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HOW TO CHANGE WAREHOUSING PROCESSES WITH INDUSTRIAL REVOLUTION 4.0

Master Thesis

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ABSTRACT

HOW TO CHANGE WAREHOUSING PROCESSES WITH INDUSTRIAL REVOLUTION 4.0

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This study is about the developments in the processes carried out in storage systems with Industry 4.0. Within this study, how to change warehouses processes are ready to change thanks to tecnological progresses.Some of new ways to make productivity higher for warehouse processes will be stated in this study.Cyber-Physical Systems, The Internet of Things (IoT), The Internet of Services (IoS), Smart Factory are the most important components of the Industry 4.0 for useful developments in the future.

Adopting the Industry 4.0 concept and applying it in the organization is crucial iiiechnol competitive and meet growing consumer expectations and to catch the trend. By making storage systems compatible with Industry 4.0, it provides advantages in terms of healthier and instant data management of storage systems, higher storage efficiency, speed of shipments and increasing accuracy.

The fourth industrial revolution, declared with the strategy of the rapid development of the Internet, ultimately leads to the integration of the Internet of Things and the real and virtual iiiechn.

In addition to increasingly rapid and widespread developments in the automation and integration industry, all companies use smarter monitoring and control iiiechnologies to manage and optimize their value chain networks in real time.

The Advantages Of Industry 4.0 Organization are important such as cost advantage, effective use of capacities, more accurate, faster operation.

As a result, the use of Industry 4.0 in the storage systems contributes to the effective use of the workforce, the ability to take rapid action, and to increase the accuracy of the work and decrease the costs.

Keywords: Industry 4.0, Warehouse Processes, Cyber-Physical Systems (CPS), The Internet of Things (IoT), The Internet of Services (IoS)

ÖZET

ENDÜSTRİ 4.0 İLE BERABER DEPOLAMA SÜREÇLERİ NASIL DEĞİŞTİ

Çayan DENEK

Endüstri Mühendisliği

Tez Danışmanı: Prof. Dr. Mustafa ÖZBAYRAK

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Bu çalışma, Endüstri 4.0 ile depolama sistemlerinde yürütülen süreçlerdeki gelişmeler hakkındadır. Bu çalışmada, teknolojik gelişmelere bağlı olarak depo süreçlerinin nasıl değiştirilebileceğine karar verilmiştir. Bu süreçte depo süreçlerinde verimliliği arttırmanın yeni yollarından bazıları da bu çalışmada yer alacaktır. Servislerin İnterneti (IoS), Akıllı Fabrika, Endüstri 4.0'ın gelecekteki yararlı gelişmeler için en önemli bileşenleridir.

Endüstri 4.0 konseptini benimsemek ve bunu organizasyonda uygulamak, rekabet gücünü korumak ve artan tüketici beklentilerini karşılamak ve trendi yakalamak için çok önemlidir. Depolama sistemlerinin Endüstri 4.0'a uygun hale getirilmesi ile beraber depolama sistemlerinin daha sağlıklı ve anlık veri yönetimi, depolama verimliliğinin yükselmesi, sevkiyatlardaki hızlılık ve doğruluk oranlarında artış noktalarında avantajlar sağlamaktadır.

İnternetin hızla gelişmesinin yol açtığı strateji ile ilan edilen dördüncü sanayi devrimi, nihayetinde nesnelerin interneti ile gerçek ve sanal dünyanın kaynaşmasına yol açıyor.

Endüstri 4.0'ın organizasyonlara sağladığı önemli avanjalar; maliyet avantajı, kapasitelerin etkin kullanımı, daha doğru ve daha hızlı çalışma .

Sonuç olarak depolama sistemlerinde Endüstri 4.0 kullanılması firmaya katkısı iş gücünün efektif kullanımı, hızlı aksiyon alabilme kabiliyeti kazanılması ve işin doğruluk oranının artması ve maliyetlerin azalması yönünde olumlu etkileri olmaktadır.

Anahtar Kelimeler: Endüstri 4.0, Depo Süreçleri ,Yapay Zeka, Nesnelerin İnterneti

CONTENTS

TABLES viii

FIGURES ix

ABBREVATIONS x

1. INTRODUCTION 1

2. INDUSTRY 4.0 AND ITS EFFECTS ON SYSTEM PERFORMANCE 2

2.1 INTRODUCTION 3

2.1.1 History Of Developments in Industry 3

2.1.1.1 The first industrial revolution 3

2.1.1.2. The second industrial revolution 5

2.1.1.3 The Third Industrial Revolution 6

2.1.2 INDUSTRY 4.0 9

2.1.3 COMPONENTS OF INDUSTRY 4.0 11

2.1.3.1 Cyber-Physical Systems 12

2.1.3.2 The Internet of Things (IoT) 12

2.1.3.3 The Internet of Services (IoS) 13

2.1.3.4 Smart Factory 13

3. THE PERFORMANCE METRICS OF INDUSTRY 4.0 14

4. COMMUNICATION NETWORKS 15

4.1 RELEVANCE TO RAMI 4.0 15

4.2 PROTOCOLS(NETWORK) 17

4.3 NETWORK LAYER 17

4.4 TRANSPORT AND APPLICATION LAYER 18

5. STORAGE SYSTEM IN MANUFACTURING AND SERVICE 20

5.1 WAREHOUSING PROCESSESS 20

5.1.1 Receiving 20

5.1.2 Put Away 20
5.1.3 Order Picking 21
5.1.4 Checking and Packing 22
5.1.5 Shipping 22
5.1.6 Storage 23
5.1.6.1 Pallet Storage 23
5.1.6.1.1 Bin-shelving or static rack 24
5.1.6.1.2 Automated Storage Systems 24
5.1.6.1.2.1 Automated Storage/Retrieval System (AS/RS) 25
5.1.6.1.2.2 Carousel Storage Systems 26
6. LITERATURE REVIEW 28
6.1 LITERTURE REVIEW RESULTS 28
6.1.1 Industry 4.0 28
6.1.2 Internet Of Things 29
6.1.3 Warehousing 30
6.1.4 Cyber Physical System 31
6.1.5 Digitalization 32
7. THE STORAGE OPERATING SYSTEMS IN INDUSTRY 4.0 34
7.1 WAREHOUSE MANAGEMENT SYSTEM (WMS) 34
7.2 HOW DOES INDUSTRY 4.0 AFFECT WMS? 34
7.3 HOW TO PREPARE FOR INDUSTRY 4.0 37
7.4 WMS AND IOT 37
7.5 THE AIM OF THE RESEARCH 38
7.6 THE OBJECTIVES FRAMEWORK 39
7.7 CAROUSEL SYSTEM 40
7.8 AS/RS 42

7.9 CLEANING ROBOTS 44

7.10 PICK BY VOICE 46

7.11 PICK BY LIGHT 48

7.12 PICK BY VISION 50

7.13 FOLLOW ME TRUCK 51

7.14 TELEMATICS 54

7.15 DRONE CYCLE COUNTING 55

8. CONCLUSION 57

REFERENCES 58

TABLES

Table 4.1: IoT Communication Protocols Comparison 19

Table 5.1: Activity Percentage In Order Picking………………………………………21

Table 6.1: Literature Review…………………………………………………………...28

Table 7.1: Calculation method Cleaning Robot………………………………………..45

Table 7.2: Result of the Follow Me Truck Test 53

FIGURES

Figure 7.1: Industry 4.0 Affect WMS Concept....................35

Figure 7.2: Cleaning Machine Revolution....................45

Figure 7.3: Pick by Voice Concept....................47

Figure 7.4: Comparision of With and Without Pick by Voice....................48

Figure 7.5: Pick by Light Working Concept....................48

Figure 7.6: Vision Picking Technology....................51

Figure 7.7: Follow me Truck Concept....................52

Figure 7.8: How to Follow me Truck reduce process time....................53

Figure 7.9: Telematic working Concept....................55

Figure 7.10: Drones Working Concept....................56

ABBREVATIONS

CPS	:	CYBER PHYSICAL SYSTEM
ERP	:	Enterprise Resource Planning
I4.0	:	Industry 4.0
IoS	:	Internet Of Services
IoT	:	Internet of Things
RAMI	:	Reference Architecture Model Industry 4.0
WMS	:	Warehouse Management System

1. INTRODUCTION

This study provides information about the developments in the processes carried out in storage systems with Industry 4.0. In the process of storage, inbound, handling, put away, storage, picking, packing, order preparation, loading operations with the help of artificial intelligence and robotic applications will be carried out without the need for manpower. Cyber-Physical Systems, The Internet of Things (IoT), The Internet of Services (IoS), Smart Factory are the key components of the Industry 4.0

2. INDUSTRY 4.0 AND ITS EFFECTS ON SYSTEM PERFORMANCE

Industry 4.0, dedicated to as the “Fourth Industrial Revolution”, also known as “smart manufacturing”, “industrial internet” or “integrated industry”, is still a much-discussed issue which alleged has the potential to influnce whole industrys by transforming the way goods are designed, manufactured, delivered and payed. The studies prove the potential of Industry 4.0 inferences in the context of Just-in-Time/Just-in-Sequence and cross-company Kanban systems in a certain manner. Practitioners can use the described scenarios as a reference to foster their own Industry 4.0 attempts, with respect to logistics management.

Industry 4.0 is noted a new industrial stage in that vertical and horizontal production processes integration and product connectivity can help firms to succeed higher industrial performance. In addition to this, little is known about how industrys see the potential contribution of the Industry 4.0 related technologies and innovations for industrial performance, particularly in the third world how the adoption of different Industry 4.0 technological developments is associated with expectable utilities for product, operations and side-effects aspects. This study makes contribution to by discussing the real expectations on the future performance of the industry when implementing new technologies and innovations , providing a background to advance in the research on real benefits of the Industry 4.0.

With the implementation of smart technology concepts, the fourth stage of industrialization, stated to as Industry 4.0, is believed to be approaching.

The paper shows the extent to that smart factory and smart warehouses concepts and e-learning have already deeply affected manufacturing and warehousing industries in terms of performances in transitional economy. Experimental results refer that manufacturing companies which have introduce both e-learning and selected smart factory technology concepts differ dramatically. E-learning is applied on graduates in production systems. Results reveal that 2 smart factory concepts are a considerable extent and positively relevant to the company performance when e-learning is applied.

Industry 4.0, a new fundamental example shift in industrial is a result of the basis of an on highest degree digitalization within factories, the combination of Internet technologies and future-oriented technologies in the field of “smart” objects.Industry

4.0 stands for a smart manufacturing networking concept where machines and products affect each other without man control. This concept does not consider less employees in production, the contrary, human resources are known as the most flexible parts in the production system being maximally customizable to the more and more challenging work environment. The success of manufacturing enterprises depends on their capacity to quickly adapt in more and more complex environments . The implementation of sufficient qualification evaluates is required including both the organizational and technological concepts in order to enable the employees at all levels such as unskilled, technicians, graduates etc to fulfil their tasks efficiently. The firm will succeed only if the rate of aqcuisition of knowledge is greater than the rate of change of environment and discrete, unexpected impacts . The aim of this study is to analyze and understand the extent to that smart factory and warehouse concepts and computer-aided technologies for training purposes have already affected manufacturing industrys with regards to performances in transitional economy

2.1 INTRODUCTION

2.1.1 History Of Developments in Industry

2.1.1.1 The first industrial revolution

The story of the Industrial Revolution begins on the small island of Great Britain. By the early 18th century, people there had used up most of their trees for building houses and ships and for cooking and heating. In their search for something else to burn, they turned to the hunks of black stone (coal) that they found near the surface of the earth. Soon they were digging deeper to mine it. Their coal mines filled with water that needed to be removed; horses pulling up bucketfuls proved slow going.

To the rescue came James Watt (1736–1819), a Scottish instrument-maker who in 1776 designed an engine in which burning coal produced steam, which drove a piston assisted by a partial vacuum. (There had been earlier steam engines in Britain, and also in China and in Turkey, where one was used to turn the spit that roasts a lamb over a fire.) Its first application was to more quickly and efficiently pump water out of coal mines, to better allow for extraction of the natural resource, but Watt's engine worked well enough to be put to other uses; he became a wealthy man. After his patent ran out in 1800, others improved upon his engine. By 1900 engines burned 10 times more efficiently than they had a hundred years before.

