Customizing Smart Warehouse Management for Large Scale Production Industries

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***Abstract*—Rapid changes in the level of digitalization have changed manufacturing and production industries during our lifetime. Several industries have explored the extent to which these changes can be utilized to optimize supply chain processes and increase sustainability – they have achieved success in implementation. The energy industry, being one of the world's largest and most financially consuming industries, is yet to benefit from such work as it has not been prioritized or investigated thoroughly. This paper will offer specification criteria for energy companies' implementation of smart warehouse management systems (SWM). This will be done on the basis of a literature review on warehouse management (WM), warehouse management systems (WMS), and Industry 4.0 technologies.**

Keywords—smart warehouse management (SWM), Industry 4.0, energy industry, sustainability

I. Introduction

The fourth industrial revolution has had a major impact on production industries since its introduction. Warehousing, manufacturing processes, and transportation are just some examples of industrial practices whose operations have been altered due to the adoption of Industry 4.0 technologies [1]. The current technological implementation and their ensuing results have created a world in which production companies and their stakeholders more than ever are alert to new developments in technology and their potential benefits in improved competitiveness and sustainability.

A smart warehouse (SW) refers often to an unmanned and automated warehouse. A smart warehouse management system (SWM) is a combination of planning and control systems and the decision rules used for managing all logistics flows - inbound, storage, and outbound – in an intelligent way [2]. SWM systems aim to streamline and optimize warehouse operations to the extent of zero waste and high profitability [3][4]. An SWM has the benefits of maximized efficiency, responsiveness, and ultimate profitability for the entire logistics system, of which a warehouse is an essential part.

An SWM system is especially important for large-scale production industries, i.e., the energy production industry. This is mainly because its warehousing has been counted as one of the largest non-profitable logistics activities. Further, the energy industry is under constant pressure to decarbonize and move toward more sustainable practices. Using Industry 4.0 technologies to improve the performance of warehousing will contribute to positive outcomes in terms of its sustainability.

Despite the obvious benefits of having SWM systems for the energy production industry, its implementation is challenging. The items stored in warehouses are typically large, made of heavy and corrosion-exposed materials, and requires special transportation methods. Although there are existing mature SWM systems, their implementation in the energy production industry must be tailored to the industry's needs and characteristics. As the implementation goes in parallel with technological advancement, one should also consider incorporating these technologies whenever they are applicable.

This paper starts with a comprehensive review of warehouse management (WM), warehouse management system (WMS), and SWM. The authors further investigate which Industry 4.0 technologies are especially relevant to SWM. Thereafter, the nature of the energy production industry and its requirements for an SWM are explored. Then, the paper proposes a set of specific criteria for the tailored SWM for the energy production industry. Finally, suggestions for further work based on this research are made.

II. LITERATURE REVIEW

A. Warehouse Management (WM)

Warehouse Management (WM) can be defined as "A combination of the planning and control systems and the decision rules used for inbound, storage, and outbound flows." [2]

This planning and control are illustrated in Fig. 1:

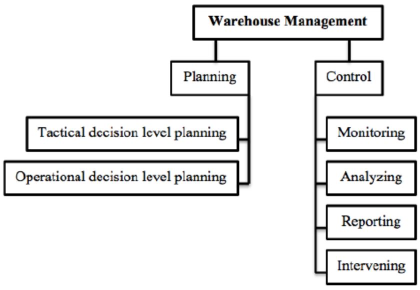

Fig. 1. Warehouse Management (WM).

The objective of WM is the efficient and effective coordination of all warehouse processes and activities for the sake of producing products and services as intended. In the operation of a warehouse, planning and control procedures take place [2].

Planning is the activity that describes the decision-making in what is to be done and how, while control is the activity of ensuring that the plan in question is followed.

When considering planning, there are two decision levels specifying the work that should be done:

- Tactical decision planning, which plans for efficient resource utilization and for meeting the customer demands; and
- operational decision planning, whose purpose is to handle decision rules for sequencing, scheduling, and optimization of planned activities.

