Acta of Turin Polytechnic University in Tashkent, 2023, 30, 7-11
Published Online September 2023 in Acta TTPU (http://www.acta.polito.uz/)

PERSPECTIVES AND CHALLENGES OF ASSEMBLY 4.0 TECHNOLOGIES FOR FINAL AUTOMOTIVE ASSEMBLY OPERATIONS IN UZBEKISTAN

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Abstract– Nowadays, manufacturing is moving to the next phase of digitalization through the "Assembly 4.0" concept. This new paradigm is supported by innovative technologies such as the Internet of Things, assembly control systems, augmented reality, system simulation, system integration, and other advanced digitalization technologies. These advanced technologies allow optimizing final automotive assembly systems to achieve greater flexibility and efficiency in production processes, generate a value-added proposition for their customers, and provide a timely response to their market needs. However, despite the potential benefits of Assembly 4.0, organizations face common obstacles and challenges in adopting new technologies and successfully implementing them in their assembly operations. Therefore, this article identifies and analyzes the problems that may hinder the implementation of Assembly 4.0 technologies in final automotive assembly organizations and gives practical recommendations for their elimination.

Key words– Assembly 4.0, digitalization, manufacturing, developing country

I Introduction

The automobile sector in the Republic of Uzbekistan is currently expanding rapidly, increasing exports, luring foreign investment, and modernizing manufacturing procedures dramatically in terms of technology. The automobile industry includes dozens of large and medium-sized enterprises, including companies with foreign participation in the automotive industry and manufacturers of consumer goods. Figure 1 shows passenger car production volume in Uzbekistan between 1999 and 2020. It shows that passenger car production has increased over the years, but some have decreased due to the economic crisis in the world. Nevertheless, it can be seen that it started to increase in recent years, and according to Presential Degree No. PQ-4397 of July 18, 2019, the passenger car production volume must reach 350 000 units per year until the end of 2023. To cope with these requirements, the final automotive assembly systems must be integrated with advanced technologies to increase the production volume and flexibility of the manufacturing systems.

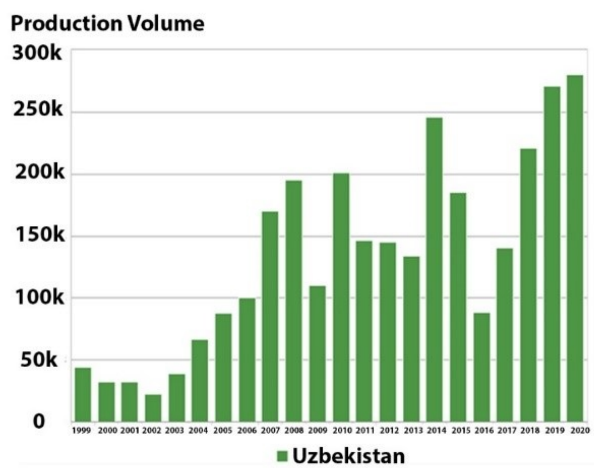

Fig. 1: The passenger car production volume in Uzbekistan

However, today‘s final automotive assembly systems in Uzbekistan have to manage hundreds of different product mixes, distinguished by different assembly cycles, as well as thousands of different parts, hundreds of tools and, equipment, and several workers [1]. Besides, final automotive assembly processes struggle with several challenges, such as the growing complexity of their operations and value chain, cost requirements, increasing customer demands for product quality, time to market, and personal customization [2, 3]. The literature analyses indicate the importance of assembly and the potential savings that can be achieved by the efficient deployment of advanced Assembly 4.0 technologies and system changes. The optimal design and management of these system features are crucial to achieving final automotive assembly operation efficiency, product quality, and customer satisfaction. In response to these requirements, assembly systems are being managed with several Lean Principles, like just-in-time (JIT) to deal with market demand [4, 5]. Moreover, to respond to frequent market changes and reduce time to market, - flexible, adaptable, changeable and reconfigurable assembly system concepts must be developed. Therefore, in this article, the authors identify and analyze the problems that may hinder the implementation of Assembly 4.0 technologies in final automotive assembly organizations and give practical recommendations for their elimination.