At the outset of the 19th century, British colonies in North America were producing lots of cotton, using machines to spin the cotton thread on spindles and to weave it into cloth on looms. When they attached a steam engine to these machines, they could easily outproduce India, up until then the world's leading producer of cotton cloth. One steam engine could power many spindles and looms. This meant that people had to leave their homes and work together in factories.

Early in the 19th century the British also invented steam locomotives and steamships, which revolutionized travel. In 1851 they held the first world's fair, at which they exhibited telegraphs, sewing machines, revolvers, reaping machines, and steam hammers to demonstrate *they that were the world's leading manufacturer of machinery. By this time the characteristics of industrial society — smoke rising from factories, bigger cities and denser populations, railroads — could be seen in many places in Britain.*(Antoux and Galbraith, 2014)

Where Industry 4.0 Was Born?

Although the British coal beds are not the only place, why the Industrial Revolution in another country has emerged in Britain.? Did it start in isolation in Britain, or were there global forces at work that shaped it? Was it geography or cultural institutions that mattered most? Historians have debated these type of questions about Industrial Revolution, amassing as much evidence as possible for their answers.

Why Britain?

a) Shortage of wood and the wealth of convenient coal deposits
b) Commercial-minded aristocracy; limited monarchy
c) System of free enterprise; limited government involvement
d) Government support for commercial projects, for a strong navy to protect ships
e) Cheap cotton produced by slaves in North America
f) High literacy rates
g) Rule of law; protection of assets
h) Valuable immigrants

Possible reasons why industrialization did not begin in China include:

i) Location of China's coal, which was in the north, while economic activity was centered in the south
j) Rapid growth of population in China, giving less incentive for machines and more for labor-intensive methods
k) Confucian ideals that valued stability and frowned upon experimentation and change
l) Lack of Chinese government support for maritime explorations, thinking its empire seemed large enough to provide everything needed
m) China's focus on defending self from nomadic attacks from the north and west

Global forces influencing the development of industrialization in Britain include:

n) Britain's location on the Atlantic Ocean

o) British colonies in North America, which provided land, labor, and markets
p) Silver from the Americas, used in trade with China
q) Social and ideological conditions in Britain, and new thoughts about the economy, that encouraged an entrepreneurial spirit

2.1.1.2. The second industrial revolution

The second industrial revolution started after the civil war between 1870 and 1914. In this time period, many advances in technological development and factories made it easier and quicker for farmers and manufacturers to produced more and quality goods. The industrial revolution brought out mass technological advancements in agriculture, manufacturing and transportation which begun in Britain and provided way to Europe and North America, and then rapidly to the rest of the world Under favour of all of the inventions that created and made contribution to this revolution, it made an beneficial experience Americans and people who live all around the world and was truly a blessing to almost everyone. The main reasons of the second industrial revolution were due to: natural resources, plenty of labor resource , government policy, newly found sources of power, railroads. This provided a higher standard of living, but also resulted in a major decline in unemployment because of machines taking the jobs of people. Production costs and prices fell significantly and there was a perfect increasing for productivity. The natural resources comprised of coal, oil, iron and ore. Migration was also one of the main reasons for the second industrial revolution, because more and more people approached the seas, bringing new ideas and inventions that spread rapidly. Inventions and inventors from America also made a big beneficial contribution to this cause because they were supplying the world with new ways of doing things that made almost everything easier and more accessible for people to create and make new products.

Transportation provided to link communities together and for the first time, goods from the American interior could be shipped directly from the Atlantic. The railways were the first spark of the second industrial revolution, and when people learned they could blame other people to drive the train, local cities began to link the railways. Before the development of elaborate transportation systems, economies were often localized and based off the barter system. This did not allow cities to grow very large and forced them to stay within a certain range of each other. The new transportation system also opened up a new market for people who strive in farm, allowing them to sell their good to not only their neighbors and people in their own city, but also to people all around the world. When loads became too big to transport, railroads were invented. These made it easier for mass amounts to be transported at the same time to a far away destination. A lot of inventions in history contributed to the benefit of this revolution. The important invention was the telephone, invented by Alexander Graham Bell in 1876. This invention allowed people to easily communicate with other people all around the world. With the invention of the light bulb, people had the opportunity to work at night and benefit from daytime work at night.The other invention was in 1903 when the Wright brothers had their first powered piloted plane flight. Now that it was possible to fly, it seemed as though everything was possible. There were lots of things people could do now . Although the main purpose was to use the planes for quicker transportation and to transport products, it was later used for leisure as well.Each new invention made life easier and more interesting during this era. Because of all of these inventions and new ideas, the second industrial revolution would definitely have to be summed up as a positive, beneficial time for people. Each new thing allow to another and due to created a new age of discoveries and inventions.

2.1.1.3 The Third Industrial Revolution

With the diffusion of Fab Labs and advanced fabrication machines outside the industrial context, several authors theorized the idea of a Third Industrial Revolution (among them Gershenfeld 2005; Anderson 2010; Rifkin 2011; Troxler 2013). The opportunity for a production shift is enabled by a common "computational control" in advanced manufacturing across different fields. Software in any production area, but especially in construction design and engineering, has been strongly developed. Operations that would be difficult to manage just a few years ago are now more and more accessible, reducing the time required to design, simulate, build and test complex manufactured products. The first industrial revolution began in Britain in the late 18th century with the mechanisation of the textile industry. A single cotton mill could instantly replace hundreds of weaver cottages. In this way a new productive era began based on the concept of mechanization, centralized factories and industrial capitalists. The second industrial revolution occurred later, in the early 20th century. Henry Ford mastered the moving assembly line, opening up the age of mass production. Automation, scientific management and management consultants were introduced and the social effect was the division of society in white-collar and blue-collar workforces (Troxler 2013). Today we are facing the third industrial revolution, characterized by affordable manufacturing tools connected to the internet. As Troxler notices, this implies two major changes: First, affordable tools do not require huge capital investments, they bridge the labourcapital-divide; the owner-maker is re-emerging. Second, digital tools connect designing and manufacturing, they bridge the white-collar-blue-collar-divide; the designer-producer is having a comeback (Troxler 2013). As for the field of architecture and construction, this determines a new production context where design and construction can be rejoined into a continuous process as it used to be before the Renaissance, when the architect was the “masterbuilder”. Nowadays architects can design a building, not only focusing on defining spatial and aesthetic characteristics (important aspects, but not exclusive), but also controlling the whole process “file-to-construction” and actively design building components, fabrication strategies and operative tools. One of the main concerns and skepticisms is the concrete possibility to produce custom construction components without referring to specialized producers. Workers and owners are historically divided by the possession of the means of 16 2 The Third Industrial Revolution industrial production (Gershenfeld 2005). Thanks to several technological advancements those means of production are becoming more and more accessible, in a “democratization of production” that is following what has already taken place in the software and the music industry: Music labels and software companies such as Microsoft or IBM were dominating the market. Now anybody can create music, anybody can create software. It is not one versus the others, but an ecology of market that did not exist. There are still labels, there are still mass market softwares, but the most interesting things happening in these sectors are in the intermediate market (Gershenfeld 2013). In architecture a similar phenomenon is happening, even though dealing with construction requires a much more intensive material engagement than other industrys. In this sense, it is improbable to imagine that advanced fabrication means could completely replace the company’s means of production, but they are stimulating the concept of customization and have the potential to create a wide variety of new building components that, having the possibility to be uniquely produced, can achieve higher levels of performance and degrees of personalization, overcoming the stagnation of repetitive production in construction (Gramazio et al. 2014). Finally, as Anderson stated, the Third Industrial Revolution is best seen as the combination of digital manufacturing and personal manufacturing (Anderson 2010), which suggests a possible answer to doubts on the radical diffusion of customized products. With the propagation of digital tools and advanced means of fabrication, collaborations on design and production become easier, overcoming typical limitations such as distance and logistic concerns. Products and components can be tested in a desktop-scale, eventually in a collaborative manner, and can then be transferred to specialized manufacturing resources able to afford large-scale production. One of the main questions is what can be the impact of such an industrial revolution upon the construction sector, which is typically more resilient to innovation. It is fundamental to highlight how the "digital revolution" has been led by architects in the 1990s, and just 20 years later the topic is becoming globally recognized as an emergent production shift. Nowadays the potential of advanced manufacturing is no longer a matter for a restricted group of interested actors but a priority for the development of a new industrial paradigm. Proof of this can be seen by the decision of the President of United States, Barack Obama, to invest about $2.9 billion for advanced manufacturing Research and Development, including $1 billion to launch a network of up to 15 innovative manufacturing institutes by 2015 (Sargent 2014). In many design fields, particularly in architecture, drafting and rendering industrys have emerged in generating construction documents and images quicker and quicker. Nowadays inventors are fascinated and interested in the availability of computer controlled machines, instead of large factories, and in open-source 2.5 The Third Industrial Revolution 17 software and CAD tools instead of sophisticated software and high-powered computers. In the digital age, ideas are conceived as real products traded online (Sass 2010). When we contextualize this production shift to architecture, typical concerns arise. The first one is from a technical perspective: can we realistically build architecture with Fab Lab facilities? The second concern is in terms of industrial systems: can the Fab Lab network (or others) develop extensively and support midscale production in a sustainable way? The last one is related to the concept of open-source: how can intellectual properties and manufacturing production in constructions be managed? In the following paragraphs we attempt at suggesting possible answers to these fundamental topics.

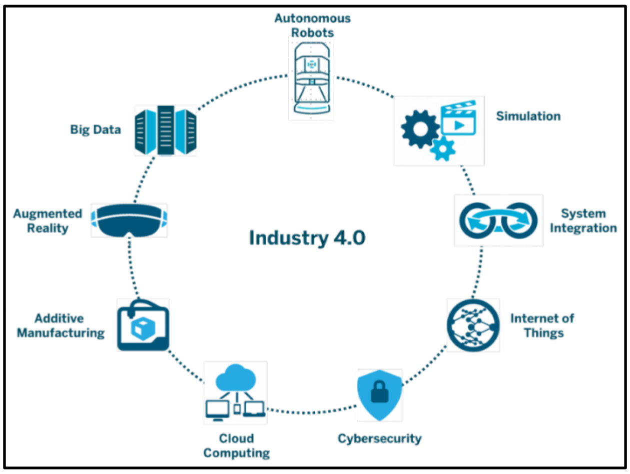
2.1.2 INDUSTRY 4.0

Structure of Industry 4.0

Vaidya, Ambad, & Bhosle, (2018) stated "The term also Industry 4.0 stands for the fourth Industrial Revolution which is defined as a new level of organization and control over the entire value chain of life cycle of products ; it is geared towards increasingly individualised customer requirements. Industry 4.0 is still visionary but a realistic concept which includes Internet of Things, Industrial Internet, Smart Manufacturing and Cloud based Manufacturing. Industry 4.0 concerns the strict integration of human in the manufacturing process so as to have continuous improvement and focus on value adding activities and avoiding wastes. "

Within the scope of the smart factories with Industry 4.0, it is aimed to monitor the physical processes with cyber-physical systems, to create a virtual copy of the physical world and to make decentralized decisions.

Figure 2.1: Structure of Industry 4.0



The design principles allow to investigate a potential transformation to Industry 4.0 technologies. Based upon the Industrial 4.0 components are mentioned above, the following are the design principles(Luenendonks, 2017):

a) **Interoperability**: Objects, machines and people need to be able to communicate with the Internet of Things.This is the most main principle which completely makes a factory or warehouse a smart one.

b) **Virtualization**: CPSs should have ability to simulate and create a virtual copy of the real world. They must also follow all objects where environmentç Everything shoul have virtual copy.

c) **Decentralization**: CPSs are able to work independently. This gives room for customized products and solving of problems. This also provides to create a more flexible environment for production process. In the event of failure or having conflicting goals, the subject is moved to a higher level.However, even with such technologies implemented, the need for quality assurance remains a necessity on the entire process

d) **Real-Time Capability**: A smart facility must be able to get real time data, store or analyze it, and then make decisions based on new findings. This is not only limited to market research but also to internal processes such as the failure of a machine in production line. Smart objects should have ability to define the defect and transfer duty to other operating machines. This also provides to the flexibility and the optimization of production.

e) **Service-Orientation**: Production must focused for customers. People and smart devices should be able to connect efficiently through the Internet of Services to create products based on the customer's specifications. This is where the Internet of Services becomes must.

f) **Modularity** A Smart Factory's have ability to adapt to a new market is essential in a dynamic market . Generally, it would probably take a week for an average company to study the market and change its production accordingly.Besides, smart factories must be able to adapt fast and smoothly to seasonal changes and market trends.