The control aspect of WM comprises the activities of monitoring, analyzing, reporting, and intervening. The general comprehension obtained from these descriptions is simple: in any cases where the execution of operations does not go as planned due to unforeseen events, control must be established to ensure the continuation of the work. Such events include failure of equipment, illness or injury among staff, delay in delivery of items to the warehouse, and order changes. To maintain full control over operations and situations in which operations do not go as planned, an exact overview of such information is required.

B. Warehouse Management System (WMS)

A warehouse management system (WMS) is a software or information technology that can control various warehouse activities, such as receiving, inspection, address, storage, separation, package, and shipping [2]. The word "control" in this case includes the concepts of monitoring, recording, and in some cases automating relevant processes. The intention of the software or information technology that controls warehouse processes is the desired increase in productivity and efficiency, as well as cost-efficiency in the long run.

Being a software or information technology, it is ideal for a WMS to monitor the job order information, such as stock time, route, and stock status, and highlight potential faults. A WMS is a bridge between the operational and the strategic levels and allows dynamic order handling, which in turn can reduce costs and provide accurate data.

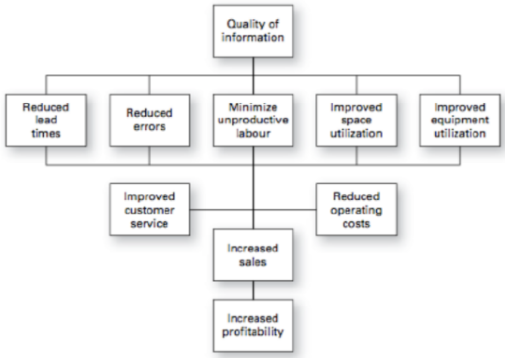

Fig. 2. The layered benefits of decent information systems.

With the gradual establishment of globalization over the past years, rapid technological developments have made complex planning throughout the supply chain necessary [2]. Demands from the customer standpoint are higher – all communication is expected to be digital, warehouses must be present in the online sphere, and queries must be handled efficiently [5]. An optimal WMS can be the appropriate response to such expectations, having many benefits that help improve the information quality, as Fig. 2 shows.

The selection of WMS is a delicate process. With many suppliers available on the market, industries and companies can vary from each other to the point where choosing the "wrong" supplier can turn out costly and problematic. There is not much literature available on the road to WMS choice recommended for all, regardless of industry or company. However, Richards [5] suggests the following process:

1. Establish a dedicated project team;
2. gain an overview of current processes. Eliminate redundant processes;
3. produce a list of key functions needed in the new system;
4. include future growth plans in your list;
5. pinpoint the WMS benefits to your company;
6. contact some vendors and choose a few experienced ones from your market sector;
7. visit company sites to observe operational changes that have occurred since the WMS system's implementation; and
8. write a return on investment (ROI) report.

C. Smart Warehouse Management (SWM)

A smart warehouse is an automated, unmanned, and paperless warehouse when conducting the operations of pickup, delivery, and bookkeeping [6]. There are substantial reasons today for companies to convert their traditional warehouses with human operators for all processes, to smart warehouses where processes are fulfilled differently. Liu et al. [6] list the following reasons:

- Traditional warehouse operation storage and fetching techniques are time-consuming;
- Using human operators is a waste of human labor resources;
- The use of paper and physical bookkeeping is not environmentally friendly. With the application of higher degrees of digitalization, significant levels of sustainability can be achieved.

The very definition of a smart warehouse incorporates well-known facets of Industry 4.0. The characterizations automated, unmanned, and paperless are possible only with the technologies brought forth by the fourth industrial revolution, which will be defined next.

D. Industry 4.0 – Concept and relevant technologies

From a scientific standpoint, literature shows that researchers have not yet agreed upon one unison definition of Industry 4.0. For this reason, it is deemed wise to include a few of those definitions here, to gain an understanding of the term that is as wholesome and comprehensive as possible.

