ministry of Energy and Natural Resources (ETKB) records. In 2009, energy need of Turkey is about 108 million TOE. On the other hand, energy resource production amount is about 29 million TOE. This shows that Turkey is dependent at energy about 73 % rate to abroad.

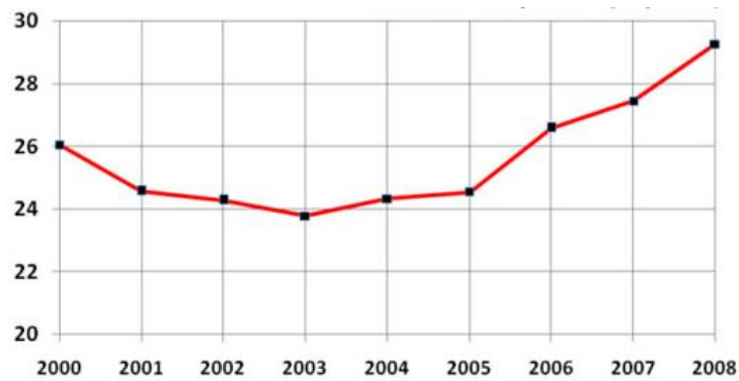


Figure 2.1 Energy resource production of Turkey (ETKB, 2011).

■ Primary energy production(Million TOE)

Figure 2.2 shows energy dependence rate of Turkey according to ETKB records.

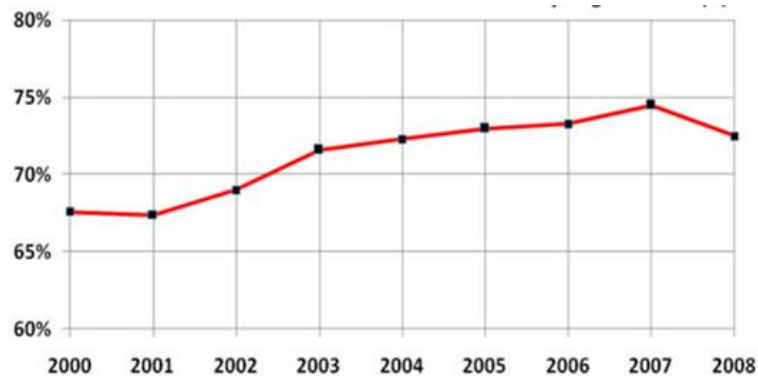


Figure 2.2 Energy dependence rate of Turkey (ETKB, 2011).

■ Energy dependence rate(%)

Also we can see breakdown of sectoral consumption from figure 2.3, that in industry, energy consumption is about 37% of total consumption. And in industry energy consumption, energy supply from coal is about 39% of total energy consumed in industry. Oil consumption at transportation is 60% of total oil consumption in 2007. Figure 2.3 shows breakdown of sectoral final consumption by source.

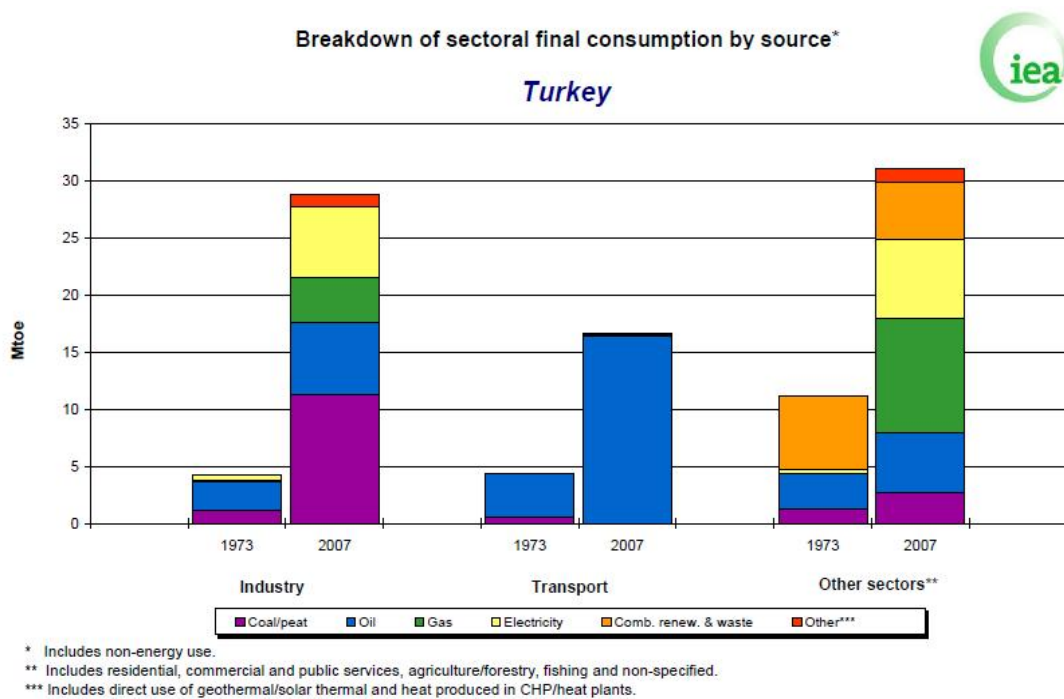


Figure 2.3 Breakdown of sectoral final consumption by source (IEA, 2011).

Due to the diversification efforts of energy sources, use of natural gas that was newly introduced into Turkish economy, has been growing rapidly. On the other hand, Turkey, with its young population and growing energy demand per person, its fast growing urbanization, and its economic development, has been one of the fast growing power markets of the world for the last two decades. Oil has the biggest share in total primary energy consumption. But it is expected that natural gas consumption will be higher than oil in future. Table 2.3 depicts the historical and projected relationship between population, economic output and energy demand. (Koyun, 2007)

Table2.3 Population, economy and energy of Turkey. (Koyun, 2007)

| Years | Population<br>(000s) | GNP/capita | Total GNP   | Total<br>Energy<br>Demand<br>(Mtoe) | Energy/capita<br>(Kep) | Energy<br>İntensity |
|-------|----------------------|------------|-------------|-------------------------------------|------------------------|---------------------|
| 1973  | 38,072               | 1994       | 75,915,568  | 24.6                                | 646                    | 81                  |
| 1990  | 56,098               | 2674       | 150,006,052 | 53.7                                | 957                    | 50                  |
| 1995  | 62,171               | 2861       | 177,871,231 | 64.6                                | 1,039                  | 44                  |
| 2000  | 67,618               | 3303       | 223,342,254 | 82.6                                | 1,218                  | 40                  |
| 2010  | 78,459               | 5366       | 421,010,994 | 153.9                               | 1,962                  | 35                  |
| 2020  | 87,759               | 9261       | 812,736,099 | 282.2                               | 3,216                  | 33                  |

The main energy resources of Turkey are hard coal, lignite, asphaltite, petroleum, natural gas, hydroelectric energy, and geothermal energy. Table 2.4 shows the amount of fossil energy resources in Turkey. Turkey's renewable energy sources are plentiful and extensive and represent the second-largest domestic energy source after coal. Primary renewable energy resources in Turkey are: hydro, biomass, wind, biogas, geothermal and solar (Table 2.5).

Table 2.4 The amount of fossil energy resources in Turkey (Koyun, 2007).

| Sources                               | Apparent | Probable | Possible | Total |
|---------------------------------------|----------|----------|----------|-------|
| Hard coal (million tons)              | 428      | 449      | 249      | 1126  |
| Lignite (million tons)                | 7339     | 626      | 110      | 8075  |
| Asphaltite (million tons)             | 45       | 29       | 8        | 82    |
| Bituminous schist (million tons)      | 555      | 1086     | 269      | 1641  |
| Oil (million tons)                    | 36       | -        | -        | 36    |
| Natural gas (billion m <sup>3</sup> ) |          | -        | -        | 8     |

Similar to other industrialized countries, with the increases in energy consumption and economical growth, energy related environmental problems are rapidly growing in Turkey. In 2003, it is estimated that 36 % of CO<sub>2</sub> emissions occurred due to energy, 34 % due to industry, 15 % due to transportation and 14 % due to other sectors such as housing, agriculture and forestry and in 2020 40 % will occur due to energy, 35 % due to industry, 14 % due to transportation and 11 % due

to other sectors. To control these problems for sustainable development, energy related policy should be well determined. (Koyun, 2007)

Table2.5. Renewable energy potential of Turkey(Koyun, 2007).

| Energy type       |                          | Usage purpose               | Natural capacity | Technical | Economical |
|-------------------|--------------------------|-----------------------------|------------------|-----------|------------|
| Solar energy      |                          | Electric (billion kWh)      | 977.000          | 6.105     | 305        |
|                   |                          | Thermal(mtoe)               | 80.000           | 500       | 25         |
| Hydro power       |                          | Electric (billion kWh)      | 430              | 215       | 124.5      |
| Wind              | Direct energy(land)      | Electric (billion kWh)      | 400              | 110       | 50         |
|                   | Direct energy(off shore) | Electric (billion kWh)      | -                | 180       | -          |
|                   | Wave energy              | (billion kWh)               | 150              | 18        | -          |
| Geothermal Energy |                          | Electric (1000 billion kWh) | -                | -         | 1.4        |
|                   |                          | Thermal(mtoe)               | 31.500           | 7.500     | 2.843      |
| Biomass energy    |                          | Total (mtoe)                | 120              | 50        | 32         |

In Turkey, electricity is produced by thermal power plants (TPPs), consuming coal, lignite, natural gas, fuel oil and geothermal energy, and hydropower plants (HPPs) (Table 2.6). The development of nuclear power in Turkey is so new.

Table2.6 Electricity production from thermal and hydropower sources according to years in Turkey (Koyun, 2007).

| Year | Thermal(GWh) | Hydropower(GWh) | Total (GWh) | % of hydropower |
|------|--------------|-----------------|-------------|-----------------|
| 1950 | 759          | 30              | 789         | 3,80            |
| 1960 | 1814         | 1001            | 2815        | 35,55           |
| 1970 | 5590         | 3033            | 8623        | 35,17           |
| 1980 | 11.927       | 11.348          | 23.275      | 48,75           |
| 1990 | 34.395       | 23.148          | 57.543      | 40,22           |
| 1995 | 50.621       | 35.541          | 86.153      | 41,25           |
| 1999 | 81.661       | 34.678          | 116.339     | 29,81           |
| 2000 | 93.934       | 30.879          | 124.813     | 24,74           |
| 2001 | 98.563       | 24.010          | 122.573     | 19,60           |
| 2002 | 71.966       | 44.034          | 116.000     | 38,00           |
| 2003 | 104.898      | 35.324          | 140.283     | 25,18           |

Cogeneration, or autoproduction, is known as Combined Heat and Power (CHP), which has been developed by governmental support to support the continuing need for additional electricity generation.

Turkey spent a total of US\$ 120 million (2005 prices and exchange rates) on government energy R&D between 1980 and 2005. In this period, 15.6% of its total energy research and development (R&D) budget (US\$ 17.4 million) was allocated to renewable energy.

Among the renewable technologies, geothermal received the most sustained funding over the past two decades and the highest level of funding, equivalent to US\$6.1 million or 37% of the renewables R&D expenditures between 1980 and 2005. In addition, Turkey participates in international collaborative R&D in Photovoltaic Power Systems through the IEA Implementing Agreements. (Koyun, 2007)

### **2.5.1 Department Of Energy Resources Administration**

In Turkey, Energy conservation and efficiency studies have been carried out since 1981. In this period some organizations and Ministries and especially the General Directorate of Electrical Power Resources Survey Administration (EIE), Energy Conservation Division (ECD) has been involved in the studies.

In December 1992, National Energy Conservation Center (NECC) was established within the body of EIE by the Ministry of Energy and Natural Resources to increase the effectiveness of the activities and extend them overall the Country.

In the past, the primary organization for energy conservation, EIE/ NECC conducted three Energy Conservation projects financed by foreign sources. All, were mostly technical in nature and focused on energy audits, staff training, promotion and policy development.

As a result of all the above mentioned projects, EIE/NECC established its own energy conservation team of 25 persons trained by foreign experts and provided it with necessary equipment and vehicles (three Energy Buses and one Training Bus) to carry out various energy conservation activities overall Turkey. In order to recover potential energy savings identified by these projects, the following activities conducted by NECC. (EIE, 2011)

### **2.5.2 Energy Conservation Potential**

As an investigation of “ Department of Energy Resources Administration of EIE”, it has been identified that the energy conservation potential in the Turkish economy appears to be large. On the sectoral basis , in residential sector which is the largest energy consuming end- use sector in Turkey energy conservation potential is over 30% , in industrial sector it is over 20% and in transport sector, almost 30% depending in the measures to be taken. Total energy saving potential for the three sectors has been identified to be approximately 3 billion dollars or 14 million TOEs annually.

EIE/NECC has undertaken the leading role and conducted many efforts and gained experiences in energy conservation field so far. However for improving the effectiveness of all these efforts carried by on the volutarily basis it is necessary that an Energy Conservation Law should be put into force and some financial incentives on energy efficiency be provided without delay. We believe that all these efforts will help to achieve the conservation potential of which magnitude is being expressed in billion dollars on an annual basis. (EIE, 2011)

### **3. LIQUID OIL PROCESS IN MARSAN**

#### **3.1. History Of MARSAN GIDA SAN. ve TİC. A.Ş**

Today, Marsan Gıda Sanayi, one of former foundation of Turk Food Sector, was founded as “Glido Vegetable Oil Factory” trade name in 1925. But because of financial straits, they attempted to find new partner. Hacı Omer Sabancı bought Glido Vegetable Oil Factory and changed trade name as “Toroslar Vegetable Oil Factory”.

Firstly, Toroslar launched production as simple Kotton Factory. But by the time, as a result of both development of Turkey and enterprising character of Hacı Omer Sabancı; fat oil production was launched in Toroslar Vegetable Oil Factory in 1957. The trade name of Toroslar Vegetable Oil Factory changed as MARSA which is merge of MARGARİN and SANAYİ words. Marsa growth trend increased upside between 1973-1987.

Both production capacity and production variety number increase provided export chance. By this way, Marsa launched from local service to worldwide service. “Evin” brand fat oil which is produced in 1983, is the first brand which carried Marsa from local service to worldwide service. 1987 is a mile stone for Marsa. Marsa founded a new plant in İstanbul Büyük Çekmece and increased capacity. Marketing activity developed. Product development and efficiency sources were realized and paid attention much. Also investment started for training. Export increased. Investments started for automation technology. Marsa, by drawing a trend upside since 1987, had become a former liquid and fat oil producer in Turkey. Marsa added SUSA A.Ş under its frame and renamed as HAYAT SU. This is first step of Marsa to become a food foundation. In 1993, Marsa merged with Kraft and Philip Morris, leading to the trade name Marsa Kraft General Foods Sabancı Gıda San. ve Tic. A.Ş. Then, KGF, bought Jacobs Suchard and leaded to the trade name Kraft Jacobs Suchard and as a result, new trade name, became Marsa Kraft Jacobs Suchard in 1994.

In 1996, Marsa KJS achieved ISO 9002 Quality Certificate. In 1997, Marsa KJS founded first GOFRET Production line and Milka Gofrets were started to be sold in Turkey. In same year(1997), Marsa KJS achieved ISO 14000 Environment Certificate and ISO 9001 Quality Certificate. In 1998, Marsa KJS established second GOFRET Production line. In 1999, Tang Production Plant was founded.

In 2002, Suchard left from Marsa KJS and new trade name became Marsa Kraft Foods Sabancı Gıda San. ve Tic. A.Ş. In 2005, Marsa left from Kraft & Philip Morris and trade name again become Marsa as it was in 1973.

In 2008 Marsa, the essential brand, together Luna, Ona, Hüner, Sabah, Evet, Soyola, Deren, Ustam, Ice Tea, Soza and Saka become a member of Marsan family.

The capacity of MARSAN Gıda San. Ve Tic. A.Ş is 300 tons per day as liquid oil, 600-650 tons per day as fat oil.

### **3.2. Vegetable Oil Production**

Below all steps of cruid oil process in MARSAN A.Ş is given. In figure 3.1 process flow chart is presented firstly and each step is explained briefly in the following lines.

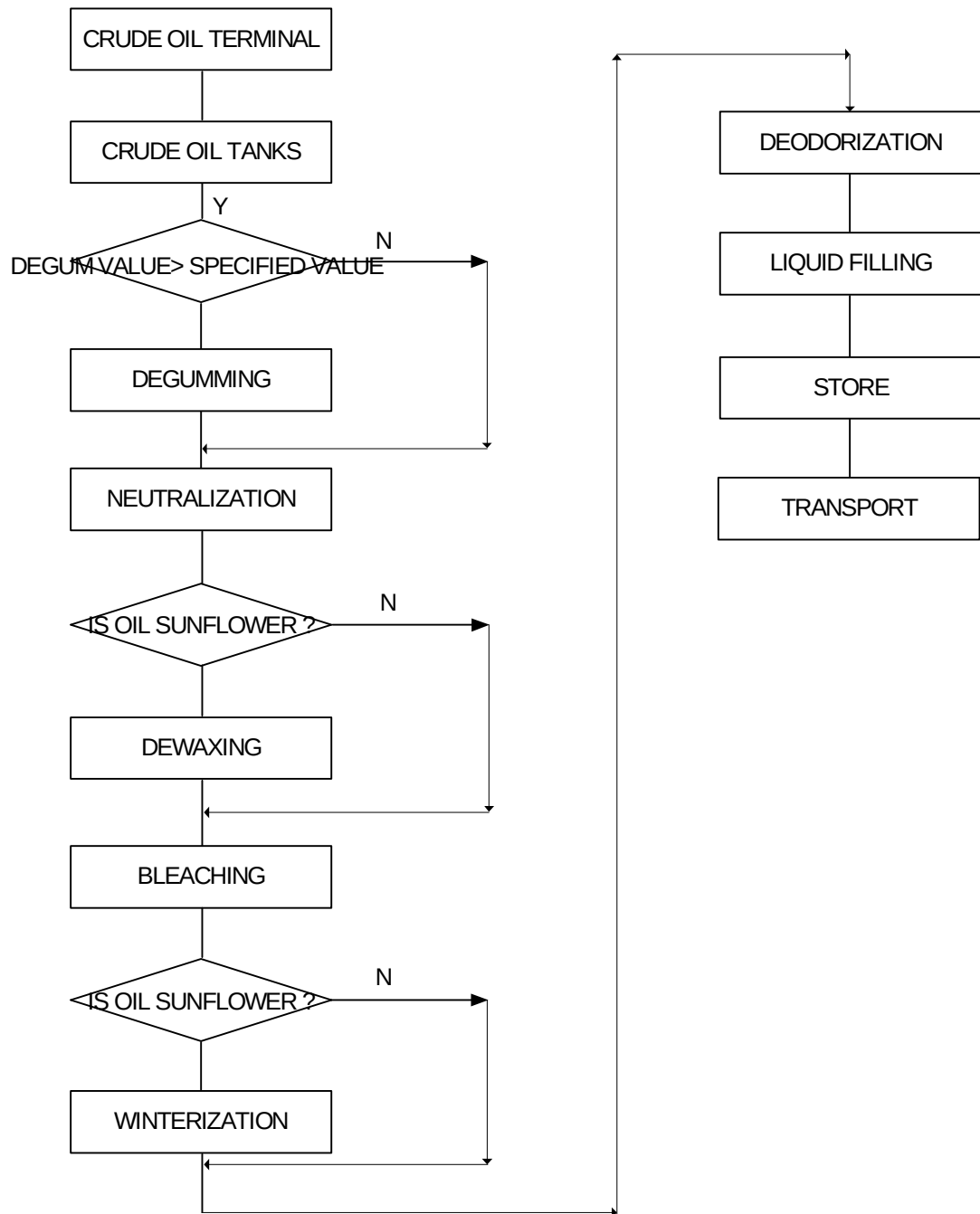


Figure 3.1. Liquid oil process overview flow diagram.

### 3.2.1. Oils

Oils are composed of tryglycerides and according to their hydrophobis structure they do only solve in organic solvents.

Oils can be classified in two groups

1. vegetable oils ; sunflower, rapeseed, soybean, palm, cotton.
2. animal oils; oil from fish and marine mammals.

According to their physical structure in ambient temperature; oils and fats can be named as liquid-oil or solid – fat.

### **3.2.2. The Refining Stage Of Crude Oil:**

The crude oil produced by chemical extraction by using hexane – a petroleum derived solvent- includes also residual materials. These residual materials are volatile aldehydes and ketones, some colouring pigments, free fatty acids, materials that gives an undesired odor and taste (flavor) to oil.

Refining is done to give oil a stability without changing the original trygliceride structure so that by removing these residual materials, the oil is going to be ready for consumption. Refining can be done in both chemical and physical processes. The chemical refining process includes neutralization, degumming, bleaching and deodorization.

### **3.2.3. Degumming :**

Crude oils include phospholipids and waxes as well as heavy metals. Phospholipids are a major class of impurities removed in conventional processes by oil degumming, at significant cost to oil yield. Phospholipids must be removed because they cause oil darkening (or browning) during the subsequent bleaching, hydrogenating, and deodorizing steps of refining. The reaction temperature of degumming is between 60 - 80°C and above and below that temperature, the separation is not done efficiently.

### 3.2.4. Neutralization:

Neutralization is done to remove free fatty acids by using alkaline and converting these free fatty acids to soap so that the density difference between soap and oil, this mixture is separated in centrifuges.

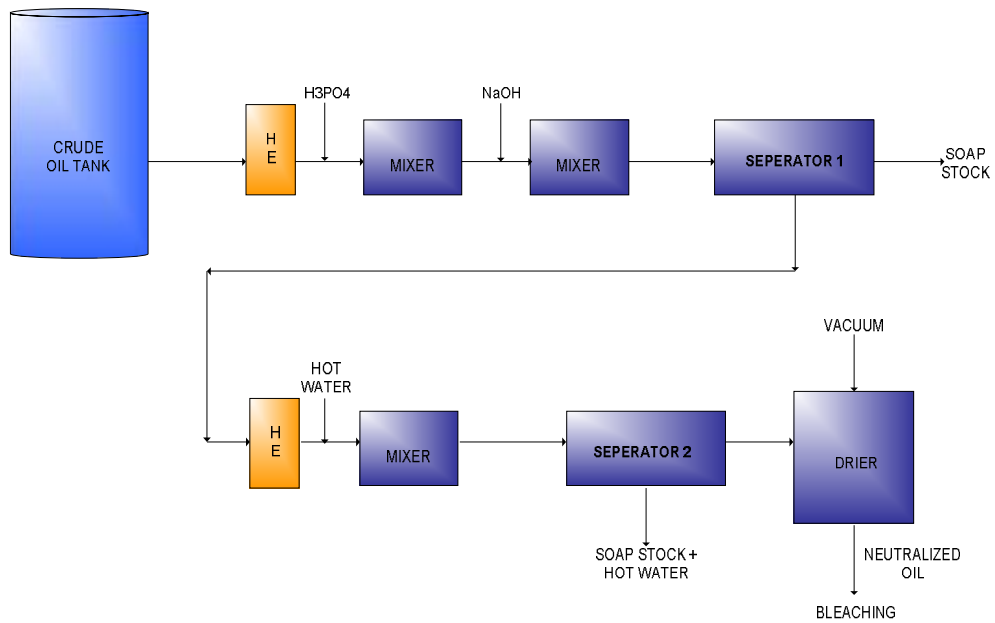


Figure 3.2. Neutralization process flow diagram.

### 3.2.5. Dewaxing:

Besides free fatty acids, also wax - a wax is a type of lipid that may contain a wide variety of long-chain alkanes, esters, polyesters and hydroxy esters of long-chain primary alcohols and fatty acids – is included in crude oil and it must be removed. Wax molecules are not removed by neutralization because of high temperature that allow the sedimentation of these molecules in neutralization process. Because of above mentioned reasons, wax molecules are crystallized in low temperatures and then separated.

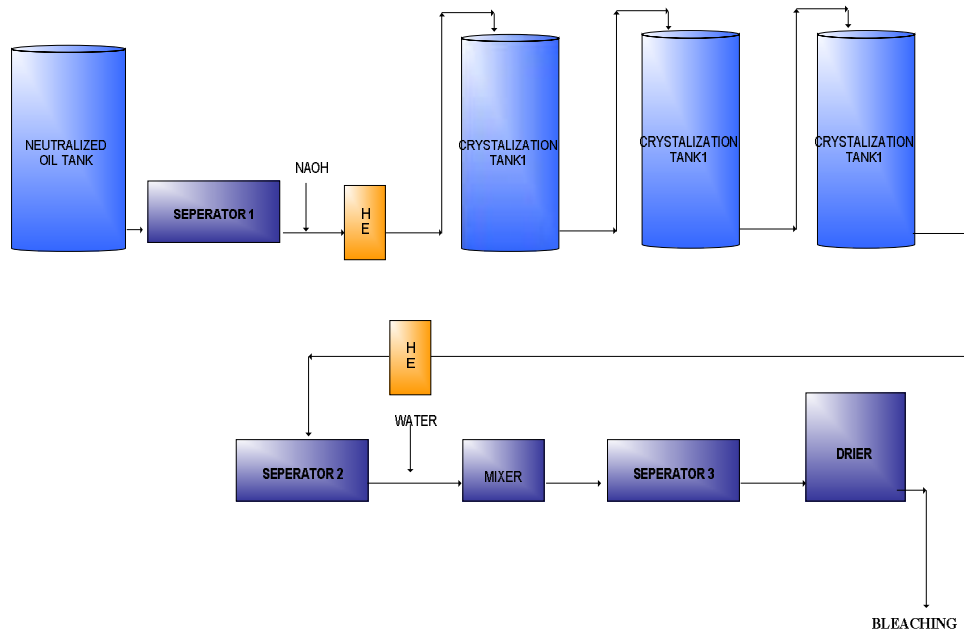


Figure 3.3. Dewaxing process flow diagram.

### 3.2.6. Bleaching

The colour of oils are derived from the colouring pigments, alpha and beta caratone and especially called chlorophyll. The concentration of chlorophyll varies in oilseeds. The storage and transportation conditions, the quality of raw materials used in refining process, temperature and reaction time also trigger the quality of edible oil. The oil which has bad starting qualities is refined more difficult compared with good one.

The best method to remove these colouring pigments and oxidative materials is using bleaching earth as an adsorbent and then filter the bleaching earth by filtration process. To protect the oil from oxidation, bleaching process is operated under low pressure (vacuum) and high temperature. And finally, bleaching process has an extra contribution to the flavor of produced edible oil.

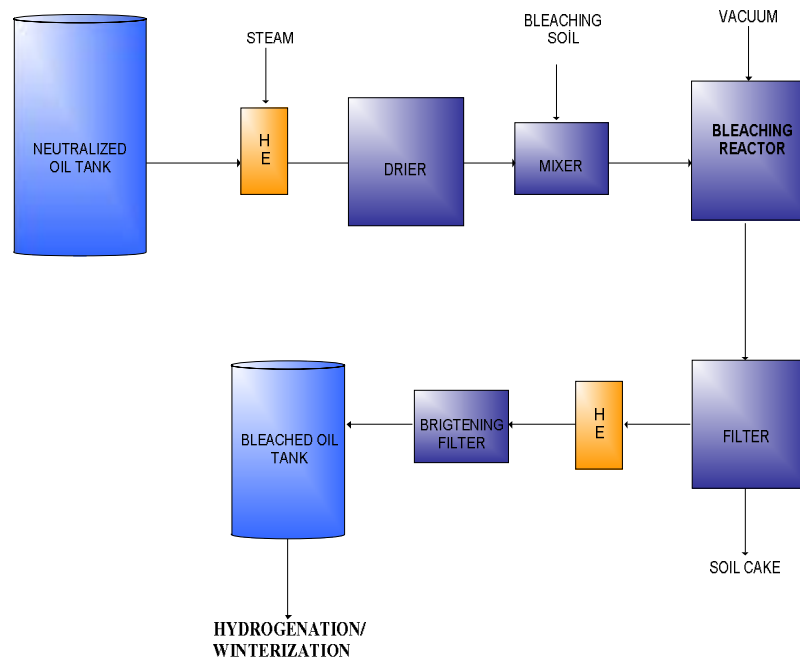


Figure 3.4. Bleaching process flow diagram.

### 3.2.7. Winterization:

After refining process, refined oil may have remnant/trace materials that cause a precipitation/sedimentation so that affect the appearance of end product in shelves. These trace materials are derived from the high melting point stearin and varies in different vegetable oils as cotton , sunflower, rapeseed and olive oil. Winterization process takes place in reactors – vessels that are cooled and agitated slowly to provide better reaction conditions to precipitate and seperate these undesired materials. A special earth is used in winterization process to start the crystallization. Cooled oil is kept at fix temperature for a certain period of time to seperate solid phase from liquid oil by filtration of the oil-solid fat slurry.

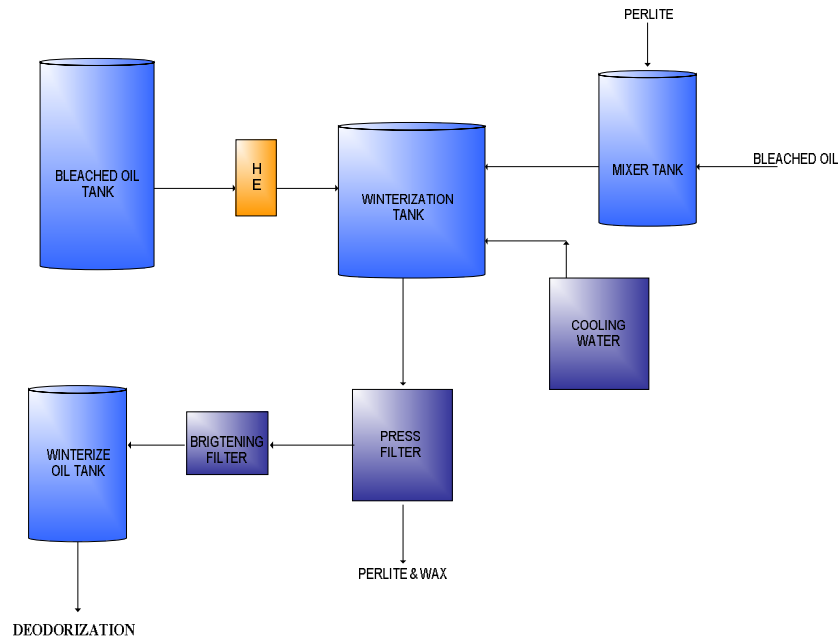


Figure 3.5. Winterization process flow diagram.

### 3.2.8. Deodorization:

Deodorization is a chemical process (steam distillation) that is used to remove free fatty acids, undesired metals and colouring pigments. This process is operated under high temperature (220 – 240 °C) and low vacuum (2 -5 mbar).

The aim of this process can be listed as;

- To remove the volatile components which give a strange odor and flavor to the oil.
- To remove the free fatty acids.
- To remove the colouring pigments and so that to polish the colour of end product/edible oil.
- To give a more stable condition without changing the original tryglyceride structure.

Materials that are removed by deodorization process can be classified in three groups:

saponifiable materials called free fatty acids and partial glycerides,  
unsaponifiable materials called sterols and tocopherols,

oxidative products called aldehydes and ketones.

Steam distillation is feasible because the flavor and odor compounds that are to be removed, have appreciably greater volatility than do triglycerides. Operation in high temperature 240-260 °C and low vacuum 1-8 mbar increases the volatility of those compounds and provides a better reaction to remove these materials as well. Reduced pressure operation further aids in removal of these materials and protects the oil from atmospheric oxidation.

Deodorization temperature is generally 220-260 °C. But above this temperature, the decomposition of unsaturated fatty acids can cause the lack of natural antioxidants and this situation adversely affects the stability of end product.