Benefits of Industry 4.0

Optimization: Optimizing is a key word for Industry 4.0. A Smart Facilitiy containing thousands of Smart Devices which are able to self-optimize production will cause to an almost zero down time in production. This is very important for industrys which use valuable manufacturing equipment such as the semi-conductors industry. Being able to utilize production constantly and consistently will make profit the company.

Customization Creating a customer-oriented, flexible market will help to meet the needs of the population quickly and smoothly. It will also remove the gap between the customer and manufacturer. Communication will take place between both directly. Manufacturers won't have to communicate internally (in companies and factories) and externally (to customers). This fastens the production and delivery processes.

Pushing Research: The adoption of Industry 4.0 technologies will push research in various fields such as IT security and will have its effect on the education in particular. A new industry will require a new set of skills. Eventually, education and training will take a new shape that provides such an industry will the required qualified labor.

2.1.3 COMPONENTS OF INDUSTRY 4.0

The components that Industry 4.0 have been agreed upon by many organizations and can be best stated in 9 key points. The nine important points of I4.0 will turn into insulated and optimized cells production into a fully integrated, automated, and optimized production flow. This leads to greater efficiency and change in traditional production relationships among suppliers, producers, and customers as well as between human and machine (Vaidya, Ambad and Bhosle, 2018)

Although "Industry 4.0" is the common term referring to the fourth industrial revolution, academics still struggle to properly define the approach. This makes it even harder to distinguish the main components of such an approach. In their Literature Review,Hermann, Pentek, and Otto take it upon themselves to find out the main components of the industry (Luenendonks, 2017).

Given the fact that the term originated in a German-speaking area, they set out to find out the most frequently cited terms and definitions relating to the industry.

In their research, of course, the German equivalent of each term (or perhaps the English equivalent) was used. The results were as follows (Hermann Mario, Pentek Tobias, Otto Boris, 2015)

Cyber-Physical Systems, Internet of Things, Smart Factory, and Internet of Services are the most common four terms cited in academic research publications related to the industry. Consequently, and given its initial stage, these are the four main components of the industry.

2.1.3.1 Cyber-Physical Systems

As mentioned above, a cyber-physical system has target at the integration of computation and physical processes. This argue that computers and networks are able to monitor the physical process of manufacturing at a certain process. The development of such a system consists of three phases (Luenendonks, 2017):

a) **Identification**: Unique identification is very important and required in manufacturing. This is the very simple and basic language by that a machine can communicate. RFID (Radio-frequency identification) is a good example for this. RFID uses an electromagnetic field to identify a certain tag that is often attached to an object. Although such technology has been around since 1999, it still gives service as a great example of how Industry 4.0 operated initially.

b) **The Integration of Sensors:** This is very important for the operation of the machine. the integration of sensors states which a certain machine's step is under control and that it can sense changes in the environment.

c) **The Development of Sensors and Actuators**: Such developments provided to create opportunity to machines to archive and analyze data. A CPS is be rigged with multiple sensors and actuators which can be networked for the change of information.

2.1.3.2 The Internet of Things (IoT)

A CPS terminology still sounds familiar to us nowadays. Machines can interchange data and, in lots of applications, can make sense the changes in the environment around them. Fire alarms might be very good example of that. IoT, however, is thought to be what truly has initiated Industry 4.0.

The Internet of Things is what enables objects and machines such as mobile phones and sensors to "communicate" with each other people to solve problems. The integration of such technology allows objects to work and solve problems independently. Sure , this is not all true as people are also allowed to intervene.

furthermore,when there is conflicts, the case is usually raised to higher positions. *According to Hermann, Pentek, and Otto, ""things" and "objects" can be understood as CPS. Therefore, the IoT can be defined as a network in which CPS cooperate with each other through unique addressing schemas.*

2.1.3.3 The Internet of Services (IoS)

In today's world it is easy to see that every electronic device is more likely to connect to another device or the Internet. Thanks to big development and variety in electronic and smart devices, acquisitioning more of them creates complexities and sabotage the effectiveness of each added device.

Electronic devices such as phones, pc tablets, laptops, TVs or even watches are being more and more interconnected, barely the more you buy, the added value of the last device can be more unrecognizable. The Internet of Services(IoS) purposes at creating a wrapper which make simpler all connected electronic devices to make the most out of them by reducting the process. It is the customer's entrance to the manufacturer.

2.1.3.4 Smart Factory

In Industry 4.0: Definition, Design Principles, Challenges, and the Future of Employment Magazinne writer Martin (2017) explained "*Smart factories are a key feature of Industry 4.0. A smart factory adopts a so called Calm-system. A calm system is a system that is able to deal with both the physical world as well as the virtual. Such systems are called "background systems" and in a way operate behind the scene. A calm system is aware of the surrounding environment and the objects around it."*

3. THE PERFORMANCE METRICS OF INDUSTRY 4.0

Performance measurement can be summarized as follows. It is the digitization of all operation processes in the facilities.From the operational perspective, digital technologies, such as CPS, are proposed to reduce;

a) set-up times,

b) labor and material costs

c) process cycle times, resulting in higher productivity of production processes**.**

4. COMMUNICATION NETWORKS

The Industry 4.0 is used for three, mutually interconnected factors.

a) Digitization and integration of any simple technical – economical relation to complex technical – economical complex networks
b) Digitization of products and services offer

New market models All these human activities are interconnected by a lot of communication systems in the moment. The most promising technologies will be Internet of things (IoT), Internet of Services (IoS) and Internet of People (IoP).Thanks to these communication technologies, communication entities will be able (in the Industry 4.0 environment) to communicate with each other and utilize data from the production owner during the all life cycle of systems without respect to border among enterprises and countries. All entities of the whole production – market network will be able to have relevant data as well. It will be very helpful for all entities while producers will be able to work out systems with features of very modern components which will be even in the design and testing phase. Such a digitization of industrial production can create quite new digital market models. On the basis of the data (accessible in cloud) users will be able to predict a shutdown of production of some of production entities etc. For purposes of such a complex production – market networks the leading institution and firms in Germany – the leading country of the Industry 4.0 activities and ideas - developed and published the RAMI 4.0 (Reference Architecture Model Industry 4.0) and the Industry 4.0 Component models in the last year. Because of the above mentioned three interconnected factors, the 3D graphical model RAMI 4.0 has been developed(Graf Ulrich, Kadel Gerhard, Heidel Roland, Kärcher Bernd, Mildner Frank, Schulz Dirk, Tenhagen Detlef, 2016)

4.1 RELEVANCE TO RAMI 4.0

As described In Network-based communication for Industrie 4.0 (April 2016, Federal Ministry for Economic Affairs and Energy (BMWi)),

> *"The Internet of Things – meaning IP-converged local and global communication infrastructures – is at the very core of Industry 4.0. Communication is one of the core layers of the Reference Architecture Model of Industry 4.0 (RAMI 4.0) now globally established, which amalgamates all important lifecycle and hierarchy-level aspects, including process- and IT-based levels, in one generic model for Industry 4.0. The Communication Layer on which network-based communication is implemented is the link between the Integration Layer, which*

makes the properties of the physical world accessible to computer systems ('digitises' assets), and the Information Layer, which contains the functional data and thus represents both destination and source of transmitted information (Figure 2 RAMI 4.0 with Communication Layer)

This poses the following central questions for the SWG on network-based communication:

a) *What communication functionality does the Information Layer need, which describes/contains the data and functions described in the Industry 4.0 administration shell? Questions about these requirements must be answered by the information users, i.e., the functional level.*
b) *How will the communication functionalities be made available via Industry 4.0-compliant interfaces? In other words: What must the administration shells of the communication assets look like? This must be specified by the Information Layer to ensure the interoperability of Industry 4.0 systems.*
c) *What are the relevant security aspects and how will these be taken into account in the reference architecture?"*

Model for network-based communication in Industry 4.0 To be able to describe the relevant requirements, functions and interfaces for the Communication Layer in structured form, a model for network-based communication needs to be designed as an extension of and supplement to the RAMI 4.0 model. As a step in this direction, a Communication Layer structuring has been proposed as outlined in Figure 2 (Graf Ulrich, Kadel Gerhard, Heidel Roland, Kärcher Bernd, Mildner Frank, Schulz Dirk, Tenhagen Detlef, 2016)

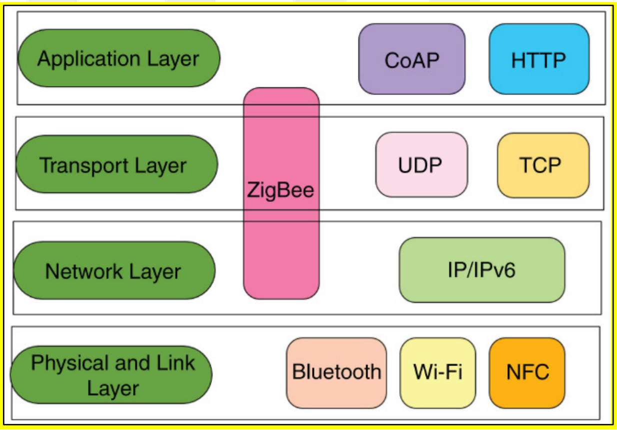
One dimension describes the so-called Hierarchy Layer of RAMI 4.0 and the other contains the latency requirements. The various communication networks used for networkbased communication are depicted in these two dimensions. These differ depending on which of the hierarchy levels they are located in or which latency requirements can be met with the networks. The cylinders delineated in the networks illustrate Industry 4.0 components that communicate with each other via a specific network.

A major point in the reference model are the gateways connecting the various networks. This kind of gateway can, for example, act as a transition from a local network inside the company to the global network of a network provider. Industry 4.0-compliant end-to-end connections are made inside the Industry 4.0 networks (connected via gateways).(Graf Ulrich, Kadel Gerhard, Heidel Roland, Kärcher Bernd, Mildner Frank, Schulz Dirk, Tenhagen Detlef, 2016)

4.2 PROTOCOLS(NETWORK)

From the network and communication perspective, IoT can be viewed as an aggregation of different networks, including mobile networks (3G, 4G, CDMA, etc.), WLANs, WSN, and Mobile Adhoc Networks (MANET). Seamless connectivity is a key requirement for IoT. Network-communication speed, reliability, and connection durability will impact the overall IoT experience. With the emergence of high-speed mobile networks like 5G, and the higher availability of local and urban network communication protocols such as Wi-Fi, Bluetooth, and WiMax, creating an interconnected network of objects seems feasible, however,dealing with different communication protocols that link these environments is still challenging (Rajkumar Buyya, Amir Vahid Dastjerdi,2016)

Figure 4.1:Protocols



4.3 NETWORK LAYER

Based on the device's specification (memory, CPU, storage, battery life), the communication means and protocols vary. However, the commonly used communication protocols and standards are listed below:

a) RFID (eg, ISO 18000 series that comes with five classes and two generations, and covers both active and passive RFID tags)
b) IEEE 802.11 (WLAN), IEEE 802.15.4 (ZigBee), Near Field Communication (NFC), IEEE 802.15.1 (Bluetooth)

c) Low-power Wireless Personal Area Networks (6LoWPAN) standards by IEFT
d) M2M protocols such as MQTT and CoAP
e) IP layer technologies, such as IPv4, IPv6, etc. (Rajkumar Buyya, Amir Vahid Dastjerdi,2016)

4.4 TRANSPORT AND APPLICATION LAYER

Segmentation and poor consistencylevel, that are results of pushes from individual firms to maximize their market share and turnover, has made developing IoT implementations unfavorable. Universal applications that need one-time coding and can be executed on multiple devices are the most efficient. Protocols in IoT can be

a) General-purpose protocols like IP and SNMP that have been around for many years and are vastly used to manage, monitor, configure network devices, and establish communication links;
b) Lightweight protocols such as CoAP that have been developed to meet the requirements of constrained devices with tiny hardware and limited resources;
c) Device- or vendor-specific protocols and APIs that usually require a certain build environment and toolset.