Ojra [7] explains Industry 4.0 as a complex digitalized manufacturing, where the Internet of Things (IoT) is implemented within the manufacturing operation. Tay et al. [8] write: “A set of technological changes in manufacturing and sets out priorities of a coherent policy framework with the purpose of maintaining the global competitiveness.”

There is a particular interest in the definition that emphasizes Industry 4.0’s interconnection with the Internet of Things (IoT). Ojra [7] specifies that Industry 4.0 links products and services with each other and with their particular environments through the internet and other network services, enabling the development of new products or services so that several functions of products work autonomously without human intervention. The digitalization, which includes sensors and automated equipment, has reached another level with Industry 4.0. This elevated form is specific to technology being intertwined with the Internet. Ojra [7] makes it clear that without the inclusion of the Internet’s role in the definition and explanation, Industry 4.0’s true meaning is not presented sufficiently.

In literature, there are also slight variations in the definitions of Industry 4.0 technologies, and which technologies to include. However, there seems to be agreement on the most important ones, and what functions these technologies provide.

Fig. 3. Industry 4.0 technologies.

In these next definitions, we will follow the framework shown in Fig. 3.

1) Internet of Things (IoT)

The Internet of Things (IoT) is a category of network to connect anything to the Internet. This is based on stipulated protocols through information sensing equipment to conduct information exchange and communications in order to achieve smart recognitions, positioning, tracing, monitoring, and administration [9].

Today, the possibility for objects to sense surroundings, share information with each other, and communicate has allowed for a world that was unimaginable not too long ago. Such objects have become common in society: from phone applications analyzing our sleep quality and smartwatches counting our steps to smart assistants like Amazon’s Alexa [10] responding to human speech and requests. All these things are feasible due to the possibilities that exist with the utilization of IoT.

2) Smart sensors

Smart sensors are sensors integrated with objects. The purpose of a sensor is to enable the interconnection between physical and digital worlds, allowing for real-time information to be available always as well as being collected and processed. Depending on the industry or company, operators may want to utilize certain types of sensors, as different sensors can serve different purposes. Their primary job is to take measurements of relevant parameters as requested by the company in question [11].

3) Big Data Analytics

Big Data is the collection of large amounts of data, often collected from equipment such as sensors and computers, and it includes the evolution of data variety, data velocity, and data volume. Of particular interest to companies is data pattern, which is simplified in use through Big Data analytics [12].

Big data Analytics is the complex process of identifying common characteristics of unstructured data, used for examining hidden patterns, trends, and unknown correlations. It can be used for significantly optimizing warehouse processes and reducing costs through efficient analyses [12], [13].

Many companies face Big Data challenges today [14]. Such challenges are related to having access to vast amounts of data, but not knowing how to gain value from it. The technology that companies have access to today allows for the collection of data, but without the tools for big data processing and usage, the data may remain unstructured, leaving companies uncertain as to whether they should keep the data or have it removed [14].

The reason for Big Data Analysis to be of interest is the increasing amounts of data existing on a global scale, which companies and organizations wish to structure and gain benefits from. According to Eaton et al. [14], 35 zettabytes (ZB) of data were stored in the world as of the year 2020. The number was 800,000 petabytes (PB) just twenty years ago. With zetta meaning trillion and peta meaning billion, that constitutes an increase of almost 44 times since the year 2000. With some enterprises generating several terabytes of data per hour every day of the year, these already impressive numbers are expected to increase even more in the coming years [14].

4) Advanced Robotics

Advanced robotics refers to robotic vehicles equipped with technologies such as LIDAR (light detection and ranging), GPS (global positioning system), base station radio, laser sensors, and/or ultrasonic technologies. Robots of different sizes can be used for autonomous positioning and guiding. There are robots on the market today that can be very accurate during driving operations, down to centimeter level in precision. All the robots are controlled by intelligent scheduling systems and can achieve high quality, high efficiency, reduced accidents, and zero emissions. [15].