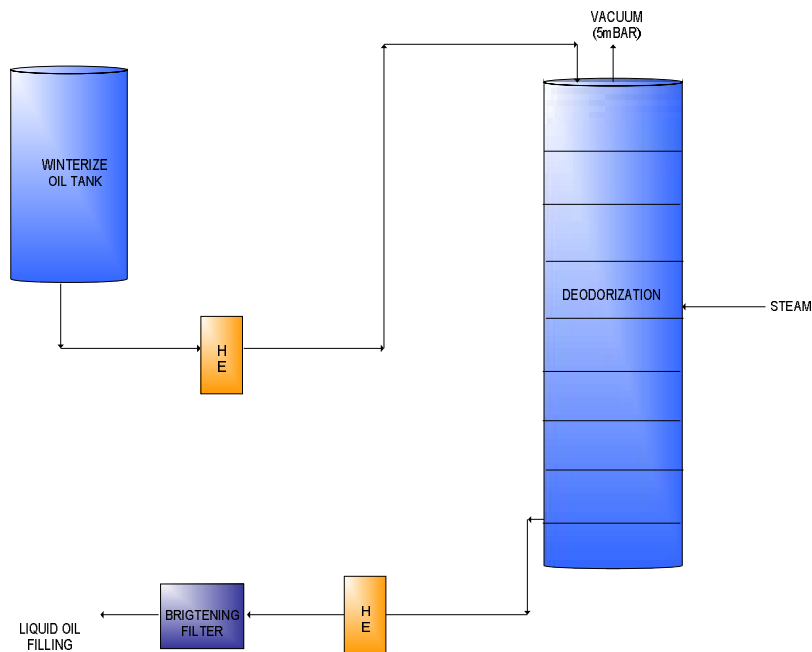


Figure 3.6. Deodorization process flow diagram.

### 3.2.9. Liquid Filling

After deodorization process, liquid oil comes into liquid filling plant. Liquid oils are filled in vessels and packed. After packing, oils are sent into cool warehouse.

### **3.3. General Overview Of Deodorization**

Deodorization process clearly covers preparation of fat blends according to desired composition and control all the production steps to produce both liquid and fat oils.

#### **3.3.1. Preparation Of Fat Composition (Blend)**

According to a previously determined composition, preparing a fat blend can be explained as using different solid fats that have different slip melting point and liquid oils together. This mixture is named as fat blend or composition.

In deodorization department, there is a fully automatic system that controls all parameters required in the preparation of composition called PCS7 ROUTE CONTROL SYSTEM.

According to a previously determined recipe formulation, compositions are prepared as batch systems. After then, a composition sample is sent to the laboratory and analysis results are saved in related documents.

If the analysis results are matched with the standart values, then composition is fed to the deodorization process. On the contrary, with the orientation of chief of deodorization department, the composition is modified with adding extra oil to reach the desired values.

#### **3.3.2. Deodorization Process**

Deodorization is a chemical process that is used to remove free fatty acids, undesired metals and colouring pigments. Deodorization is operated under high temperature (220 – 240 °C) and low vacuum (2 -5 mbar). This reaction takes place in a cylindrical vessel that has 8-10 units called deodorizer.

The parameters that determine the efficiency of deodorizer are;

1. Vacuum ( under 5 mbar)
2. Temperature (210 – 240 °C)
3. Direct/complete contact surface of oil and steam
4. Deodorization time

At the beginning of deodorization, the inlet oil which is pumped by a centrifugal pump is met with the outlet oil in a plate heat exchanger. Then the inlet oil is sent to the degaser where dissolved gases and moistures are removed from oil here.

Then, inlet oil is processed in the deodorizer under low pressure- vacuum and high temperature with direct steam. Each unit of deodorizer has a different set temperature and when the oil temperature reaches the set value, oil is sent to the other unit.

By this process; free fatty acids, aldehydes, ketones, undesired colouring pigments and metals are removed from the oil. Free fatty acids which are removed from the oil are collected in a vessel by seperating them from the barometric condenser and these fatty acids are the product of this process. Then, the oil is cooled to the 40 -60 °C in a heat exchanger with cooling water before it is sent to the margarine production vessels.

### 3.3.3. Operation Principles Of Deodorizer-2

Deodorizer 2 has nine seperate units and the last unit (9th unit) is acid compartment. Figure 3.7 shows deodorization 2 system briefly. Compartments 1,2,3,6,7,8 have heating coils. Between 1- 7 and 2 - 6 compartments, there are thermosyphon systems and vaporax is directly connected with 3rd compartment.

Starting temperature for the 1st compartment is 100 °C and 7th compartment temperature is 190 °C. Thermospyhon system provides a heat exchange between 1st and 7th compartments so that while the inlet oil heats up from 100°C to 120-130°C, deodorized oil cools down from 200°C to 180-170 °C. Similarly, between 2nd and 6th compartments, this heat exchange is done. While the inlet oil heats up from 120-

130°C to 150-160°C, the deodorized oil cools down from 230-240°C to 210-200°C. Third compartment is heated up by vaporax system about 230-240°C. Vaporax system is like thermosyphon system. There are two heating coil which are connected each other by pipe. One of the heating coil is in 3th unit of deodorization and the other heating coil is in LNG boiler. LNG is fired and closed loop water starts heating. Heated steam goes up and meet with oil. By heat transfer in 3th unit, oil is heated and steam is cooled and transforms to water(from gas to liquid phase) and goes down into LNG boiler. Heated steam goes up again into 3th unit heating coil. By this circulation, 3th unit oil temperature is increased. In 4th and 5th units, there are not any heating system. In those two units, steam is fed into oil by a pump. By this way, oil acids are removed.

Initial temperature of oil which flows from 7th unit into 8th unit is about 170°C. 8th unit is cooled by soft water. External cooling is applied only at 8th unit of deodorization system. In this unit, heating coil is used for cooling. There is a closed loop water cycle system for cooling vegetable oil which is in 8th unit of deodorization system. Cold soft water flows inside heating coil which is in 8th unit of deodorization system. When cold soft water and hot vegetable oil meets in 8th unit, heat exchange occurs; vegetable oil temperature decreases and soft water temperature increases. After leaving of hot soft water from 8th unit, it flows through a shell and tube heat exchanger. In that heat exchanger, soft hot water meets with cold water which is pumped(each 150t/h capacity, 5 pumps) from cooling tower(open loop cooling water cycle). In this system, soft water cools and flows in soft water tank. And again pumped into 8th unit of deodorization by soft water pump(75t/h capacity). Cooling tower water is heated at shell and tube heat exchanger and for cooling, pumped to cooling tower.

Cooled oil is pumped into 881b cooling shell and tube heat exchanger. In this heat exchanger, cooling is done by cooling tower. Cooled oil (about 50-65°C) is pumped in chemical additive tanks for fat oil production.

| Deodorizer name | production year | capacity M <sup>3</sup> oil/day | heating system |
|-----------------|-----------------|---------------------------------|----------------|
| Deodorizer 1    | 1991            | 170tons/day                     | vaporax        |
| Deodorizer 2    | 2005            | 300tons/day                     | vaporax        |
| Deodorizer 3    | 2006            | 180tons/day                     | vaporax        |

Because deodorizer 1 is too old, it is not running. Deodorizer 2 is always run. If monthly production demand is too high,deorizer 3 is also started.

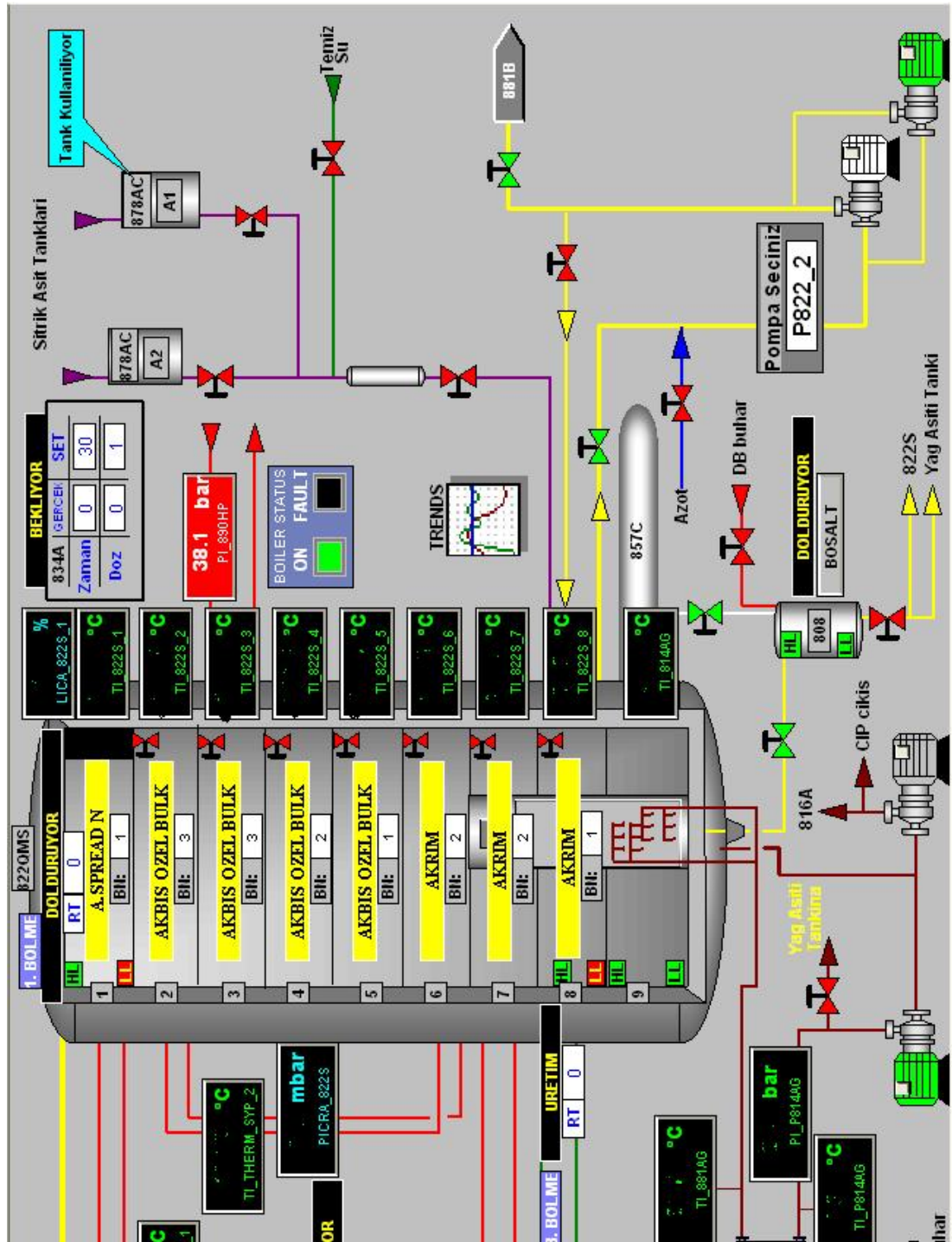


Figure 3.7 SCADA of deodorization system 2.

## **4. BOILERS**

### **4.1. Boiler**

A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam, its volume increases about 1.600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

The process of heating a liquid until it reaches its gaseous state is called evaporation. Heat is transferred from one body to another by means of (1) radiation, which is the transfer of heat from a hot body to a cold body without a conveying medium, (2) convection, the transfer of heat by a conveying medium, such as air or water and (3) conduction, transfer of heat by actual physical contact, molecule to molecule. (Bee India, 2011)

### **4.2. Boiler Specification:**

The heating surface is any part of the boiler metal that has hot gases of combustion on one side and water on the other. Any part of the boiler metal that actually contributes to making steam is heating surface. The amount of heating surface of a boiler is expressed in square meters. The larger the heating surface a boiler has, the more efficient it becomes. The quantity of the steam produced is indicated in tons of water evaporated to steam per hour. Maximum continuous rating is the hourly evaporation that can be maintained for 24 hours. F & A means the amount of steam generated from water at 100°C to saturated steam at 100°C.

Table 4.1 Typical Boiler Specification (Bee India, 2011).

|                                |                              |
|--------------------------------|------------------------------|
| Boiler Make & Year             | XYZ & 2003                   |
| MCR(Maximum Continuous Rating) | 10TPH (F & A 100°C)          |
| Rated Working Pressure         | 10.54 kg/cm <sup>2</sup> (g) |
| Type of Boiler                 | 3 Pass Fire tube             |
| Fuel Fired                     | Fuel Oil                     |

### 4.3. Boiler Systems

The boiler system comprises of feed water system, steam system and fuel system. The feed water system provides water to the boiler and regulates it automatically to meet the steam demand. Various valves provide access for maintenance and repair. The steam system collects and controls the steam produced in the boiler. Steam is directed through a piping system to the point of use. Throughout the system, steam pressure is regulated using valves and checked with steam pressure gauges. The fuel system includes all equipment used to provide fuel to generate the necessary heat. The equipment required in the fuel system depends on the type of fuel used in the system. A typical boiler room schematic is shown in Figure 4.1.

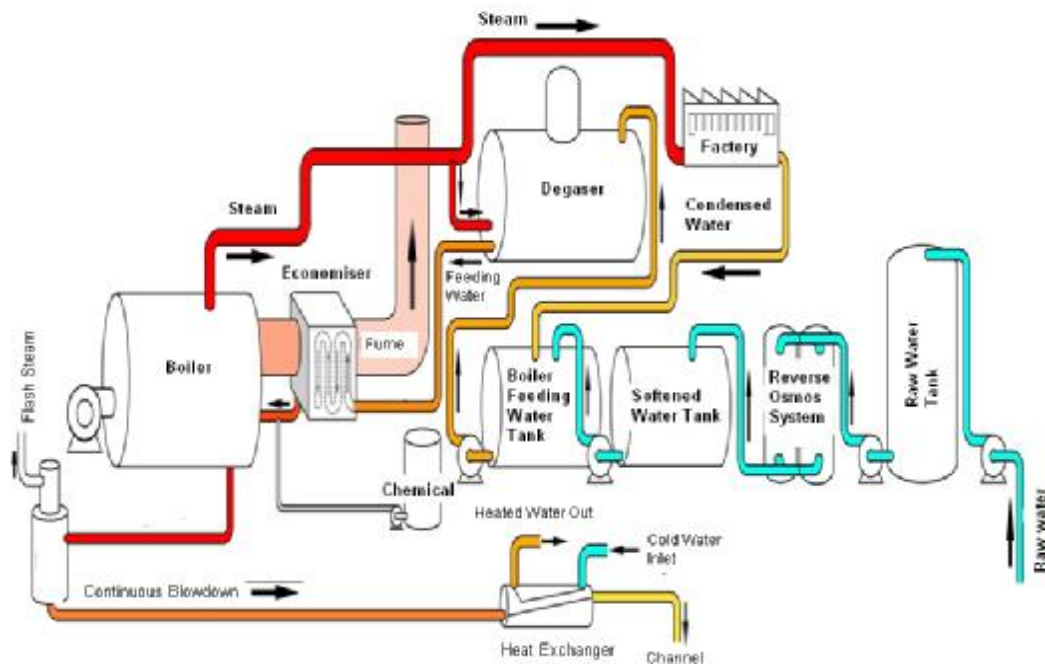


Figure 4.1 Boiler Room Schematic

The water supplied to the boiler that is converted into steam is called feed water. The two sources of feed water are: (1) Condensate or condensed steam returned from the processes and (2) Makeup water (treated raw water) which must come from outside the boiler room and plant processes. For higher boiler efficiencies, the feed water is preheated by economizer, using the waste heat in the flue gas (Bee India, 2011).

#### 4.4. Classification

Boiler classification can be based on many factors like usage, fuel fired, fuel firing system, type of arrangement etc. Commonly known types are pulverized coal fired boilers, fluidized bed boilers, super critical boilers, oil and gas fired boilers. All cater to industrial and power generation.

From 200 B.C. to date, many developments have taken place that today allow us to classify steam boilers in different ways. Hence steam generating boilers can be classified under various categories. The main purpose of steam boilers is to generate steam, and so the way in which the steam is generated and consumed forms the

major category. The major two groups of boiler application are Industrial steam generators and power generation boilers. Boilers are also classified as fire tube and water tube boilers. (Sathyanathan, 2011)

#### 4.4.1. Fire tube

Fire tube or “fire in tube” boilers; contain long steel tubes through which the hot gasses from a furnace pass and around which the water to be converted to steam circulates. (Refer Figure 4.2). Fire tube boilers, typically have a lower initial cost, are more fuel efficient and easier to operate, but they are limited generally to capacities of 25 tons/hr and pressures of 17.5 kg/cm<sup>2</sup>.

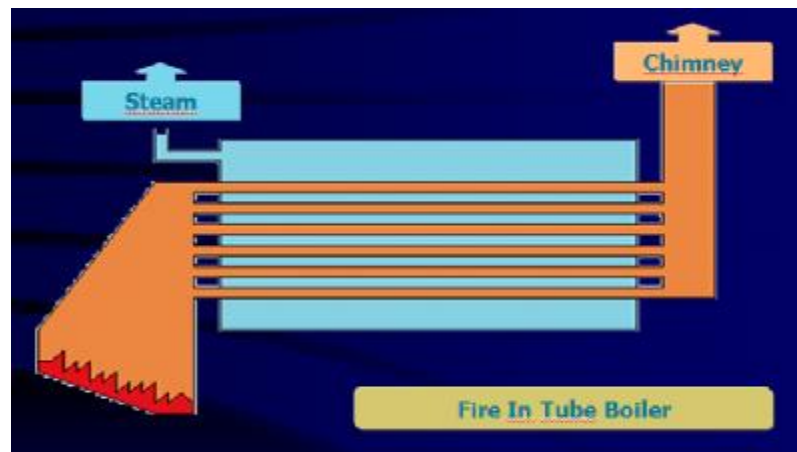


Figure 4.2 Fire Tube Boiler (Bee India, 2011).

#### 4.4.2. Water tube

Water tube or “water in tube” boilers in which the conditions are reversed with the water passing through the tubes and the hot gasses passing outside the tubes (see figure 4.3). These boilers can be of single- or multiple-drum type. These boilers can be built to any steam capacities and pressures, and have higher efficiencies than fire tube boilers.

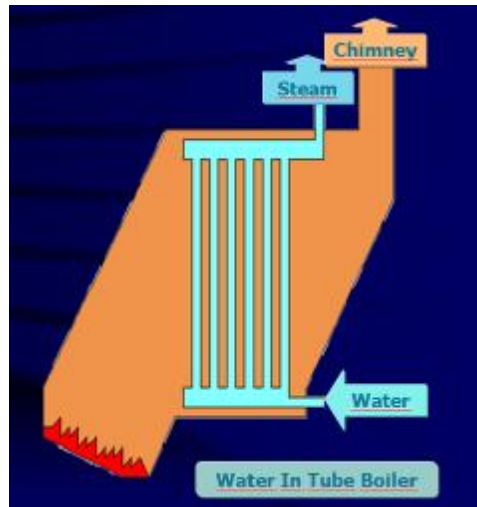


Figure 4.3 Water Tube Boiler(Bee India, 2011).

Depending on type of firing adopted in boilers they can be classified as

- Stoker fired
- Pulverized coal fired
- Down shot fired
- Fluidized bed boilers
- Cyclone fired
- Chemical recovery boilers

Incinerators (Sathyanathan, 2011).

Because MARSAN A.Ş Plant boiler type is Chain Grate stoker fired type boiler, we will mention about stoker fired types

#### 4.4.3. Stoker Fired Boiler:

Stokers are classified according to the method of feeding fuel to the furnace and by the type of grate. The main classifications are:

1. Chain-grate or traveling-grate stoker
2. Spreader stoker

#### 4.4.3.1. Chain-Grate or Traveling-Grate Stoker Boiler

Coal is fed onto one end of a moving steel chain grate. As grate moves along the length of the furnace, the coal burns before dropping off at the end as ash. Some degree of skill is required, particularly when setting up the grate, air dampers and baffles, to ensure clean combustion leaving minimum of unburnt carbon in the ash.

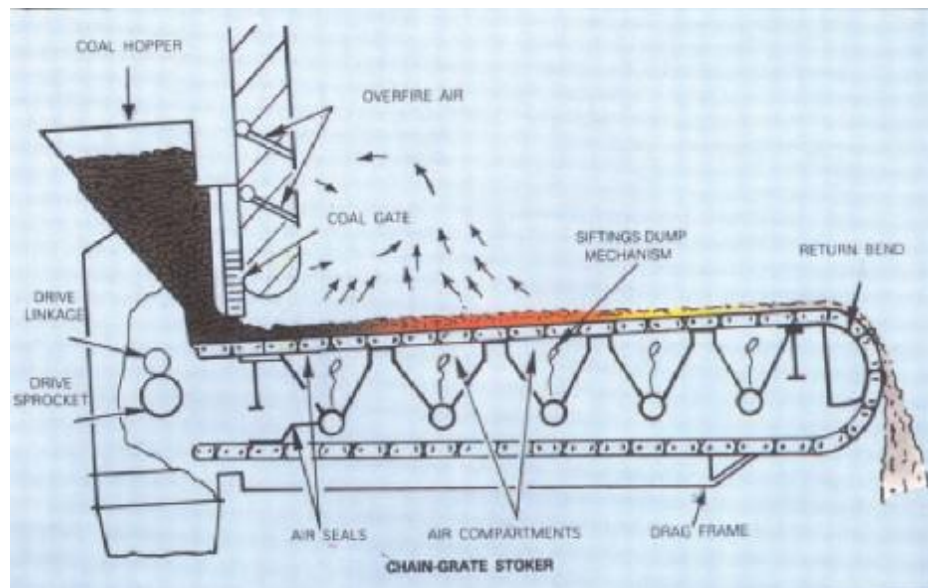


Figure 4.4 Chain Grate Stoker (Bee India, 2011).

The coal-feed hopper runs along the entire coal-feed end of the furnace. A coal grate is used to control the rate at which coal is fed into the furnace, and to control the thickness of the coal bed and speed of the grate. Coal must be uniform in size, as large lumps will not burn out completely by the time they reach the end of the grate. As the bed thickness decreases from coalfeed end to rear end, different amounts of air are required- more quantity at coal-feed end and less at rear end (see Figure 4.4). (Bee India, 2011).

#### 4.4.3.2. Spreader Stoker Boiler

Spreader stokers (see figure 4.5) utilize a combination of suspension burning and grate burning. The coal is continually fed into the furnace above a burning bed of

coal. The coal fines are burned in suspension; the larger particles fall to the grate, where they are burned in a thin, fastburning coal bed. This method of firing provides good flexibility to meet load fluctuations, since ignition is almost instantaneous when firing rate is increased. Hence, the spreader stoker is favored over other types of stokers in many industrial applications.

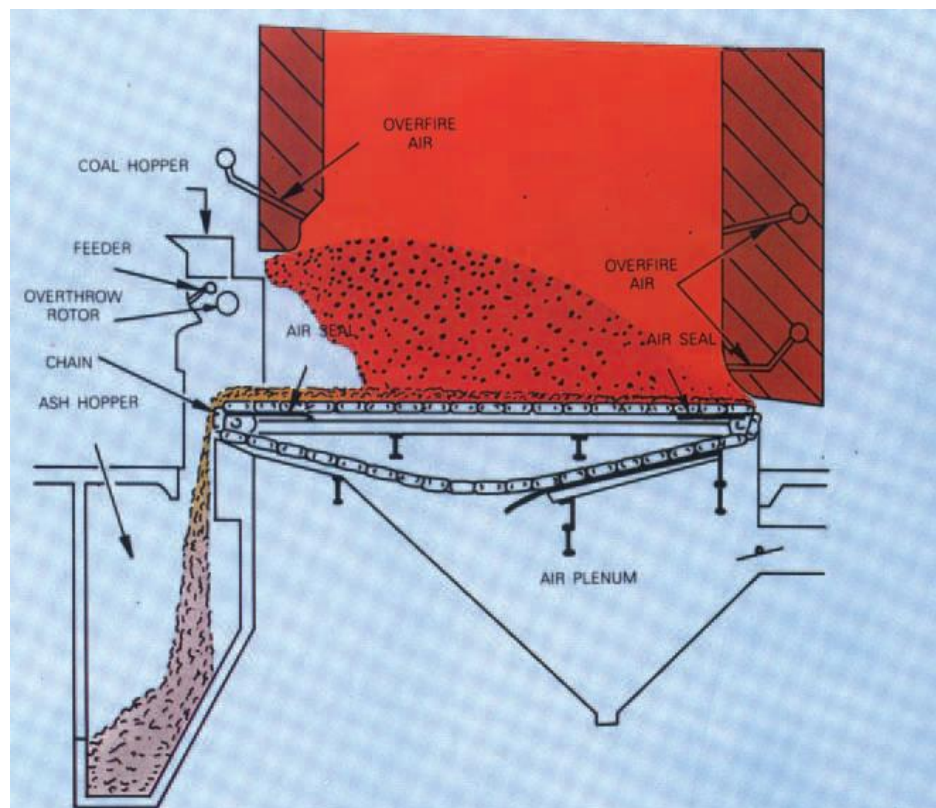


Figure 4.5 Spreader Stoker (Bee India, 2011).

Of these the stokers which were predominantly used in early days of high pressure high capacity boilers are being replaced by pulverized coal fired boilers and fluidized bed boilers. Stoker boilers are still designed and used in few applications like sugar industries, etc. Fluidized boilers are also going through fast development and can be now subclassified as

- Bubbling fluidized bed boilers
- Pressurized fluidized bed boilers
- Circulating fluidized bed boilers.

The higher capacity boilers are mainly circulating fluidized bed boilers due to inherent limitations in bubbling bed boilers.

Boilers can be classified based on the type of fuel used as

- Coal fired boilers
- Oil fired boilers
- Gas fired boilers
- Multi-fuel fired
- Industrial waste fired boilers
- Biomass fired boilers.

Various types of arrangement are used by designers in designing the boiler for meeting the end requirement. Hence boilers are classified based on the arrangement as

- Top supported boilers
- Bottom supported
- Package boilers
- Field erected boilers
- Drum type boilers
  - o Single drum
  - o Bi drum
  - o Three drums, but these are presently out of use
- Tower type or single pass
- Close coupled
- Two pass boilers

Boilers therefore can be classified based on firing type, fuel used, construction type, circulation type, firing system design nature, and nature of steam application. Today's steam generating systems owe their dependability and safety to more than 125 years of experience in the design, fabrication, and operation of water tube boilers (Sathyanathan, 2011).

**4.5. MARSAN A.Ş Steam Boiler Plant**

MARSAN A.Ş steam boiler is 1987 model, coal fired chain grate stoker type, 25t/h steam capacity and specifications of boiler is given in table 4.2. Monthly steam consumption is about 11.000 tons. Minimum consumption is 9.000 tons, maximum consumption is 12.000 tons in a month. Monthly coal consumption is about 1.500-1.700 tons.

Table 4.2 MARSAN boiler specification table

|                  |                               |
|------------------|-------------------------------|
| Manufacturer     | Sungurlar                     |
| Type             | Water tube-Chain Grate Stoker |
| fuel type        | Coal                          |
| Burning system   | reciprocating grate mechanism |
| Capacity         | 25 t/h                        |
| Steam type       | super heated                  |
| Production year  | 1987                          |
| Working pressure | 15 bar                        |
| Test pressure    | 22 bar                        |

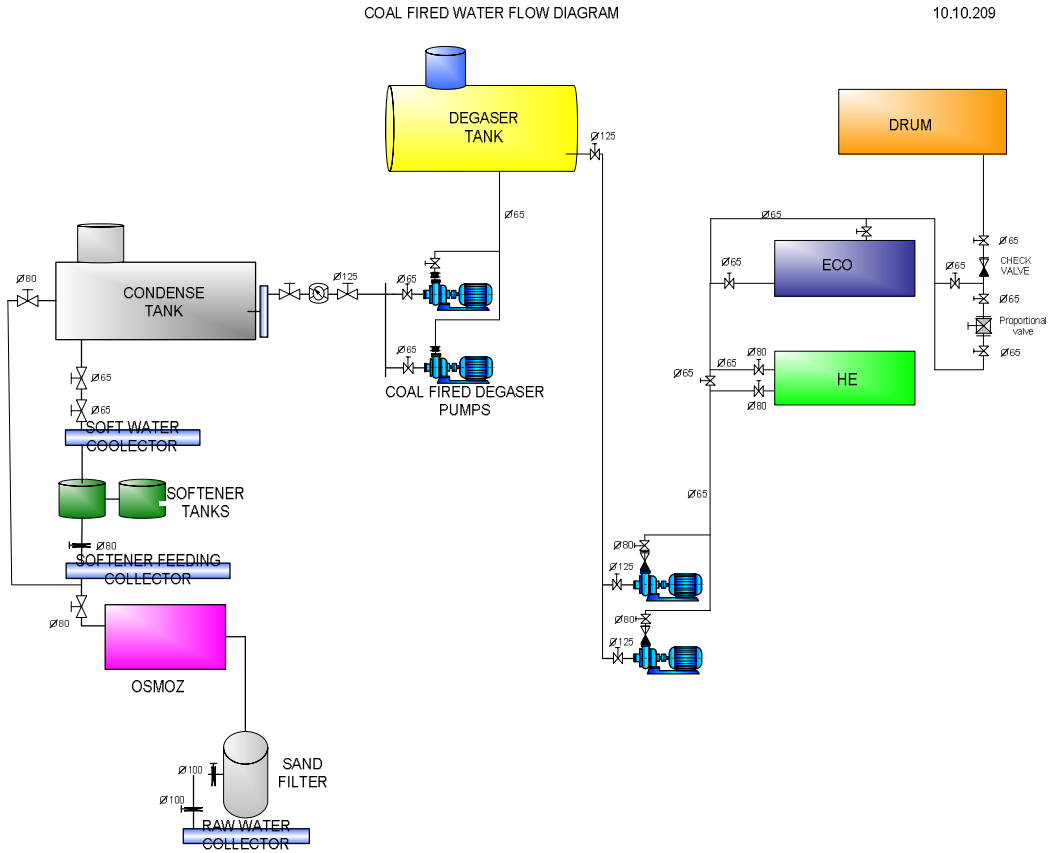


Figure 4.6 MARSAN A.Ş. Boiler water flow diagram

Cold raw water is supplied from underground by pumps and fed to collector. By passing raw water from sand filter, water is cleaned from big particles. Then by osmosis system, water is softened. Drum must be fed by softened water. Otherwise drum will be exposed to corrosion. Softened water is fed to condense tank (60 tons of water capacity). Also there is a buffer tank for returned condense (5 tons of water capacity). If analysis of condense sample is clean, then it is fed to condense tank manually.

Condense tank water is fed into degaser tank. Function of degaser tank is cleaning softened water from gas (oxygen). Capacity of degaser tank is 20 tons. There is horizontal steam pipes under degaser tank. Steam is controlled by proportional valve. Proportional valve is controlled by a temperature controller as PID control. Set value of degaser tank temperature is 102°C. When steam is fed into degaser tank from bottom, it moves to upside. At this movement, free oxygens moves from water to outside. In this way water is cleaned from oxygen. There are

two sensors at degaser tank. If degaser water level beyond low level sensor, degaser feeding pumps runs until degaser water level reaches high level sensor.

Degased water is fed to drum by drum pumps. On the way firstly there is a shell and tube heat exchanger. In one side, there is steam and at other side there is drum water. In this heat exchange, water temperature is increased up about 125°C.

After leaving from shell and tube heat exchanger, water passes through economiser. Economiser is like heating coil. It is placed inside chimney. Smoke temperature before economiser is about 220°C. Smoke heat is transfered to water which flows inside the heating coil. While leaving water from economiser, temperature of water is increased up about 145°C.

There is a level transmitter at drum, water is fed from degaser to drum by driver controlled pump. In this way, water passes inside steam-water heat exchanger and water temperature increases about 125°C. By passing from economiser, water is poured into drum as 145°C.



Figure 4.7 An overview of coal fire boiler of MARSAN A.Ş



## 5. DESIGN AND IMPLEMENTATION OF PROJECT

### 5.1. Proposed Study:

In this thesis, it is aimed to make an integrated system between deodorization unit that needs cooling and boiler unit that needs heat to work in an efficient way and gain energy in MARSAN Plants. Energy efficiency and additionally these two units and their control automations with logic parameters are also covered with this study.

Steam is produced from water. So water is one of main needs of boiler units. While producing steam, water is heated. The more cold water, the more energy consumption to get steam. So if boiler can be fed with hotter water, then energy consumption of course decreases. In Marsan boiler unit, in steam production, the flow diagram of water is explained in chapter 4. In this thesis, condense tank level is controlled by founded automation system in boiler unit. So condense tank level old control system is explained at below. And in chapter 5.2, new designed condense tank level control system will be explained.

Cold raw water is supplied from underground by pumps and fed into collector. By passing raw water from sand filter, water is cleaned from big particles. Then by osmosis system, water is softened. Drum must be fed by softened water. Otherwise drum will be exposed to corrosion.

Softened water is fed into condense tank. Condense tank capacity is 60 tons of water. Also returned condense is fed if analyses of sample is clean.