To deal with this problem, this paper is organized as follows: Section 2 presents the research approach and its underlying rationale in detail; Section 3 gives a brief review of the of Assembly 4.0" technologies and vision; and Section 4 outlines the challenges and perspectives of the "Assembly 4.0" technologies for final automotive assembly systems. Finally, Section 5 concludes the study with insightful perspectives on the results and findings.

II THE METHODOLOGY

The approach followed in this study includes a System Development Methodology, to get a systematic background on the Assembly 4.0 technologies as shown in Figure 2.

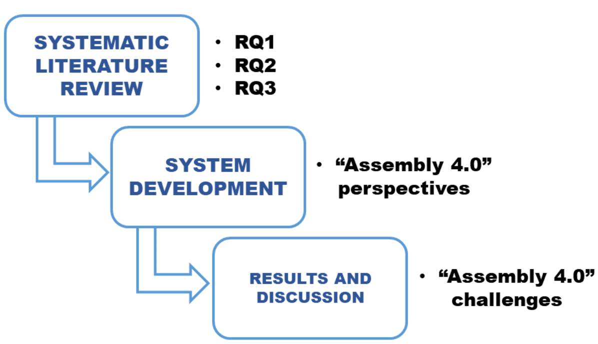

Fig. 2: System Development Methodology

To fulfill the scope of the research, the following three-point methodology was implemented: A systematic literature review (SLR) study of "Assembly 4.0", to understand its practical aspects and requirements in final automotive assembly. Based on the outcomes of SLR, the conceptual framework of "Assembly 4.0 was highlighted for final automotive assembly operations.

Then we defined the perspectives of the Assembly 4.0 technologies. In the results and discussion phase, it depicts the existing challenges of Assembly 4.0 technologies on final automotive assembly systems and gives practical recommendations for their elimination. In this paper, the authors answer the following research questions:

RQ1: What are the key "Assembly 4.0" enabling technologies and features proposed to be integrated into final automotive assembly systems?

RQ2: What are the perspectives of Assembly 4.0 technologies when integrated into final automotive assembly systems?

RQ3: What are the adoption challenges of Assembly 4.0 technologies in the final automotive assembly systems organization?

III STATE OF ART

As part of a high-tech strategy plan for 2020, the German government initially announced the "Industry 4.0" paradigm in 2011. It refers to the fourth industrial revolution. [8]. This industrial revolutions are depicted in Figure 3 below, together with the related cutting-edge technology.

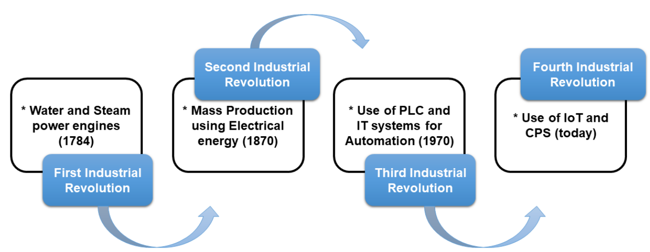

Fig. 3: Development four industrial revolutions

As "Assembly 4.0" is a rapidly expanding field of study in system engineering, it makes sense to analyze the idea of assembly under the "Industry 4.0" period with this investigation's primary focus being the design and administration of assembly systems. [13, 14].

Despite, that the terms “Assembly System 4.0” and “Smart Assembly Stations” are novel and evolving concepts, which remain abstract phenomenon, [6] highlighted the advanced assembly technologies. In addition, they also concluded that integrated IT systems are a key element of design smart and digital manufacturing systems. Alternatively, [14] on their keynote paper, divided the main design principles of the efficient “Assembly System 4.0” into four layers, namely into connectivity, information, knowledge, and smart layers. In addition, they proposed a future framework of the assembly paradigms as an effect of the integration with the “Industry 4.0” technologies. However, case uses are needed to quantify the different impacting variables for validating the proposed framework. The later one [13] developed a general framework of assembly system design in the “Industry 4.0” era using Assembly System (AS) design method, which is illustrated in the corresponding Figure 4. This illustrates the vision of future assembly systems as assisted technologies for human operator to increase the product quality, production volume and decrease production time.