Selecting the right protocols at the development phase can be challenging and complex, as factors such as future support, ease of implementation, and universal accessibility have to be considered (Rajkumar Buyya, Amir Vahid Dastjerdi,2016)
Additionally, thinking of other aspects that will affect the final deployment and execution, like required level of security and performance, will add to the sophistication of the protocol-selection stage. Lack of standardization for particular applications and protocols is another factor that increases the risk of poor protocol selection and strategic mistakes that are more expensive to fix in the future.
In order to enhance their adoption, it is important to make sure that communication protocols are well documented; sensors and smart devices limit their usage in IoT.
Table 1 summarizes the characteristics of major communication protocols in IoT, while it also compares their deployment topology and environments. (Rajkumar Buyya, Amir Vahid Dastjerdi,2016)
M2M communication aims to enable seamless integration of physical and virtual objects into larger and geographically distributed enterprises by eliminating the need for human intervention. However, to achieve this, the enforcement of harmony and

collaboration among different communication layers (physical, transport, presentation, application), as well as the approaches used by devices for message storage and passing, can be challenging.

The publish/subscribe model is a common way of exchanging messages in distributed environments, and, because of simplicity, it has been adopted by popular M2M communication protocols like MQTT. In dynamic scenarios, where nodes join or leave the network frequently and handoffs are required to keep the connections alive, the publish/subscribe model is efficient. This is because of using push-based notifications and maintaining queues for delayed delivery of messages.

Table 4.1: IoT Communication Protocols Comparison

IoT Communication Protocols Comparison					
Protocol Name	**Transport Protocol**	**Messaging Model**	**Security**	**Best-Use Cases**	**Architecture**
AMPQ	TCP	Publish/Subscribe	High-Optional	Enterprise integration	P2P
CoAP	UDP	Request/Response	Medium-Optional	Utility field	Tree
DDS	UDP	Publish/Subscribe and Request/Response	High-Optional	Military	Bus
MQTT	TCP	Publish/Subscribe and Request/Response	Medium-Optional	IoT messaging	Tree
UPnP	-	Publish/Subscribe and Request/Response	None	Consumer	P2P
XMPP	TCP	Publish/Subscribe and Request/Response	High-Compulsory	Remote management	Client server
ZeroMQ	UDP	Publish/Subscribe and Request/Response	High-Optional	CERN	P2P

On the other hand, protocols like HTTP/REST and CoAP only support the request model, in that a pulling mechanism is used to fetch new messages from the queue. CoAP also uses IPv6 and 6LoWPAN protocols in its network layer to handle node identification. Ongoing efforts are still beingmade to merge these protocols and standardize them, as to support both publish/subscribe and request/response models.

5. STORAGE SYSTEM IN MANUFACTURING AND SERVICE

5.1 WAREHOUSING PROCESSESS

5.1.1 Receiving

Receiving process in Warehouse starts with advance notification of the inbound of goods. This lets the warehouse to schedule receipt and unloading to coordinate efficiently with other activities in the warehouse. It is usual for warehouses to schedule inbound trucks to within 30-minute time windows.

When the goods has arrived to warehouse , it is unloaded and possibly staged in staging zone for put away. It is likely to be scanned with hand terminal to register its arrival so that ownership is assumed, payments dispatched, and so that it is known to be available to fulfill customer demand. Product will be inspected visual and any exceptions noted, such as damage, incorrect counts, wrong descriptions etc.

Goods generally may come in larger units, such as pallets, from upstream and so FTE requirements are not usually great. (However, mixed pallets may need to be broken out into separate cases; and loose cases may need to be palletized again for storage.) In the end, receiving accounts for only about 10% of operating costs in a typical distribution center and RFID is expected to further reduce this.

5.1.2 Put Away

Before put away process, goods can be an appropriate storage location in rack must be determined.This is very important decision because where you store the good determines to a large extent how it can be quick and at what cost you later retrieve it for a customer. This requires managing a second inventory, not of goods , but of storage locations. Which storage locations are available must be known by Warehouse admins and , how much weight they can bear, how large they are. When product is put away, the storage location must also be scanned to record where the product has been placed. This information will later be used to construct efficient picking lists to guide the order pickers in retrieving the goods for customers. For put-away process may be needed a fair amount of FTE because inbound goods can need to be moved siginificant distance to its storage location. Put-away frequently accounts for about 15% of warehouse operating cost

5.1.3 Order Picking

On received of a customer order the warehouse should perform checks such as verifying that inventory is available to shipping. After that the warehouse must prepare picking lists to guide the order picking process. Finally, it must prepare any necessary shipping documentation and schedule the order picking and shipping. These type of activities are typically carried out by a warehouse management system(WMS), a large software system that manages the activities of the warehouse. This is all part of the support to expedite the sending of the goods to the customer.
Order-picking typically accounts for about 55% of warehouse operating expenses ; and order picking itself might be further broken like this (Antoux and Galbraith, 2014):

Table 5.1: Activity Percentage In Order Picking

Activity	% Order-picking time
Traveling	55%
Searching	15%
Extracting	10%
Paperwork and other activities	20%

Notice that traveling comprises the big part of the cost of order picking process in warehousing activities, that is itself the most expensive part of warehouse operating expenses. Much of the design of the order picking process is directed to saving this waste time. The outbound processes of the warehouse are initiated by received of a customer order, that might be thought of as a consignee list. Each line on the list is referred to as an orderline and typically comprise of the item and quantity requested. The warehouse management system (WMS) then checks the order against available inventory and notices any shortages. AT the same time, the WMS may reorganize the list to match the layout and operations of the warehouse for better efficiency. For instance , if a client has ordered 15 of a particular item, the warehouse management system (WMS) may check to see how the item is packaged. If 12 of the item comprise a carton, the WMS may convert the orderline for 15 eaches to two picklines, one for 1 box and the other for 3 eaches. In some warehouses, each picking and carton picking are separate processes, and the picklines are directed appropriately.

5.1.4 Checking and Packing

Packing process can be labor-intensive because each piece of a client order must be handled by warehouse worker ; but there is little walking distance and because each piece will be handled, this is a appropiate time to check which the customer order is in full and accurate. Order accuracy is a key measure of service to the customer, that is, in turn, that on which most businesses compete.

Incorrect orders not only disturbing issue for customers by disrupting their operations, they also come up with returns; and returns are expensive process to handle (up to ten times the cost of shipping the product out). One complication of packing is that customers usually would prefer to receive all the parts of their order in as few containers as possible because this reduces distribution and handling fees. This means that care should be taken to try to get all the parts of an their order to arrive at packing together. Otherwise parcel shipments must be staged, awaiting completion before packing. Amazon, the web-based trader , will in all likelihood ship separate packages if you order two books 15 minutes apart. For them fast response is very important and so product is never staged. They can ship with different packages because their customers do not mind and Amazon is willing to pay the additional shipping as part of customer service. Packed goods can be scanned with RF hand termianl to record the availability of a customer order for shipping. This also starts the tracking of the individual containers that are about to leave the warehouse and enter the system of a shipper(Antoux and Galbraith, 2014)

5.1.5 Shipping

Shipping in general handles larger units than picking, because packing has consolidated the items into fewer containers (boxes, pallets). Eventually, there is still less labor here. There can be some walking if product is staged before being loaded into freight carriers.

Product is likely to be staged if it must be loaded in reverse order of delivery or if shipping long distances, when one must work hard to completely fill each trailer.Staging freight creates more work because staged freight must be double-handled.The truck is likely to be scanned here to register its departure from the warehouse.However, an inventory update may be sent to the customer.

5.1.6 Storage

There are lots of types of special equipment which have been designed to reduce labor costs and/or increase space utilization in warehouse

Storage and receiving equipment can reduce labor costs by;

a) Allowing many SKUs to be on the pick face, that increases pick density and so travelling distance for per picking process, which states more picks per person/hour
b) Making easier efficient picking operation stocking goods again by making the product easier for handling.For instance, by providing it at a suitable height and orientation).
c) Moving goods from receiving area to storage rac ; or from storage to shipping are
d) Partitioning space into sub regions (bays, shelves) which can be loaded with same sized SKUs. This allows intenser packing and provides to make material handling processes uniform.
e) Help to store goods high, where, up to about 30 feet (10 meters),space is relatively much cheaper. (Above this height, the building needs additional structural elements.)

5.1.6.1 Pallet Storage

a) Selective rack or single-deep rack
b) Double-deep rack
c) Push-back rack.
d) Drive-In or drive-through rack
e) Pallet flow rack

5.1.6.1.1 Bin-shelving or static rack

Shelving storage system is the most basic storage model and the not much expensive. The shelves are shallow: 18 or 24 inches (0.46 or 0.61 meters) are typical, for instance , but 36 inch (0.91 meter) deep shelf is rarely used for larger boxes. Because the shelves are shallow, any significant quantity of a SKU must spread out along the pickface.This reduces SKU-density and therefore tends to reduce pick density, increase travel time, and reduce picks/person-hour.

Skus that locate more than one shelf of bin-shelving are candidates for storage in another method which will allow much more SKU density. A ordinary picking rate from bin-shelving is 50–100 picks/man-hour. (Of course this and the pick rates for any equipment depends on which SKUs are stored .)

With shelving, both picking and restocking must be handled from the pick-face and so, to avoid interference, should be scheduled at different times. This implies working an additional shift.

5.1.6.1.2 Automated Storage Systems

Mechanized and automated storage equipments to decrease the human resources necessary to manage a storage facility

Reasons for Automating Storage Operations:

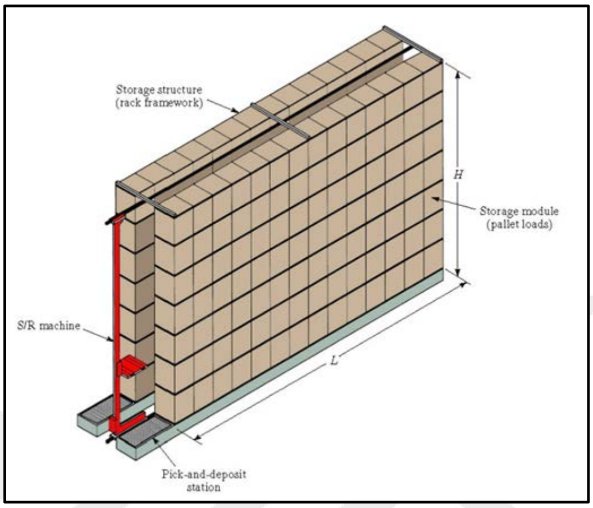
Mikell P. Groover state (2007, p. 337-338):

a) To increase storage capacity
b) To increase storage density
c) To recover factory floor space currently used for WIP
d) To improve security and reduce pilferage
e) To reduce labor cost and/or increase productivity
f) To improve safety
g) To improve inventory control
h) To improve stock rotation
i) To improve customer service
j) To increase throughput

5.1.6.1.2.1 Automated Storage/Retrieval System (AS/RS)

Rack system with mechanized or automated crane to store/retrieve loads.
Unit load on pallet AS/RS with one aisle

Figure 5.1: AS/RS



Mikell P. Groover as mentioned in his book about the function of AS / RS (2007, p.337-338)

a) Unit load AS/RS - large automated system for pallet loads
b) Deep-lane AS/RS - uses flow-through racks and fewer access aisles
c) Mini load AS/RS - handles small loads contained in bins or drawers to perform order picking
d) Man-on-board AS/RS - human operator rides on the carriage to pick individual items from storage
e) Automated item retrieval system - picks individual items
f) Vertical lift storage modules (VLSM) - uses a vertical aisle rather than a horizontal aisle as in other AS/RS types

Unit Load Storage And Retrieval

a) Warehousing and distribution operations
b) AS/RS types: unit load, deep lane (food industry)

Order Picking

a) AS/RS types: miniload, man-on-board, item retrieval

Work-In-Process Storage

a. Helps to manage WIP in factory operations
b. Buffer storage between operations with different production rates
c. Supports JIT manufacturing strategy
d. Kitting of parts for assembly

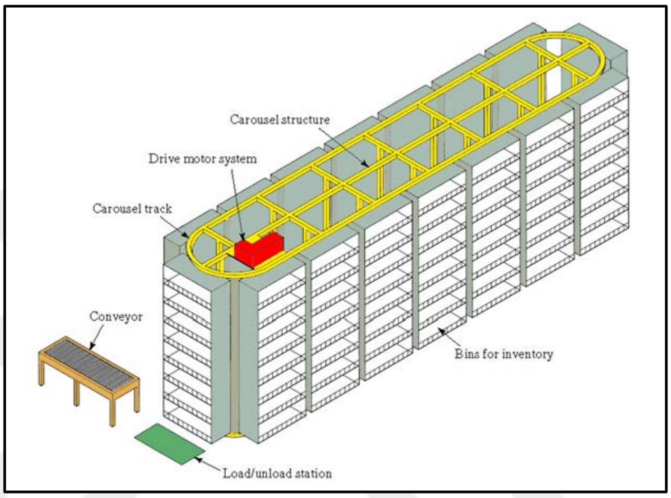
5.1.6.1.2.2 Carousel Storage Systems

Mikell P. Groover also as mentioned in his book about the function Carousel Storage Systems (2007, p.342-343-344)