Level control of condense tank of old system is so simple. There are two level sensors(HL, LL). When condense tank water level is below LL sensor, reverse pump starts running until condense tank water level reaches HL sensor level. When condense tank water level reaches HL sensor level, reverse pump stops until condense tank water level decreases below LL sensor level. But there is no SCADA system at boiler plant to monitor condense tank level or to monitor other control systems. So this is also a risk.

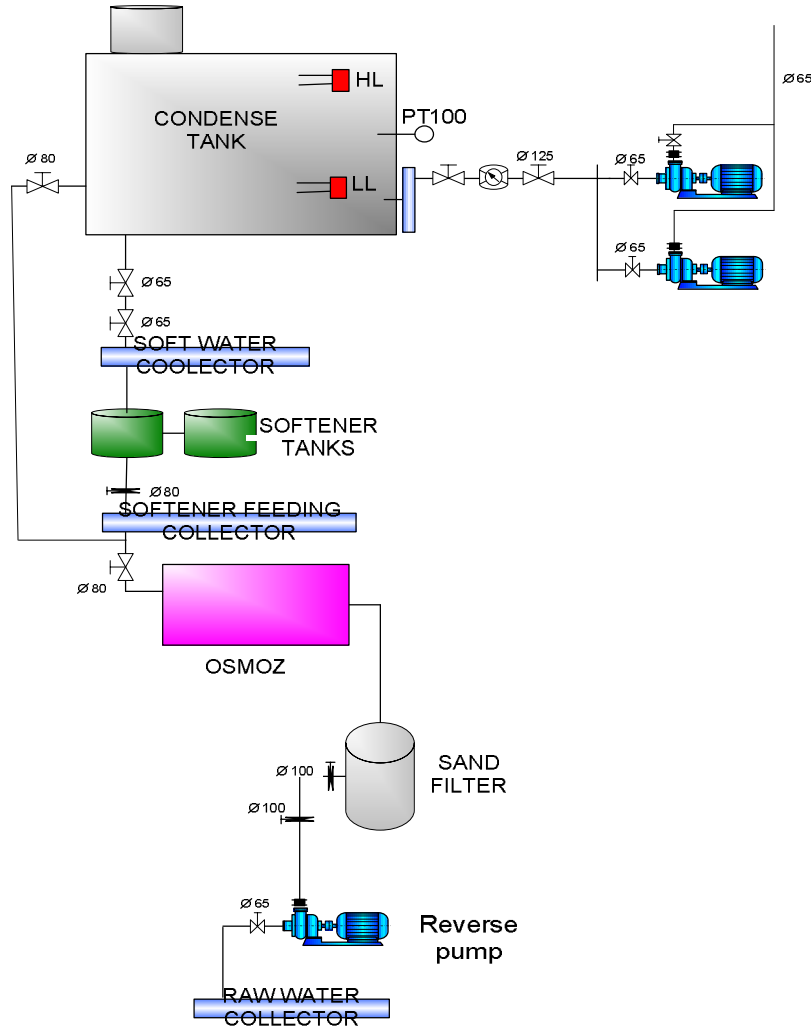


Figure 5.1 MARSAN Boiler Plant condense tank level control old system

In new designed system, the other controlled parameter is cooling of 8th unit of deodorization plant. Generally 170°C hot vegetable oil is cooled about 80°C. The process of deodorization is explained in chapter 3.3.3 in detail. So 8th unit of deodorization process cooling old control system is explained below. And in chapter 5.2, new designed cooling control system of 8th unit of deodorization process will be explained.

Deodorization takes place in a cylindrical vessel which is divided with 9 units Figure(5.2). The inlet vegetable oil comes from up of the deodorizer and heated up in first three units. The fourth and fifth units are the units that deodorization is made by steam. In the last three units, the outlet vegetable oil is confronted with the inlet

vegetable oil so that the outlet vegetable oil is cooled for the desired operation conditions while the inlet vegetable oil is heated up as well.

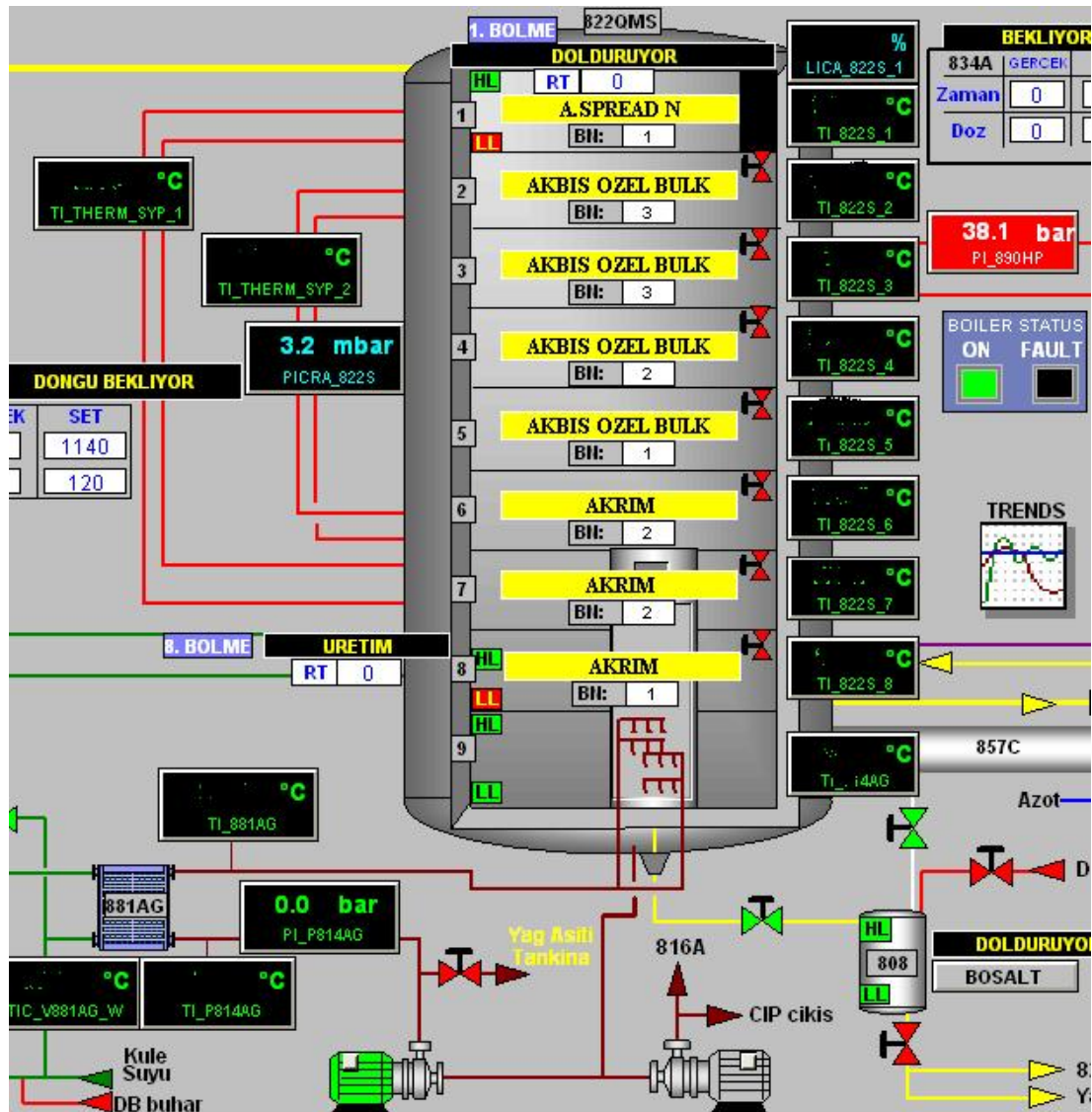


Figure 5.2 Deodorization system overview

There are thermosiphon systems between first & 7th units and second & 6th units. At third unit by vaporax system, vegetable oil temperature is increased about 230-250 °C.

External cooling is applied only at 8th unit of deodorization system. In this unit, heating coil is used for cooling. There is a closed loop water cycle system for cooling vegetable oil which is in 8th unit of deodorization system(see figure 5.3).

Cold soft water flows inside heating coil which is in 8th unit of deodorization system. When cold soft water and hot vegetable oil meets in 8th unit, heat exchange occurs; vegetable oil temperature decreases and soft water temperature increases. After leaving hot soft water from 8th unit, it flows through a shell and tube heat exchanger. In that heat exchanger, soft hot water meets with cold water which pumped(each 150t/h capacity, 5 pumps) from cooling tower(open loop cooling water cycle). In this system, soft water cools and pours in soft water tank and again pumped into 8th unit of deodorization by soft water pump(75t/h capacity). Cooling tower water is heated at shell and tube heat exchanger and for cooling, pumped into cooling tower.

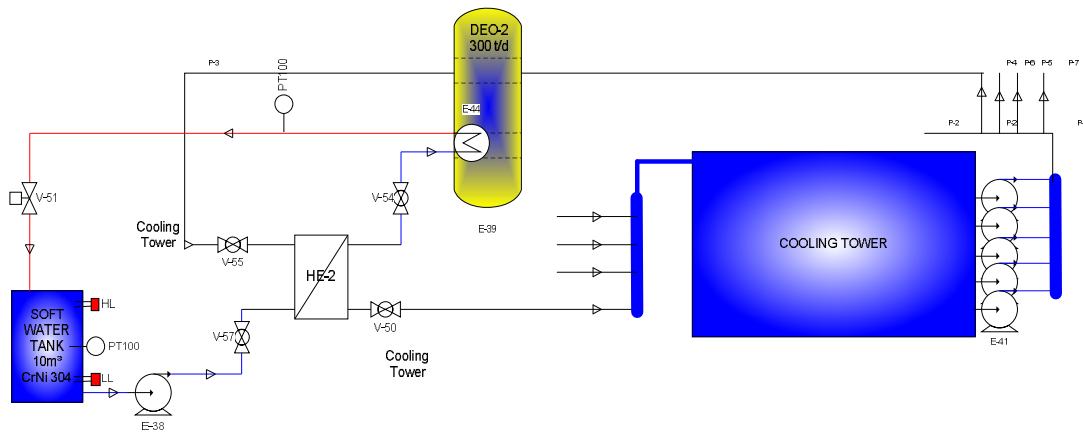


Figure 5.3 MARSAN old cooling system of 8th unit of deodorization plant.

In old cooling system of 8th unit of deodorization, normally operator sets vegetable oil temperature for cooling from SCADA. But vegetable oil temperature is never decreased until set value. The reason is; cooling tower cold water temperature is (before shell and tube heat exchanger) 30-35°C. Cooling soft hot water temperature is about 65-70°C. And after leaving from shell and tube heat exchanger, cooling soft water temperature decreases between 45-50°C. Cooling tower water leaves about 45-50°C. Because deodorization cycle time is between 17-28 minutes(changes according to vegetable oil type), vegetable oil set value of 8th unit can not be caught.

Synchronization and integration are the most important steps in a control system representation. Because water is a must for the boiler unit to generate steam. If boiler does not get water properly, the pipes in boiler unit will be empty and there may be leaks in the surface of pipes with the effect of heat. In addition to that if there is no water in boiler unit, the water in pipes will be evaporated and so pressure in boiler unit will increase up to 60 bars. In this situation, if water is fed to the boiler unit, it may cause an explosion in boiler unit. For those reasons, it is important feeding required water into boiler in a steady way. But the required water for the boiler unit and steam for departments in plant can be easily changed with consumptions.

On the other hand for the deodorization unit, to cool the oil for the desired temperature, cooling water must be fed properly. In deodorization unit, each oil which must be deodorized has a different retention time in deodorization unit. These retention times can be a value between 17 minutes and 28 minutes. If boiler unit stops when it gets the required water, then it can halt the booster pump which regulates the water for the boiler unit and as a result, production in plant can be halted. For these reasons, an integral control system must be prepared according to these datas which also provide an efficient way and a reliable working conditions.

Basically this project covers these issues:

- 1- The philosophy of energy conservation between deodorization unit and boiler unit
- 2- Cooling tower load decrease.
- 3- 8th unit of deodorization cooling achievement perfect. So, getting production quality better.
- 4- Fuel consumption decrease. So pollution of environment rate decrease.
- 5- By a strong alarm system, problem risk decrease at boiler plant.
- 6- Trend logs(archives), in future, can lighten new projects.
- 7- By trend logs, problem decisions or maintenance needs can be defined.

## **5.2. Project Design.**

### **5.2.1. Main Principle Of Project Design.**

When we summarize new designed system, there are two main principles of the project:

- 1) At deodorization side, supply perfect cooling at each batch.

Deodorization processes as batch method. Each batch takes 17-28 minutes. At each batch, vegetable oil temperature must be cooled until set value, not much or less. Otherwise vegetable oil quality will be affected.

- 2) Supply enough water to condense unit of boiler plant.

If condense tank takes much water, condense feeding pump stops. (so deodorization cooling stops). On the other side, if condense tank water finishes, drum will not be fed and drum steam pressure increases and explosion risk occurs. Also, drum waterless pipes will be exposed to fire directly. So pipes will be damaged.

By integration of two systems; condense feeding cold water flows through 8th unit of deodorization heating coil, condense feeding water will be heated and also in same cycle 8th unit of deodorization will be cooled. But the most important point is continuity of cycle.

Because of these reasons; robust, reliable and comprehensive automation control system must be designed.

### **5.2.2. Design And Implementation Of Control Strategy Of New System**

Control strategy is to ensure long-term, stable, reliable operation of heating cooling system based on the composition and feature of the system. Designed control system is divided into two parts: Deodorization cooling control subsystems and boiler condense tank feeding control subsystems. Control object of deodorization cooling control subsystem is feeding cold water at each batch and achieve vegetable oil temperature at setted value which is important for quality of vegetable oil process. Control object of condense tank water feeding control subsystem is to keep water

level in safe area range. But control strategy of whole system is determined as follow:

- 1) For deodorization cooling control subsystem, it is to keep enough water flow for cooling of vegetable oil by some control strategy, based on which keeping condense tank level in safe area range.
- 2) For condense tank water feeding control subsystem, it is to keep water level in safe area range by some control strategy, based on which supplying enough water for vegetable oil cooling.

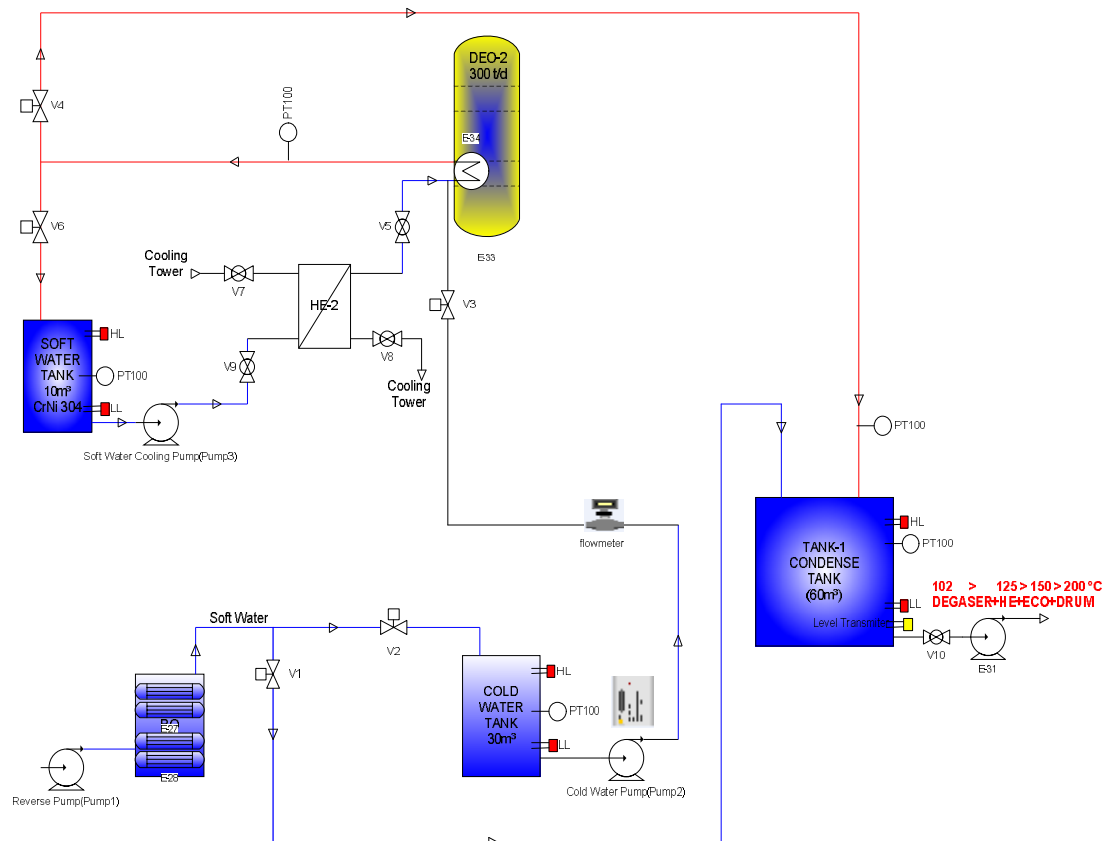


Figure 5.4 Designed system overview(P&I diagram of new system)

### 5.2.3. Automation Control Principle And Flowcharts Of Control Units

Control system of valve1: Function of valve1: Valve1 is used to direct water which is pumped by reverse osmosis pump. When valve1 is open, water flows

through valve1 and pours into condense tank. When valve 1 is closed, -and valve2 is open- water flows through valve2 and pours into cold water tank.

Open conditions of valve1: When condense tank level is below *Condense tank emergency level* which is set from SCADA, valve1 is opened.

When operator aparts two units(deodorization unit and boiler unit) from SCADA, then valve1 is opened and condense tank level is controlled by HL LL levels which are defined from SCADA.

When operator opens valve1 manually from SCADA, valve1 is opened.

Closed conditions of valve1:When condense tank level is above *Condense tank emergency reset level* which is set from SCADA, valve1 is closed.

When operator merges two units(deodorization unit and boiler unit) from SCADA, then valve1 is closed and condense tank level is controlled by cold water pump(pump2).

When operator closes valve1 manually from SCADA, valve1 is closed.

Alarm conditions of valve1:When a position change command is sent to valve1, a timer starts running and if valve1 position change can not be achieved before setted time, valve1 gives alarm. Alarm horn becomes active. This alarm is seen from SCADA alarm page and also valve1 figure flashes in SCADA general overview page.

Control system of valve2:Function of Valve2: Valve2 is used to direct water which is pumped by reverse osmosis pump. When valve2 is open, water flows through valve2 and pours into cold water tank. When valve 2 is closed, -and valve1 is open- water flows through valve1 and pours into condense tank.

Open conditions of valve2: When condense tank level is above *Condense tank emergency reset level* which is set from SCADA, valve2 is opened.

When operator merges two units(deodorization unit and boiler unit) from SCADA, then valve2 is opened and condense tank level is controlled by cold water pump(pump2).

When operator opens valve2 manually from SCADA, valve2 is opened.

Closed conditions of valve2:When condense tank level is below *Condense tank emergency level* which is set from SCADA, valve2 is closed.

When operator aparts two units(deodorization unit and boiler unit) from SCADA, then valve2 is closed and condense tank level is controlled by HL LL levels which are defined from SCADA.

When operator closes valve2 manually from SCADA, valve2 is closed.

Alarm conditions of valve2:When a position change command is send to valve2, a timer starts running and if valve2 position change can not be achieved before setted time, valve2 gives alarm. Alarm horn becomes active. This alarm is seen from SCADA alarm page and also valve2 figure flashes in SCADA general overview page.

Control systems of Valve3 and Valve4:Function of Valve3 and Valve4: Valve3 and Valve4 are used to direct water which is pumped by cold water pump. When valve3 and valve4 are open, water flows through valve3, deodrization unit heat coil, valve4 and pours into condense tank. When valve3 and valve4 are closed, -valve5, valve6 and valve7 are open- deodorization cooling water flows through valve5, valve6 and pours into soft water tank.

Open conditions of Valve3 and Valve4: When condense tank level is above *Condense tank emergency reset level* which is set from SCADA, valve3 and valve4 are opened.

When operator merges two units(deodorization unit and boiler unit) from SCADA, then valve3 and valve4 are opened and condense tank level is controlled by cold water pump(pump2).

When operator opens valve3 or valve4 manually from SCADA, commanded valve is opened.

Closed conditions of Valve3 and Valve4:When condense tank level is below *Condense tank emergency level* which is set from SCADA, valve3 and valve4 are closed.

When operator aparts two units(deodorization unit and boiler unit) from SCADA, then valve3 and valve4 are closed and condense tank level is controlled by HL LL levels which are defined from SCADA.

When condense tank level reaches above “Condense tank maximum set level” value, then valve 3 and valve4 are closed

When operator closes valve3 or valve4 manually from SCADA, commanded valve is closed.

Alarm conditions of Valve3 and Valve4: When a position change command is send to valve3 or valve4, a timer starts running and if commanded valve position change can not be achieved before setted time, commanded valve gives alarm. Alarm horn becomes active. This alarm is seen from SCADA alarm page and also commanded valve figure flashes in SCADA general overview page.

Control systems of Valve5, Valve6 and Valve7: Function of Valve5, Valve6 and Valve7: Valve5 and Valve6 are used to direct water which is pumped by soft water cooling pump. Valve7 is used to direct water which is pumped by cooling tower pumps. When valve5 and valve6 are open, water flows through valve5, deodorization unit heat coil and valve6 and pours into soft water tank. When valve5 and valve6 are closed, -valve3 and valve4 are open- deodorization cooling water flows through valve3 and valve4 and pours into condense tank.

Open conditions of Valve5, Valve6 and Valve7: When condense tank level is below *Condense tank emergency set level* which is set from SCADA, valve5, valve6 and valve7 are opened.

When operator dismerges two units(deodorization unit and boiler unit) from SCADA, then valve5, valve6 and valve7 are opened and condense tank level is controlled by reverse osmosis pump.

When condense tank level reaches above “Condense tank maximum set level” value, then valve5, valve6 and valve7 are opened.

When operator opens valve5, valve6 or valve7 manually from SCADA, commanded valve is opened.

Closed conditions of Valve5, Valve6 and Valve7: When condense tank level is above *Condense tank emergency reset level* which is set from SCADA, valve5, valve6 and valve7 are closed.

When operator merges two units(deodorization unit and boiler unit) from SCADA, then valve5, valve6 and valve7 are closed and condense tank level is controlled by cold water pump(pump2).

When operator closes valve5, valve6 or valve7 manually from SCADA, commanded valve is closed.

Alarm conditions of Valve5, Valve6 and Valve7: When a position change command is send to valve5, valve6 or valve7, a timer starts running and if commanded valve position change can not be achieved before setted time, it gives alarm. Alarm horn becomes active. This alarm is seen from SCADA alarm page and also valve figure flashes in SCADA general overview page.

Control system of reverse osmosis pump(pump1): Function of pump1: Pump1 is used to pump water from main collector to condense tank or cold water tank.

Run conditions of reverse osmosis pump(pump1): If pump1 is used to fill condense tank, it runs until water level reaches above HL level which is defined from SCADA.

If pump1 is used to fill cold water tank, it runs until water level reaches above HL sensor of cold water tank.

When operator runs pump1 manually from SCADA, if valve1 or valve2 is open, then it runs. Otherwise it does not run.

All conditions of reverse osmosis pump are defined at flowchart diagram in figure 5.5.

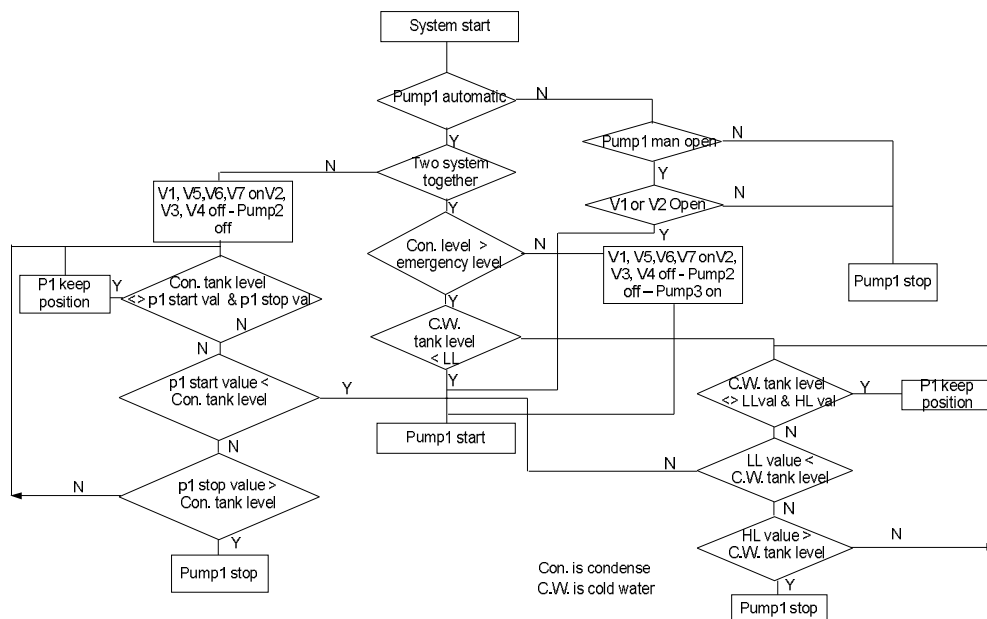


Figure 5.5 Flowchart of reverse osmosis pump(Pump1)

Stop conditions of reverse osmosis pump(pump1):

If pump1 is used to fill condense tank, it stops until water level decreases below LL level which is defined from SCADA.

If pump1 is used to fill cold water tank, it stops until water level decreases below LL sensor of cold water tank.

When operator stops pump1 manually from SCADA, pump1 stops.

Alarm conditions of reverse osmosis pump(pump1):When a position change command is send to pump1, a timer starts running and if pump1 position change can not be achieved before setted time, pump1 gives alarm. Alarm horn becomes active. This alarm is seen from SCADA alarm page and also pump1 figure flashes in SCADA general overview page.

Control system of cold water pump(pump2):Function of pump2: Pump2 is used to pump water from cold water tank to condense tank flowing through 8th part of deodorization unit. Cold water pump is controlled by variable speed driver. A level transmitter has mounted on condense tank. Condense tank level has divided into 5 parts. First part is 20tons(for safety). Other parts are 5tons. Operator sets frequency values on SCADA. At bottom level(first level), frequency value is highest(usually 50 Hz). At fifth level, frequency value is lowest(usually 15Hz). Level transmitter measures tank level and by measured value, variable speed driver is set to a frequency.

Run conditions of cold water pump(pump2): At deodorization plant SCADA system, oil temperature set value is added(see figure 5.6). Operator sets this value according to vegetable oil type. When 8th part of deodorization unit temperature decreases at setted value, deodorization PLC activates an output. This output signal is used at new control system as input. This case is seen on flow chart in figure 5.7 as “deo set” parameter. If two system(deodorization and boiler) runs together and valve 7 of deodorization unit is open or oil temperature is over “deo set” value, then pump2 runs.

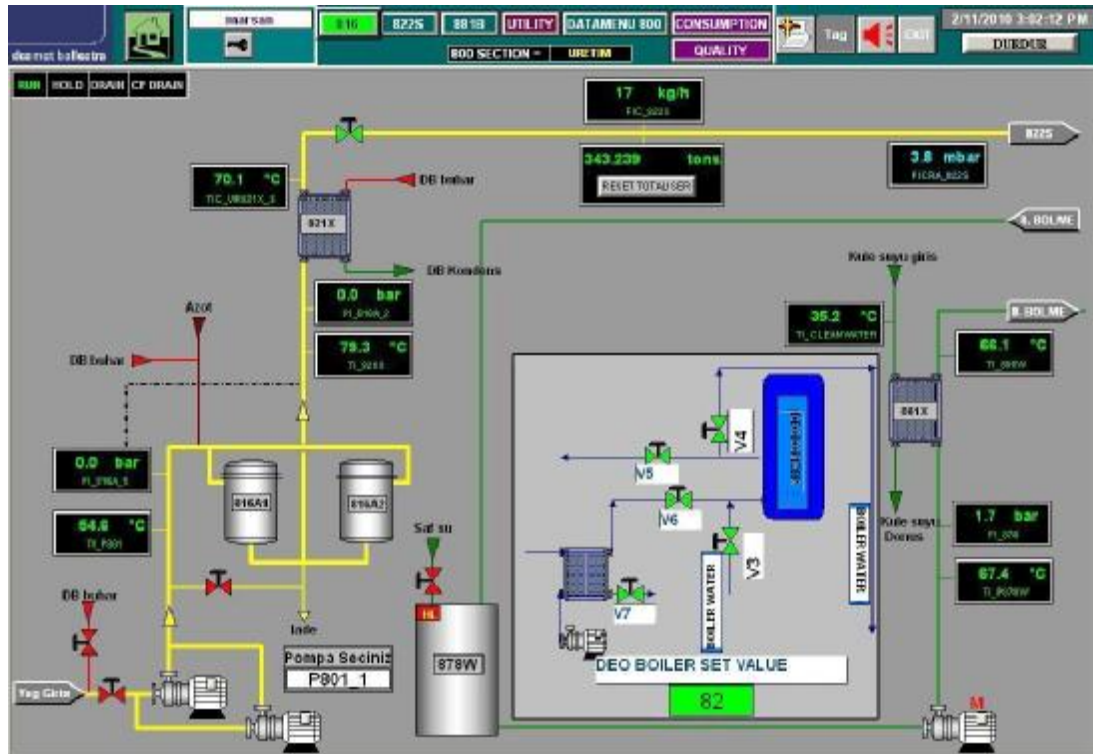


Figure 5.6 New SCADA system of Deodorization Plant

When operator runs pump2 manually from SCADA, if valve3 and valve4 are open, then it runs. Otherwise it does not run.

All conditions of cold water pump are defined at flowchart diagram in figure 5.7.

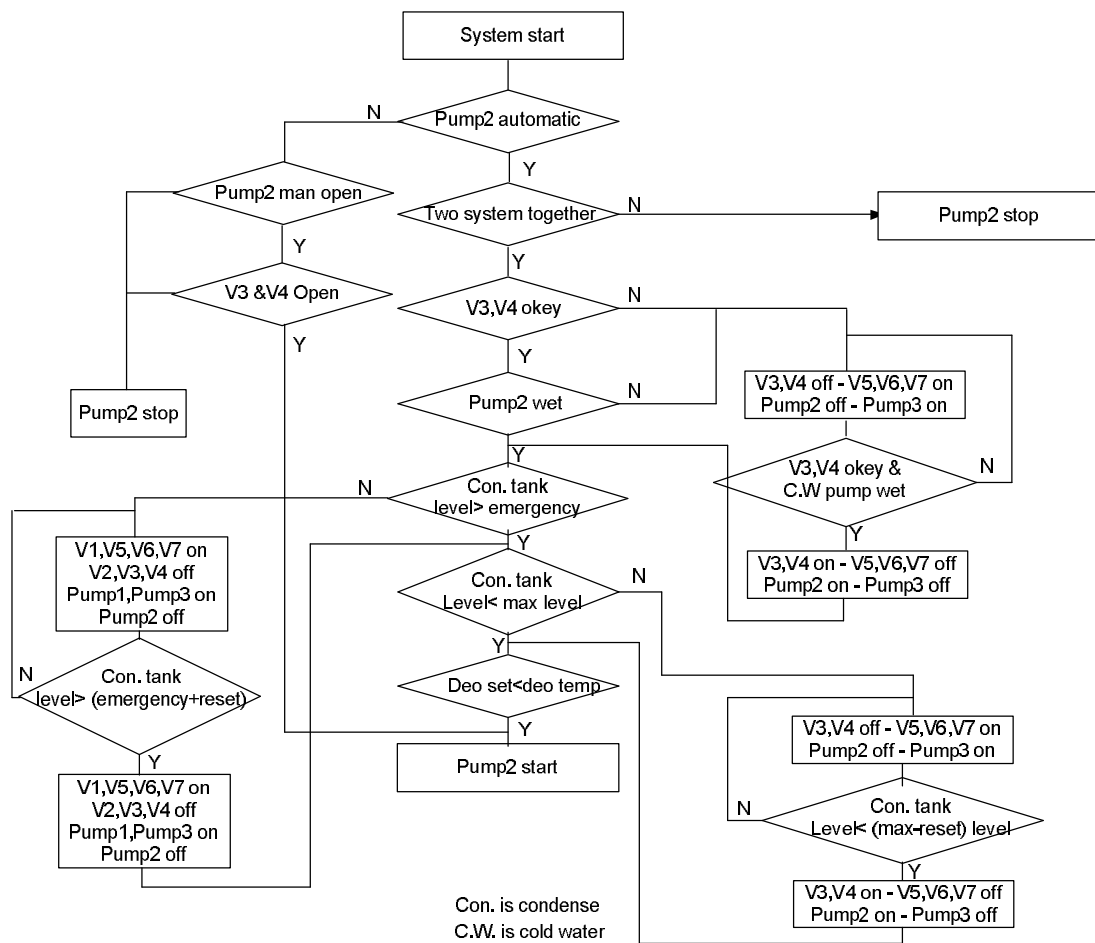


Figure 5.7 Flowchart of cold water pump(Pump2)

Stop conditions cold water pump(pump2):If two system(deodorization and boiler) run together and valve7 of deodorization unit is closed or oil temperature is below “deo set” value, then pump2 stops.