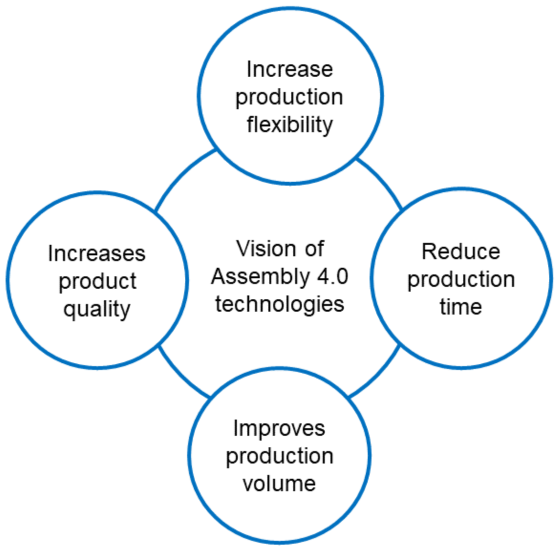

Fig. 4: Main characteristics of assembly system 4.0

Improves ergonomics: According to systematic literature review [13], technologies of the aided assembly boost the handling and joining tasks by different technologies decreasing their continuity and securing safe and ergonomic work condition. For instance, when a product arrives at an assembly station, assisted handling equipment, such as a tightening system, automatically directs the components to handle from the storage positions for the operator while taking the finished product's assembly and the best picking sequence that reduces worker execution time into consideration. Alternately, augmented reality technologies, which direct the sequencing of the jobs to finish an assembly task while taking into account the client personalisation, could assist the operator during assembly processes. Light robots are another example of how Assembly 4.0 advanced technology helps the operators during assembly operations. They adjust their layout automatically and in real-time to best suit the anthropometric characteristics of the assembly task and the worker. Additionally, collaborative robots offer operators a synthetic force to perform risky and uncomfortable activities, lowering the risk of damage.

Increase flexibility: An intelligent storage management system is another Assembly 4.0 technology that has been approved. These systems have an integrated storage system for the assembly station that tracks the inventory level and automatically notifies the supply chain department when it needs to be refilled [13]. Because of the system's adaptability, unexpected usage rates do not result in stock-outs. Additionally, this system might be linked to the supply chain division in order to transfer the out-of-date raw materials used in the assembly process, eliminating needless orders, and maintaining the just-in-time principles of the system. The inventory level at the assembly station eventually stays as low as it can give the manufacturing cost regulations.

Reduce assembly time: A self-configured workstation is the next emerging technology that Assembly 4.0 is proposing. With the assembly product and the designated operator for the assembly process taken into consideration, this technology independently modifies the layout dimensions of the workstation. The assembly station construction has integrated sensors and actuators that allow the shelves and workstation dimensions to be adjusted automatically. By reducing handling and joining times, this technology hopes to provide an ergonomic working environment.

Increase operation efficiency: In order to assure total product and process detectability, the resources have smart sensors implanted into the assembly system. Each work is decentralized and detects potential errors or disobedience in real-time [13]. This results in an improvement in product quality by replacing statistical fault analysis with unique item. Additionally, operator tasks are observed as they are carried out to course the built pieces and keep an eye on task completion.