Horizontal

a) Operation is similar to overhead conveyor system used in dry cleaning establishments
b) Items are stored in bins suspended from the conveyor
c) Lengths range between 3 m and 30 m
d) Horizontal is most common type

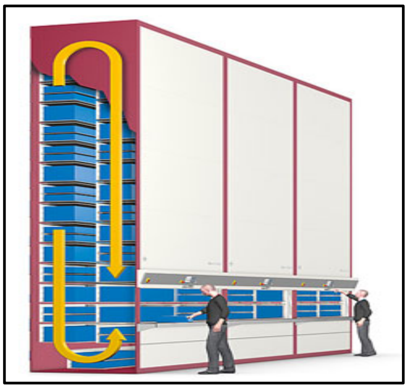
Figure 5.2: Horizontal Carousel Storage System



Vertical

a) Operates around a vertical conveyor loop
b) Less floor space required, but overhead room must be provided

Figure 5.3: Vertical Carousel Storage System



Carousel Applications;

a) *Storage and retrieval operations*
Order picking
Kitting of parts for assembly

b) *Transport and accumulation*
Progressive assembly with assembly stations located around carousel

c) *Work-in-process*
WIP applications in electronics industry are common

d) *Unique applications*

Example: time testing of electrical products

6. LITERATURE REVIEW

6.1 LITERTURE REVIEW RESULTS

The aim of this literature review is to talk about industry 4.0 and related research.The literature review identified key components of this papers: Research and developments about Industry 4.0, Internet of Things, Cyber Physical Systems (CPS), digitalization and Warehousing processess.

Table 6.1: Literature Review

Search Term
Industry 4.0
Internet of things
Warehousing System
Cyber Physical System
Digitazation

6.1.1 Industry 4.0

In this section the researches are about Industry 4.0 will be mentioned.
Industry 4.0 can create many opportunities in the area of logistics management. People who are interested in logistics management, can use the described scenarios as a reference to encourage their own Industry 4.0 initiatives, with respect to logistics management. (Erik Hofmann, Marco Rüsch; 2017). Having a detailed, practical discussion of Industry 4.0, an to suggest policy applications to transition against Industry 4.0 in Korea. (Tae Kyung Sung;2017)
Nine technology trends which are the building stone of I4.0 and researches their potential technical and economic advantage for production equipment suppliers and manufacturers.
In order to demonstrate the findings of Industry 4.0, case studies from Germany, which is considered the world leader in industrial automation, are used. (Michael Rüßmann, Markus Lorenz, Philipp Gerbert, Manuela Waldner, Jan Justus, Pascal Engel, and Michael Harnisch,2015). A group of German experts have explained the concepts

related to the Industry 4.0 concept. (Jozef HERČKO, Eva SLAMKOVÁ, Jozef HNÁT,2015). The advances of robotic and automation technology in achieving industry 4.0 has reviewed. Too many companies, researching centers, and universities acknowledge which robotics and automation technology is based on basis of of industrial manufacturing and an significant driver for Industry 4.0. (Mohd Aiman Kamarul Bahrin, Mohd Fauzi Othman, Nor Hayati Nor Azli, Muhamad Farihin Talib,2016). In addition, this research is the subject of how technology has made the business performance of the sector. (Lucas Santos Dalenogare,Guilherme Brittes Benitez,Néstor Fabián Ayala,Alejandro Germán Frank). Today, products customization by consumers tends to be one more variable in the manufacturing process, and smart facilties must be able to customize what each customers have into consideration, adapting to the choices. An example of the key features of Industry 4.0 is to support the integration and virtualization of the production design and production process by using information and the Internet to create intelligent products. (Kassio Santos, Eduardo Loures, Flavio Piechnicki, Osiris Canciglieri, 2017). A classification scheme endured in two main pillars, on one hand the specialities that characterize which term and besides the technologies and concepts that support their development is also defined. (David Pérez Perales, F. Alarcón, Andrés Boza,2018).Possible revolutions in the business life of the Industry 4.0 are covered in this study[1].Historical developments of industry is part of the this study. (Lord Kumar Bhattacharyya Chairman, 2017)

6.1.2 Internet Of Things

In this section, Internet of Things research, which is one of the components of Industry 4.0, will be mentioned.

Internet of Things is a platform where devices become smarter day by day, every day processing in industry comes in more intelligent, and communication is getting informative. A base contribution of this survey paper is that it summarizes the current state of the art of Internet of Things architectures in several domains systematically. (P.P. Ray;2016). Data communication comes into prominence as part of the digital production.Projects such as big data analytics, preventive maintenance, and remote

[1] Industry 4.0: How to Revolutionize your Business (https://courses.edx.org/courses/course-v1:HKPolyUx+I4.0x+2T2018/course/)

maintenance by experts are targeted as the first step in the process in some cases, As a second step, the first objective is to be success the integration of business processes through cloud technologies, that help implement synergy in the firm. The coordination of supply chains is a good example (Cisco Public, 2016). The Internet of Things (IoT) approach makes promise to make "things" including customer electronic devices or home appliances, such as fridge, cameras, and sensors, medical devices, part of the Internet environment (Rajkumar Buyya, Amir Vahid Dastjerdi, 2016). There are some innovations in the field of technology and organization with Industry 4.0. These innovations can be implemented by the logistics sector, which plays a very important role in the era of globalization. (Krzyszto Witkowsk , 2016). Industry 4.0 is to prepare advices on the developments for next and standardisation of solutions for network based communication as part of Industry 4.0.It will determine the basic requirements for such network-based communication and evaluate existing standards and norms or those in preparation. To structure the various scenarios and requirements for network-based communication, a central field of activity of the sub-working group is to draw up a relative reference model as a supplement to RAMI 4.0. A main part of reference model comes out of in services through that implementations can negotiate the required Industry 4.0 compatible (Federal Ministry for Economic Affairs and Energy (BMWi) Public Relations, 2016).

What is stated by Industrial IoT (IIoT) and relationships to concepts such as cyber-physical systems and Industry 4.0 is mentioned in this study (Hugh Boyes ,Bil Hallaq, Joe Cunningham, Tim Watson, 2018).There is a need to develop the complexity of the IoT, the complexity of the increasingly interconnected environment, and the development of partnerships to create innovative solutions.(Ted Saarikko, Ulrika H. Westergren, Tomas Blomquist, 2017)

6.1.3 Warehousing

Researches about Warehousing, which is important part of Industry 4.0, will be mentioned İn this section.

Warehouse layout and operational science Industry 4.0 has a lot to do with storage operations.The term of "science" comes from developing mathematical and computer models. Current storage practices are based on basic rules and simple rates. This is fine as far as it goes; but there is much more that can be done. Warehouses elaborates reording data of exactly what every consumer ordered and when. Characteristically this information is generated by the IT and IS department as part of financial reporting; but this information could be used by operations to “tune” the warehouse layout and operations to the templates of customer orders (John J. Bartholdi,Steven T. Hackman, 2017).The need to improve logistics facilities was emphasized as a key aspect of increasing the efficiency, flexibility and reliability of supply chains. For this purpose, the warehouse process and the most common sub-operations and activities within it have been defined. (Michał Kłodawski, Marianna Jacyna, Konrad Lewczuk, Mariusz Wasiak,2017)

The progressing in Distribution Center functionality and explore implementation of emerging Industry 4.0 driven technologies to allow a more flexible, adaptable, and productive DC. Finally, Firms evaluate the situation the ways in that these new technologies will effect talent needs, business strategies, and data management for DCs (Alan Taliaferro, Charles-Andre Guenette, Ankit Agarwal, Mathilde Pochon,2016). Karen Leavitt, chief marketing officer of Locus Robotics, explains why retailers and warehouse logistics providers are having trouble finding and retaining labor and explores automation as a possible solution to the problem.[2]

A messy and dirty warehouse can damage your business in several ways. First, a dirty and messy working environment can disrupt the productivity and morale of employees. When the products are stacked irregularly in the warehouse, it increases the inefficiency of the employees.

6.1.4 Cyber Physical System

In this section, Cyber Physical System research, which is one of the components of Industry 4.0, will be mentioned.

The state of the art techniques in cyber-physical systems sease construct smart warehouses to reach success the promising vision of Industry 4.0. There are four important issues when implementing CPS techniques in smart warehouses. First, efficient CPS data collection secondly, accurate and robust localization,thirdly, human

2 https://www.supplychainbrain.com/articles/29094-qa-the-warehouse-labor-shortage-problem-and-solutions

activity recognition,fourth is multi-robot collaboration.Finally, some challenging issues in the future CPS-based smart warehouse, that could open some new research directions (Xiulong Liu ID , Jiannong Cao , Yanni Yang and Shan Jiang, 2018).Industry 4.0 or the fourth industrial revolution states to the trend of integrating cyber physical systems into manufacturing or production systems. Equipped manufacturing units with an array of sensors/end effectors supplies the skill to build a virtual model of the unit. (Achal Arvind, 2016)

The RAMI 4.0 as well as the Industry 4.0 Components models that stand for required first background of any Industry 4.0 application. The major stress is given to the Industry 4.0 components model, that allows designers from companies to understand already current Industry 4.0 case studies and to develop their first Industry 4.0 case studies implementation (F. Zezulka, P. Marcon, I. Vesely, O. Sajd, 2016).

6.1.5 Digitalization

In this section, Digitalization which is one of the components of Industry 4.0, will be mentioned.

How to Revolutionize Business life is most important part between Industry 4.0 and Digiatalization component.[3]

2nd International Conference on Materials Manufacturing and Design Engineering-Industry 4.0 – A Glimpse (Saurabh Vaidya, Prashant Ambad, Santosh Bhoshle; 2018)

Saurabh Vaidya, Prashant Ambad, Santosh Bhoshle argue:

"Digitization and intelligentization of manufacturing process is the need for today's industry. The manufacturing industries are currently changing from mass production to customized production. The rapid advancements in manufacturing technologies and applications in the industries help in increasing productivity. The term Industry 4.0 stands for the fourth industrial revolution which is defined as a new level of organization and control over the entire value chain of the life cycle of products; it is geared towards increasingly individualized customer requirements. Industry 4.0 is still visionary but a realistic concept which includes Internet of Things, Industrial Internet, Smart Manufacturing and Cloud based Manufacturing. Industry 4.0 concerns the strict integration of human in the manufacturing process so as to have continuous improvement and focus on value adding activities and avoiding wastes. The objective of this paper is to provide an overview of Industry 4.0 and understanding of the nine pillars of Industry 4.0 with its applications and identifying the challenges and issues occurring with implementation the Industry 4.0 and to study the new trends and streams related to Industry 4.0."

[3] https://courses.edx.org/courses/course-v1:HKPolyUx+I4.0x+2T2018/course/

(2nd International Conference on Materials Manufacturing and Design Engineering- Industry 4.0 – A Glimpse (Saurabh Vaidya, Prashant Ambad, Santosh Bhoshle; 2018)). With the implementation of smart technology themes, the fourth stage of industrialization, stated to as Industry 4.0, is upcoming. The extent to that smart factory concepts and e-learning have already influenced deeply manufacturing industries in terms of performances in transitional economy is analyzed. Experimental results refer that manufacturing firms that have present both e-learning and selected smart factory technology concepts differ considerably. E-learning is applied on graduates in production. Results find out which two smart factory concepts are a considerable extent and positively related to the firm performance when e-learning is applied (Bojan Lalic , Vidosav Majstorovic, Ugljesa Marjanovic, Milan Delić, Nemanja Tasic, 2017)

7. THE STORAGE OPERATING SYSTEMS IN INDUSTRY 4.0

7.1 WAREHOUSE MANAGEMENT SYSTEM (WMS)

A warehouse management system (WMS) is software and processes that allow organizations to control and administer warehouse operations from the time goods or materials enter a warehouse until they move out. Operations in a warehouse include inventory management, picking processes and auditing. 5.1 Warehouse Management System (WMS)

Types of warehouse management systems:

Warehouse management systems (WMS) become a various and application methods, and the type usually depends on the size and enviroment of the organization. They are independent systems or modules in larger enterprise resource planning (ERP) systems or supply chain systems.