Also if there is an alarm at valve3 or valve4 or if there is no water at cold water tank, then cold water pump stops running until there will be no alarms at valve3, valve4 and cold water tank level will be above cold water wet switch.

When condense tank level reaches above “Condense tank maximum set level” value, then cold water pump stops running.

When operator stops pump2 manually from SCADA, pump2 stops.

Alarm conditions of cold water pump(pump2):When a position change command is send to pump2, a timer starts running and if pump2 position change can not be achieved before setted time, pump2 gives alarm. Alarm horn becomes active.

This alarm is seen from SCADA alarm page and also pump2 figure flashes in SCADA general overview page.

Frequency adjustment of cold water pump:As mentioned above, cold water pump is controlled by variable speed driver. A level transmitter has been mounted on condense tank. Condense tank level has been divided into 5 parts. First part is 20tons(for safety). Other parts are 5tons. Operator sets frequency values on SCADA. At bottom level(first level), frequency value is highest(usually 50 Hz). At fifth level, frequency value is lowest(usually 15Hz). Level transmitter measures tank level and by measured value, variable speed driver is set to a frequency.

Frequency decrease parameters:When 8th part of deodorization unit valve is opened, amount of hot vegetable oil starts decreasing and as parallel, returned heated water temperature decreases sharply. To eliminate this sharply temperature decrease, we decrease flow rate of cold water. This decrease value is set from SCADA.

Start set parameters(maximum frequency value and time of maximum frequency):When hot vegetable oil flows into 8th unit of deodorization unit(when 7th unit valve is opened), a defined time period (set parameter from SCADA) a defined frequency value(set parameter from SCADA) is set first. When time is over, frequency value is set normal value. The reason of this is; if frequency is low, then 170°C hot vegetable oil meets with low flow rate water, and low flow rate water temperature increases over 100°C(steam occurs in coil heat exchanger). A bit time later, cold water meets with steam and steam hammer occurs in coil heat exchanger. At this action, coil heat exchanger is damaged by the time.

Flow chart of frequency control is in figure 5.8.

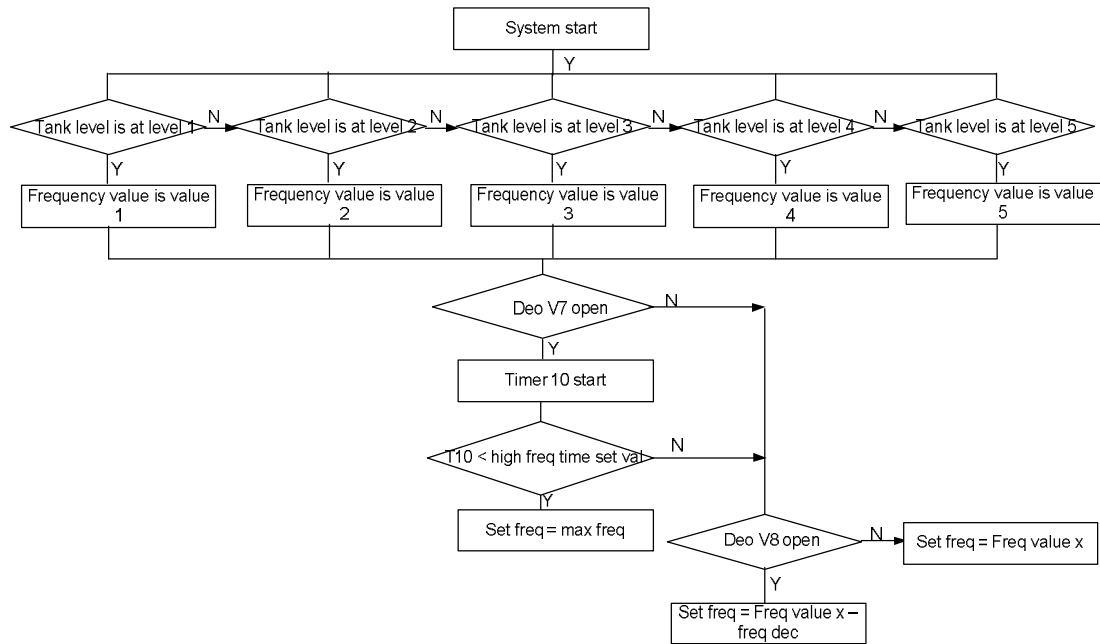


Figure 5.8 Flowchart of cold water pump frequency control(Pump2)

Control system of soft water cooling pump(pump3):Function of pump3: Pump3 is used to pump water from soft water tank to again soft water tank flowing through HE and 8th part of deodorization unit. It is controlled as on/off control system.

Soft water cooling pump control system is a bit different. A control system made at deodorization electrical panel by relays. If two systems are controlled separately, soft water cooling pump is controlled from deodorization control system(old control system). If two system is together, then by relays, deodorization control system is canceled and control is supplied from new system. (Figure 5.9).

Run conditions of soft water cooling pump(pump3):When two system are together and condense tank level is over max level, then pump3 starts running

If two system are apart, then control is at deodorization unit. In deodorization unit control program block of soft water cooling pump is: If 8th part of deodorization unit oil temperature is below 65°C, then pump3 stops. Otherwise it runs.

If condense tank level is below *Condense tank emergency level* which is set from SCADA, then pump3 starts running.

If there is an alarm at valve3 or valve4 or if there is no water at cold water tank, then soft water pump starts running until there will be no alarms at valve3, valve4 and cold water tank level will be above cold water wet switch.

When operator runs pump3 manually from SCADA, if valve5 and valve6 are open, then it runs. Otherwise it does not run.

All conditions of soft water cooling pump are defined at flowchart diagram in figure 5.9.

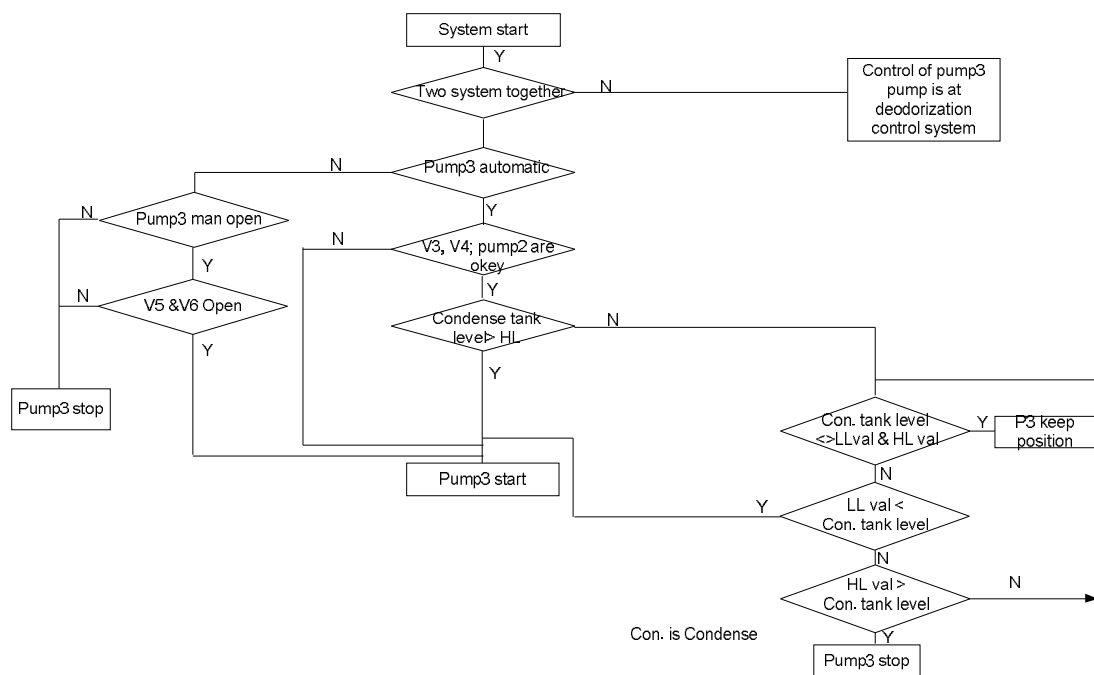


Figure 5.9 Flowchart of soft water cooling pump(Pump3)

Stop conditions of soft water cooling pump(pump3):When condense tank level reaches above “Condense tank maximum set level” value, then cold water pump stops running.

Also if there is an alarm at valve5 or valve6, then cold water pump stops running until there will be no alarms at valve5 and valve6.

When operator stops pump2 manually from SCADA, pump2 stops.

Alarm conditions of soft water cooling pump(pump3):When a position change command is send to pump3, a timer starts running and if pump3 position change can not be achieved before setted time, pump3 gives alarm. Alarm horn

becomes active. This alarm is seen from SCADA alarm page and also pump3 figure flashes in SCADA general overview page.

There is a flowmeter on outlet pipe of cold water pump. The function of this flowmeter is controlling flow rate of returned water. And also used for some calculations.

### **5.3. Feasibility**

#### **5.3.1. Feasibility**

The feasibility analysis is designed to determine whether or not, given the project environment, a project will be successful. A feasibility analysis may be conducted for a project with an emphasis on financial(economic) viability, technical viability, legal viability, operational viability. It is a determination as to the likelihood of success and a description of how that determination was achieved.

We will mention about technical feasibility a bit. And will focus on economic feasibility.

#### **5.3.2. Technical Feasibility**

In technical feasibility the following issues are taken into consideration.

- Whether the required technology is available or not.
- Whether the required resources(Manpower, programmers, testers, debuggers, software and hardware) are available.

Once the technical feasibility is established, it is important to consider the monetary factors also. Since it might happen that developing a particular system may be technically possible but it may require huge investments and benefits may be less. For evaluating this, economic feasibility of the proposed system is carried out.

Proposed project is technically feasible.

### 5.3.3. Economic Feasibility

For any system if the expected benefits equal or exceed the expected costs, the system can be judged to be economically feasible. In economic feasibility, cost benefit analysis is done in which expected costs and benefits are evaluated. Economic analysis is used for evaluating the effectiveness of the proposed system.

In economic feasibility, the most important point is cost-benefit analysis. As the name suggests, it is an analysis of the costs to be incurred in the system and benefits derivable out of the system.

After decision of flow diagram and materials of project, for deodorization cooling system, a test has been applied. In test system (figure 5.10); an external flexible pipe mounted on 8th unit cooling system of deodorization by closing old cooling sides by valves. A 30t/h capacity pump mounted for water flow. Also for flow rate control, a valve mounted between test water tank and pump. At each batch, by adjusting flow rate from control valve, some parameters are defined. They are:

- 1) Minimum flow rate for cooling of 1 batch 170°C vegetable oil until 80°C at a period of 1 batch (minimum 17 minutes) by 20°C water and mean temperature of heated water are defined.
- 2) Time period for cooling of 1 batch 170°C vegetable oil until 80°C by 20°C water at 25t/h capacity flow rate and mean temperature of heated water are defined.
- 3) Time periods for cooling of 1 batch 170°C vegetable oil until 80°C by 20°C water at some flow rates which are between minimum and maximum flow rate capacities and mean temperature of heated water are defined.

According to test results; minimum flow rate is defined as 15t/h. According to 15t/h flow rate, 4.25 tons of water is consumed and cooling water mean temperature is measured as 70 °C. At boiler capacity level flow rate: (25t/h), 52 °C mean temperature cold water is measured. 5.62 tons of water is consumed. Some other flow rates which are between 15-30t/h are applied and consumed cold water and mean temperature of returned water are recorded. They are listed in table 5.1.

By measured values in this test application; material capacities of the project are defined, costs were calculated, feasibility and payback time are defined.

Table 5.1. Measured values at test application.

| Flow Rate | Completed Time | Total Water | Mean Temperature |
|-----------|----------------|-------------|------------------|
| 15t/h     | 17 min         | 4,25tons    | 70°C             |
| 20t/h     | 15 min         | 5,02tons    | 59°C             |
| 25t/h     | 13,5 min       | 5,62tons    | 52°C             |
| 30t/h     | 13,5m in       | 6,25tons    | 47°C             |

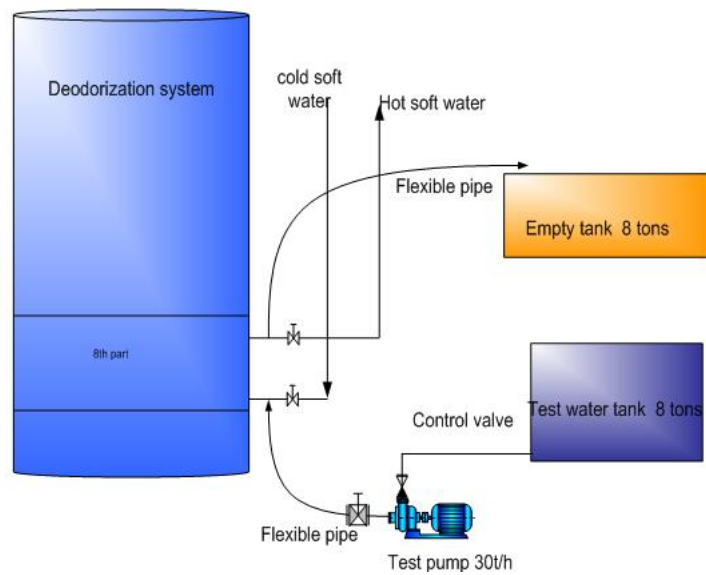


Figure 5.10 Test application.

New designed pump current consumption at different frequencies are measured and written in table 5.2. 6 Amper is consumed in 20Hz frequency, to feed 13,9t/h water.

Table 5.2 New designed pump frequency-current table.

| Frequency | Current |
|-----------|---------|
| 15        | 4.95    |
| 18.2      | 5.7     |
| 20        | 6       |
| 30        | 7.6     |
| 40        | 8.8     |
| 50        | 11.5    |

#### 5.3.4. Energy Saving Calculation

Energy saving calculation can be summarized in two main title. Energy saving from coal and energy saving from electricity. Details of calculation is explained in Appendix A. There are two tables which summarize results below.

Table 5.3. Energy saving from coal

| ENERGY SAVING FROM COAL                                    |                                                                         |
|------------------------------------------------------------|-------------------------------------------------------------------------|
| Mean steam consumption                                     | 10.000 tons                                                             |
| Boiler mean steam production per hour                      | $10.000/(30 \times 24) = 13,9 \text{ t/h}$                              |
| Amount of one batch oil                                    | 4 tons                                                                  |
| Batch number at each hour                                  | 3                                                                       |
| Amount of processed oil in one hour                        | 12 tons                                                                 |
| Energy transfer from oil to water in one batch             | $Q_{\text{oil}} = 4000 \times 0,92 \times 80 = 883,2 \text{ Kcal}$      |
| Energy transfer from oil to water in one hour              | $883,2 \times 3 = 2.649,6 \text{ Kcal}$                                 |
| 13,9t/h Water temperature increase in one hour             | $2.649,6 \text{ Kcal} = 13.900 \times 1 \times \Delta t_{\text{water}}$ |
| Cold water mean initial temperature                        | 20°C                                                                    |
| Cold water mean final temperature                          | 63,5°C                                                                  |
| Temperature increase of 10.000tons of water as 43,5°C      | $Q = 435.000 \text{ Kcal}$                                              |
| The lower calorific value of coal                          | 4500 Kcal/kg                                                            |
| Coal need = $435000_{\text{kcal}} / 4500_{\text{kcal/kg}}$ | 96,6 tons                                                               |
| 1 ton of Ermenek coal cost                                 | 245 TL                                                                  |
| Monthly energy saving from coal                            | 23.680 TL ( $96,666 \times 245$ )                                       |

Table 5.4 Energy saving from electricity

| <b>ENERGY SAVING FROM ELECTRICITY</b>      |                                  |
|--------------------------------------------|----------------------------------|
| <b>FROM COOLING TOWER PUMP</b>             |                                  |
| Power                                      | 45kw                             |
| Monthly saving (kwh)                       | 29.867KWh                        |
| Monthly saving (TL)                        | 4.928 TL                         |
| <b>FROM COOLING SOFT WATER PUMP</b>        |                                  |
| Power                                      | 11kw                             |
| Monthly saving (kwh)                       | 6.184KWh                         |
| Monthly saving (TL)                        | 1.020 TL                         |
| <b>DESIGNED SYSTEM PUMP</b>                |                                  |
| Power                                      | 5,5kw                            |
| Monthly saving (kwh)                       | 2.108KWh                         |
| Monthly saving (TL)                        | 348 TL                           |
| <b>ENERGY SAVING FROM ELECTRICITY (TL)</b> | <b>4.928+1.020-348 = 5.600TL</b> |

Monthly project energy saving:

Energy saving from coal + energy saving from electricity.

$$23.680 \text{ TL} + 5.600 \text{ TL} = 29.280 \text{ TL.}$$

### 5.3.5. Payback Time Calculation

Yearly:  $12 \times 29.280 = 351.360 \text{ TL.}$

Cost price of project is aimed as 100.000TL

System total cost/ monthly energy saving =  $100.000 / 29.280 = 3,4$  month.

Project payback time is 3,4 month.

As we see from result, this project is suitable for investment.

## 6. SYSTEM CONFIGURATION

Sytem configuration can be summarized as below:

- 1) Field instruments
- 2) PLC
  - a) Hardware Configuration.
  - b) Software Configuration.
  - c) Communication.
- 3) SCADA
  - a) Hardware Configuration.
  - b) Software Configuration.
  - c) Communication.

### 6.1 Field Instruments

Field instruments are used for data acquisition and control (valves for controlling direction of water). All them are wired to PLC. In this part, specifications of equipments which are used in the project are explained. Firstly, in table 6.1 equipment names and quantities in project are defined.

Table 6.1 Equipment names and quantities in project

| EQUIPMENT                                                                                          | QUANTITY |
|----------------------------------------------------------------------------------------------------|----------|
| Krohne OPTISWIRL 4070C vortex flowmeter                                                            | 1        |
| DA 120 F05-F07 OMAL on/off ball valves                                                             | 7        |
| DMP 331BD level sensor 0-0,4 bar                                                                   | 1        |
| Elimko RT04-1P06-10-U. PT100 temperature sensor                                                    | 4        |
| Endress Hauser FTL 260 Vibration limit switch for liquids                                          | 4        |
| CRNE 32 – 4, driver controlled, : 25 m <sup>3</sup> /h flowrate,5bar pressure, 7,5KW grundfos pump | 1        |

Krohne OPTISWIRL 4070C Vortex Flowmeter: This flowmeter seen specifications on table 6.2, is used between cold water tank and deodorization plant on cold water line. The function of this flowmeter is measuring flow rate of returned water, for energy saving calculation and calculation for total heated water and also shows that whether there is flow or not.

Table 6.2 Specification of Krohne OPTISWIRL 4070C vortex flowmeter

| <b>Specifications</b>               |                                                                                                      |
|-------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Meter Technology</b>             | Vortex (Shedding) Meter                                                                              |
| <b>Process Operating Conditions</b> |                                                                                                      |
| Process Media Type                  | Liquid; Gas; Steam                                                                                   |
| Operating Pressure                  | 15.00 to 300 psi                                                                                     |
| Media Temperature                   | -40 to 240 F                                                                                         |
| <b>Flow Performance Range</b>       |                                                                                                      |
| Meter Type                          | Velocity Flow Meter                                                                                  |
| Velocity Flow Rate                  | 1.31 to 262 ft/sec                                                                                   |
| Accuracy                            | 0.7500 ±%                                                                                            |
| <b>Physical Specifications</b>      |                                                                                                      |
| Pipe Diameter                       | 0.50 to 4.00 inch                                                                                    |
| Mounting                            | In-line                                                                                              |
| End Fittings                        | In-line Flanged                                                                                      |
| <b>Output Options</b>               |                                                                                                      |
| Electrical Output                   | Current                                                                                              |
| Interface Options                   | Network/Fieldbus                                                                                     |
| <b>User Interface</b>               |                                                                                                      |
| Display                             | Digital                                                                                              |
| Front Panel Interface               | Digital Front Panel                                                                                  |
| Features                            | Controller; Recorder / Totalizer Functions; Sanitary Applications Rated; Suspended Solids / Slurries |
| Additional Variables Measured       | Temperature                                                                                          |
| Approvals                           | ATEX, FM                                                                                             |
| Operating Temperature               | -40 to 185 F                                                                                         |

Figure 6.1 shows general overview of flowmeter and device on line.



Figure 6.1 General overview of flowmeter and device on line.

DA 120 F05-F07 OMAL On/Off Ball Valves: Main function of valves seen technical specifications on table 6.3, are controlling water flow. 7 on/off ball valves are used at project.

Used places are:

Between reverse osmosis system and condense tank.

Between reverse osmosis system and cold water tank.

Between cold water tank and deodorization plant on cold water line, closer to 8th unit of deodorization.

Between deodorization plant and condense tank on heated water line, closer to 8th unit of deodorization.

Between 8th unit of deodorization and deodorization shell and tube heat exchanger.

Between 8th unit of deodorization and deodorization softened water tank.

Between cooling tower and deodorization shell and tube heat exchanger, closer to shell and tube heat exchanger.

Table 6.3 Specification of DA 120 F05-F07 OMAL on/off ball valves

| <b>Technical Features</b>                                                                                     |
|---------------------------------------------------------------------------------------------------------------|
| Torque from 8 Nm to 3840 Nm.                                                                                  |
| Mounting flange according to DIN/ISO 5211 DIN 3337                                                            |
| F03 - F04 - F05 - F07 - F10 - F12 - F14 - F16.                                                                |
| NAMUR connection for accessories.                                                                             |
| Rotation angle 90°                                                                                            |
| Torque: directly proportional to the air supply (see table).                                                  |
| The code numbers after the DA letters, always correspond to the breakaway torque in Nm by 5,6 bar air supply. |
| <b>Working Condition</b>                                                                                      |
| Temperature: from 0°C to +80°C; from -20°C to +80°C with dry air only. (+150°C in special execution)          |
| Air supply: 5,6 bar; maximum 8,4 bar.                                                                         |
| Operating media: compressed filtered air, not necessarily lubricated.                                         |
| In case of lubricated air, either non detergent oil or NBR compatible oil, must be used.                      |

Figure 6.2 shows an on/off ball valve mounted on line.



Figure 6.2 DA 120 F05-F07 OMAL on/off ball valves mounted on system

DMP 331BD 0-0,4 Bar Range, Level Transmitter: This Transmitter is used at condense tank for level measurement. By condense tank level, cold water pump frequency is adjusted.

Table 6.4 Specification of DMP 331BD 0-0,4 bar range level transmitter.

| <b>Input Pressure Range</b>    |        |      |      |      |     |     |   |     |     |    |
|--------------------------------|--------|------|------|------|-----|-----|---|-----|-----|----|
| Nominal pressure gauge [bar]   | -1...0 | 0.10 | 0.16 | 0.25 | 0.4 | 0.6 | 1 | 1.6 | 2.5 | 4  |
| Nominal pressure abs. [bar]    | -      | 0.10 | 0.16 | 0.25 | 0.4 | 0.6 | 1 | 1.6 | 2.5 | 4  |
| Permissible overpressure [bar] | 1      | 1    | 1    | 1    | 3   | 3   | 6 | 6   | 20  | 20 |

Figure 6.3 shows general overview of level Transmitter and device on line

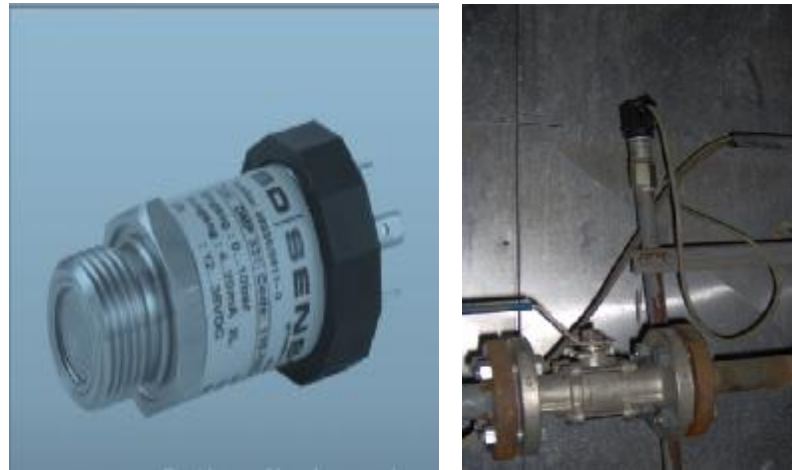


Figure 6.3. DMP 331BD 0-0,4 bar range level transmitter

Endress Hauser FTL 260 Vibration Limit Switch For Liquids: 4 FTL 260 Vibration limit switches are used at this project.

Used places are

At cold water tank, for minimum level definition.

At cold water tank, for maximum level definition.

At condense tank, for minimum level definition.

At condense tank, for maximum level definition.

Their functions are definition of water level digitally.

Table 6.5 shows specification of Endress Hauser FTL 260 Vibration limit switch.

Table 6.5 Specification of Endress Hauser FTL 260 Vibration limit switch for liquids

| <b>Specifications</b>         |                                                                                        |
|-------------------------------|----------------------------------------------------------------------------------------|
| Media Type                    | Liquid                                                                                 |
| Switch Type                   | Electro-mechanical switch (optional feature);<br>Solid-state switch (optional feature) |
| Pole and Throw Specifications | Double Pole, Double Throw (DPDT)<br>(optional feature)                                 |
| Max AC Voltage Rating         | 253 volts                                                                              |
| Max DC Voltage Rating         | 55.00 volts                                                                            |
| Maximum Operating Pressure    | 360 psi                                                                                |
| Material Temperature Range    | -40 to 300 F                                                                           |
| Mounting Options              | Side mount; Top mount                                                                  |
| Meter Technology Type         | Vibrating/Tuning Fork Method                                                           |
| <b>Environment</b>            |                                                                                        |
| Operating Temp                | -40 to 300 F                                                                           |

Figure 6.4 shows general overview of vibration limit switch and device on tank.



Figure 6.4 Endress Hauser FTL 260 Vibration limit switch for liquids.

CRNE 32 – 4, Driver Controlled, 25 m<sup>3</sup>/h Flowrate, 5bar Pressure, 7.5KW Grundfos Pump: This pump is used for adequate water pump for cooling of 8th unit of deodorization and condense tank. Table 6.6 shows specification of cold water driver controlled pump.

Table 6.6 Specification of cold water driver controlled pump.

| <b>Specification</b> |                         |
|----------------------|-------------------------|
| Model                | CRNE 32 – 4             |
| Flowrate             | 25 m <sup>3</sup> /h    |
| Pressure             | 60 mSS                  |
| Motor power          | 7,5 kW                  |
| Motor rpm            | 480 – 3500 rpm          |
| Connection           | IN DN65 / OUT DN65      |
| Supply               | 3 X 380 – 480 V & 50 Hz |
| Efficiency class     | EFF 1                   |

Figure 6.5 shows general overview of pump and also device on line.



Figure 6.5 CRNE 32-4 A-F-G-E HQQE pump

Resistance Thermometers(PT100 RT04-1P06-10-U PT 100):Resistance Thermometers are used widely from -200 to +850°C in different processes. Especially at low temperature, resistance thermometers are preferred since their

accuracy is much better than thermocouples. Up to 500°C standard types and between 500 - 850°C special types are used.

Used places are:

Condense tank entry pipe from deodorization unit.

Deodorization unit 8th part entry pipe

Deodorization unit 8th part exit pipe

Deodorization unit HE exit pipe

Main steam pipe

Figure 6.6 shows general overview of thermometer and device on line.



Figure 6.6 General overview and device on line of PT100.

Elimko RT04-1P06-10-U. PT100 temperature sensor specifications are shown in table 6.7.

Table 6.7 PT100 temperature sensor specification table.

| <b>Specifications</b> |                                   |
|-----------------------|-----------------------------------|
| RT04                  | drawing number in manual          |
| 1                     | Number of elements(single)        |
| P                     | Protecting tube type(304)         |
| 06                    | Protecting tube diameter(mm)      |
| 10                    | Resistance thermometer length(mm) |
| U                     | Three wires                       |

## 6.2 PLC

A programmable logic controller, also called a PLC or programmable controller, is a computer-type device used to control equipment in an industrial facility. The kinds of equipment that PLCs can control are as varied as industrial facilities themselves. Conveyor systems, food processing machinery, auto assembly lines.

In a traditional industrial control system, all control devices are wired directly to each other according to how the system is supposed to operate. In a PLC system, however, the PLC replaces the wiring between the devices. Thus, instead of being wired directly to each other, all equipment is wired to the PLC(See figure 6.7). Then, the control program inside the PLC provides the “wiring” connection between the devices. The control program is the computer program stored in the PLC’s memory that tells the PLC what’s supposed to be going on in the system. The use of a PLC to provide the wiring connections between system devices is called softwiring.

As PLC technology has advanced, so have programming languages and communications capabilities, along with many other important features. Today's PLCs offer faster scan times, space efficient high-density input/output systems, and special interfaces to allow non-traditional devices to be attached directly to the PLC. Not only can they communicate with other control systems, they can also perform reporting functions and diagnose their own failures, as well as the failure of a machine or process.

A PLC basically consists of two elements:

- the central processing unit
- the input/output system

The Central Processing Unit:

The central processing unit (CPU) is the part of a programmable controller that retrieves, decodes, stores, and processes information. It also executes the control program stored in the PLC’s memory. In essence, the CPU is the “brains” of a programmable controller. It functions much the same way the CPU of a regular

computer does, except that it uses special instructions and coding to perform its functions. The CPU has three parts:

- the processor
- the memory system
- the power supply

The processor is the section of the CPU that codes, decodes, and computes data. The memory system is the section of the CPU that stores both the control program and data from the equipment connected to the PLC. The power supply is the section that provides the PLC with the voltage and current it needs to operate.

#### The Input/Output System

The input/output (I/O) system is the section of a PLC to which all of the field devices are connected. If the CPU can be thought of as the brains of a PLC, then the I/O system can be thought of as the arms and legs. The I/O system is what actually physically carries out the control commands from the program stored in the PLC's memory. The I/O system consists of two main parts:

- the rack
- I/O modules

The rack is an enclosure with slots in it that is connected to the CPU. I/O modules are devices with connection terminals to which the field devices are wired. Together, the rack and the I/O modules form the interface between the field devices and the PLC. When set up properly, each I/O module is both securely wired to its corresponding field devices and securely installed in a slot in the rack. This creates the physical connection between the field equipment and the PLC. In some small PLCs, the rack and the I/O modules come prepackaged as one unit.

All of the field devices connected to a PLC can be classified in one of two categories:

- inputs
- outputs

Inputs are devices that supply a signal/data to a PLC. Typical examples of inputs are push buttons, switches, and measurement devices.

Outputs are devices that await a signal/data from the PLC to perform their control functions. Lights, horns, motors, and valves are all good examples of output devices.

There are two basic types of input and output devices:

- discrete
- analog

Discrete devices are inputs and outputs that have only two states: on and off. As a result, they send/receive simple signals to/from a PLC. These signals consist of only 1s and 0s. A 1 means that the device is on and a 0 means that the device is off. Figure 6.7 shows PLC process overview.