Recent technological advancements in the field of robotics have allowed new robots to have high-quality sensors, fast and cheap processors, open-source robotic software, less energy consumption, and high connectivity [13]. However, challenges in optimal robotic function are still present – the ability to process Big Data, deal with uncertainty, perception in the real environment and efficient cognitive decision-making are considered areas in which the robots still have room for improvement [16].

5) Cloud Computing

Cloud computing is a paradigm where information is permanently stored in servers on the Internet, and temporarily stashed on equipment such as desktops, computers, handhelds, sensors, monitors, and tablets [7]. Cloud computing offers clouds, which are virtualized resources, to provide service through the Internet, and is described as on-demand network access to a shared consortium of configurable manufacturing resources such as software tools, equipment, and capabilities [7].

In the use of the term “cloud”, the meaning is related to both cloud computing and cloud-based manufacturing and design [16]. Cloud manufacturing suggests a coordinated and linked production that provides manufacturing resources available on demand. Demand-based manufacturing uses the collection of distributed manufacturing resources to create reconfigurable cyber-physical manufacturing processes. The purpose is to improve effectiveness by reducing product lifecycle costs and to achieve ideal resource usage by dealing with variable-demand customer-focused work. Cloud-based design and manufacturing operations show the integrated and collective product development models based on innovation through social networking and crowd-sourcing platforms [16].

6) Additive Manufacturing (AM)

Additive manufacturing, informally known as 3D printing, is a manufacturing technology in which an item is designed digitally and then printed as a three-dimensional physical object using a layer-by-layer material build-up approach [17].

In a warehouse setting, the idea of additive manufacturing is interesting. It opens for the possibility of a company maintaining one or several 3D printers and producing parts on demand themselves, rather than having to order from a supplier. With the high rate of technological development in the field, companies in need of items made of steel and titanium can purchase 3D printers capable of printing such parts, in comparison to earlier versions of 3D printers which could only print using carbon and plastic [17].

7) Augmented Reality

Augmented reality (AR) can, according to Wu et al. [18], be defined in two ways: one broad approach and one limited approach. In the broad approach, augmented reality refers to augmenting real-world feedback to an operator with simulated cues. The limited approach focuses on the substantial aspect and refers to augmented reality as a form of virtual reality where a participant has a transparent display mounted on their head, and this display allows for a clear view of the real world [18]. Wu et al. [18] also refer to a definition by Ronald T. Azuma from 1997, which states that augmented reality is a system designed to fulfill three features: a combination of virtual and real worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The information provided by such a combination can help a user perform several tasks and is considered highly useful in the industry [16].

8) Location Detection

Location information plays an important role in several wireless sensor network applications [19]. Location-based technologies can track and trace items, products, and assets throughout entire value chains by gathering and transferring data without human intervention. Such technologies are often sensors of some sort; particularly smart sensors, as reviewed in section 2). Location data is among the most important information they can provide, in addition to vibration, temperature, humidity, arriving time, speed, and vehicle status, in an automated and well-timed way that permits early decisions and removes manual activities that are error-prone [16].

III. The Energy Industry and SWM

The energy industry consists of the production and storage of fossil fuels, electrical power, nuclear power, and renewable energy. Supplying energy to a worldwide population of billions daily, the energy industry is inevitable to humans. However, the level of sustainability in energy production is much debated. For the industry to meet the requirements for sustainability as stated in the United Nations Sustainable Development Goals, much work remains [20].

The magnitude of the energy industry’s daily production requires large and complex facilities. Installations such as oil platforms consist of components made of durable materials meant to last for several years. However, some of the components are made of materials that are exposed to corrosion, erosion, and short life cycles. This results in the costly yet necessary action of regular maintenance. Maintenance often sees old and worn components replaced with new ones. Such new components are usually placed in the company’s warehouse before potential usage [21].