WMS can be also vary extensively in complexity. Some small organizations may use a simple set of hard copy documents or spreadsheet files, but most large enterprises - from small to medium enterprises (SMEs) - to corporate companies - use complex WMS software. Some WMS installations are specifically designed for the organization's size, and most vendors have versions of WMS products that can be scaled to different enterprise sizes.(Margaret Rouse,2018)

7.2 HOW DOES INDUSTRY 4.0 AFFECT WMS?

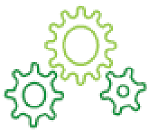
Industry 4.0 has covered the way for increasingly interconnected experiences which affected everything from product design and planning to supply chain and manufacturing. However processes of designing and manufacturing goods, at the same time , the technologies connatural in Industry 4.0 may also effect the manner in that finished goods are moved, warehoused, and distributed

Industry 4.0 technologies make enable warehousing sites to adjust to remarkable alterationd in their business. The last years have seen the migration away from warehouse based stocking of inventory to high-velocity operations, pushing more goods through the same physical assets while bringing down overall costs.(Taliaferro *et al.*, 2013)

Alan Taliaferro, Charles-Andre Guenette, Ankit Agarwal, Mathilde Pochon mentioned in Industry 4.0 and Distribution centers essay (2016, p. 2)

Industry 4.0 technologies can help pave the way for the evolving DC, enabling automated systems to adapt to their environment and tackle tasks more efficiently, while working with humans. Technologies such as lowcost sensors, computer vision, augmented reality (AR), wearables, Internet of Things (IoT),5 robotic prehensility, human-robot safety, analytics, and high-performance computing— all inherent in Industry 4.0—are being used to enhance existing automation. At the same time, they are also enabling new types of smart automation that can help transform DC operations

Figure 7.1: Industry 4.0 Affect WMS Concept

Product impact	Key objectives	Transformational plays
 Business operations	Improve productivity Reduce risk	• Removing or reducing delays and improving response time • Maximizing asset utilization and minimizing downtime • Automating activities • Driving further direct and indirect labor efficiency

Using Industry 4.0 technologies to adapt to changing

Smart Industry 4.0 technologies,such as sensors, artificial intelligence, AR,and autonomous vehicles, to create a more adaptablefacility. Notable technologies include:

a. Vision picking as an extension of voice picking via AR
b. Adaptive robots and connected automated guided vehicles
c. Semiautonomous, flexible machines for valueadded services
d. Fully automated picking and quality assurance to adjust to rapid changes in demand
e. Next-generation distribution operation systems
f. Smart, automated facility management for greater efficiency
g. Safety enhancements and modularity

(Taliaferro *et al.*, 2013)

Industry 4.0 have been detached from five unique points that the major disruptors have converged to allow:

a. Big data and its constant volume or capacity
b. Connectivity and its growing availability
c. Actual time analytics
d. Cost-effective sensors, meaning the emergence of human-machine mutual effects via touch interfaces, etc.
e. Advanced robotics and the general advances in instructing the physical world via digitized commands

This all shows that computer intelligence is attending and admitting more devices to connect and communicate, meaning more big data. Of course, this situations perfectly provide the needs of a warehouse. In a warehouse, SKUs (stock keeping units) communicate with machines, machines connect to and communicate with other machines and then, successively,ERP devices and warehouse management systems are connected and communicated .

This mini ecosystem in itself drives the distribution processes for your warehouse. It can make a response to any updates in the task sheet and the robotics which attending can reconfigure themselves to react in real-time without involving human “colleagues.” These technologies are used more widely for a number of applications as well as being more reliable and less costly than ever. This means warehouses can incorporate them, by that means automating their operations and decreasing the logistics industry’s dependence on labor. Every part of a product's life cycle must be automated. The fact that America's industrial production in 1987 is more than 85 percent proves this situation. . Warehouses experience issues with labor — mainly for the time of the busier seasons. Especially trends are moving people away from manufacturing and supply chain work because labor remains limited and the competition for this reducing employee pool is high. Therefore, Industry 4.0 will provide a much-needed solution for this productivity hindrance through system-integrated, intelligent and collaborative robots who are able to work next to humans in a warehouse.

7.3 HOW TO PREPARE FOR INDUSTRY 4.0

In order to address the data produced by Industry 4.0 and to develop the infrastructure that will enable them to make the most of these data, material transport organizations need to prepare themselves:

1. You should consult a data scientist or work with a consultant to improve your services in this infrastructure.

2. Creating a data repository including ERP and WMS will have another requirement in this process.

3. To collect meaningful data, you must use inspection devices to help understand where the cost-effective sensors in the tank are installed.

4. Understand how to interpret data to obtain information in a timely manner.

Industry 4.0 will revolutionize and protect your warehouse and therefore your entire business. It will show you to know that all necessary changes will take place in real time by an efficient, intelligent, reliable and accurate integrated system, and at the same time understand what is happening in real time. In addition to collecting information from your data that will protect your company more from productivity issues such as labor shortages, it will also allow you to estimate the future needs of your business from a logistical perspective.

7.4 WMS AND IOT

The right amount of products at the right place at the right time to produce and send the products to the right place is provided by the connected devices and sensors in the products and materials. All of these features fall under the internet of things (IoT). To help manage the routing of products from the collection point to the endpoint, these IoT data can be integrated into a WMS. Establishment of pull-based supply chains instead of push-based supply chains is provided with this integration. The organization of pull-based supply chains according to customer demand provides greater flexibility and responsiveness to the organization, while the push-based supply chain predicts long-term customer demand.

7.5 THE AIM OF THE RESEARCH

To investigate the effects and changes of Industry 4.0 revolution on general industries and especially storage activities by researching component of Industry 4.0 such as CPS, IOT, The Internet of Services (IoS), Smart Factory.
In this study, AS / RS and Carousel storage systems, new technological developments will be analyzed by using real data. In addition to this, some other innovations that will benefit from storage systems in the Industry 4.0 concept will be mentioned.

With the contribution of the past industrial developments, automation systems are used in production area, storage systems and many areas.In the current situation The use of the Internet in separate parts into the operative process, CPS are also important parts.

The solution we will propose in this study will show how the different concepts mentioned above will work together.

The current inputs and outputs of AS / RS and Carousel storage systems mentioned in the previous sections will be mentioned.When calculating these inputs and outputs, the data of companies using these systems will be used.

With the Industry 4.0 revolution, the solution of the inputs - outputs of these systems and how the working concept changes will be investigated.

With the Industry 4.0 revolution, there are technological developments not only in storage operations but also in other warehouse processes such as integretion between WMS and IOT will contribute to use robots in Warehouse for some process such as order picking, Packing, efficient using of WMS.

The variables to be compared in 2 cases;

FTE: How much manpower needs

Process times: How long the processes take in the above mentioned storage systems.

Reaction times: Reaction times of the current system and recommended system for possible instantaneous changes.

A possible solution to the future with the Industry 4.0 revolution and the comparison of the Variables of the current situation will be one of the important points of this research.

With the widespread use and use of Industry 4.0 applications, we will determine how much improvement has been experienced in the systems used in the past.

7.6 THE OBJECTIVES FRAMEWORK

In today's industry, companies need to improve their competitive conditions so that they can survive and ensure continuity. All operations performed by manpower are error-prone and these errors constitute an extra cost for companies. On the other hand, they are open to innovation. The main purpose is reducing cost and increase service quality for customer. All innovations to be carried out as mentioned above will ensure the sustainability of the companies and help them to compete with other firms by creating value added.

AS/RS’s play an important role in improving these conditions. The speed of the companies that make the storage and unloading process with the forklifts based on the conventional human operation is slow in the production-storage-shipment processes and the control of these operations is made more difficult than the automatic systems. In these transactions, the inventory data management and the dispatch of the products to the appropriate places cause some errors and problems. For this reason, large firms require that the loading and unloading of products into the warehouse is not human-based. When AS/RS is used instead of the known systems, the space required for the forklift is saved and the control of the system can be made easier via the computer database.

When the international studies on the subject are examined, it is seen that various demo studies have been done and automation solutions and control structures are presented and time optimization is frequently studied.

In this study, some suggestions that will be useful in AS / RS, Carousel, cleaning machine, order picking and warehouse operations will be explained.

7.7 CAROUSEL SYSTEM

Problems

a. Recognise critical stock:

This can lead to many problems, such as shortages and overstock. If you don't know how much inventory you have in stock, you might be running dangerously low on certain items or else you might have over-ordered and now have too many items for your warehouse to handle. Both options can lead to unnecessary expenses.(Robert Lockard,2017)

b. Long processing time for picking/loading & Picking Errors & Automatic error reporting

Those mentioned above in the problem often create an extra cost to organizations.

c. Business intelligence (Identifying trend, daily operation picking rate, monthly picking rate and etc)

It can be result in missed the trend to adding value to business.

d. Space inefficiency

Space inefficiency can be big problem for warehouse by appliying classical rack storage

Solutions

Before starting the solution, we need to say that the carousel storage system should be integrated with a warehouse management system via some ERP Systems.

Recognise critical stock

When integrated in ERP Systems, the storage carousel is controlled directly via either the ERP systems warehouse management systems. The software modules map all the storage carousel processes on a uniform and company-wide technology platform. Furthermore, the characteristics and number of carousels, trays and storage locations are also mapped in ERP Systems. The ERP dialogs that need to be available as operating dialogs at the control unit are defined. Optimized user guidance with ERP dialogs and graphical tray display provide for simple and intuitive use. Inventory management and postings are handled directly in ERP via the input terminal of the storage carousel.

Thanks to ERP integration,the system gives warning message to prevent about critical stock message to user.After recognising critical stock, replenishment can be done that critical stock goods to Carousel Storage.(SAP Vertical Lift Integration Solution-ViaStore Software Brochure,2016)

Long processing time for picking/loading & Picking Errors & Automatic error reporting

As mentioned in 3.7.1.3 Order Picking chapter, picking process is most expensive part of warehouse operating expenses. For this reason, the errors in this step will be returned to the companies as extra cost. With the addition of new technologies to be integrated into Carousel storage systems, the picking process will provide a significant reduction in the operation times of the current picking processes. The most important of these is the time in the process of traveling between the shelves while the warehouse worker picking the goods. If we talk about the technologies to be integrated, pick by voice and pick by vision is very useful with Carousel system.

IOT is one of the most important parts of this process. It is important in terms of the flow of information between the systems and providing instant updates. Some examples will be given in next part of my work.

Other solutions;

a. Thanks to the integrated technologies, errors in the Picking process are minimize .Individual 4.0 together with the increasing technological intelligence can immediately report the wrong received product from the shelf.
b. Business intelligence

   The recording of all the steps of the technologies mentioned in the previous sections during the operations helps the development of the business intelligence related to the improvement of the processes that are made in the following periods.

In addition to the data held with the companies in the coming periods, which products do peaks, clogged processes may offer solutions in advance.

Introducing all details about the picking process to the user is one of the solutions.

BENEFITS

a) Reduced logistics costs due to reduced inventory levels and better use of resources
b) Easier management of complex processes through greater transparency, effective collaboration and reliable compliance
c) Satisfied customers since the right products are in the right place at the right time

7.8 AS/RS

Problems & Solutions

AS / RS is not a technological development emerging with industry 4.0. However, the contribution of Industry 4.0 to AS / RS will be explained in this study. It will be mentioned how the components of Industry 4.0 will bring about improvements to this important storage system such as IOT, Digitalization.

AS/RS Problems

Finding and maintaining labor is extremely hard,

“The increase of e-commerce sector by 10-12% every year increases the labor force requirement in logistics sector Now, a lot of that work has been pushed up into the warehouse. When somebody goes online and clicks to purchase something, it magically arrives at their doorstep 24 hours later. But the magic is human labor. Somebody in a warehouse has to read the order, pick it off of a shelf, box it up and ship it to that consumer. That's very labor-intensive.”(Karen Leavitt, Chief marketing officer of Locus Robotics,2018).

Another reason why people do not prefer to work in warehouses is that the warehouses are either too cold or too hot. Also, a warehouse employee has an average distance of 15-16 km in 10-12 hours daily.