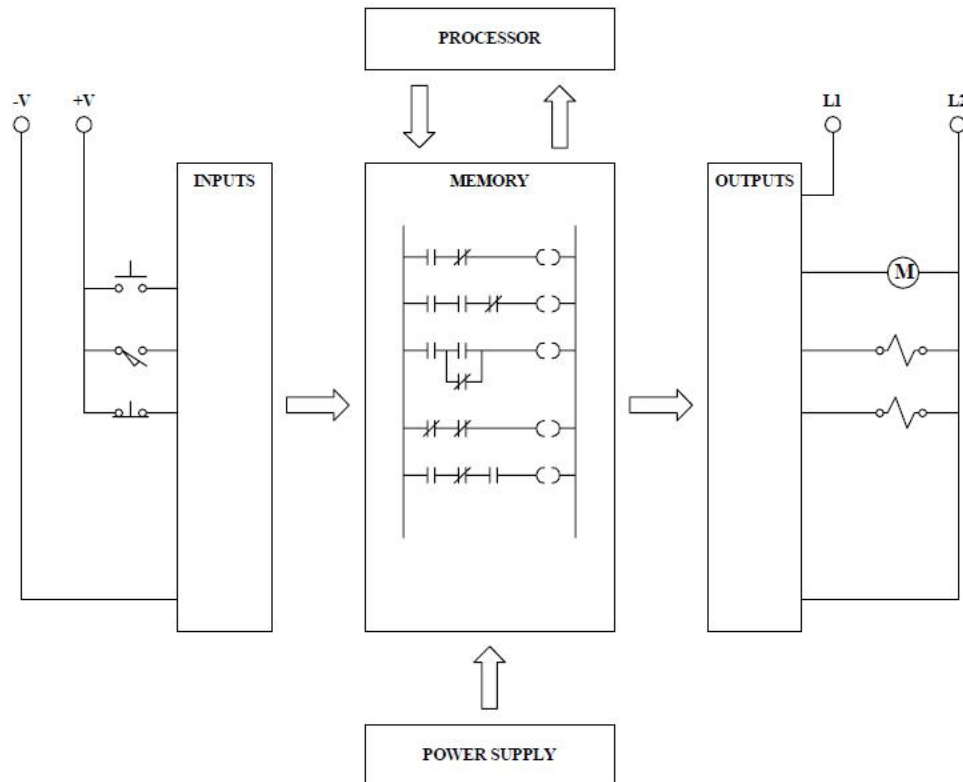


Figure 6.7 PLC process overview. (Centec)

Analog devices are inputs and outputs that can have an infinite number of states. These devices can not only be on and off, but they can also be barely on, almost totally on, not quite off, etc. These devices send/receive complex signals to/from a PLC. Their communications consist of a variety of signals, not just 1s and 0s.

The SIMATIC S7-300: The SIMATIC S7-300 has been designed for innovative system solutions with the focus on manufacturing engineering, and as a universal automation system, it represents an optimal solution for applications in centralized and distributed configurations: The product range comprises 7 Standard CPUs, 6 Compact CPUs, 6 failsafe CPUs and 2 TechnologySiemens PLC CPUs.

The ability to integrate powerful CPUs with Industrial Ethernet/PROFINET interface, integrated technological functions, or fail-safe designs make additional investments unnecessary.

The S7-300 can be set up in a modular configuration without the need for slot rules for I/O modules. There is a wide range of modules available both for the centralized and the distributed configuration with ET 200M.

The Micro Memory Card as a data and program memory makes a backup battery superfluous, and with it, part of the maintenance costs. In addition, an associated project, including symbols and comments, can be stored on this memory card to facilitate service calls.

The Micro Memory Card also enables simple program or firmware updates. The Micro Memory Card can be used during operation for storing and accessing data, e.g. for measured value archiving or recipe processing.

In addition to standard automation, safety technology and motion control can also be integrated in an S7-300.

Many of the S7-300 components are also available in a SIPLUS version for external environmental conditions, e.g. extended temperature range (-25...+60 °C) and for use where there is aggressive atmosphere/condensation.

Application:

- Automotive industry
- Machine building
- Plastics processing
- Packaging industry
- Food and beverages industry

### 6.2.1 Hardware Configuration Of PLC

Siemens brand is the mainstream product at hardware configuration. Configuration for PLC, Siemens S7 300 is selected. At field side, as CPU, Siemens CPU 315-2DP is used.

Siemens CPU 315 2 DP: The reason for choosing CPU 315 -2DP is that it has two ports: MPI and Profibus DP. MPI port is used for SCADA communication and Profibus DP port is used for remote I/O module communication. Also CPU 315 -2DP communication speed is enough for this application and available number of inputs and outputs are 2Kbyte. Other specifications of CPU 315 –2DP are defined in table 6.8.

Table 6.8 CPU 315 –2DP technical specifications

| <b>6ES7 315-2AG10-0AB0 Specifications</b>          |                                 |
|----------------------------------------------------|---------------------------------|
| Work memory                                        | 128KB                           |
| Transmission speeds, max.                          | 12 Mbit/s                       |
| Number of DP slaves, max.                          | 124; Per station                |
| Inputs, max.                                       | 2048 byte                       |
| Outputs, max.                                      | 2048 byte                       |
| Number of connections                              | 16                              |
| Number of blocks (total)                           | 1024; (DBs, FCs, FBs OBs, SDBs) |
| MPI connection                                     | Yes                             |
| DP connection                                      | Yes                             |
| multi-tier configuration, max                      | 32                              |
| send & receive capability for direct data exchange | Yes                             |
| Firmware                                           | V2.0                            |

This controller is main instrument of project. All input datas are processed and commands are given as outputs by this controller. This CPU is mounted in boiler

plant electrical panel. In figure 6.8, all control modules which are in boiler unit are seen.

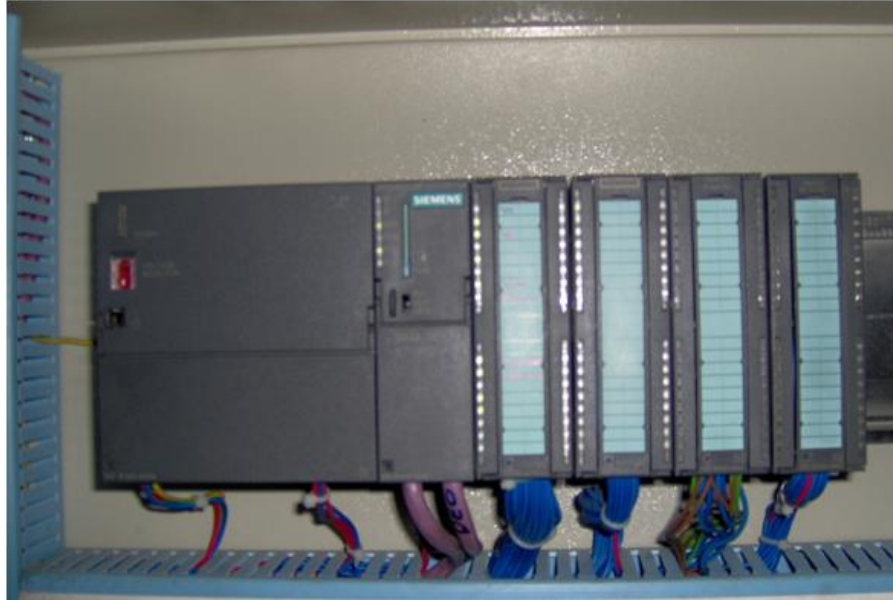


Figure 6.8 Boiler plant side. Control system of project.

Left first instrument is power supply, second: CPU, third: digital input card, fourth: digital output card, fifth: analog input card, sixth: analog output card.

For data receiving from field side, two types of card are used: digital signal cards and analog signal cards. At below firstly digital signal card which is used in project is introduced.

Digital input card:

Description: 6ES7-321 1BL00-0AA0 Simatic S7-300, digital input sm 321, optically isolated 32di, 24 v dc, 1 x 40 pin, grouping 32.

Digital input modules are used for digital data collection. This type of digital module has 32 input channel. Input power of signal is 24VDC. In this project, two digital input modules are used. One is used in boiler unit, the other is used in deodorization unit. 14 digital inputs are used in boiler unit and 15 digital inputs are used in deodorization unit. Digital input list is given in table 6.9.

Table 6.9 Digital inputs of project.

| <b>SYMBOL</b>                 | <b>ADRES</b> | <b>DATA</b> | <b>COMMENT</b>                           |
|-------------------------------|--------------|-------------|------------------------------------------|
| VALVE 1 OPENED                | I 0.0        | BOOL        |                                          |
| VALVE 1 CLOSED                | I 0.1        | BOOL        |                                          |
| VALVE 2 OPENED                | I 0.2        | BOOL        |                                          |
| VALVE 2 CLOSED                | I 0.3        | BOOL        |                                          |
| COLD WATER PUMP DRY SW        | I 0.4        | BOOL        | COLD WATER PUMP DRY SWITCH               |
| CONDENSE HH LEVEL             | I 0.5        | BOOL        |                                          |
| CONDENSE LL LEVEL             | I 0.6        | BOOL        |                                          |
| COLD WATER TANK HH LEVEL      | I 0.7        | BOOL        |                                          |
| COLD WATER TANK LL LEVEL      | I 1.0        | BOOL        |                                          |
| REVERSE PUMP THERMAL RELAY    | I 1.1        | BOOL        |                                          |
| REVERSE PUMP RUNNING          | I 1.2        | BOOL        |                                          |
| COLD WATER PUMP RUNNING       | I 1.3        | BOOL        |                                          |
| COLD WATER PUMP THERMAL RELAY | I 1.4        | BOOL        |                                          |
| FLOWMETER PULSE COUNTER       | I 1.5        | BOOL        |                                          |
| VALVE 3 OPENED IN             | I 4.0        | BOOL        |                                          |
| VALVE 3 CLOSED IN             | I 4.1        | BOOL        |                                          |
| VALVE 4 OPENED IN             | I 4.2        | BOOL        |                                          |
| VALVE 4 CLOSED IN             | I 4.3        | BOOL        |                                          |
| VALVE 5 OPENED IN             | I 4.4        | BOOL        |                                          |
| VALVE 5 CLOSED IN             | I 4.5        | BOOL        |                                          |
| VALVE 6 OPENED IN             | I 4.6        | BOOL        |                                          |
| VALVE 6 CLOSED IN             | I 4.7        | BOOL        |                                          |
| VALVE 7 OPENED IN             | I 5.0        | BOOL        |                                          |
| VALVE 7 CLOSED IN             | I 5.1        | BOOL        |                                          |
| DEO PUMP THERMIC              | I 5.2        | BOOL        |                                          |
| DEO PUMP RUNNING              | I 5.3        | BOOL        |                                          |
| DEO PANE COLDWTR PMP RUN      | I 5.4        | BOOL        | DEO ELECTRICAL PANEL COLD WATER PUMP RUN |
| DEO 7 UNIT VALVE OPENED       | I 5.5        | BOOL        | DEO 7TH UNIT VALVE OPENED                |
| DEO 8 UNIT VALVE OPENED       | I 5.6        | BOOL        | DEO 8TH UNIT VALVE OPENED                |

Analog input card:

Description:6ES7 331-1KF01-0AB0. Simatic s7-300, analog input sm 331, optically isolated, 8 ai, 13 bit resolution.

Plant analog inputs (condense level, temperature value...) are collected and used as input at PLC by this module. Analog input list is in table 6.10.

Table 6.10 Analog inputs of project.

| <b>SYMBOL</b>              | <b>ADRESS</b> | <b>DATA TYPE</b> | <b>COMMENT</b> |
|----------------------------|---------------|------------------|----------------|
| CONDENSE LEVEL TRANSMITTER | PIW 288       | WORD             |                |
| FLOWMETER ANALOG VALUE     | PIW 290       | WORD             |                |
| STEAM PRESSURE             | PIW 292       | WORD             |                |
| STEAM FLOW                 | PIW 294       | WORD             |                |
| CONDENSE RETURNED TEMP     | PIW 296       | WORD             |                |
| STEAM TEMPERATURE          | PIW 302       | WORD             |                |
| DEO OUT TEMP               | PIW 312       | WORD             |                |
| DEO 8 UNIT TEMP            | PIW 314       | WORD             |                |
| DEO HE OUT TEMP            | PIW 316       | WORD             |                |

Digital output card:

Description:6ES7 322-1BL00-0AA0 Digital output module DO32 24V/0.5A, grouping 8;

Digital output modules are used for digital data sending. This type of digital module has 32 output channel. Output power of signal is 24VDC. In this project two digital output modules are used. One is used in boiler unit, the other is used in deodorization unit. 8 digital outputs are used in boiler unit and 19 digital outputs are used in deodorization unit. Digital output list is given in table 6.11.

Table 6.11 Digital outputs of project.

| <b>SYMBOL</b>           | <b>ADRESS</b> | <b>DATA<br/>TYPE</b> | <b>COMMENT</b> |
|-------------------------|---------------|----------------------|----------------|
| COLD WATER PUMP RUN OUT | Q 0.0         | BOOL                 |                |
| REVERSE PUMP RUN OUT    | Q 0.1         | BOOL                 |                |
| VALVE 1 OPEN OUT        | Q 0.2         | BOOL                 |                |
| VALVE 2 OPEN OUT        | Q 0.3         | BOOL                 |                |
| COLD WATER SAFETY       | Q 1.0         | BOOL                 |                |
| COND MAX LEVEL CLOSER   | Q 1.5         | BOOL                 |                |
| COND EMERG LEVEL CLOSER | Q 1.6         | BOOL                 |                |
| GENERAL ALARM OUT       | Q 1.7         | BOOL                 |                |
| VALVE 3 OPEN OUT        | Q 4.0         | BOOL                 |                |
| VALVE 4 OPEN OUT        | Q 4.1         | BOOL                 |                |
| VALVE 5 OPEN OUT        | Q 4.2         | BOOL                 |                |
| VALVE 6 OPEN OUT        | Q 4.3         | BOOL                 |                |
| VALVE 7 OPEN OUT        | Q 4.4         | BOOL                 |                |
| DEO PUMP RUN OUT        | Q 4.5         | BOOL                 |                |
| DEO PANEL CONTROL GET   | Q 4.6         | BOOL                 |                |
| DEO IN VALVE3 OPENED    | Q 5.0         | BOOL                 |                |
| VALVE 3 CLOSED OUT      | Q 5.1         | BOOL                 |                |
| VALVE 4 OPENED OUT      | Q 5.2         | BOOL                 |                |
| VALVE 4 CLOSED OUT      | Q 5.3         | BOOL                 |                |
| VALVE 5 OPENED OUT      | Q 5.4         | BOOL                 |                |
| VALVE 5 CLOSED OUT      | Q 5.5         | BOOL                 |                |
| VALVE 6 OPENED OUT      | Q 5.6         | BOOL                 |                |
| VALVE 6 CLOSED OUT      | Q 5.7         | BOOL                 |                |
| VALVE 7 OPENED OUT      | Q 6.0         | BOOL                 |                |
| VALVE 7 CLOSED OUT      | Q 6.1         | BOOL                 |                |
| DEO PUMP RUNNING OUT    | Q 6.2         | BOOL                 |                |
| CONDENSE HL             | Q 6.3         | BOOL                 |                |

Analog output card:

Description:6ES7 332-5HF00-0AB0 Simatic S7-300, analog output sm 332, optically isolated, 8 ao, u/i; diagnostics; resolution 11/12 bits, 40 pin, remove/insert w. active, backplane bus.

Plant analog outputs are sent to field by this module. Analog output list is given in table 6.12.

Table 6.12 Analog output of project.

| SYMBOL           | ADDRESS | DATA TYPE | COMMENT |
|------------------|---------|-----------|---------|
| DRIVER FREQ. OUT | PQW 288 | WORD      |         |

Power supply:

Description: 6ES7 307-1KA00-0AA0 Load supply voltage 120 / 230 VAC:24 VDC / 10 A.

Supplies power to PLC modules (also supplies to electrical control panel in our project). There are two power supplies in this project.

Profibus Repeater:

Description: 6ES7 972- 0AA01- 0XA0. Profibus-MPI signal repeater.

Area of application:

The RS 485 IP20 repeater connects two PROFIBUS or MPI bus segments using the RS 485 system with up to 32 stations. Data transmission rates of 9.6 kbit/s to 12 Mbit/s are then possible(See figure 6.9).

Mode of operation

- Increasing the number of stations (max. 127) and the expansion.
- Regenerating the signals in amplitude and time.
- Electrical isolation of the connected bus systems.

Table 6.13. Data transmission rate of Profibus DP

| Data transmission rate | Max. segment length |
|------------------------|---------------------|
| 9.6 kbit/s             | 1000 m              |
| 19.2 kbit/s            | 1000 m              |
| 45.45 kbit/s           | 1000 m              |
| 93.75 kbit/s           | 1000 m              |
| 187.5 kbit/s           | 1000 m              |
| 500 kbit/s             | 400 m               |
| 1500 kbit/s            | 200 m               |
| 3000 kbit/s            | 100 m               |
| 6000 kbit/s            | 100 m               |
| 12000 kbit/s           | 100 m               |



Figure 6.9. Repeater for regenerating the signals in amplitude and time.

ET 200M module:

Description: 6ES7 153-1AA00-0XB0. Bus interface module for S7-300 SMs, FM 350 to FM 352, FM 355, CP 340.

SIMATIC ET 200M is the modular I/O station for the control cabinet with high density-channel applications. Connection to PROFIBUS and PROFINET is achieved using interface modules – optionally for PROFIBUS also using fiber optic cables. The ET 200M can be used for standard as well as failsafe applications. Up to 12 multi-channel signal modules (e.g. 64 digital inputs) and function modules as well as S7-300 communications processors can be used as I/O modules – the interface to the process. ET 200M supports modules with expanded user data, e.g. HART modules with HART minor variables. In addition to proven connection techniques the ET 200M offers the insulation displacement method Fast Connect for easy wiring.

#### Benefits

- High density channel design (up to 64 channels per module).
- Reduced wiring efforts.
- High plant availability.
- -Configuration in RUN.
- -Hot Swapping of modules.
- -Redundant design.
- Modular design.

- Use of S7-300 modules
- Safety functions integrated
- Integrated diagnostic function channel by channel
- Certified for Ex-zone 2

This module is used for communication of PLC module groups. This module is mounted at deodorization unit side in electrical control panel (figure 6.10 below).



Figure 6.10 Deodorization plant side. Control system of project

Left first instrument is power supply, second: ET200M communication module, third: digital input card, fourth: digital output, fifth: analog input.

In figure 6.11, a general hardware configuration including field instruments and PLC components is seen.

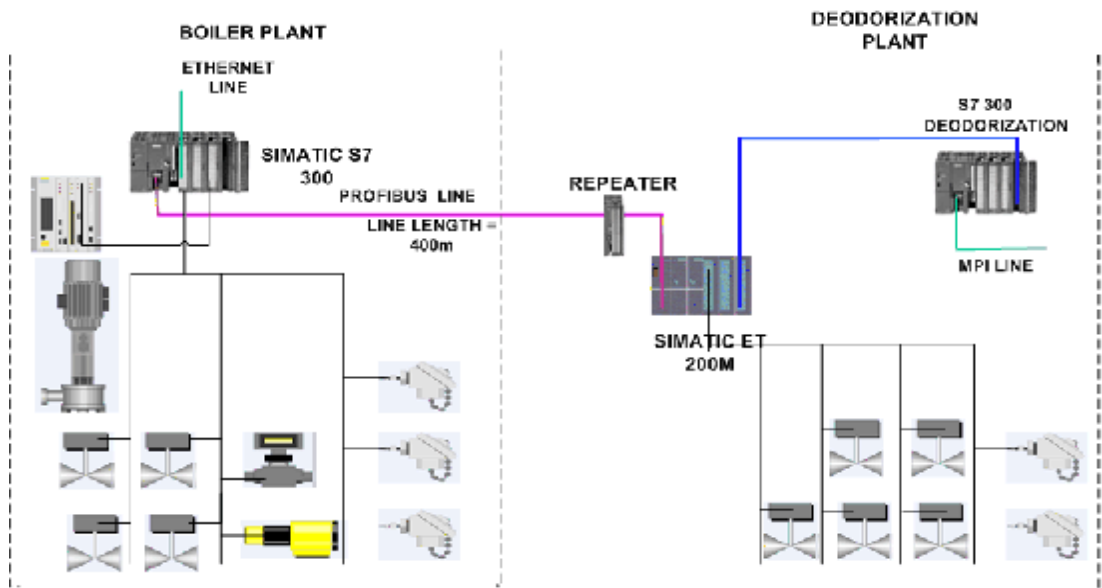


Figure 6.11 Hardware configuration of new system with field instruments.

## 6.2.2 Software

As software program, Simatic S7 is used. Software program instruction consists of four main program blocks. They are OBs, FBs, FCs and DBs. They are generally explained as below.

### 6.2.2.1 Organization Blocks and Program Structure

Organization blocks (OBs) represent the interface between the operating system and the user program. Called by the operating system, they control cyclic and interrupt driven program execution, startup behavior of the PLC and error handling. You can program the organization blocks to determine CPU behavior. (Simatic Step7)

Function blocks (FBs) belong to the blocks that you program yourself. A function block is a block "with memory." It is assigned a data block as its memory (instance data block). The parameters that are transferred to the FB and the static variables are saved in the instance DB. Temporary variables are saved in the local data stack.

Datas saved in the instance DB are not lost when execution of the FB is complete. Data saved in the local data stack are, however, lost when execution of the FB is completed.

**Application:**An FB contains a program that is always executed when the FB is called by a different logic block. Function blocks make it much easier to program frequently occurring, complex functions. (Simatic Step7)

**Function Blocks and Instance Data Blocks:**An instance data block is assigned to every function block call that transfers parameters.

By calling more than one instance of an FB, you can control more than one device with one FB. An FB for a motor type, can, for example, control various motors by using a different set of instance data for each different motor. The data for each motor (for example, speed, ramping, accumulated operating time etc.) can be saved in one or more instance DBs.

The following figure shows the formal parameters of an FB that uses the actual parameters saved in the instance DB. (Simatic Step7)

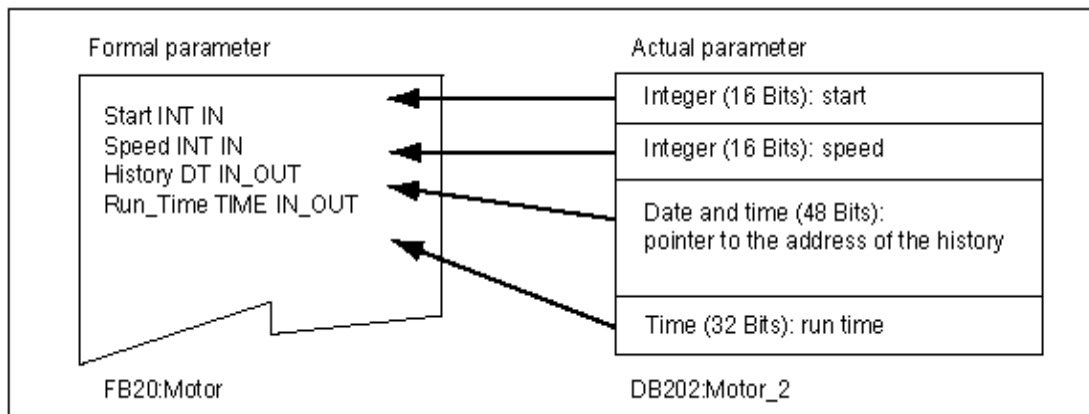


Figure 6.12 The formal parameters of an FB that uses the actual parameters saved in the instance DB. (Simatic Step7)

**Instance Data Blocks:**An instance data block is assigned to every function block call that transfers parameters. The actual parameters and the static data of the FB are saved in the instance DB. The variables declared in the FB determine the structure of the instance data block. Instance means a function block call. If,

for example, a function block is called five times in the S7 user program, there are five instances of this block. (Simatic Step7)

:Before you create an instance data block, the corresponding FB must already exist. You specify the number of the FB when you create the instance data block.

#### One Instance DB for Each Separate Instance

If you assign several instance data blocks to a function block (FB) that controls a motor, you can use this FB to control different motors.

The data for each specific motor (for example, speed, runup time, total operating time) are saved in different data blocks. The DB associated with the FB when it is called determines which motor is controlled. With this technique, only one function block is necessary for several motors (see the following figure 6.13). (Simatic Step7)

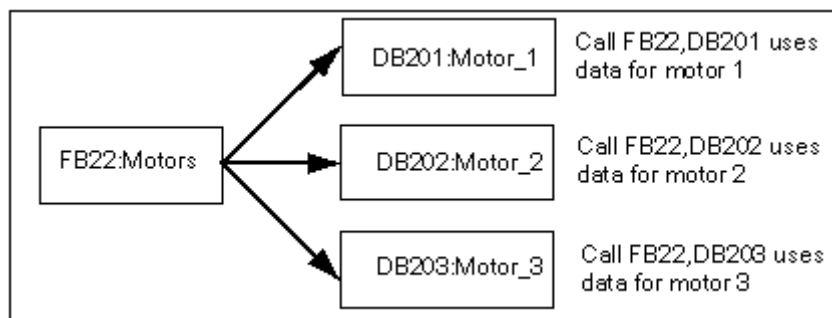


Figure 6.13 One function block calls several motors. (Simatic Step7)

Functions (FC): Functions (FCs) belong to the blocks that you program yourself. A function is a logic block "without memory." Temporary variables belonging to the FC are saved in the local data stack. This data is then lost when the FC has been executed. To save data permanently, functions can also use shared data blocks.

Since an FC does not have any memory of its own, you must always specify actual parameters for it. You cannot assign initial values for the local data of an FC.

An FC contains a program section that is always executed when the FC is called by a different logic block. You can use functions for the following purposes:

- To return a function value to the calling block (example: math functions)

- To execute a technological function (example: single control function with a bit logic operation). (Simatic Step7)

Shared Data Blocks (DB): In contrast to logic blocks, data blocks do not contain STEP 7 instructions. They are used to store user data, in other words, data blocks contain variable data with which the user program works. Shared data blocks are used to store user data that can be accessed by all other blocks.

The size of DBs can vary. Refer to the description of your CPU for the maximum possible size.

You can structure shared data blocks in any way to suit your particular requirements.

#### Shared Data Blocks in the User Program

If a logic block (FC, FB, or OB) is called, it can occupy space in the local data area (L stack) temporarily. In addition to this local data area, a logic block can open a memory area in the form of a DB. In contrast to the data in the local data area, the data in a DB are not deleted when the DB is closed, in other words, after the corresponding logic block has been executed.

Each FB, FC, or OB can read the data from a shared DB or write data to a shared DB. This data remains in the DB after the DB is exited.

A shared DB and an instance DB can be opened at the same time. The following figure shows the different methods of access to data blocks. (Simatic Step7)

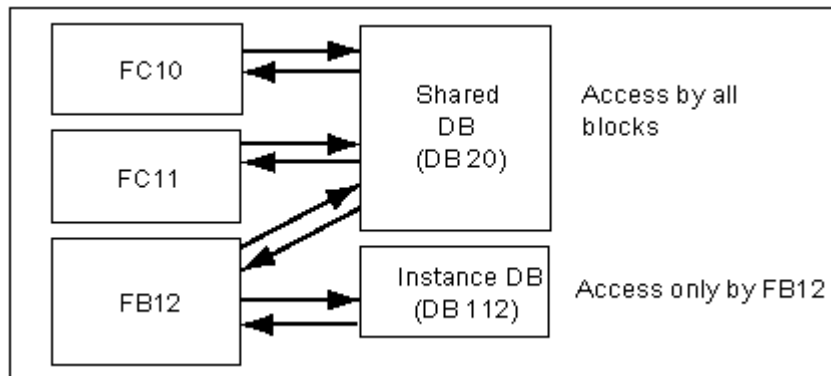


Figure 6.14 Different methods of access to data blocks. (Simatic Step7)

General program cycle is seen in figure 6.15. Each FB has its own datablock as instance datablock seen under FBs as grey colour. Shared datablocks are defined as blue colour. FC13 is called only by FB7, FB8 and FB9. FC66 is called only by FC104. DB201, DB202, DB203, DB204, DB205, DB206 and DB207 are called only by FC66. Because other shared datablocks are called by all other FBs and FCs, they are not declared by separate arrows. When power on system, OB100 runs once. Except OB1 and OB100, other OBs are called by operating system indepently. Functions of each blocks will be explained below.

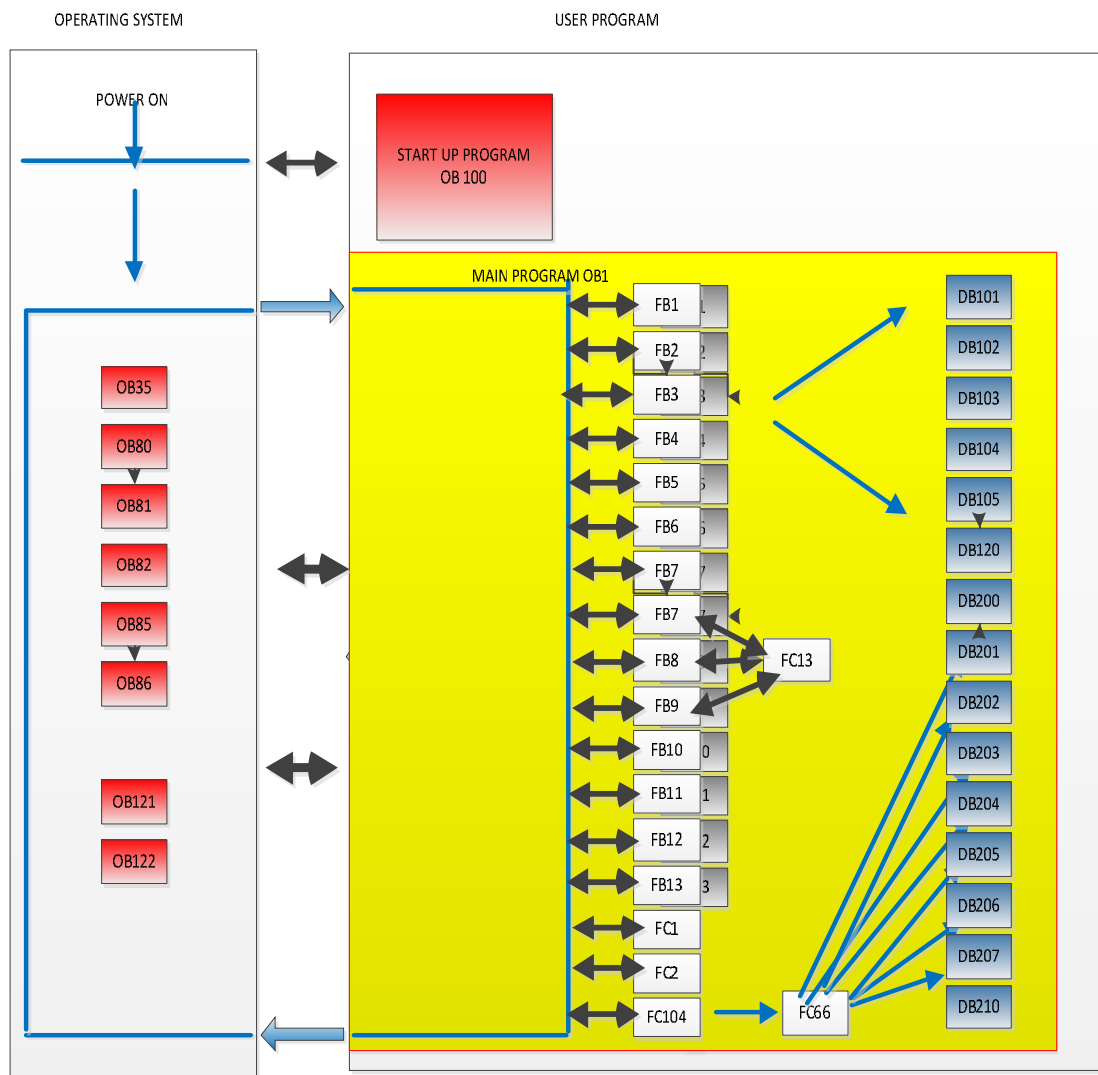


Figure 6.15 General program cycle

### 6.2.2.2 OBs Of Program

OB1, OB35, OB80, OB82, OB85, OB87, OB121 and OB122 blocks are used in the project. Function of blocks and used places in the project are explained below.

Program Cycle Organization Block (OB1):In the project; FB1, FB2, FB3, FB4, FB5, FB6, FB7, FB8, FB9, FB10, FB11, FB12, FC1, FC2, FC3, FC14, FC24, FC104 are called in this block

:The operating system of the S7 CPU executes OB1 periodically. When OB1 has been executed, the operating system starts it again. Cyclic execution of OB1 is started after the startup has been completed. You can call other function blocks (FBs, SFBs) or functions (FCs, SFCs) in OB1.