This results in large, expensive, and sometimes over-filled warehouses for energy companies. Since the companies produce energy at a rapid pace for a population that is dependent on its usage daily, the production systems must always run smoothly. If any of the systems at the facility needs maintenance to the point where production must stop, companies maintain spare parts and components at their warehouses, to ensure a quick maintenance process. The companies look to avoid long production halts due to consumer and financial considerations.

Aspects of the energy industry such as large spare parts, consistent production runs, safety requirements for production, and constant needs for maintenance have led to the industry not yet fully utilizing the potential for digitalization and optimization in their warehouse processes. While industries such as e-commerce have made changes to their warehouse operations by including Industry 4.0 technologies to a large extent, the energy industry's operations largely remain as they have been for the past decades [22].

Due to the specifications of the energy industry's daily operations, a potential SWM and usage of Industry 4.0 technologies would have to be tailored to energy companies' needs. Strategies such as higher digitalization and fewer human workers in the warehouse can be adopted from industries such as e-commerce, but the specifics would be different: a robot in an energy company warehouse would likely need to carry more weight and have a larger surface area than a robot in an e-commerce warehouse.

IV. Specification Criteria For SWM in the Energy Industry

Warehouse operation in energy companies may often be divided into the following activities [5]:

TABLE 1. WAREHOUSE ACTIVITIES IN THE ENERGY INDUSTRY.

Warehouse activities	Description
Receiving	Receiving of goods as they arrive in the warehouse from manufacturer or supplier.
Put-Away	Transport and placing of received goods in the warehouse. This placement is normally according to a plan and/or structure.
Storage	The exact placing of goods in the warehouse over time. The placement of goods in shelves or on pallets often follows a pattern (item type, life cycle, etc.)
Order picking	The consolidation of a set quantity of goods, for the purpose of delivering to installation or plant.
Shipping	The process of goods being sent from the warehouse to the installation or plant.

The overviews obtained from Sections II and III, along with knowledge of warehouse activities as presented in Table 1, allow for criteria to be suggested for SWM implementation in the energy industry. For increased sustainability and optimization and decreased warehouse and supply chain expenditure, criteria specific to the energy industry must be developed for implementation work to start. In Table 2, we present five specification criteria for large scale energy production companies to root their SWM strategies in for the process of SWM implementation to succeed.

TABLE 2. SPECIFICATION CRITERIA FOR SWM IMPLEMENTATION IN THE ENERGY INDUSTRY.

Specification criteria	Elaboration
Level of automation	The availability of Industry 4.0 technologies gives decision makers an opportunity, in combination with their warehouse needs, to determine what level of automation is desired for optimal operation
Determine which I4.0 technologies to use	Once the desired/needed level of automation is determined, the specific technologies required to achieve this level of automation should be chosen
Additive manufacturing usage	One of the I4.0 technologies, additive manufacturing, should be considered specifically. The potential that lies in AM is of interest to the energy industry for sustainable, operational, and financial reasons
Balance between onshore and offshore	A balance between contents of spare parts storages onshore and offshore should be established, for optimal sustainability
Criticality of spare parts	When creating an optimal SWM setup, energy production companies should take the criticality of spare parts into consideration. This would be to ensure a balance between onshore and offshore warehouse setups

Firstly, an approximated level of automation should be determined. Taking into consideration the five warehouse activities explained above, an energy company should be able to create an overview of which tasks in each activity they could automate. Examples of such tasks could be lifting heavy spare parts into shelves during put-away, and transportation of equipment from the storage area to the shipping area.

It would also be during this time that the warehouse workers and their managers decide what purposes they would have for the automation of certain processes. It would be of particular importance that the warehouse workers contribute with their experiences and provide feedback on automation tasks that could ease their physical workload and thereby contribute to a safer and healthier environment.