“The demand for workers has increased steadily over the last five years, Nathan Coin, director of divisional operations-commercial division at Aerotek, a national recruiting and staffing agency told Supply Chain Dive. Nationally, his division is scrambling to find traditional warehouse workers to pull orders and move products by hand, in addition to driving forklifts”(Deborah Abrams Kaplan,2018).

Shortage of skilled workers and specialists and an aging workforce

In addition to the shortage of finding the work force mentioned in the previous title, the companies are experiencing difficulties due to the lack of qualified personnel to replace the blue and white collar personnel that will be old and retired. For this reason, the cost of qualified workers is increasing. Money talks, and increased pay helps warehouses fill the jobs faster than those offering less

Increasing space cost due to uneffiency

Storing large volume and heavy loads where storage density is high due to insufficient space

Long Warehousing process time

Warehousing processes such as inbound, put away, picking and outbound are main cost element of warehouse activity. Productivity can be vary so it may affect company expenses and may cause loss.

Solution

IT System requirements.

The warehouse management system should be fully integrated into the IT landscape of the supply chain and controls all processess.

Finding and maintaining labor is extremely hard,

Chief marketing officer of Locus Robotics Karen Leavitt, put into words why retailers and warehouse logistics service providers are having problem fot finding and retaining labor — and explores automation as a possible solution to the problem (Robert J. Bowman,2018) .

Shortage of skilled workers and specialistsand an aging workforce

Increasing production and logistics costs due to unrestricted availability

Customers are demanding more in terms of service

BENEFITS

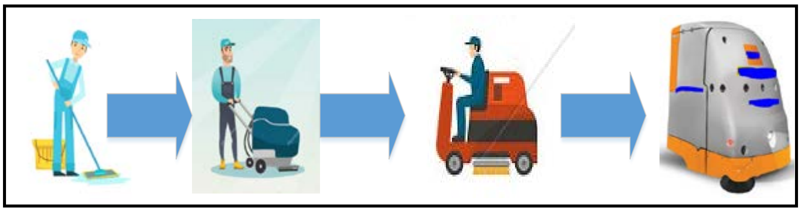
a) Reduced logistics costs due to reduced inventory levels and better use of resources
b) Easier management of complex processes through greater transparency, effective collaboration and reliable compliance
c) Satisfied customers since the right products are in the right place at the right time

7.9 CLEANING ROBOTS

Dirty and cluttered warehouse may cause aloss your business in a some ways. Firstly , it conduces to a disorganized and off-putting work environment, that can hurt employee productivity and morale. This type of warehouse may also pose health hazards to employees. When the warehouse can be organized and cleaned the warehouse, processes can be more productive and tidy.

The warehouse cleaning processes from the past to the present continue to improve.Previously, warehousing cleaning operations were doing by manpower then it was replaced by the cleaning tools used by the warehouse staff.(Samantha Kemp,2017)

Figure 7.2: Cleaning Machine Revolution



The cleaning process with Industry 4.0 has undergone a great change. Cleaning robots where the human factor is minimum are used in warehouses today.(Still manpower needed to fill robot with water + charge/change battery + guide robot to cleaning area)

ROI analysis can be vary according to Country because manpower costs are very different between countries.Also currency may effect ROI analysis.There is standart calculation example tool globaly in the Table 4.

* The values in the table may vary depending on the countries and conditions.

Table 7.1: Calculation method Cleaning Robot

Cleaning Robot Assumptions	
One Robot	
Buying price	€ 32.000,00
Depreciation/Right off Years	5
Yearly service fee	€ 2.570,00
Yearly useables	€ 801,00
Percentage free floor	60%
M2 per Clean run	3.000
Country/Branch/Contract	
Labor costs per hour	€ 25,00
Yearly current cost	
Machine	€ 4.100,00
Service	€
Useables	€ 900,00
Damages	€ 3.500,00
Hours spend on cleaning	468
Number cycles cleaning	52
Square meters WHS	35.000

Business case (Yearly)		
Costs	***Current***	***Robot***
Leasecosts + Maintenance	€ 8.500,00	€ 9.771,00
Manpower Cleaning	€ 11.700,00	
Total	€ 20.200,00	€ 9.771,00

Difference
€ 10.429,00

Benefits of Autonomous Cleaning Robot

a) Time saving

Operator only needs to refresh the usable water and chemicals after that the machine runs on it's own so the operator can do other tasks. Cleaning in hours when there is less traffic impoves quality (preferrably at night)

b) No need to ride the machine around.

c) Hight Quality cleaning

Better quality of cleaning because of lower driving speed.Existing machine

d) Reduction of cleaning costs by up to 70 %

e) Monitoring robots online via mobile app , pc etc.

f) Taking operational report of robots about Total running hours

Interested in the usage of one specific machine during a defined period of time? Click on the machine number to get the broad data of exact geoposition, detailed operating times, battery level, date of last message and more.

g) Usage analytics

The icons "low usage" or "not used" indicate the number of machines that haven't been in use on a regular basis for a defined period of time

7.10 PICK BY VOICE

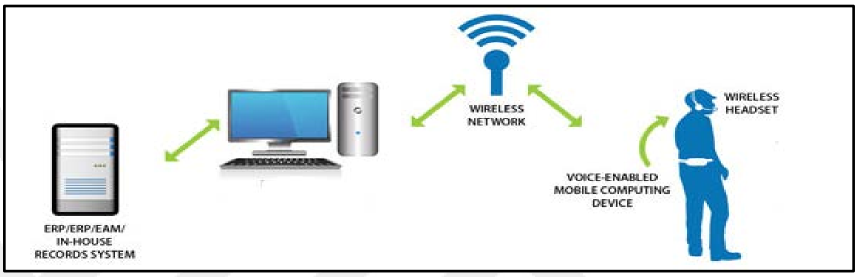
The Inther Group published magazinne about Pick By Voice (Inther Group,2019)

Pick by Voice is a paperless system based upon voice recognition procedures for warehouse processes and production facilities. Voicedirected systems build a handsfree environment for employees. This eliminates the handling of RFscanners keeping the operator's focus on the materials and their environment at all times. A working method that will increase performance, accuracy and safety.Pick By Voice speech recognition is currently used in a wide variety of industries and in different temperature zones (3PL, Food, Media, Spare parts, etc.).

Paper based order picking is literally 'old hat'. Where operators used to read the pick instructions of a paper sheet or RFterminal, all necessary information is now given by a natural friendly voice. The operator confirms everything by simply talking into the microphone telling the system which actions have just been performed. This makes the Inther voice solution well accepted by the operators. Speaking and listening are two human capabilities that require very little effort. Instead of having to stop and focus on elements like paper, RFterminal and article info, Voice makes it possible to simplify the processes. A true 'hands and eyes free' system. Other processes like put away, replenishment and stocktaking are also supported. Typically, our customers see an increased productivity, a dramatic reduction of error rates and a payback that normally is achieved in less than one year.

Pick by Voice can be integrated with many ERP and WMS systems like SAP, Oracle etc.

Figure 7.3: Pick by Voice Concept



<u>Benefits of Autonomous Pick By Voice</u>

a. No operator speech training

b. Improved productivity typically +25%

c. Higher accuracy: 99.9% is possible

d. Natural voice output

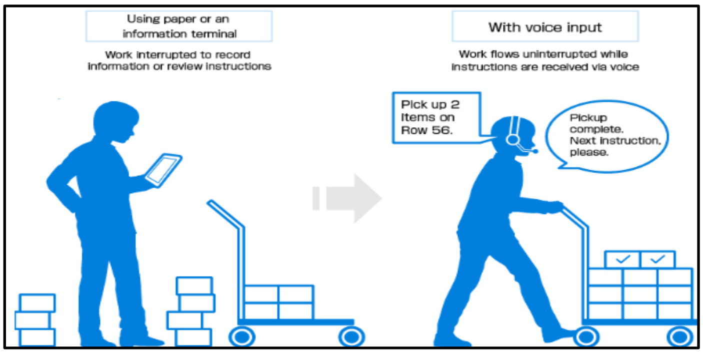
e. Payback time less than 1 year

f. Open system

g. Ergonomic use

h. Processing of different processes in logistics

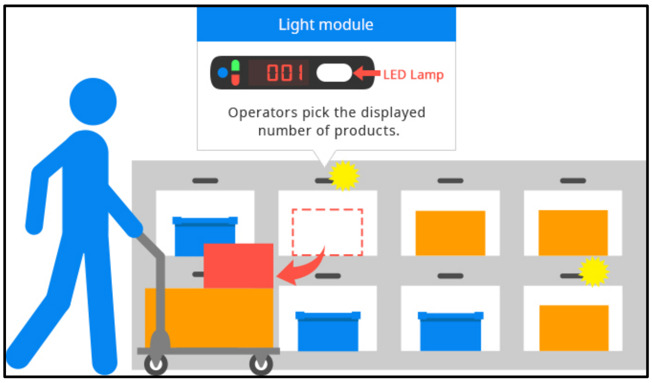
Figure 7.4: Comparision of With and Without Pick by Voice



7.11 PICK BY LIGHT

Pick to light technology is a system that provides picking items from warehouse shelf racks by using lights to direct warehouse workers. As opposed to other warehouse picking systems, pick to light allows for fast collection without a list. A typical light-based picking system uses different colored LED lights along with a series of letters and numbers. These tracking components allow for faster accumulation while maintaining inventory accuracy. Actions (correct or false) are shown by means of lights and optional audible signals. Completed operations can either be automatically or manually confirmed.(Angela Stringfellow,2017)

Figure 7.5: Pick by Light Working Concept



Pick to light technology working procedures is;

a) Lights should be on all storage unit.

b) These units can be reusable totes, shelves etc.

c) Each unit must be have at least two different-colored LED lights and a unique barcode.
d) All of the lights will be the same color (typically red) when there is nothing required from those units.
e) When something is needed, the red light goes out, and the appropriate light turns on.
f) If there is more than one type of item in the unit, there can be different colored lights. Or, if more than one of the item is needed, there may be a different light.
g) All of the lighting is tailored to the needs of the organization.
h) Once the employee reaches the right unit, there is usually a barcode to scan which updates the system to know that the appropriate item has been removed.

Benefits of Pick to Light

Improving of Performance

Some picking systems are separate from the warehouse inventory software, that makes it complicated of tracking picking progress and improve in time. Pick to light is first hand connected with inventory to provide accuracy, but also to give valuable insights to also improve the performance of warehouse operations over time

Decrease Waste time

Order picker workers have to walk back and forth through the warehouse shelving only to print out a new list and start fresh can lead to idle time, unnecessary walking and potentially missed items. All which add up to waste and possible health concerns over time. Pick to light provides for workers to be separated into zones. Once items are ready to be picked, employees work through their zones. When completed, they begin again

User friendly

Hiring and training temporary workers can be costly for the firms. Mistakes can also be made when the picking system and inventory software are difficult to learn quickly. Pick to light gives an advantage due to its sheer simplicity, making it easier to train temporary help.

Greater Accuracy

When filling a cart, the display can read with a complete location for the site. For instance, "Aisle 3, east shelf, section two, level three, pick 12x SKU1234."

Lower Cost of Goods

Increasing productivity can lower the cost of goods and increase profitability at the same time.

7.12 PICK BY VISION

Using pick by vision technology to improve order picking may be futuristic, lots of companies and warehouses are already excetuing vision picking solutions to make picking operation faster, smoother and significantly less errorprone. By choosing a solution that integrates with no problems into your warehouse management system (WMS) , we can be sure to optimize those benefits even further. Pick by vision technology have a similar DNA with pick by voice (Simon Dereeper, Nico Deleener,2018).

The main purpose of the project is the user optimal supply of information using data glasses to be carried by the warehouse worker who handle picking operation that shows all data for the correct execution of the picking operation depending on location , time, field of view and the order status.