IV RESULTS AND DISCUSSION

In order to meet the expectations of the contemporary market, vehicle manufacturers in Uzbekistan must digitize and intellectualize their assembly operations as they go from mass manufacturing to personal production. With the use of cyber-physical products and human-machine interfaces, assembly 4.0 technologies integrate the digital and physical worlds, increasing the efficiency of assembly processes. Through smart machines, smart sensors, and other computer-based technologies, Assembly 4.0 will offer individualized and effective production at a fair price. The vehicle manufacturing companies in our nation will need to create clearly defined strategies for transforming their assembly processes from analogue to digital and human-centered. Despite the many benefits of Assembly 4.0 technologies, adoption of these new cutting-edge technologies and their influence on current assembly procedures are hampered by a number of issues. It is crucial to identify the obstacles to the adoption of Assembly 4.0 technologies and to keep track of how they interact in order to solve these challenges. The auto industry in our nation needs to be aware of potential issues with the digital transformation process and be equipped to deal with them. We can benefit from the practical research of several scientists who have performed research in this area as well as the experiences of international businesses for this purpose. We can identify a number of obstacles that may exist in assembly systems for the adoption of Assembly 4.0 after studying and analyzing them, including cyber security, an unskilled work force, and excessive implementation costs. Below are the identified challenges and their description.

Table 1 represents the existing challenges of Assembly 4.0 technologies for adoption in automotive assembly operations in Uzbekistan.

Challenges	**Description**
Complexity of value chain integration	IoT (internet of things) integration is a big problem in the assembly 4.0 environment as creating infrastructure between cyber - physical technologies and systems is difficult task.
Lack of relevant skills in the workforce	The lack of digital skills is a major challenge in the successful implementation of Assembly 4.0.
High investment necessity	Difficulties in introducing new technologies in their production environment due to the lack of resources.
Unemployment level	Ongoing technological progress and automation are changing the structure of existing jobs, creating challenges for labor markets.
Abstraction of economic efficiency	The economic benefits of capital investments in the introduction of Assembly 4.0 technologies have not been clearly assessed.

TABLE 1: CHALLENGES OF ASSEMBLY 4.0 TECHNOLOGIES FOR AUTOMOTIVE ASSEMBLY IN UZBEKISTAN

The table shows that "Lack of Value chain integration" is the most important root or major barrier to the adoption of Assembly 4.0 technologies in final automotive assembly operation. The uncertainty about economic benefits and lack of necessary skills in the workforce can be caused by a lack of infrastructure to implement Assembly 4.0. Inadequate skills of employees and lack of clarity about economic benefits can lead to difficulties in value chain integration between assembly stations units and other organizational department of the company. It can be seen from the that “high investment necessity” is third barrier of adoption Assembly 4.0 technologies. In addition, "unemployment level" is the fourth level. Finally, abstraction efficiency of Assembly 4.0 technologies can be considered as last challenges. In order to successfully implement Assembly 4.0 technologies, automotive manufacturing organizations in Uzbekistan must have sufficient and capable technological infrastructure in their production facilities, such as reliable high-speed connectivity, uninterrupted power supply, and IoT architecture for cyber-physical systems. This is the most important factor that plays an important role in the successful implementation of Assembly 4.0 technologies into assembly stations. Unless this barrier is alleviated, it may not be effective to focus on alleviating other barriers. Next, it is necessary to improve the technical skills of employees in these emerging technologies, as well as to improve the entire value chain network of suppliers and partners through networking and rapid connectivity. Organizations should evaluate the economic benefits of using these technologies in assembly stations. A poor value chain can lead to high investments, cybersecurity issues, and challenges in data quality and management. Therefore, automotive manufacturers must take necessary measures to overcome these obstacles, as they can lead to ineffective implementation of Assembly 4.0 technologies.

V CONCLUSION

In this paper, the authors identified and analyzed the problems that may hinder the implementation of Assembly 4.0 technologies in final automotive assembly organizations in Uzbekistan and gives practical recommendations for their elimination.

The findings indicate that in order for Assembly 4.0 technologies to be properly adopted by the industry, the companies must give it access to the required digital infrastructure. The financial advantages of Assembly 4.0 to industry must be shown by academic institutions and research groups. To increase trust in the automobile sector, it is desirable to create pilot initiatives. Another significant and essential barrier that requires immediate eradication is a lack of the necessary workforce skills. Therefore, universities should develop training programs in various aspects such as sensor technology, cyber security, machine-machine-human integration, data analytics, business intelligence, collaborative robotics, CPS, IoT, etc

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