#### Understanding the Operation of OB1

OB1 has the lowest priority of all of the OBs whose run-times are monitored, in other words, all of the other OBs except OB90 can interrupt the execution of OB1. The following events cause the operating system to call OB1:

The startup is completed.

The execution of OB1 (the previous cycle) has finished.

When OB1 has been executed, the operating system sends global data. Before restarting OB1, the operating system writes the process-image output table to the output modules, updates the process-image input table and receives any global data for the CPU.

S7 monitors the maximum scan time, ensuring a maximum response time. The value for the maximum scan time is preset to 150 ms. You can set a new value or you can restart the time monitoring anywhere within your program with SFC43 "RE\_TRIGR." If your program exceeds the maximum cycle time for OB1, the operating system calls OB80 (time error OB); if OB80 is not programmed, the CPU changes to the STOP mode. (Simatic Step7)

Cyclic Interrupt Organization Blocks (OB30 to OB38).:Total steam calculation and energy saving calculation is done in this block(OB 35)

Description: S7 provides up to nine cyclic interrupt OBs (OB30 to OB38) which interrupt your program at fixed intervals. The following table shows the default intervals and priority classes for the cyclic interrupt OBs.

| OB Number | Default Interval | Default Priority Class |
|-----------|------------------|------------------------|
| OB30      | 5 s              | 7                      |
| OB31      | 2 s              | 8                      |
| OB32      | 1 s              | 9                      |
| OB33      | 500 ms           | 10                     |
| OB34      | 200 ms           | 11                     |
| OB35      | 100 ms           | 12                     |
| OB36      | 50 ms            | 13                     |
| OB37      | 20 ms            | 14                     |
| OB38      | 10 ms            | 15                     |

#### Understanding the Operation of Cyclic Interrupt OBs

The equidistant start times of the cyclic interrupt OBs are determined by the interval and the phase offset.

Time Error Organization Block (OB80): For only alarm, a set bit written in this block

OB80: Description: The operating system of the S7-300 CPU calls OB80 whenever an error occurs while executing an OB. Such errors include: exceeding the cycle time, an acknowledgement error when executing an OB, moving the time forward so that the start time for the OB is skipped, resume RUN mode after CiR. If, for example, a start event for a cyclic interrupt OB occurs while the same OB is still being executed following a previous call, the operating system calls OB80.

If OB80 has not been programmed, the CPU changes to the STOP mode.

You can disable or delay and re-enable the time error OB using SFCs 39 to 42.

Note, if OB80 is called twice during the same scan cycle due to the scan time being exceeded, the CPU changes to the STOP mode. You can prevent this by calling SFC43 "RE\_TRIGR" at a suitable point in the program. (Simatic Step7)

Diagnostic Interrupt Organization Block (OB82).For only alarm, a set bit written in this block.

OB82: Description:If a module with diagnostic capability for which you have enabled the diagnostic interrupt detects an error, it outputs a request for a diagnostic interrupt to the CPU (when entering and outgoing event). The operating system then calls OB82.

The local variables of OB82 contain the logical base address as well as four bytes of diagnostic data of the defective module (see the following table).

If OB82 has not been programmed, the CPU changes to the STOP mode.

You can disable or delay and re-enable the diagnostic interrupt OB using SFCs 39 to 42.

Priority Class Error Organization Block (OB85).:For only alarm, a set bit written in this block

OB85: Description:The operating system of the CPU calls OB85 whenever one of the following events occurs:

- Start event for an OB that has not been loaded (except OB81).
- Error when the operating system accesses a module.
- I/O access error during update of the process image by the system (if the OB85 call was not suppressed due to the configuration).

Note, if OB85 has not been programmed, the CPU changes to STOP mode when one of these events is detected.

You can disable or delay and re-enable the priority class error OB using SFCs 39 to 42.

Communication Error Organization Block (OB87):For only alarm, a set bit written in this block

OB87: Description:The operating system of the CPU calls OB87 whenever an event occurs that was caused by a communication error.

The CPU does not change to the STOP mode if OB87 has not been programmed.

You can disable or delay and re-enable the communication error OB using SFCs 39 to 42.

Programming Error Organization Block (OB121):For only alarm, a set bit written in this block

OB121: Description:The operating system of the CPU calls OB121 whenever an event occurs that is caused by an error related to the processing of the program. For example, if your program calls a block that has not been loaded on the CPU, OB121 is called.

Understanding the Operation of the Programming Error OB

OB121 is executed in the same priority class as the interrupted block.

If OB121 is not programmed, the CPU changes from the RUN mode to the STOP mode.

S7 provides the following SFCs for masking and unmasking start events for OB121 during the execution of your program:

SFC36 (MSK\_FLT): masks specific error codes

SFC37 (DMSK\_FLT): unmask the error codes that were masked by SFC36

SFC38 (READ\_ERR): reads the error register

I/O Access Error Organization Block (OB122):For only alarm, a set bit written in this block

OB122: Description:The operating system of the CPU calls OB122 whenever an error occurs while accessing data on a module. For example, if the CPU detects a read error when accessing data on an I/O module, the operating system calls OB122.

Understanding the Operation of the I/O Access Error OB

OB122 is executed in the same priority class as the interrupted OB. If OB122 is not programmed, the CPU changes from the RUN mode to the STOP mode.

S7 provides the following SFCs for masking and unmasking start events for OB122 during the execution of your program:

SFC36 (MSK\_FLT): masks specific error codes

SFC37 (DMSK\_FLT): unmask the error codes that were masked by SFC36

SFC38 (READ\_ERR): reads the error register. (Simatic Step7)

### 6.2.2.3 FBs and FCs Of Program

FB1: Conversion Of Condense Tank Level Analog Value To Centimeter Scale Block:FB1 is used to convert PIW288 analog input(condense tank level transmitter) to centimeter scale. Level transmitter is mounted 75cm above condense tank floor. Also scale of transmitter is for 0-4 meter. Firstly zero span adjustments have been done. And as offset value, 75cm is added. Result has been assigned to "CONDENSE TANK LEVEL TEMP"(MW82 ) word.

FB2: Driver Frequency Adjustment Block:In this block; frequency value is defined. Condense tank control level is defined as 6 units. From bottom to upside, frequency value increases. Operator sets those five set values manually from SCADA(see figure 6.16). Set frequency values are maximum 50 and minimum 15.

If program is downloaded again or because of any reason if an assignment has not been done, frequency is set maximum value and an alarm bit is activated also. According to tank level, frequency values are arranged like below:

|              |                       |
|--------------|-----------------------|
| 200cm and up | set frequency slowest |
| 175cm-200cm  | set frequency slower  |
| 150cm-175cm  | set frequency middle  |
| 125cm-150cm  | set frequency faster  |
| 100cm-125cm  | set frequency fastest |

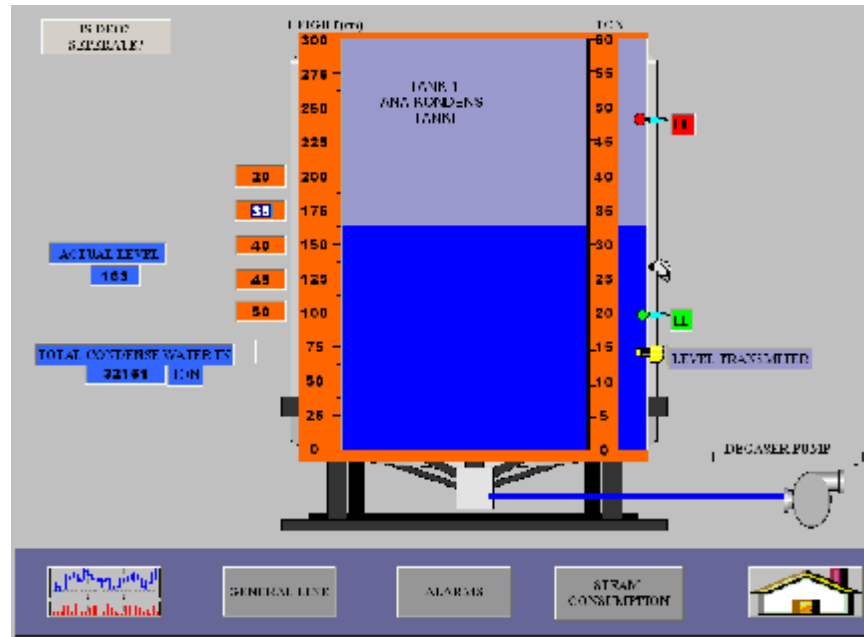


Figure 6.16 Frequency set page

In this block, when hot vegetable oil flows into 8th unit of deodorization unit (when 7th unit valve is opened), a defined time period (set from SCADA, see in figure 6.20) and defined frequency value are set first. When time is over, frequency value is set to normal value. Also when 8th unit outlet valve is opened, frequency decrease value is defined from SCADA (figure 6.17). This application is done to get hotter water.

| ONLY AUTHORIZED PERSON CHANGES                      |        |    |
|-----------------------------------------------------|--------|----|
| INITIAL FREQUENCY (Hz)                              | 7      | Hz |
| ULTIMATE FREQUENCY (Hz)                             | 5      | Hz |
| FREQUENCY DECREASE COEFFICIENT                      | 7      | Hz |
| WITH NO OIL PRESSURE UNIT, FREQUENCY                | 40     | Hz |
| WITH NO OIL PRESSURE UNIT, TIME PERIOD OF HIGH FREQ | 75,000 | ms |

GENERALIST    ALARMS       LEVEL SETTING PAGE    ZERO SPAN PAGE   

Figure 6.17 Initial and final frequency adjustment page

FB3: Driver Frequency Adjustment; From Integer Value To 4-20mA Block: In this block, frequency value (defined in FB2) is converted to 4-20mA. Value is assigned to PQW 200 output. PQW 200 output is used as input of cold water pump driver input for adjustment of frequency.

FB4: Condense Tank Entry PT100 Block: PIW 296 input is converted to temperature as °C. This value is used in energy saving calculations and also monitors heat loss on the way.

FB5: Valve Command Block: Valve open cases, alarms, mode selections (auto-man), position values and some values for SCADA are defined in this block. All 7 valve block programs are in this block.

FB6: Deodorization 8th Unit Out PT100 Block: PIW 312 input is converted to temperature as °C. This value is used in energy saving calculations and also monitors heat loss on the way.

FB7: Reverse Pump Block: Reverse pump run cases, alarms, mode selections (auto-man), position values and some values for SCADA are defined in this block.

FB8: Cold Water Pump Block: Cold water pump run cases, alarms, mode selections(auto- man), position values and some values for SCADA are defined in this block.

FB9: Soft Water Cooling Pump Block.

Cold water pump run cases, alarms, mode selections(auto- man), position values and some values for SCADA are defined in this block.

FB10: Condense Tank Level Transmitter Filter Block: Because condense tank water waves always, condense level value changes. Sometimes, this change range exceeds 25cm and this causes problem at cold water pump frequency. To eliminate this problem and to monitor on SCADA this value more stable, a filter program is written. In this program, there is a flasher block which flashes at each 3 seconds. At each flashing, current value of level transmitter is sent to a different data block. After four new value, mean of those values are calculated and assigned to condense level variable. By this way, operator monitors stable value and also because of stable value, frequency control is achieved perfectly.

FB11: Deodorization 8th Unit PT100 Block: PIW 314 input is converted to temperature as °C. This value is used to monitor vegetable oil temperature. Also operator sees whether cooling is achieved or not..

FB12: Conversion Of Flowmeter Analog Value To Flow Rate(t/h) Value Block: FB12 is used to convert PIW290 analog input(flowmeter analog input) to ton/hour scale. Scale of flowmeter is for 0-45 t/h(flowmeter scale). Firstly zero span adjustments have been done. Result has been assigned to "current flowmeter value"(MD52 memory register) in real type.

FC1: Flowmeter Pulse Program Block: Flowmeter instrument sends two outputs. One is analog output. It is used in program and SCADA to monitor current flow rate and also is used for energy saving calculation. Other output is in digital type. This output sends one pulse each 0.1 ton of water flow. In this block, this pulse is used for total water flow calculation.

FC2 Block: Alarm Reset And All System Automatic Block. This block is used for alarm reset (from SCADA see in figure 6.18) and also for all system automatic made from SCADA.

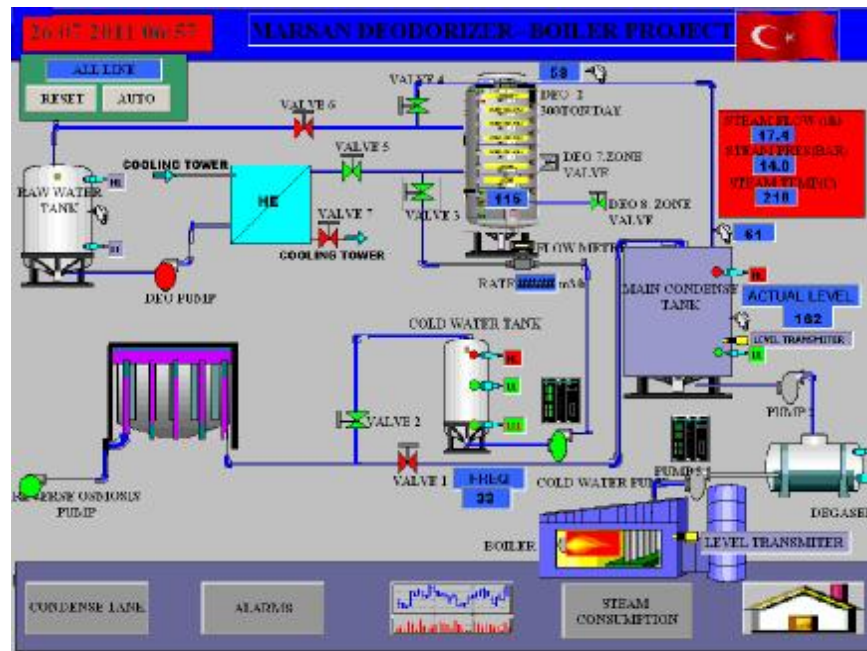


Figure 6.18 General system overview page

FC3: Steam Totalizer Reset Block. In this block, steam totalizer is reset:

FC13: Time Over Block: This timer runs like S5 on delay timer. In program, this block is usually used for position delays. If valves or pumps do not provide necessary position at permitted time, system gives alarm.

Description of On Delay Timer:

S\_ODT (On-Delay S5 Timer) starts the specified timer if there is a positive edge at the start (S) input. A signal change is always necessary in order to enable a timer. The timer runs for the time interval specified at input TV as long as the signal state at input S is positive. The signal state at output Q is "1" when the timer has elapsed without error and the signal state at the S input is still "1". When the signal state at input S changes from "1" to "0" while the timer is running, the timer is stopped. In this case the signal state of output Q is "0".

The timer is reset if the reset (R) input changes from "0" to "1" while the timer is running. The current time and the time base are set to zero. The signal state at output Q is then "0". The timer is also reset if there is a logic "1" at the R input while the timer is not running and the RLO at input S is "1" (Simatic Step7).

FC14: For Deodorization PLC Input About Situations Of Valves And Pumps Block: In this block, positions of valves and pumps (on-off-alarm) are sent as output. Those outputs are used as input by deodorization PLC

FC24: Total Water Mean Temperature Calculation Block: In this block, mean temperature of returned water (last two cycle and total mean temperature of current month) is calculated and monitored at SCADA, see in figure 6.19.

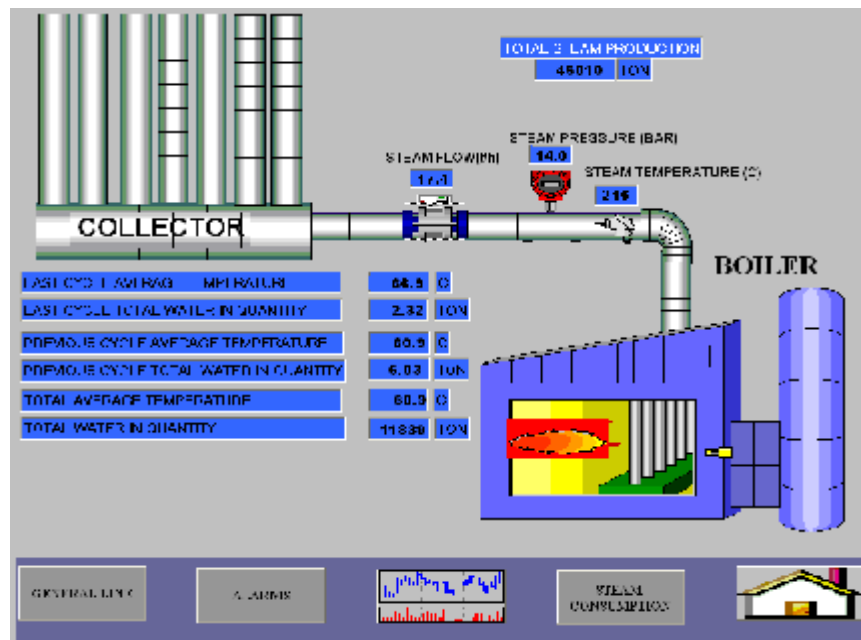


Figure 6.19 Steam line page

FC24: Total Water Fed Condense Tank And Mean Temperature Of Water Fed Condense Tank Reset Block: In this block, total water fed condense tank and mean temperature of water fed condense tank reset process is done. (see figure 6.20)

FC66: Analog Input General Operation Block: In this block, analog input; zero, span, setpoint, hysteresis, high level, low level and other alarms, positions are defined and adjusted. This block is called by FC104. Zero-span values of analog inputs are set from SCADA, see in figure 6.20.

| ONLY AUTHORIZED PERSON CHANGES                                                                                                                                                                                                                                         |       |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----|
| STEAM FLOW RATE ZERO VALUE                                                                                                                                                                                                                                             | 0.00  | kg  |
| STEAM FLOW RATE SPAN VALUE                                                                                                                                                                                                                                             | 30.00 | kg  |
| STEAM PRESSURE ZERO VALUE                                                                                                                                                                                                                                              | 0.00  | bar |
| STEAM PRESSURE SPAN VALUE                                                                                                                                                                                                                                              | 25.00 | bar |
| STEAM TEMPERATURE ZERO VALUE                                                                                                                                                                                                                                           | 0.00  | °C  |
| STEAM TEMPERATURE SPAN VALUE                                                                                                                                                                                                                                           | 300   | °C  |
| <div> <div>STEAM FLOW RATE RESULT?</div> <div>YES</div> </div> <div> <div>CONDENSED TANK WATER FLOW RATE RESULT?</div> <div>YES</div> </div> <div> <div>PUT ALL ALARM OFFSET?</div> <div>YES</div> </div> <div> <div>TOTAL SAVING REQUEST?</div> <div>YES</div> </div> |       |     |

CENTRAL LINE

ALARMS

STEAM EXPANSION PIPES

Figure 6.20 Zero, span adjustment of steam set page

FC104: Call Analog Input Block: In this block, analog inputs are called. Now only steam flow, steam temperature and steam pressure is called in this block.

### 6.2.3 Communication

In this project; between PLC (boiler plant side) and deodorization ET200M module, profibus DP communication protocol is used for data transfer. Properties of profibus DP and differences between other communication protocols are explained in part 6.4. The reason of selection of profibus DP is firstly distance between ET200M module and PLC. Two communication protocols are used for communication of PLCs and ET200M modules: MPI and Profibus. MPI is used if network size is less than 50meter. But network size of project is about 400 meters. So, we did not use MPI communication protocol.

Transmission rate of data transfer is selected as 500Kbps. Minimum transmission rate is 9.6Kbps and maximum transmission rate is 12Mbps. For short network sizes and if data transmission rate is too high, transmission rate can be selected higher. But in our project, network size is long. Because distance is too

much, we put a repeater at deodrization ET 200 Module side for regenerating the signals in amplitude and time.

### 6.3 SCADA

SCADA stands for Supervisory Control And Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level. As such, it is a purely software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules.

One distinguishes two basic layers in a SCADA system: the "client layer" which caters for the man machine interaction and the "data server layer" which handles most of the process data control activities. The data servers communicate with devices in the field through process controllers. Process controllers, e.g. PLCs, are connected to the data servers either directly or via networks or fieldbuses that are proprietary (e.g. Siemens H1), or non-proprietary (e.g. Profibus). Data servers are connected to each other and to client stations via an Ethernet LAN. The data servers and client stations are NT platforms but for many products the client stations may also be W95 machines (Daneels and Salter, 1999).

Functionality: We can group functionality into three main subtitle:

#### 1) Trending

The products all provide trending facilities and one can summarise the common capabilities as follows:

- the parameters to be trended in a specific chart can be predefined or defined online
- a chart may contain more than 8 trended parameters or pens and an unlimited number of charts can be displayed (restricted only by the readability)
- real-time and historical trending are possible, although generally not in the same chart
- historical trending is possible for any archived parameter
- zooming and scrolling functions are provided

- parameter values at the cursor position can be displayed

The trending feature is either provided as a separate module or as a graphical object (ActiveX), which can then be embedded into a synoptic display. XY and other statistical analysis plots are generally not provided.

## 2) Alarm Handling

Alarm handling is based on limit and status checking and performed in the data servers. More complicated expressions (using arithmetic or logical expressions) can be developed by creating derived parameters on which status or limit checking is then performed. The alarms are logically handled centrally, i.e., the information only exists in one place and all users see the same status (e.g., the acknowledgement), and multiple alarm priority levels (in general many more than 3 such levels) are supported. It is generally possible to group alarms and to handle these as an entity (typically filtering on group or acknowledgement of all alarms in a group). Furthermore, it is possible to suppress alarms either individually or as a complete group. The filtering of alarms seen on the alarm page or when viewing the alarm log is also possible at least on priority, time and group. However, relationships between alarms cannot generally be defined in a straightforward manner. E-mails can be generated or predefined actions automatically executed in response to alarm conditions.

## 3) Logging/Archiving

The terms logging and archiving are often used to describe the same facility. However, logging can be thought of as medium-term storage of data on disk, whereas archiving is long-term storage of data either on disk or on another permanent storage medium. Logging is typically performed on a cyclic basis, i.e., once a certain file size, time period or number of points is reached the data is overwritten. Logging of data can be performed at a set frequency, or only initiated if the value changes or when a specific predefined event occurs. Logged data can be transferred to an archive once the log is full. The logged data is time-stamped and can be filtered when viewed by a user. The logging of user actions is in general performed together with either a user ID or station ID. There is often also a VCR facility to play back archived data (Daneels and Salter, 1999).

### 6.3.1 Hardware configuration of SCADA:

As hardware configuration of SCADA, one LENOVO brand PC is used for monitoring. For communication between SCADA program and PLC CP5611 card is used. Technical specifications of CP5611 card is explained below.

CP 5611 CARD:CP5611 communication card is optoelectronic isolated design for industrial applications. There is anti-lightning & anti-surfing protection circuit and over-current protection on the RS485 port. The adoption of industrial chip applies to a wide temperature range. CP5611 card is used to achieve the PROFIBUS DP / MPI / PPI communication between PC or PG and the SIMATIC network.

In table 6.14 technical specifications of CP5611 card is seen. Also in figure 6.21, CP5611 card is seen.

Table 6.14 Technical specifications of CP5611 card

|                                                                                         |                                                                                            |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Transmission rate                                                                       | 9.6Kbps~12Mbps, corresponding maximum communication distance conforms to PROFIBUS standard |
| Interface                                                                               | PROFIBUS/MPI/PPI, isolated 9-pin Sub-D socket                                              |
| Isolation Voltage                                                                       | 1000VDC                                                                                    |
| RS485 port with anti-lightning and anti-surfing protector, repeatability surge capacity | Ipp = 100A (10/700us, 4KV)                                                                 |
| Standard                                                                                | ITU-TK20/21, VDE 0433. ± 15KV ESD (ESD) protection                                         |
| Over-current protection                                                                 | RS485 interface can withstand up to 60V voltage caused by the sustained over-current       |
| PG/PC connection                                                                        | PCI2.1 standard slot                                                                       |
| Standard voltage                                                                        | +5 VDC                                                                                     |
| Power                                                                                   | 2.0W                                                                                       |
| Operating temperature                                                                   | 0 ~ + 70 °C                                                                                |
| Size (width × high) (mm)                                                                | 102 × 130                                                                                  |
| Weight                                                                                  | 100g                                                                                       |



Figure 6.21 CP5611 card.

### 6.3.2 Software Configuration Of SCADA

As software program Simatic WINCC FLEXIBLE 2007 is used. WinCC flexible Runtime is a high-performance and comprehensive software for the visualization of processes in projects you created with the WinCC flexible Advanced programming software.

Modern automation concepts are extremely demanding on process visualization. Process control, closer to machines, must meet the demands for simple, high-performance control of the processes. The goal is to present process datas to the operator quickly and clearly in a form that can be easily understood, such as a trend display. This increasingly requires process displays that simplify understanding of the actual process. It is also becoming more important to be able to archive the data, e.g. for quality control. This makes it necessary to log process data at machine level.

WinCC flexible Runtime is designed for visualization and operation of machines and small systems. The Runtime software has a window-based pixel-graphics user interface. Due to its short response times, the software features secure process operation, jogging at the machine and secure data acquisition.

In SCADA pages, alarm and warning handlings are processed. If there is an alarm, then alarm button on SCADA flashes and also there is a horn. Horn becomes active. Details of alarm is written on alarm and warning page. Also by alarm and

warning archive page, last 500 alarm and warnings are recorded. When alarm is removed, then alarm button stops flashing. And horn becomes deactive. Also over ten parameters are logged and displayed as trend line. Trend logging is important for predicting and for searching past. At below each SCADA pages is explained.

#### **6.3.2.1 SCADA pages explanations**

Data communication network is divided into 2 level: supervisory and field level. Ethernet is used in the communication of supervisory level. In deodorization system, MPI is used in communication of supervisory level. As SCADA program, Siemens brand WINCC FLEXIBLE 2007 is used. 125 external tags and 25 internal tags are used in this project. 16 screens have been generated. As baudrate 18.500Kbps is selected. Address of HMI machine is 1 selected. Four alarm classes have been generated. These are diagnosis, errors, system and warnings. Errors and warnings have also logging. Because of project content, recipe function was not used. As historical data function, 11 data logged. Each writes in excell files addressed in C\ TRENDLER folder. Also in each excell file 500.000 data logged. As alarm log, there are two files; alarm log file and warning log file. Each saves 500 alarms and 500 warnings. At runtime user administrator part, we defined two users. Only one page(zero span page) is entered by password.

At Deodorization Plant SCADA program, Siemens brand WINCC SCADA V6.0 used.

UPS is used in power supply service for all MARSAN A.Ş SCADAs and PLCs.

Below boiler SCADA pages and their explanations are told.

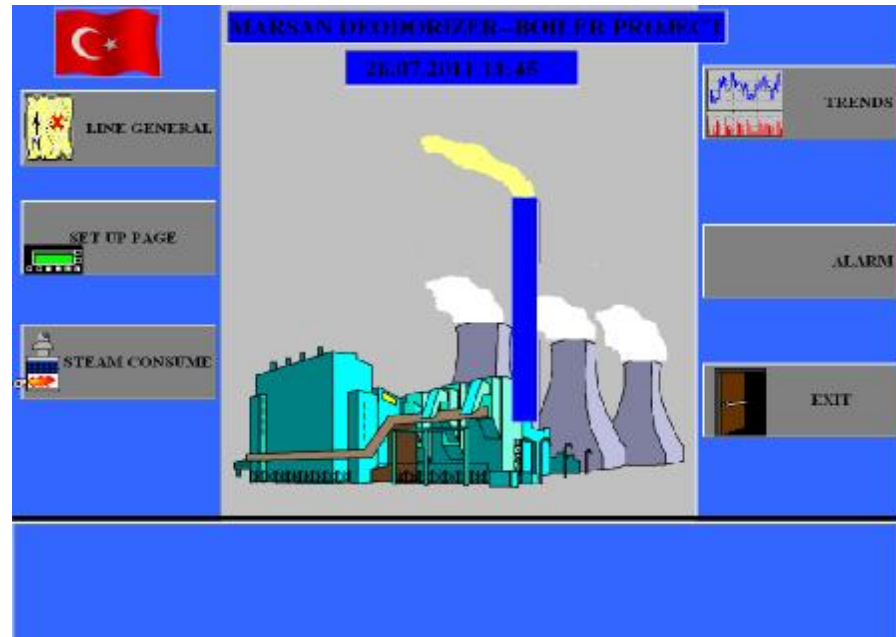


Figure 6.22 SCADA start page

In figure 6.22, we see start screen. Operator selects pages which he wants to go. Also for closing the program, there is an exit button.

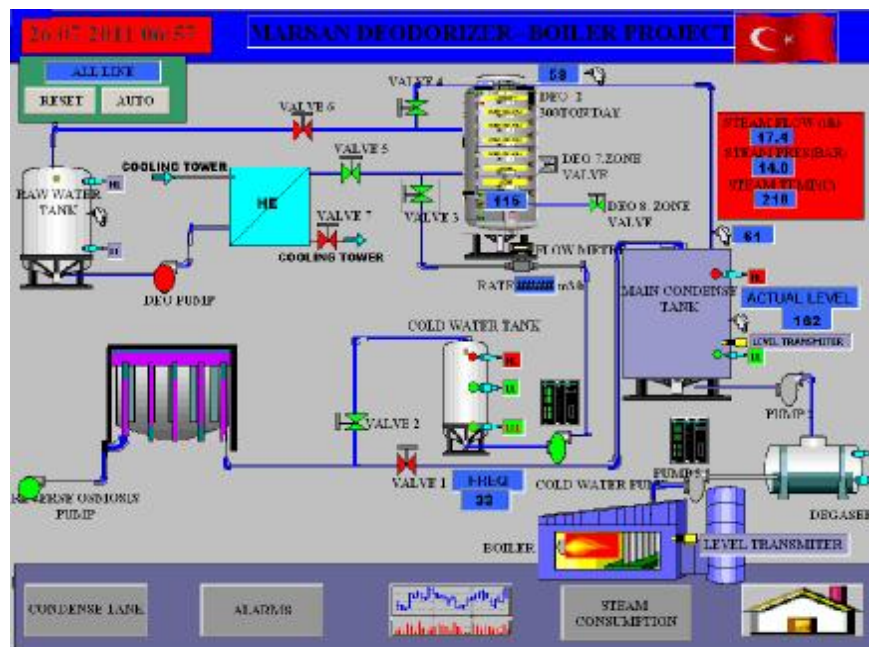


Figure 6.23. General overview page.

In general overview page, all system overview and also controls of all pumps(reverse osmosis pump,cold water pump and deo pump) and valves(V1 to V7) (auto- man) are seen. Also;

steam flow rate value,  
 steam temperature,  
 steam pressure,  
 set frequency value of cold water pump,  
 Condense tank level value (analog),  
 condense tank and cold water tank limit switches,  
 flow rate of cold water,  
 deodorization 8th unit temperature,  
 deodorization exit heat water temperature,  
 condense tank returned hot water temperature,  
 Deodrization 7th unit valve position,  
 deodorization 8th unit valve position are seen.

Also reset and take automatic mode of all system are seen in this page.

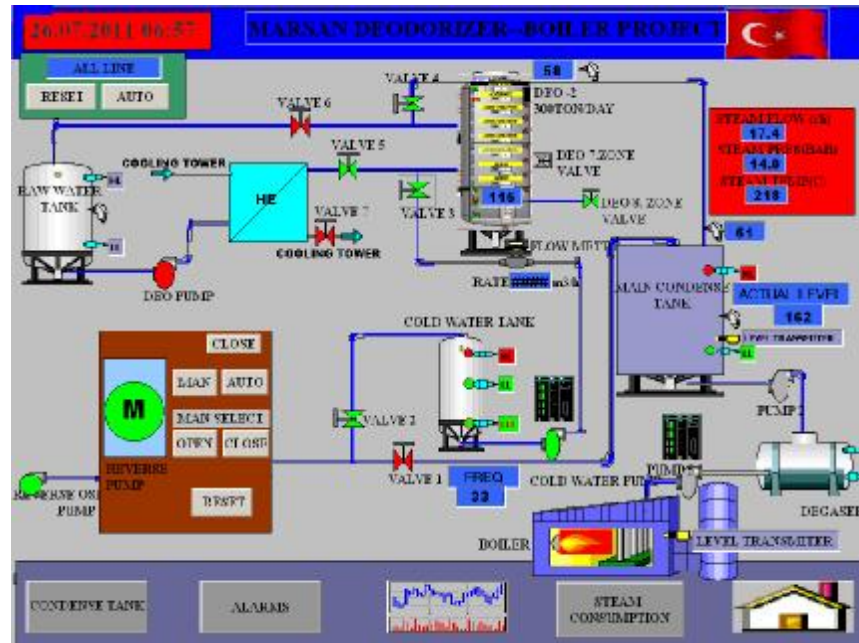


Figure 6.24. General overview page including command window.