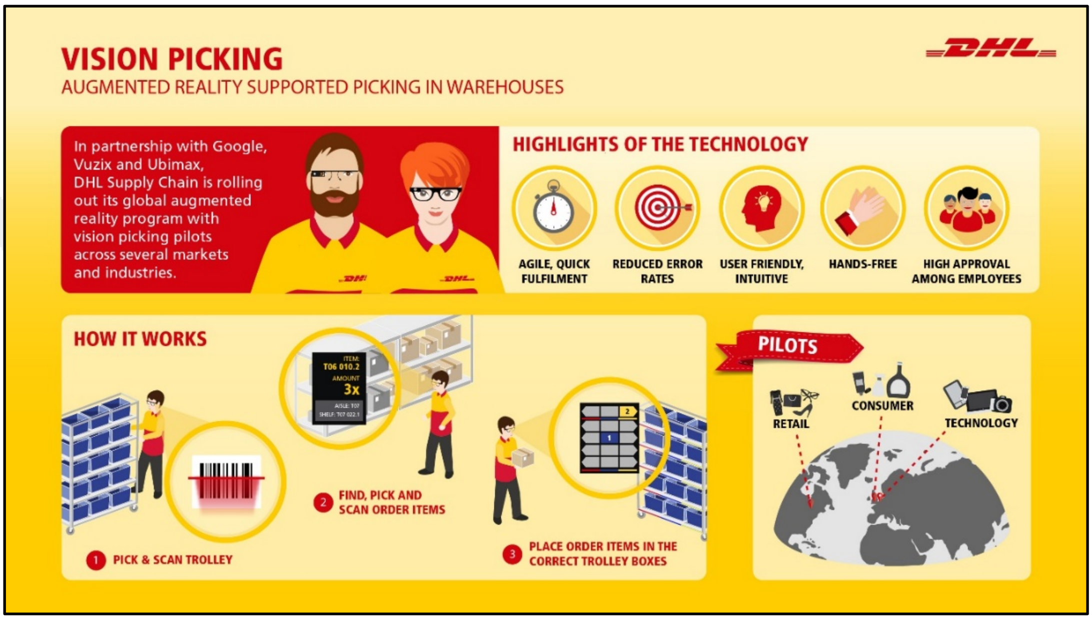
Sectors which can be concerned with this technology;spare parts business, production logisitcs,firms that have high picking density operation.

a) The IT system of the solution needs to be interfaced with our WMS to enable order preparation
b) Glass use the augmented reality or assisted reality to show the walk path/rack configuraiton/product image
c) Operator is able to use glass to scan either 1D or 2D barcode
d) Operator is able to use glass to share the live vision with supervisor or take picture and send to supervisor
e) Workflow is customizable with workflow engine if required

<u>Benefits of Autonomous Pick By Vision</u>

a) Free both hand for operation
b) Visualization of the rack/product to provide clearer instruction to operator
c) Vision sharing with supervisor to report discrepancies in real time
d) Easy workflow modification and customization of new workflow

Figure 7.6: Vision Picking Technology



Soruce : DHL Pick By Vision Implementation

7.13 FOLLOW ME TRUCK

Follow me truck is innovation for order picking process.All communication takes place between the truck's control system and glove worn by the order picker.At the start of the shift , the picker must first connect truck and glove ,using a simple key combination on the glove and truck display. (Crown Equipment Corporation,2013)

This pairing only has to be done once.It offers abroad selection of glove sizes and configurations depending on the order picker's build and whether they are right or left--handed.(Crown Equipment Corporation,2013)

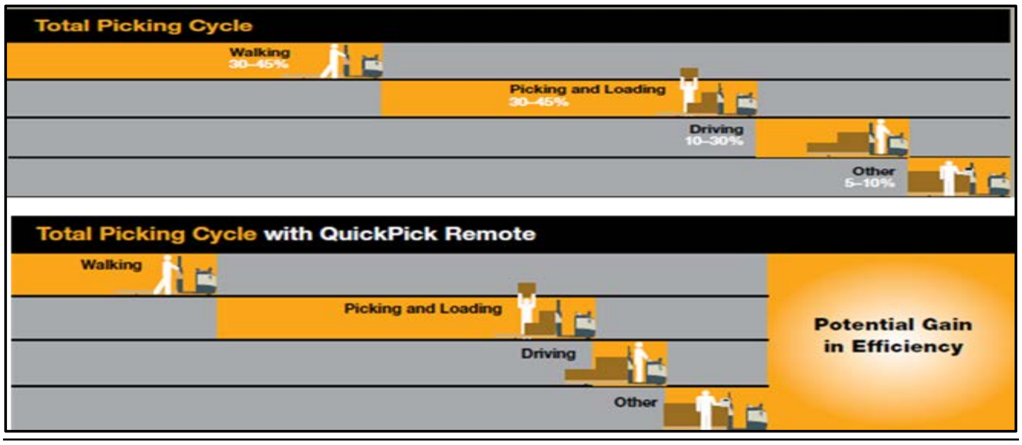
With driver on board, the truck's maximum speed is 12.4 km/h; this falls to 4.1 km/h when the system is active (Crown Equipment Corporation,2013)

Figure 7.7: Follow me Truck Concept

<u>Benefits of Follow Me Truck</u>

a) Decreasing picking process time %22, enhances operator picking efficiency accuracy
b) Reduces on/off truck motions
c) Follow me truck operators can reduce steps up to 50 % per shift compared to operators using standart pallet trucks.
d) Reduces musculoskeletal strains
e) Reduce absence due to slipping, stumbling and falling accident.
f) Eliminates needless motions,stresses
g) Keeps operator moving in forward direction
h) Reduces musculoskeletal strains
i) Automates/coordinates truck positioning with operator action
(Crown Equipment Corporation,2013)

Figure 7.8: How to Follow me Truck reduce process time



Example Test has been published in Logistiek TOTAAL magazinne,(Theo Egberts,Andersom Testing,2014)

Table 7.2: Result of the Follow Me Truck Test

		Picks per hour	Productivity increase (picks/hour)	Energy consumption (kWh/1000 picks)	Reduction in energy consumption
Circuit 1*)	Riding on the truck	292		4.0	
	Using QuickPick	323	10.6%	3.5	12.5%
Circuit 2*)	Riding on the truck	290		3.7	
	Using QuickPick	370	27.5%	2.9	21.6%
Circuit 3*)	Riding on the truck	296		3.3	
	Using QuickPick	413	39.5%	2.7	18.2%
		Acceleration over 10 metres (sec)	**Max. speed (km/h)**		
	Riding on the truck	4.9	12.38		
	Using QuickPick	8.9	4.14		

- **Circuit1**: av .distance between pick locations 6.3 metres: number of Quick Pick locations 12
- **Circuit2**: av. distance between pick locations 4.9 metres: number of Quick Pick locations 18
- **Circuit3**: av. distance between pick locations 4.0 metres: number of Quick Pick locations 22

7.14 TELEMATICS

Digitization has capability for changing the world of logistics. With increasing volumes of data and networking in the industry, logistical processes are getting more complex. Forklift trucks may sometimes even act autonomously and communicate by means of an array of sensors—the fleet becomes more and more intelligent. Fleet managers can be able to control all warehousing processes in real time and achieve siginificant rates of increase in movement of goods.(Linde Material Handling Magazinne,2014)

Connect fleet management system, Some technology service providers supply precisely the information the fleet operators need for efficient deployment of their forklift trucks, in all possible location and fleet size, whether new or existing forklift trucks or other manufacturers' products. (Linde Material Handling Magazinne,2014)

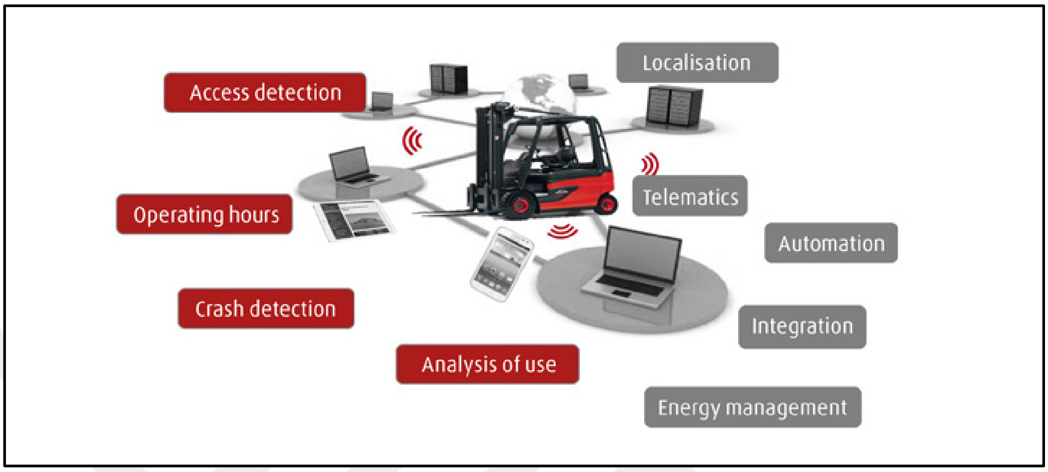
Telematics is an interdisciplinary field that contains telecommunications, technologies of vehicle, road transportation, road safety, electrical engineering such as sensors, instrumentation, wireless communications, etc. , and computer science.The system will let a full visibility of machine usage, driver performance, and incidents across the material handling equipments. Communicating directly with our servers the system requires no local router or complex infrastructure and is both fitted and maintained by engineers. (Orlando Trott,2018)

Telematics can involve any of the following:

a) Telematics is revolutionising the way in which companies run their vehicles and employees drive them.
b) The word telematics was created from the words telecommunications and informatics and essentially embraces the sending, receiving and storing of information including to and from vehicles.
c) Vehicle telematics has its roots in the HGV sector but, in more recent years, has become a popular tool for LCV fleets and today the technology is increasingly finding its way into company cars.
d) Telematics systems monitor the location of vehicles and the way they are being driven to deliver a raft of essentialoperational real-time information to fleet

decision-makers that enables them to take action to improve business efficiency, ensure legislative compliance and cut costs.

Figure 7.9: Telematic working Concept



<u>Benefits of Telematics in Warehouse</u>

a) Early detection of damage to the forklift truck
b) Identification of underused and overused MHE
c) Improvement of the logistics processes
d) More cost-effective

7.15 DRONE CYCLE COUNTING

Accurate and reliable data is very important to an efficient and effective way for business operation. Inventory states a significant portion of assets in a business. Herewith, all decision makers need to accurately and timely know how much inventory there is and where it is located in order to make effective budgeting, operating, and financial decisions.[4]

Firms which carry a remarkable amount of inventory are perpetually looking for innovative logistics solutions to develop the overall efficiency and effectiveness of their inventory checking process. While some firms stoplo logistic operations to fullfill a full

[4] https://www.pinc.com/warehouse-drone-inventory-management

physical inventory control, others perform more targeted checks, with cycle counts in areas that cope with high-value or high-volume products.[5]

Irrespective of your approach, it often indicates which there is a crew of individuals roaming the warehouse manually checking for inventory. This may be time consuming, expensive, disruptive, require equipment (people lifts), and exposes people to safety risks

Above all, the accuracy of the inventory can never be guaranteed because it is time-consuming to carry out manual verification.

Figure 7.10: Drones Working Concept

Benefits of Drone Cycle Counting

a) Time saving
b) Fully automated process with minimum human intervention
c) Provide better throughput,
d) Productivity gain, and FTE gain

[5] https://www.pinc.com/warehouse-drone-inventory-management

8. CONCLUSION

We will witness that the organizations that have embraced or embraced the Industry 4.0 concept have provided significant benefits in the future. Innovation and technological development play an important role in every organization today.

The warehouse operation processes and the design I have focused on in this study have undergone a great change with Industry 4.0.Mohd Aiman Kamarul Bahrin, Mohd Fauzi Othman, Nor Hayati Nor Azli, Muhamad Farihin Talib (2016) argue the idea of the concept of robotic technology in Industry 4.0. Since the show up of information and communication technologies (ICT), the economies of countries in the world have been increasing considerably, as firms can compete on a global scale to capture the opportunity.

Othman, Nor Hayati Nor Azli, Muhamad Farihin Talib (2016) states:

The fourth industrial Revolution will be based on cyber-physical systems, the Internet of Things and Internet of Service. More companies and nations are joining the movement with different approach so as to be competitive in order to benefit from the productivity and economic gains it provides. Although industry 4.0 covers a very wide application area in the manufacturing industry, the trend is quickly materialized with the emergence of new robotic and automation product innovation that is tailored for industrial revolution.

Developments in storage systems with Industry 4.0 will provide companies with some advantages according to the researches and demo studies carried out. These advantages are provided to eliminate the inefficient operation processes and to make the spent workforce more efficient with new methods.

A great value will be created with the synergy created by the automation systems and technologies currently used in the Industry 4.0 components and will be a double-sided acquisition for both customers and companies.

Finally, the companies that can keep up with the Fourth Industrial Revolution will follow the trend and take more confident steps to the future.

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