Secondly, it would be a natural consideration to then determine which Industry 4.0 technologies could be used to help with the automation levels decided in the previous step. Dependent on the warehouse in question, the use of the various technologies could differ.

During this step, the item types stored in the warehouse would in large part drive the final decision on technology usage. The item sizes, materials, weights, and chemical properties should be used as the baseline considerations when gathering information on Industry 4.0 technologies and the suppliers who could provide suitable equipment.

Thirdly, additive manufacturing is a technology the energy company should consider closely. If utilized well, the company could benefit greatly from additive manufacturing due to cost savings, decreased levels of warehouse space necessity, and sustainable operation. However, the process towards achieving this is intricate.

The equipment, parts, and tools used on energy production installations are normally produced and supplied by various manufacturers. If an energy company decided to produce some of these components through additive manufacturing, it would be necessary to consider copyrights and legal certifications. Some spare parts or components could be patented by the original manufacturer, which would complicate an energy company's ability to manufacture these at leisure. For this step, a legal team in collaboration with an engineering team would be of use for the energy company, to determine the parts needed for manufacturing as well as the possibilities to produce these through additive manufacturing.

Fourthly, energy companies should consider the balance between the onshore and offshore warehouses. Determining where to store parts and components would be dependent on their criticality, size, and other properties. In addition, companies would have to consider the implications of placing additive manufacturing printers offshore, for quick access to necessary spare parts. This balance would be of great significance to the sustainability aspect, as high amounts of transportation of spare parts and components from onshore warehouse to offshore warehouse would produce notable amounts of carbon emissions.

Fifthly, the criticality of spare parts would be an important consideration in an energy company's SWM composition. Onshore or offshore storage, additive manufacturing, and registration of spare parts and components in an IoT system should all relate to a part's criticality. A spare part of high criticality and importance to production would be of different considerations than one whose criticality and importance is low. Energy companies have overviews of such classifications and are aware of each part's importance to production and storage amounts. These overviews should be used extensively to achieve an optimal SWM composition.

V. Conclusion

As Industry 4.0 technologies have rapidly changed industries and societies, several manufacturing industries have taken to utilize their full potential in their production processes. Some industries, such as e-commerce, have also made great use of such technologies in various supply chain processes like warehousing. However, the energy industry as a large-scale production industry is yet to adapt to digitalization as the main tool for optimizing warehouse activities and the overall process. Being a different industry to many others regarding production, safety guidelines, and tools, energy companies would require a set of specification criteria for SWM usage for successful implementation. If done according to such specification criteria, successful implementation could lead energy companies to decreased costs, less storage space usage in warehouses, fewer warehouse employees, and time savings.

VI. Future Work

In future research, it is suggested to simulate a typical energy company's warehouse in combination with Industry 4.0 technologies to observe the effect of such optimization work. Practical research that builds upon theoretical reviews such as this paper would contribute to further understanding exactly how energy companies could fully utilize digitalization to improve their supply chain activities.

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References

[1] Javaid, M., Haleem, A., Singh, R.P., Rab, S., Suman, R, *Upgrading the manufacturing sector via applications of Industrial Internet of Things (IIoT),* Sensors International, Volume 2, 2021, 100129, ISSN 2666-3511, https://doi.org/10.1016/j.sintl.2021.100129.

[2] Atieh et al., *Performance improvement of inventory management system processes by an automated warehouse management system*, Procedia CIRP 41 (2016) 568-572, 2016.

[3] Khan, N.B., 2020. *Smart Warehouse Management - Design of Onshore Warehouse for JC Equinor*. UiT The Arctic University of Norway. MSc. thesis report.

[4] Eira, A.M., 2020. *Smart Warehouse Management - Design of Offshore Warehouse for JC Equinor*. UiT The Arctic University of Norway. MSc. thesis report.

[5] Richards, G., *Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse*, 2nd Edition, published by Kogan Page Limited, 2014.