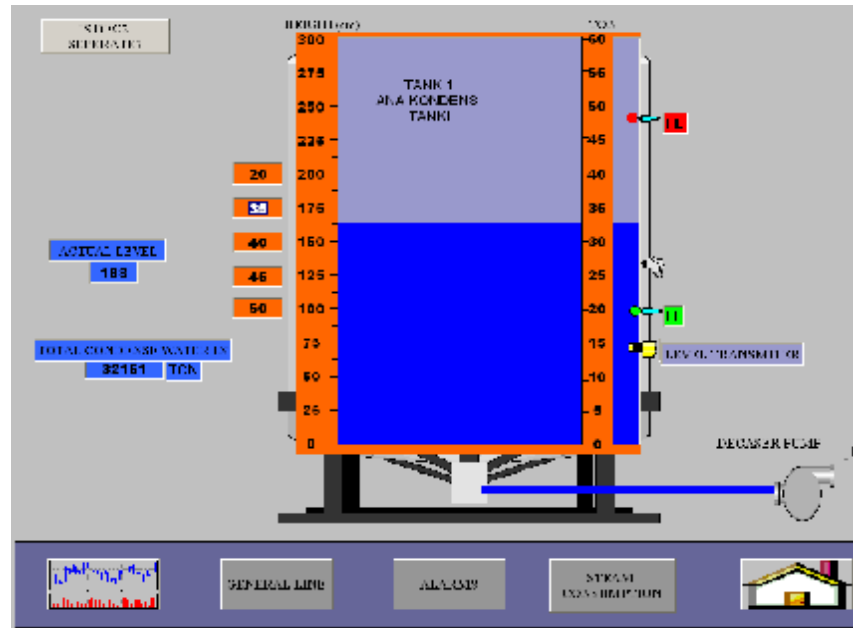


Figure 6.25 Flow rate set page

In flow rate set page, cold water pump frequency (also flowrate) is set. Also if two systems will run seperately, it is provided by “IS DEO SEPERATE?” button.

Also total water fed by cold water pump,

Current level of condense tank,

Condense tank level limit switches are seen.

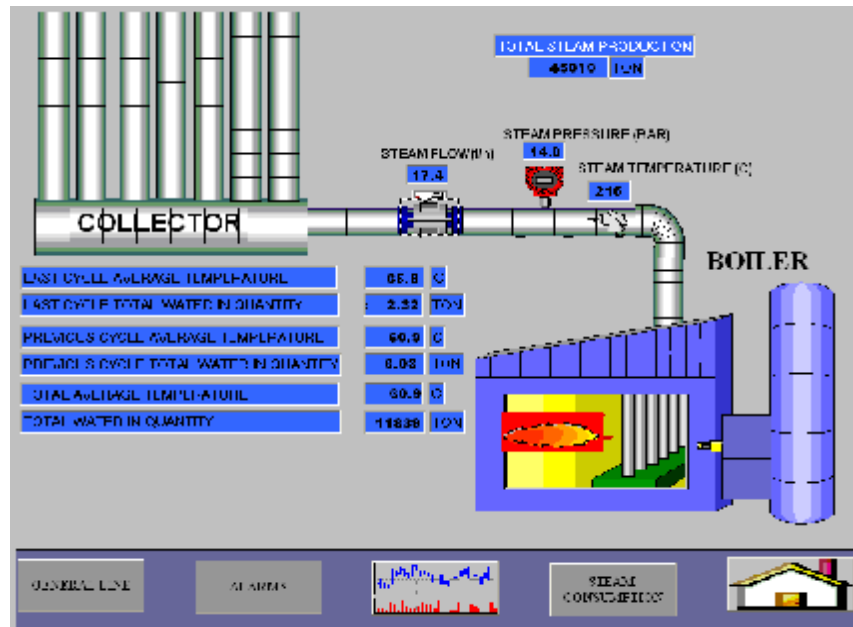


Figure 6.26 Steam page

In steam page;

mean temperature of returned total water,

amount of total water,

last two cycle and total mean temperature,

amount of last two cycle and total water,

total steam produced,

current steam pressure,

current steam temperature,

current steam flow rate are monitored.

Also when clicked on steam flow rate or steam pressure or steam temperature icons, a small window is opened and LL and HL set values are entered. When value exceeds HL value or when value decrease below LL value, warning message is seen on alarm and warning page. Also yellow lamp which is beside SCADA flashes.

| ONLY AUTHORIZED PERSON CHANGES                                     |     |
|--------------------------------------------------------------------|-----|
| CONDENSE TANK MIN LEVEL VALUE FOR EMERGENCY FILL (cm)              | 105 |
| CONDENSE TANK EMERGENCY FILL STOP VALUE (cm)                       | 150 |
| WHEN DROPS IS 0-LEVEL SET PUMP STOP LEVEL FOR CONDENSE TANK (cm)   | 150 |
| WHEN DROPS IS 0, REVERSE PUMP STOP LEVEL FOR CONDENSE TANK (cm)    | 200 |
| WHEN CONDENSE TANK IS OVER FILL, COLD WATER PUMP STOP LEVEL (cm)   | 255 |
| AFTER CONDENSE TANK IS FULL, COLD WATER PUMP ACTIVATION LEVEL (cm) | 215 |
| LAMP ACTIVATION LEVEL FOR CONDENSE TANK EMERGENCY FILL (cm)        | 20  |
| LAMP ACTIVATION LEVEL FOR CONDENSE TANK FULL LEVEL (cm)            | 30  |

GENERAL TEST    ALARM       PLANT STATUS   

Figure 6.27 Adjustment page 1.

In Adjustment page 1, there are some set values. These are:

Condense tank minimum level set value for emergency fill: If two systems run together, and if condense tank level is below this set value, then automatically valve1, valve5, valve 6 and valve7 will be opened. Valve 2, valve3, and valve4 will

be closed. Soft water pump runs for deodorization cooling. Reverse pump runs for condense tank. Cold water pump stops running.

Condense tank minimum level reset value for emergency fill: If two systems run together, and if condense tank level is above set value, then automatically valve1, valve5, valve 6 and valve7 will be closed. Valve 2, valve3, and valve4 will be opened. Soft water pump stops. Reverse pump runs for cold water tank. Cold water pump runs for deodorization cooling.

If two systems run separately, according to condense tank level, reverse pump run set value: If two systems run separately, then condense tank is filled by reverse pump. This value defines minimum condense tank level.

If two systems run separately, according to condense tank level, reverse pump run reset value: If two systems run separately, then condense tank is filled by reverse pump. This value defines maximum condense tank level.

Condense tank maximum set level: If condense tank level reaches this defined level, then valve 3 and valve4 are closed. Valve 5, valve6, valve7 are opened. Soft water pump runs for deodorization cooling. Cold water pump stops running. Reverse pump runs until cold water tank level reaches high level. Then reverse pump stops.

Condense tank maximum reset level: If condense tank level reaches until that level, then valve 3, valve4 are opened. Valve 5, valve6, valve7 are closed. Cold water pump runs for deodorization cooling. Soft water pump stops running.

Condense tank maximum level warning value: If this value is 20 and if condense maximum level value is 255, then when condense tank level is above  $235(255-20)$ , warning yellow lamp flashes. Then if frequency value is high, operator decreases frequency level.

Condense tank emergency level warning value: If this value is 20 and if condense emergency level value is 105, then when condense tank level is below  $125(105+20)$ , warning red lamp flashes. Then if frequency value is low, operator increases frequency level.

| ONLY AUTHORIZED PERSON CHANGES                          |        |                |
|---------------------------------------------------------|--------|----------------|
| INTERMEDIATE FREQ. FACT DECREASE                        | 2      | h <sub>z</sub> |
| ULTIMATE FREQ. DECREASE                                 | 5      | h <sub>z</sub> |
| FREQUENCY DECREASE CYCLE TIME                           | 7      | h <sub>z</sub> |
| WHEN HOT OIL REACHES 8th UNIT, TIME SET VALUE           | 40     | h <sub>z</sub> |
| WHEN HOT OIL REACHES 8th UNIT, TIME PERIOD OF HIGH FREQ | 75,000 | ms             |

GENERAL INT   ALARM     LEVEL SETUP PAGE   ZERO SPAN PAGE  

Figure 6.28 Adjustment page 2.

Frequency lowering parameters (first three parameters): When 8th unit valve is opened, amount of hot vegetable oil starts decreasing and in parallel, returned heated water temperature decreases sharply. To eliminate this sharply temperature decrease, we decrease flow rate of cold water.

Start set parameters (last two parameters): When hot vegetable oil flows into 8th unit of deodorization unit (when 7th unit valve opened), for a defined time period (last parameter) a defined frequency value is set first and when time is over, frequency value setted normal value. The reason of this is, if frequency is low, then 170°C hot vegetable oil meets with low flow rate water, and low flow rate water temperature increases over 100°C (steam occurs in coil heat exchanger). A bit time later, cold water meets with steam and hammering occurs in coil heat exchanger. With this action, coil heat exchanger is damaged by the time.

| ONLY AUTHORIZED PERSON CHANGES |       |     |
|--------------------------------|-------|-----|
| STEAM FLOW RATE ZERO VALUE     | 0.00  | No  |
| STEAM FLOW RATE SPAN VALUE     | 30.00 | No  |
| STEAM PRESSURE ZERO VALUE      | 0.00  | Bar |
| STEAM PRESSURE SPAN VALUE      | 25.00 | Bar |
| STEAM TEMPERATURE ZERO VALUE   | 0.00  | C   |
| STEAM TEMPERATURE SPAN VALUE   | 300   | C   |

STEAM STANDARD RESET? YES

CONDENSE TANK WATER TOTALIZER RESET? YES

TOTAL STEAM RESET? YES

CENTRAL UNIT ALARMS STEAM EXCHANGE PLOTT

Figure 6.29 Adjustment page 3.

Adjustment page 3 is accessed by password. So important parameter settings (zero span) and some reset actions (totalizers and important alarms) are done in Adjustment page 3.

Zero span of steam flow, steam temperature and steam pressure adjustments are done here.

Also total steam amount, total water, which is feeded to condense tank, total gain and I/O alarm reset is done here.



Figure 6.30 Alarm and warning page.

Current alarms and warnings are displayed in alarm and warning page. Also if there is an alarm, there is horn and also in any SCADA page alarm button flashes.

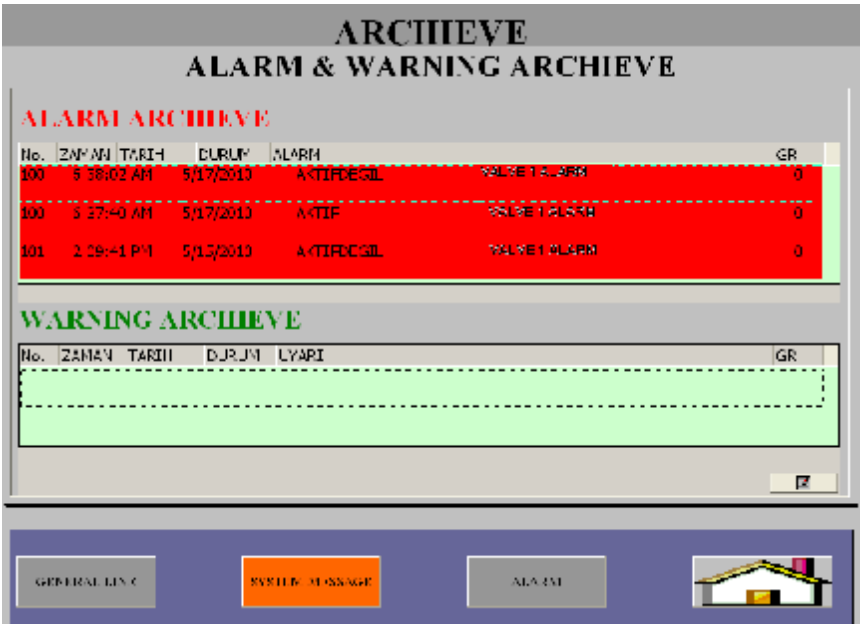


Figure 6.31 Alarm and warning archive page.

In alarm and warning archive page, last 500 alarms can be displayed. If alarm number exceeds 500 alarms, then the oldest alarm is removed. Instead of it, new alarm is written. Alarm archive is too important for fault finding.

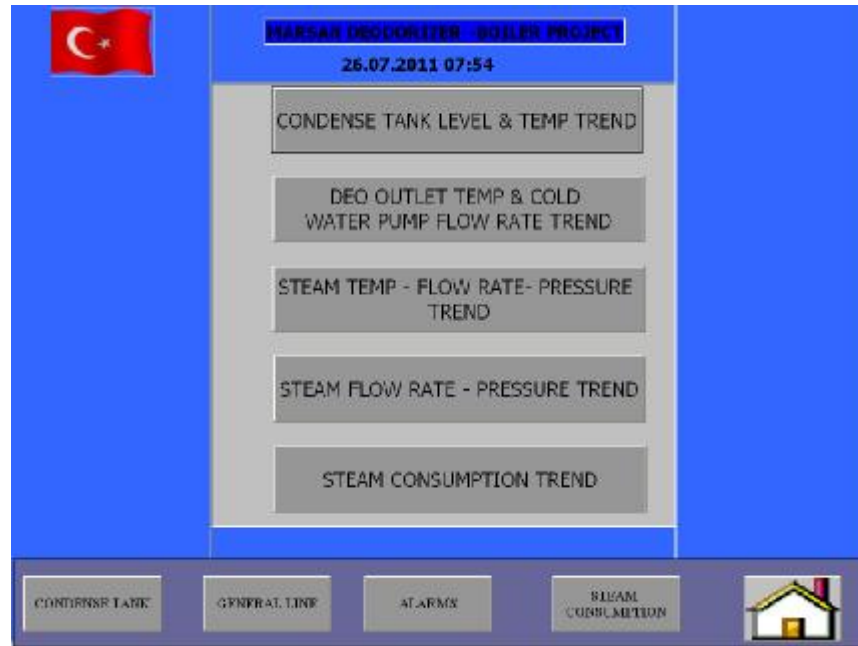


Figure 6.32 Trend selection page.

In trend selection page, trend pages are selected. As seen from buttons;

- Ø Condense tank level and condense returned( feeded) feeded water temperature trend,
- Ø Deodorization exit hot water temperature, cold water flow rate trend,
- Ø Steam temperature, steam flow, steam pressure trends,
- Ø Steam flow and steam pressure trends,
- Ø Steam consumption trend pages can be selected .

Condense tank level saves sample at each 5 seconds and condense returned (fed) water temperature trend saves samples at each 1 second.

Deodorization exit hot water temperature and cold water flow rate trend, saves samples at each 1 second.

Steam temperature, steam flow and steam pressure trends saves samples at each 5 second.

Steam flow and steam pressure trends saves samples at each 5 second.

Steam consumption trend saves samples at each 1 hour.

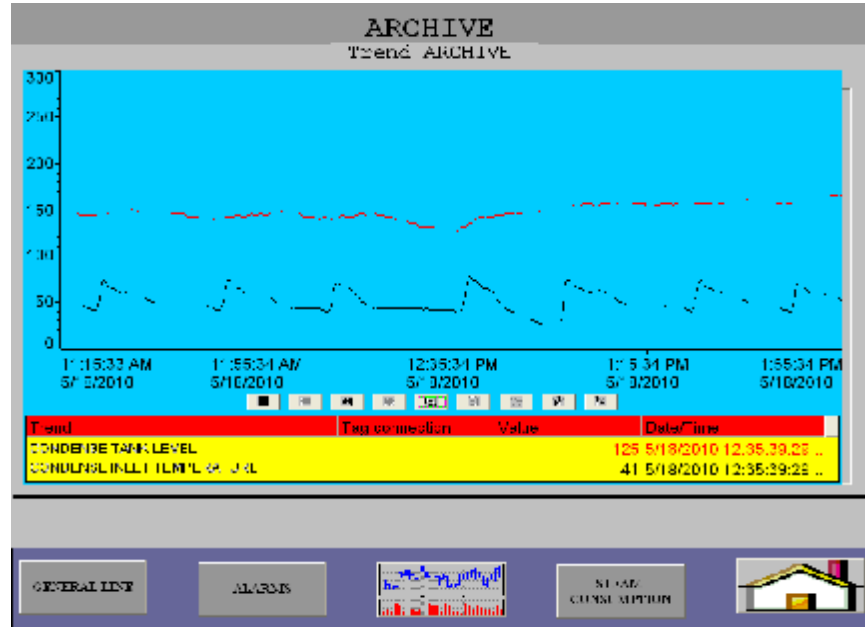


Figure 6.33 Condensate tank level and condensate entry temperature trends page.

In Condensate tank level and condensate entry temperature trends page, condensate tank level and condensate returned (fed) water temperature trends are displayed. Red line is condensate tank level, black line is condensate returned ( fed) water temperature.

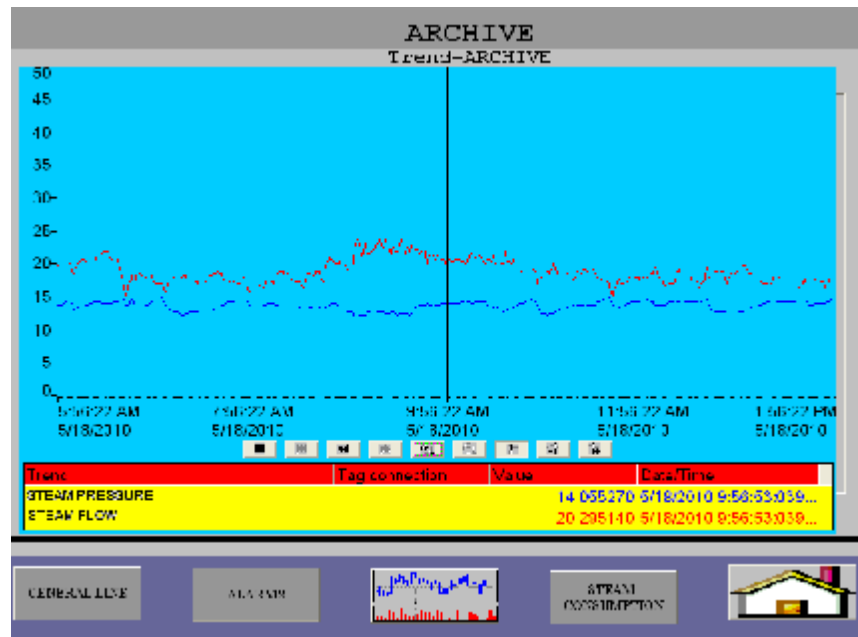


Figure 6.34 Steam pressure and steam flow rate trends page.

In steam pressure and steam flow rate trends page, steam flow and steam pressure trends are displayed. Red line is steam flow trend, blue line is steam pressure trend.

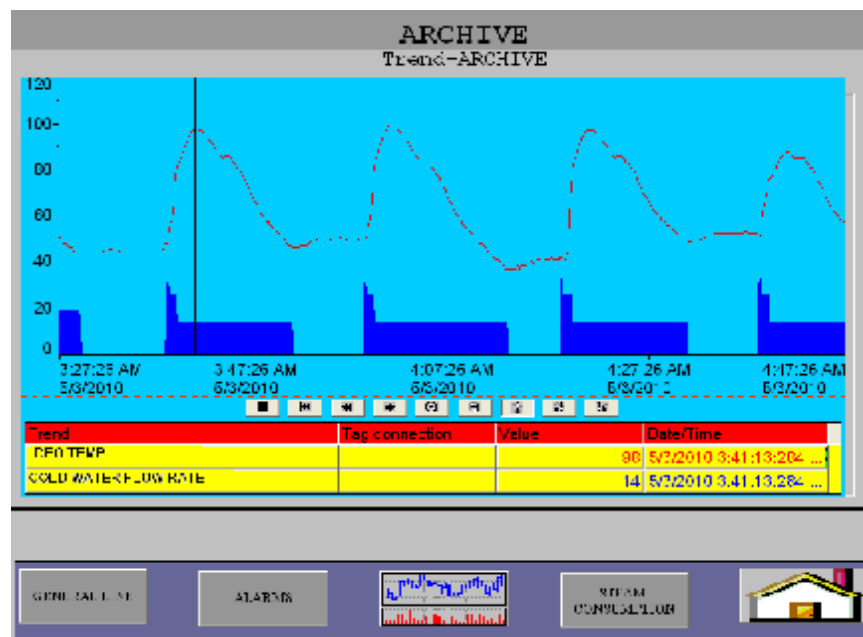


Figure 6.35 Cold water flow rate and deodorization exit hot water temperature trends page.

In Cold water flow rate and deodorization exit hot water temperature trends page, deodorization exit hot water temperature trend and cold water flow rate trend are displayed. Red line is deodorization exit hot water temperature trend and blue bar graph is cold water flow rate trend.

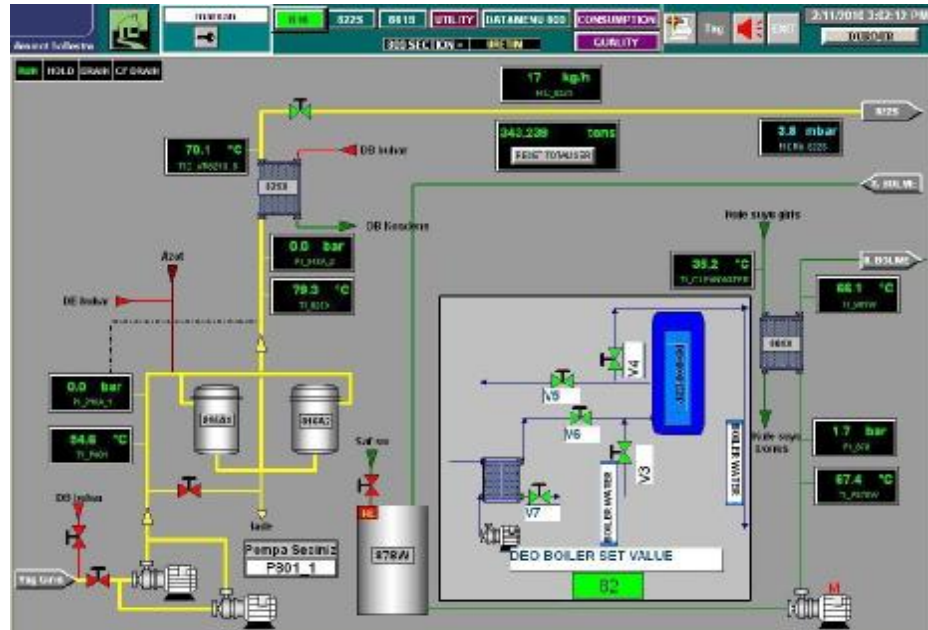


Figure 6.36 Deodorization SCADA

Deodorization SCADA page is designed at deodorization SCADA. Here, valve positions, soft water pump position and 8th unit of deodorization set temperature value are seen. Operator can not command valves from this SCADA page. Valves are controlled at boiler SCADA. But if two systems are separate, soft water pump is controlled from this SCADA(deodorization). If two systems are together, then control of soft water pump is at boiler SCADA. But 8th unit of deodorization temperature set value is entered only in deodorization SCADA.

### 6.3.3 Communication Type Of MARSAN A.Ş Project

MPI communication protocol is selected for communication between PLC and SCADA of Boiler plant. The reason of this selection is: there are two options for communication of PLC and SCADA: MPI and ethernet. Normally communication

speed of ethernet communication protocol is too high(10Mbps-1Gbps) than MPI(187.5Kbps-12Mbps). But communication speed is not much important in our project. And also there are two way for ethernet communication: 1) CPU supported, 2) ethernet communication module. Because of economical reasons, we choose MPI communication type for CPU- SCADA communication.

In deodorization control system, between PLC and SCADA of deodorization plant ethernet communication protocol is selected by supplier. The reason is, there are two operator screen for controlling system. Transmission rate of data transfer selected as 12 Mbps is selected.

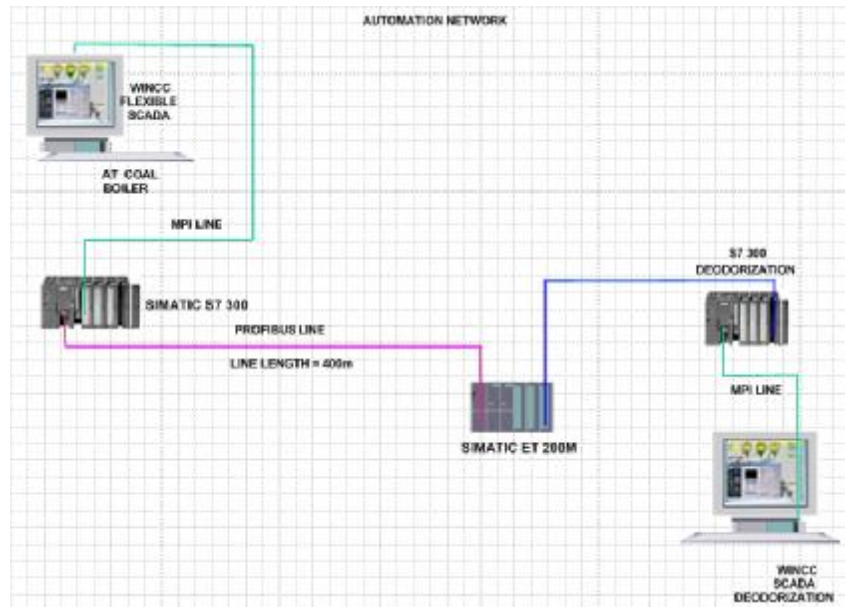


Figure 6.37 Software configuration of new system.

## 7. PROJECT RESULT

In this section, the results and benefits of designed system is presented. Energy saving calculations, cooling tower load decreases, energy consumption figures, coal saving calculations are presented. Also some healings and developments are explained.

### 7.1. Energy Saving Calculation

Case1: Decrease of coal consumption rate and cost saving.

In boiler plant process, water temperature of degaser should be increased upto 102°C by steam consuming, consequently coal firing. So the more hot water sent into degaser tank, the more energy and also cost saving in boiler process. So when condense tank water temperature is increased, automatically energy saving will be achieved. Below, MARSAN 2011 annual steam consumption, production rate of deodorization 2, returned water rate from deodorization 2, condense tank mean temperature, amount of energy save quantity and amount of coal saving are given. Then cost saving calculations and mean profit per month and payback time are given. They are shown in table 7.1.

Table 7.1. 2011 MARSAN steam production and energy saving table

| Months | Production Rate Of Deo 2 | Steam Cons. Rate(tons) | Returned water rate from Deo | Mean Temp (°C) | Amount of Energy save (Kcal) | Amount of Coal save (tons) |
|--------|--------------------------|------------------------|------------------------------|----------------|------------------------------|----------------------------|
| Jan    | 9.100                    | 11.300                 | 11.200                       | 60,2           | 450.240                      | 100,05                     |
| Feb    | 9.200                    | 10.950                 | 10.650                       | 61             | 436.650                      | 97,03                      |
| March  | 9.100                    | 11.150                 | 11.000                       | 61,3           | 454.300                      | 100,96                     |
| April  | 8.900                    | 10.800                 | 10.100                       | 60             | 404.000                      | 89,78                      |
| May    | 8.800                    | 10.100                 | 9.400                        | 59,6           | 372.240                      | 82,72                      |
| June   | 8.400                    | 9.800                  | 9.100                        | 62,5           | 386.750                      | 85,94                      |
| July   | 8.100                    | 9.650                  | 9.150                        | 62,6           | 389.790                      | 86,62                      |
| Aug    | 8.100                    | 9.200                  | 8.700                        | 62,6           | 370.620                      | 82,36                      |
| Sept   | 8.900                    | 9.350                  | 8.700                        | 60,4           | 351.480                      | 78,11                      |
| Oct    | 9.100                    | 9.900                  | 9.100                        | 60,1           | 364.910                      | 81,09                      |
| Nov    | 9.000                    | 11.150                 | 10.600                       | 61,1           | 435.660                      | 96,81                      |
| Dec    | 9.100                    | 11.300                 | 11.000                       | 60,2           | 442.200                      | 98,27                      |

Mean temperature increase has been measured as 40,98°C(60,98-20)

Mean steam consumption is 10.338 tons.

Returned water from Deodorization Unit is 9.892 tons.

Total energy saving for annual (2011) according to

$$Q_{\text{water}} = m_{\text{water}} \times c_{\text{water}} \times \Delta t_{\text{water}} \text{ formula: } 4.861.000_{\text{kcal}}.$$

The lower calorific value of coal is 4.500Kcal/kg(Ermenek coal).

Coal need=4.861.000<sub>kcal</sub>/4500<sub>kcal/kg</sub> = 1.080,222 tons of coal is needed annual(2011).

1 ton of ermenek coal costs 265 TL. (2011 september ermenek coal price ton/TL).

According to above results; by this project; when boiler feeding water temperature is increased by new system, 286.259TL energy saving is achieved annual (2011).

Mean profit per month is 23.855TL.

We can see from figure 7.1 boiler plant 2011 annual coal consumption quantities and aimed coal consumption in old system. According to process quantity and processed oil type monthly coal consumption always changes. So one parameter is always taken as theoretical.

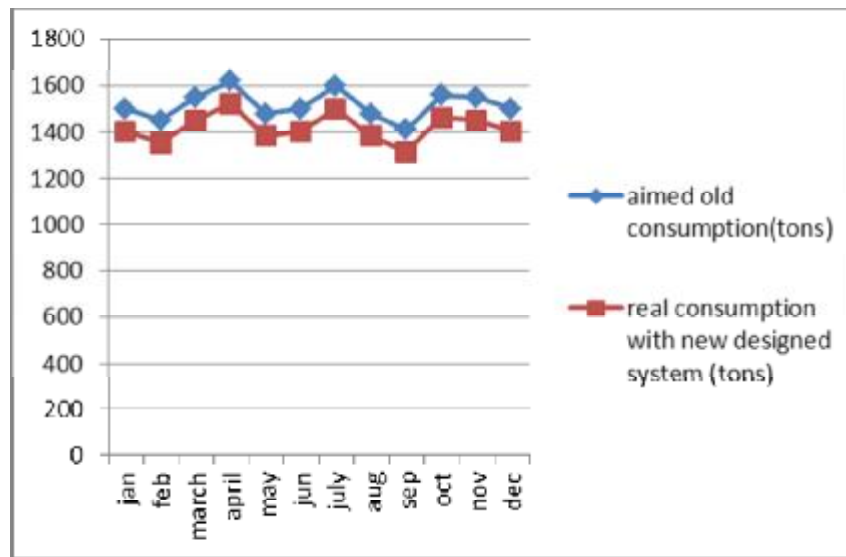


Figure 7.1 Boiler plant annual coal consumption comparison

In figure 7.2 condense tank temperature comparison is given. Well temperature shows cold water temperature (in old system condense tank was fed by cold water directly), new temperature shows condense tank returned water from deodorization 2 unit.

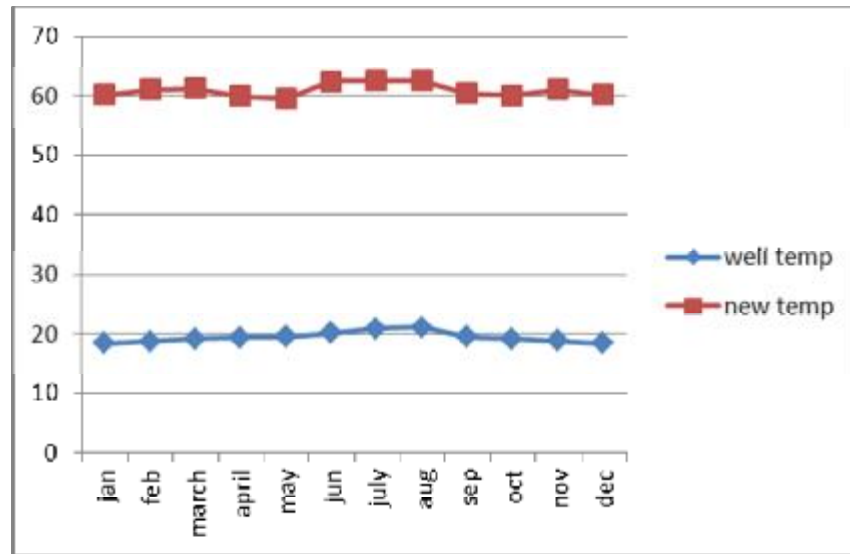


Figure 7.2 Condense tank water temperature comparison.