[6] Liu, X., Cao, J., Yang, Y., Jiang, S., *CPS-based Smart Warehouse for Industry 4.0: A Survey of the Underlying Technologies*, published in Computers, 7(1), 13, 2018.

[7] Ojra, A., *Revisiting Industry 4.0: A New Definition*, published by the Proceedings of the 2018 Computing Conference, Volume 1, Intelligent Computing, 2019, pp. 1156-1162.

[8] Tay, S.I., Chuan, L.T., Aziati, A.H.N., Ahmad, A.N.A., *An Overview of Industry 4.0: Definition, Components, and Government Initiatives*, published by Journal in Advanced Research in Dynamical and Control Systems, Vol. 10, 14-Special Issue, 2018.

[9] Patel, K., Patel, S., "*Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges*," published in International Journal of Engineering Science and Computing, Volume 6 Issue 5, 2016, pp. 6122-6131.

[10] Amazon, *Alexa User Guide: Learn What Alexa Can Do,* https://www.amazon.com/b?ie=UTF8&node=17934671011, 2020. Accessed 29th April 2020.

[11] Schütze, A., Helwig, N., Schneider, T., *Sensors 4.0 – smart sensors and measurement technology enable Industry 4.0*, published in Journal of Sensors and Sensor Systems; Gottingen Vol. 7 Iss. 1, 2018, pp. 359-371.

[12] Cao, Y., Lee, C.K.M., Ng, K.H., "Big Data Analytics for Predictive Maintenance Strategies", *Supply Chain Management in the Big Data Era,* edited by Chan et al., published by IGI Global, 2017, pp. 50-74.

[13] Bouchti, A.E., Ghaouta. A., Okar, C., *Big Data Analytics Adoption in Warehouse Management: A Systematic Review*, published by IEEE ICTMOD, 2018, pp. 86-93.

[14] Eaton, C., Deutsch, T., Deroos, D., Lapis, G., "What is Big Data? Hint: You're a Part of It Every Day", *Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data*, 1st ed., published by McGraw-Hill, 2012, pp. 3-12.

[15] Chen, Z., Ming, X., Zhang, X., *Integration of AI Technologies and Logistics Robots in Unmanned Port: A Framework and Application*, published by Proceedings of ICRAI, 2018, pp. 82-86.

[16] Ustundag, A., Cevickan, E., "A Conceptual Framework for Industry 4.0", *Industry 4.0: Managing the Digital Transformation*, published by Springer International Publishing, 2018, pp. 3-23.

[17] Duda, T., Raghavan, L.V., *3D Metal Printing Technology*, published in IFAC-PapersOnLine49(29), 2016, pp. 103-110.

[18] Wu, H.-K., Lee, S.W.-Y., Chang, H.-Y., Liang, J.-C., *Current status, opportunities and challenges of augmented reality in education*, published in Computers and Education 62(2013), 2013, pp. 41-49.

[19] Shit, R.C., Sharma, S., Puthal, D., Zomaya, A.Y., *Location of Things (LoT): A Review and Taxonomy of Sensors Localization in IoT Infrastructure*, published in IEEE Communications Surveys & Tutorials Volume 20 Issue 3, 2018, pp. 2028-2061.

[20] Bathrinath, S., Abuthakir, N., Koppiahraj, K., Saravanasankar, S., Rajpradeesh, T., Manikandan, R., *An initiative towards sustainability in the petroleum industry: A review*, published in Materials Today: Proceedings 46 (2021), pp. 7798-7802.

[21] Zhen, X., Han, Y., Huang, Y., *Optimization of preventive maintenance intervals integrating risk and cost for safety critical barriers on offshore petroleum installations*, published in Process Safety and Environmental Protection 152 (2021), pp. 230-239.

[22] Bartolini, M., Bottani, E., Grosse, E.H., *Green warehousing: Systematic literature review and bibliometric analysis*, published in Journal of Cleaner Production 226 (2019), pp. 242–258.