#### Case 2: Cooling tower load capacity decrease.

In old system, there were 5 pumps each are 45KW. All five pumps pump cooling water into same collector and then separated subdivisions. But for deodorizer 8th unit; because there is no control instrument on heat exchanger and also generally can not catch oil set value,  $150\text{m}^3/\text{h}$  flow rate needs every time from cooling tower. But other department cooling needs can change according to season and process type. By new designed system, because cooling of 8th unit of deodorization 2 is achieved by water which is sent from boiler plant, one of cooling tower pump has been stopped (seen figure 7.3). Amount of energy saving at cooling tower is calculated below.

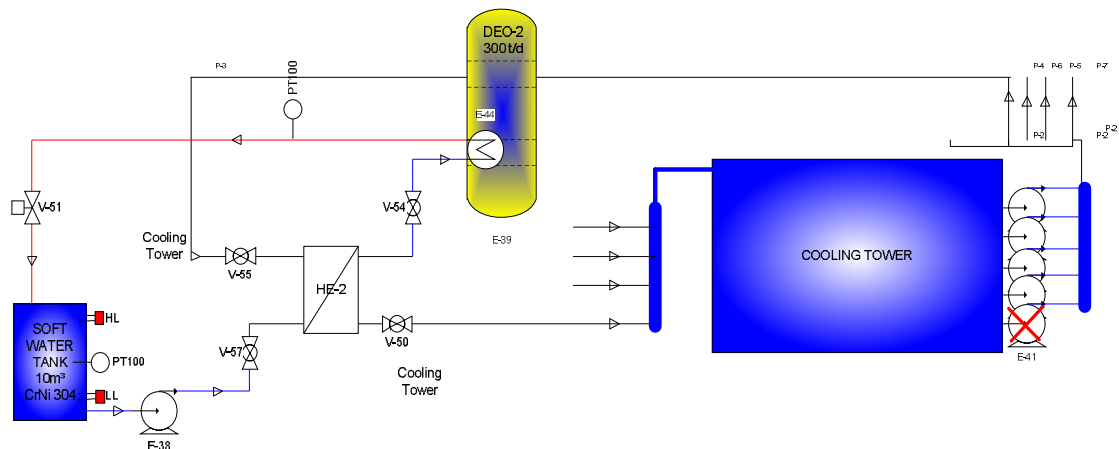


Figure 7.3 One cooling tower pump stopped by new system.

Cooling tower pump is 45KW. It runs star-delta(YΔ) and measured current is 85A.

Cooling tower monthly energy consumption details are seen in Appendix B.

Monthly energy saving is 29.867KWh.

Monthly energy cost saaving is 4.928 TL.

In figure 7.4, energy consumption of cooling tower before and after new designed sysyem is shown.

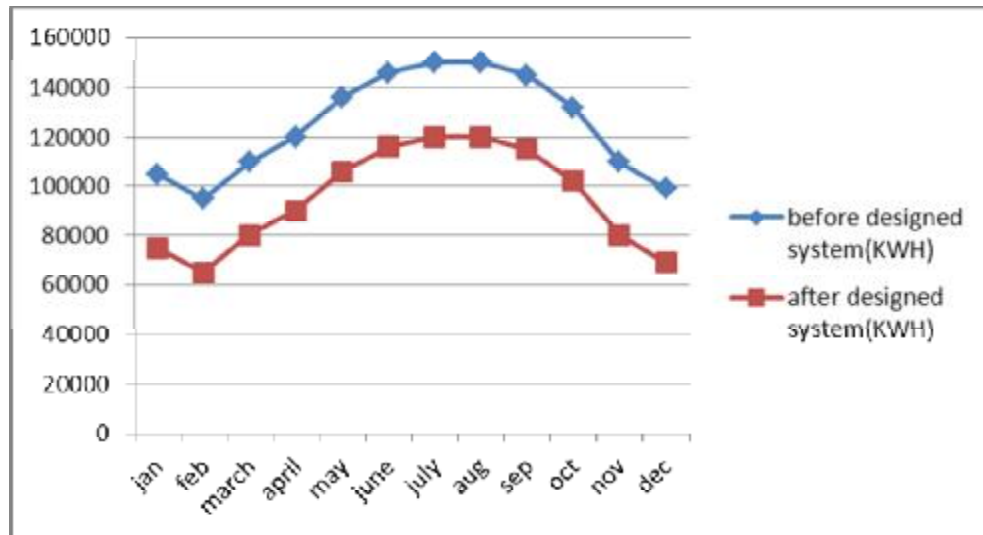


Figure 7.4 Energy consumption of cooling tower before and after new designed sysyem.

Case 3: Total electrical energy saving.

In old system; cooling soft water pump runs nearly always and capacity is 11KW. It runs direct and measured current is 17,6A. By new designed system, this pump will nearly never run like one of cooling tower pump (seen in figure 7.5).

Cooling soft water pump monthly energy consumption details are seen in Appendix B:

Monthly energy saving is 6.184KWh.

Monthly energy cost saaving is 1.020 TL.

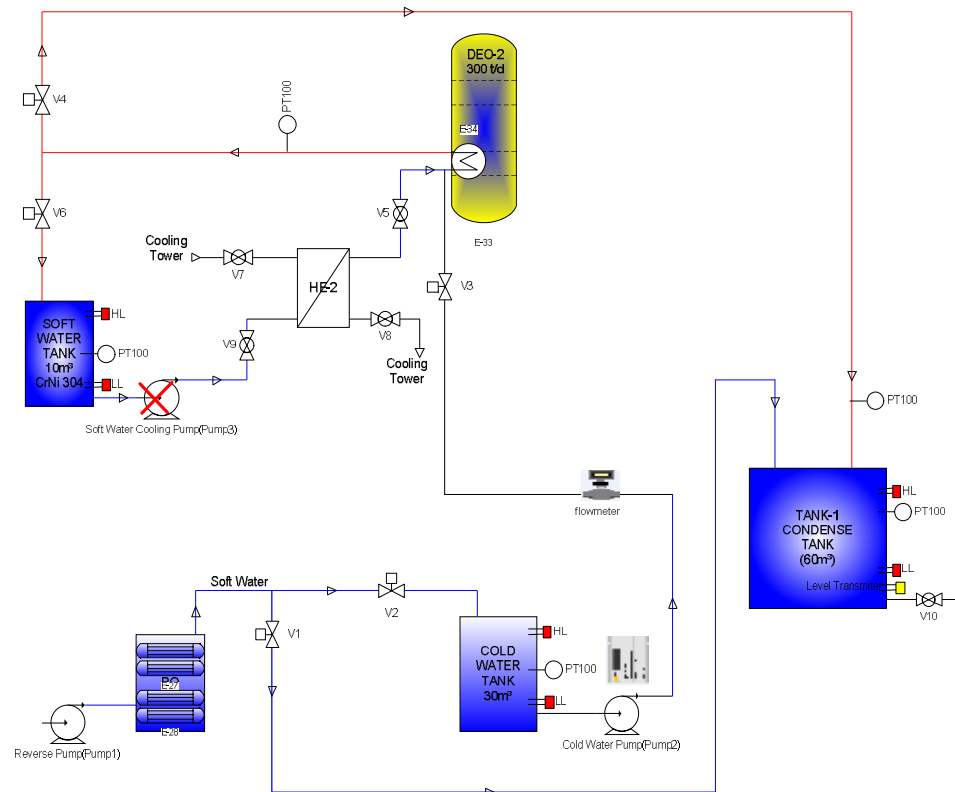


Figure 7.5 Soft water cooling pump stopped by new system.

New designed system cold water pump which pumps water from cold water tank through 8th unit of deodarizer to condense tank is 5.5KW. It runs by driver .

For 14,5t/h water feeding, pump frequency is 25Hz and consumed current is 7,2A. Details of designed system pump monthly energy consumption is seen in Appendix B.

Monthly energy saving is 2.548KWh.

Monthly energy cost saaving is 420 TL.

Monthly total electrical energy saving is:cooling tower pump + cooling soft water pump – new designed system cold water pump

$$4.928 \text{ TL} + 1.020 \text{ TL} - 420 \text{ TL} = 5.528 \text{ TL}$$

In figure 7.6, electrical energy saving/consumption of each unit and total electrical energy saving is shown.

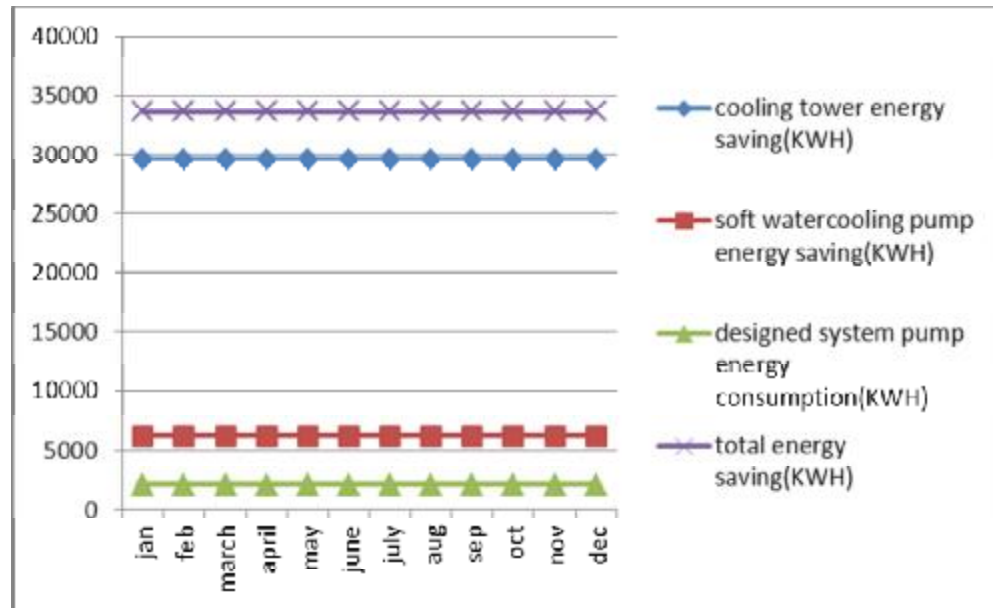


Figure 7.6 Electrical energy saving/consumption of each unit and total electrical energy saving

Case 4: Project total energy saving and payback:

We can summarize total energy saving as electrical energy saving adding thermal energy saving.

Monthly project total energy saving: Energy saving from coal + energy saving from electricity.

$$23.855 \text{ TL} + 5.528 \text{ TL} = 29.383 \text{ TL.}$$

Also we can calculate Payback Time:

$$\text{Yearly: } 12 \times 29.383 = 352.596 \text{ TL.}$$

Cost price of project is 112.000 TL.

$$\text{System total cost / monthly energy saving} = 112.000 / 29.383 = 3.8 \text{ month.}$$

Project payback time is 3.8 month.

## 7.2. Other Improvements and Benefits

Case 5: Other improvements.

After new system design and start up; some changes have been done on system. They are mentioned at below.

In order to run system effectively and without damage, some control blocks were added in PLC program and also some parameters were added in SCADA system (figure 7.7).

When hot vegetable oil runs into 8th unit of deodorization, driver controlled pump starts to run at set frequency. But temperature of hot vegetable oil is 170°C at the beginning of batch and when cold water meets with hot vegetable oil in heat exchanger, water is firstly transformed to steam (because of hot vegetable oil) and when cold water comes from back, steam and cold water meets and a strike (hammering) occurs. This strike damages heat exchanger and pipes. This is shown in figure 7.8.

To prevent that problem, two parameters were added into SCADA page (figure 7.7): Start frequency and enable time of start frequency. They are defined as below in SCADA page:

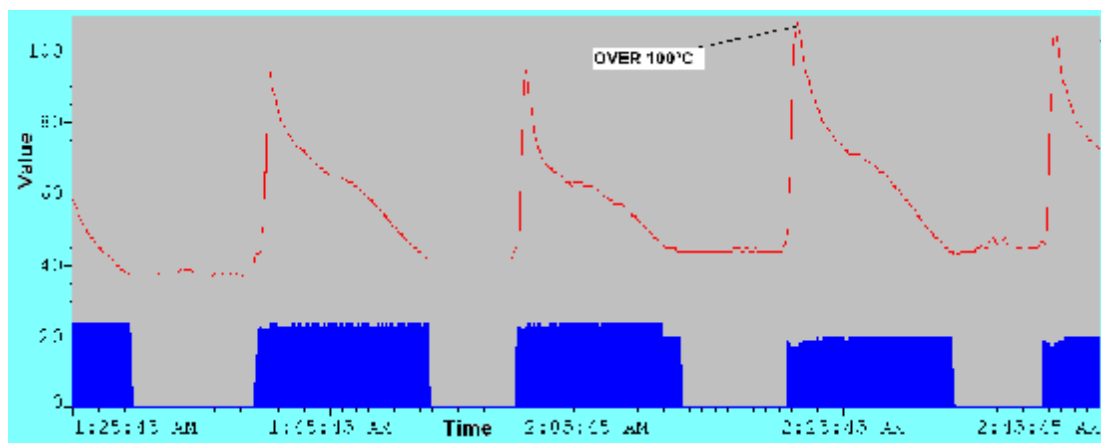
- Ø WHEN HOT OIL REACHES 8th UNIT, FREQUENCY SET VALUE.
- Ø WHEN HOT OIL REACHES 8th UNIT, TIME PERIOD FOR HIGH FREQUENCY.

After adding two parameters and set optimum values, this problem was solved. This is shown in figure 7.9.

| ONLY AUTHORIZED PERSON CHANGES                      |        |    |
|-----------------------------------------------------|--------|----|
| INTERMEDIATE FREQUENCY DEFEAT                       | 2      | hz |
| ULTRALOW FREQUENCY DEFEAT                           | 5      | hz |
| FREQUENCY DEFEAT OVERSHOOT                          | 7      | hz |
| WATER FLOW RATE HIGH LIMIT, FREQUENCY               | 40     | hz |
| WATER FLOW RATE LOW LIMIT, TIME PERIOD OF HIGH FREQ | 75,000 | ms |

GENERAL LIST   ALARMS   LEVEL SETUP PAGE   ZERO SPAN PAGE

Figure 7.7 Cold water pump parameters for effective use.

Figure 7.8 Cooling water temperature and flow rate 1. Red line is temperature of water(°C), blue bar is flow rate of water (m<sup>3</sup>/h)

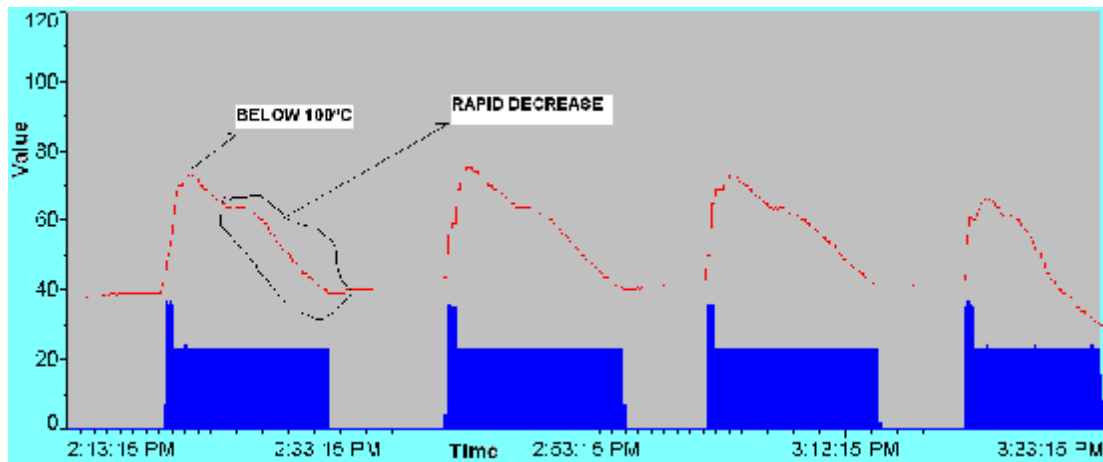


Figure 7.9 Cooling water temperature and flow rate 2. Red line is temperature of water(°C), blue bar is flow rate of water (m³/h)

There is another parameter which effects energy efficiency. When hot vegetable oil reaches to operator setted value, for caustic addition (115-130 °C), vegetable oil starts flowing out from 8th unit of deodorization system. So when vegetable oil mass is decreased, heat transfer decreases sharply. To overcome from this problem, a parameter is added into SCADA page (figure 7.7). They are defined as below in SCADA page:

- Ø BETWEEN 20 25HZ , FREQUENCY DECREASE
- Ø BETWEEN 26 35HZ , FREQUENCY DECREASE
- Ø FREQUENCY DECREASE OVER 35HZ

By adding those parameter to control system, mean water temperature of each batch were increased. This can be seen in figure 7.10.

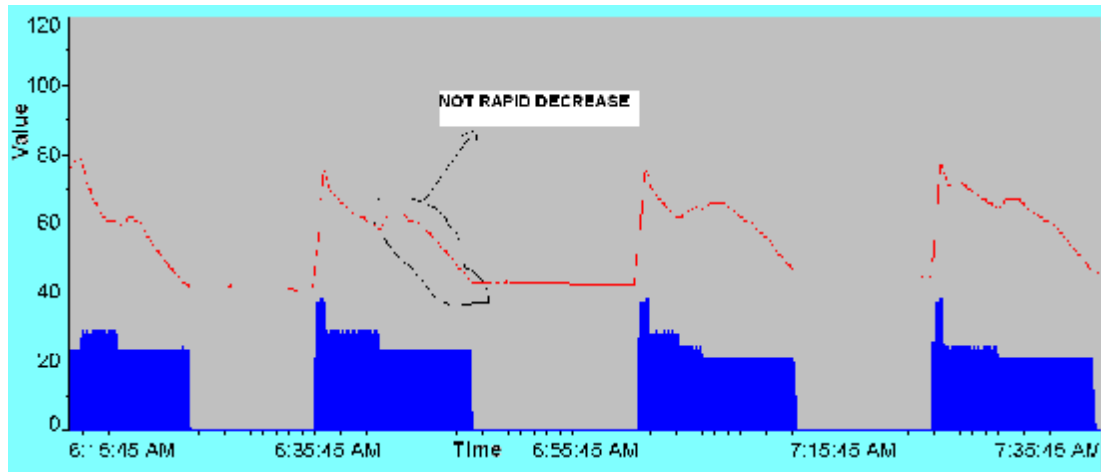


Figure 7.10 Cooling water temperature and flow rate 3. Red line is temperature of water(°C), blue bar is flow rate of water (m³/h)

In deodorization plant, in old system, in summers or in some type of oils which need much coolant, oil temperature set value could not be caught. And this situation affects process quality or keeping oils in tanks to cool, production capacity decreases had been occurred. By new design, oil temperature set value is always caught. So process quality has been achieved and production capacity losses stopped. In figure 7.11, for special oils set value, oil cooling temperatures with new system and without new system are shown.

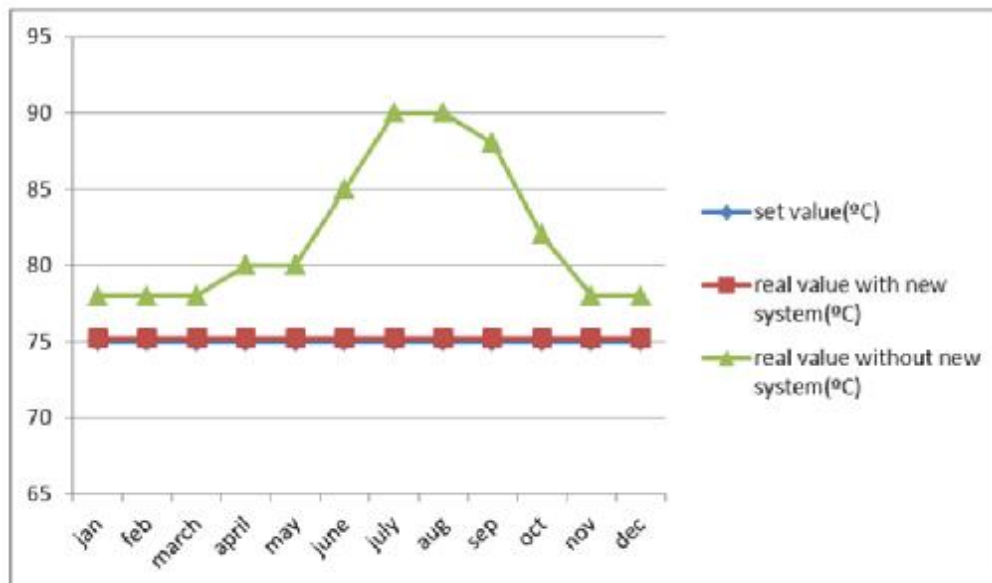


Figure 7.11 For special oils set value, oil cooling temperatures with new system and without new system.

By above changes, system stability and efficiency were developed.

Also some other healings have been achieved by new system. They are mentioned below.

- Ø Fuel consumption decreased. So pollution of environment rate decreased.
- Ø By a strong alarm system, problem rate decreased at boiler plant.
- Ø Trend logs(archives), in future, can lighten new projects.
- Ø By trend logs problem decisions or maintenance needs are defined.

## 8. CONCLUSIONS

In this project, it is aimed to make an integral system that includes not only electrically control units but also other control units in MARSAN, which produces vegetable oil, between deodorization unit that needs cooling and boiler unit that needs heat to work in an efficient way and gain energy. Energy efficiency and additionally these two units and their control automations with logic parameters are also covered in this project.

Synchronization and integration are the most important steps in a control system representation. Because water is a must for the boiler unit to regenerate steam. If it does not get water properly the pipes in boiler unit will be empty and there may be leaks in the surface of pipes with the effect of heat. In addition to that if there is no water in boiler unit, the water in pipes will be evaporate and so that the pressure in boiler unit will increase up to 60 bars. In this situation if water is fed to the boiler unit it may cause an explosion in boiler unit. For these reasons it is important to feed required water to boiler in a steady way. But the required water for the boiler unit and steam for departments in plant can be easily changed with consumptions.

On the other hand for the deodorization unit to cool the oil for the desired temperature, the cooling water must be fed properly. In deodorization unit each oil which must be deodorized has a different retention time in deodorization unit. These retentions time can be a value between 17 minutes and 28 minutes. If boiler unit stops when it gets the required water than it can halt the booster pump which regulate the water for the boiler unit and at the end production in plant can be halted. For these reasons an integral control system must be prepared according to these datas which also provide an efficient way and a reliable working conditions.

By founding robust, reliable and comprehensive automation control, synchronization and integration were achieved. By observing installed system, little design mistakes are improved by adding program blocks and some parameters on SCADA, those problems have been overcome.

In this project, Siemens brand CPU 315 -2DP controller is used to control all system. The reason for choosing CPU 315 -2DP is; it has two ports: MPI and DP. MPI port is used for SCADA communication and profibus DP port is used for remote I/O module communication. Other reasons using CPU 315 -2DP are communication speed and available number of I/O. In this project; 29 digital inputs, 9 analog inputs, 27 digital outputs and one analog output are used. Also to improve utility plant monitoring and control system, one ET200M communication module, one digital input module with 32 inputs, one digital output module with 32 outputs, one analog input module with 8 analog inputs and one analog output module with 8 analog outputs are installed in cooling tower plant. Main SCADA system is installed in boiler plant. As SCADA software; Siemens Wincc Flexible 2007 SP2 program is used. By SCADA system, condense tank level, reverse osmosis pump, cold water pump and all valves are controlled and positions are monitored. Amount of steam consumption, steam pressure and steam temperature are monitored and recorded. Many temperature values in boiler plant are monitored and recorded in SCADA system. Those datas will highlight new projects. A powerful alarm system is also installed in SCADA system. Coal saving quantity is added in SCADA system. In deodorization SCADA system; a window is added. By this window, operator can control oil temperature and monitor positions of all valves and pumps.

In field side one vortex flowmeter, seven on/off ball valves, four PT100 temperature sensors, one hydrostatic type level sensor which has 0-0,4 bar range, four vibration limit switches for liquid level control, one driver controlled pump were used. Also many other equipments were included in new system.

By this Project 4.861.000<sub>kcal</sub> per year energy is saved from coal and approximitely 407.316 KWH per year energy is saved from electricity. 353.460TL annual cost saving is achieved. For this project 112.000TL is spent. So, payback time is realized as 3,3 month.

Also by founded system, deodorization cooling system achieved more stable and so production quality is also increased. Secondly, by getting set vegetable oil temperature, second cooling process need finished.

In boiler plant, amount of coal consumption decreased noticeable. And so, environment pollution decreased.

In 2012 gas analyzer sensors will be added into that system. By this new equipment, oxygen rate, carbon monoxide rate and sulfuric acid rate will be monitored. And by adding new program blocks, combustion efficiency will be improved. Cooling tower control system will be included in that system. By this way, operator will be able to control all cooling pumps and fans. Drivers will be installed for cooling tower fans. According to cooling water inlet and outlet temperature, fan motors will be controlled by drivers and energy savings will be achieved.

This type of application is easily applied in plants which include heating and cooling process together.



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## BIOGRAPHY

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Work experineces :

|                                         |                                                               |             |
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| Toscelik Pipe, profile & Sheet Ind. A.Ş | Electrical & Electronics Maintenance Chief And Energy Manager | 2011-       |
| MARSAN A.Ş                              | Electrical & Electronics Engineer                             | 2009 - 2011 |
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## **APPENDIX**



## APPENDIX A: Energy Saving Calculation For Feasibility Study

Mean steam consumption of MARSAN is 10.000 tons/month.

Boiler mean steam production is:

Steam consumption per month / (30 day X 24 hour)

$$\text{Boiler mean steam production} = \frac{\text{mean consumption per month}}{30 \text{ day} \times 24 \text{ hour}} \quad (\text{A.1})$$

Boiler mean steam production =  $10.000 / (30 \times 24) = 13,9 \text{ t/h}$

For each batch oil energy consumption is:

$$Q_{\text{oil}} = m_{\text{oil}} \times c_{\text{oil}} \times \Delta t_{\text{oil}} \quad (\text{A.2})$$

$$Q_{\text{oil}} = 4000 \times 0,92 \times 80$$

$$Q_{\text{oil}} = 294,4 \text{ Kcal} \quad (\text{A.3})$$

In one hour, approximately 3 batches are processed. So in one hour;

$294,4 \text{ Kcal} \times 3 = 883,2 \text{ Kcal}$  energy is consumed.

$$Q_{\text{consumption}} = Q_{\text{gain}} \quad (\text{A.4})$$

In one hour inlet water temperature in condense tank is:

$$883,2 = m_{\text{water}} \times c_{\text{water}} \times \Delta t_{\text{water}}$$

$$883,2 = 13.900 \times 1 \times (t - 20) \quad \text{where } 20^\circ\text{C is cold water deodorizer inlet}$$

temperature and t is cold water deodorizer outlet temperature.

$$t = 63,5^\circ\text{C condense tank inlet water temperature.} \quad (\text{A.5})$$

According to  $Q = m.c.\Delta t$ :

To increase temperature of 10.000Kg water as  $43,5^\circ\text{C}$ ;

$$M=10.000 \text{ Kgr}$$

$$C=1\text{cal}/(\text{gr. } ^\circ\text{C})$$

$$\Delta t=43,5^\circ\text{C}$$

$$Q = m.c.\Delta t$$

$$Q= 10.000.1.43,5$$

$$Q=435.000\text{kcal} \quad (\text{A.6})$$

The lower calorific value of coal is 4500kcal/kg(Ermenek coal). (A.7)

According to (A.6) and (A.7) results, to increase temperature of 10.000 tons of water 43,5°C;

$$\text{Coal need}=435000_{\text{kcal}}/4500_{\text{kcal/kg}}$$

$$\text{Coal need}=96.666\text{kgs}(96.6 \text{ tons}) \text{ of coal is needed.} \quad (\text{A.8})$$

1 ton of ermenek coal costs 245 TL.(2010 september ermenek coal price ton/TL).

According to above results; if boiler feeding water temperature with this projects is increased 43,5°C, approximitly 23.680TL energy saving is achieved per month.

$$\text{Energy saving from coal } 23.680 \text{ TL } (96,666 \times 245) \quad (\text{A.9})$$

Energy saving from electricity energy:

Cooling tower pump is 45KW. It runs direct and measured current is 85A.

Cooling soft water pumps is 11KW. It runs direct and measured current is 17,6A.

Designed system pump is 5.5KW. It runs by driver .

$$P=3\frac{1}{2}.V.I.\cos\theta \quad (\text{A.10})$$

Monthly energy consumption:

Cooling tower monthly energy consumption:

$$(3\frac{1}{2}.380.85.0,8)KW \times 24h \times 28day=29.867KWh \quad (A.11)$$

Cooling tower monthly energy cost

$$29.867KWh \times 0.165TL =4.928 TL \quad (A.12)$$

Cooling soft water pumps monthly energy consumption:

$$(3\frac{1}{2}.380.17.6.0,8)KW \times 24h \times 28day=6.184KWh \quad (A.13)$$

Cooling soft water pumps monthly energy cost

$$6.184KWh \times 0.165TL =1.020 TL \quad (A.14)$$

For 13,9t/h water feeding, pump frequency is 20Hz and consumed current is 6A.

Designed system pump monthly energy consumption:

$$(3\frac{1}{2}.380.6.0,8)KW \times 24h \times 28day=2.108KWh \quad (A.15)$$

Designed system pump monthly energy consumption:

$$2.108KWh \times 0.165TL =348 TL. \quad (A.16)$$

Project energy saving:

$$(A.7) + (A.10) + (A.12)-(A.14)$$

$$\text{Monthly: } 23.680 TL + 4.928 TL + 1.020 TL - 348 TL=29.280 TL$$

## APPENDIX B: Electrical Energy Saving Calculation For Project Result

Cooling tower pump is 45KW. It runs direct and measured current is 85A.

Cooling soft water pumps is 11KW. It runs direct and measured current is 17,6A.

Designed system pump is 5.5KW. It runs by driver .

$$P=3\frac{1}{2}.V.I.\cos\theta \quad (B.1)$$

Monthly energy consumption:

Cooling tower monthly energy consumption:

$$(3\frac{1}{2}.380.85.0,8)KW \times 24h \times 28day=29.867KWh \quad (B.2)$$

Cooling tower monthly energy cost

$$29.867KWh \times 0.165TL =4.928 TL \quad (B.3)$$

Cooling soft water pumps monthly energy consumption:

$$(3\frac{1}{2}.380.17.6.0,8)KW \times 24h \times 28day=6.184KWh \quad (B.4)$$

Cooling soft water pumps monthly energy cost

$$6.184KWh \times 0.165TL =1.020 TL \quad (B.5)$$

For 14,5t/h water feeding, pump frequency is 25Hz and consumed current is 7,2A.

Designed system pump monthly energy consumption:

$$(3\frac{1}{2}.380.7,2.0,8)KW \times 24h \times 28day=2.548KWh \quad (B.6)$$

Designed system pump monthly energy consumption:

$$2.548\text{KWh} \times 0.165\text{TL} = 420 \text{ TL.} \quad (\text{B.7})$$

Project electrical energy saving:

$$(\text{B.1}) + (\text{B.3}) - (\text{B.7}).$$

$$\text{Monthly: } 4.928 \text{ TL} + 1.020 \text{ TL} - 420 \text{ TL} = 5.528\text{TL}.$$

## APPENDIX C: PUBLISH PERMISSION



"SYSTEM DESIGN, IMPLEMENTATION AND AUTOMATION FOR ENERGY CONSERVATION IN OIL PRODUCTION AND BOILER PROCESSES" tezinin uygulaması Süleyman YILMAZ tarafından MARSA YAĞ SAN. ve TİC. A.Ş bünyesinde yapılmıştır. Yayınlanmasında bir mahsur yoktur.



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