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DRIVING INNOVATION: UNVEILING THE TRANSFORMATIVE IMPACT OF INDUSTRY 4.0 ON THE AUTOMOTIVE SECTOR

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ABSTRACT

Industry 4.0 is a concept that aims to create a global network architecture for connecting devices to the cyberphysical environment. This work is done to understand the upcoming perspectives of IoT technology in the automotive industry and its impact on the automotive sector. This paper discusses on the challenges that are required to meet the necessities in the logistics 4.0 era. Detailed examination of the advantages and challenges that connected with the use of Industry 4.0 applications were discussed with identifying the present and upcoming technological changes in the automobile industry. Furthermore, this study is also focused on assessing various connectivity types involved and connected them with the connected applications to reveal technical changes for upcoming automotive advancements.

Keywords: Industry 4.0, Logistics, Technologies, Data, Manufacturing, And Efficiency.

I. INTRODUCTION

The Automotive Industries are undergoing tremendous transformation nowadays. It has turn out to be a typical element and the majority of those adjustments are due to the have an impact on of Industry 4.0 and its attributes. Industry 4.0 has given opportunities of digital transformations within the Automotive Sector. Industry 4.0 is anticipated to bring about a concept that grows in manufacturing which will be of great help to the industry concentrate on main functional pillars like technologies and processes. Industry 4.0 will create high-quality trends that are anticipated to play a major role inside the automotive industry's change, viz. Cyber security, Cloud computing and large Data analytics. Automotive manufacturers who have no internal competencies can mostly work with Cloud-based ecosystem people to increase their opportunities in aspects of managerial services, reduction in investments on licensing fees. Analysis of the big Data marks the start of increased potential for automotive industry to meet the current challenges and to look ahead customer expectations. This approach gives automotive manufacturers a look into upcoming trends which will help them to create research and guide them in investments, when avoiding risk related losses. By connecting all stakeholders who can understand interdependencies, process cycle times and the flow of materials. For several vehicle manufacturers, they consider product differentiation to be vital, and they are focused on consumer feedbacks on social networking sites. Access to predictable analysis that supports real-time data helps automotive manufacturers to identify the issues before the situations happen, that helps to lower inventory expenses, and reduction in capital needs. Furthermore, this study is also focused on assessing various connectivity types involved and connected them with the connected applications to reveal technical changes for upcoming automotive advancement. This work is done to shape the upcoming perspectives of Industry 4.0 technology in the automotive industry and its impact on the automotive industry/ community. Let us now see how Industry 4.0 impacts the automotive sector.

II. LITERATURE REVIEW

Industry 4.0 implications in logistics: an overview:

Barreto et al (2017). This paper discusses on the challenges that are required to meet the necessities in the logistics 4.0 era. It explains the numerous features of Cyber bodily systems together with human assist to help and help in optimizing inbound and outbound logistics, which is supported through wise systems. The essential information is provided to the intelligent systems, which are embedded in the database that are shared through Internet of Things (IoT) systems. To make the supply chain smarter, it is transformed digitally by using the intelligent and the cooperative systems that will make each stage in the supply chain more transparent and efficient.

Assembly system design in the industry 4.0 era: a general framework:

Bortolini, M.et al (2017). This paper explains that Assembly system design is a process which is aimed to make efficient strategies that would help in improving in the scheduling and the assembly line balancing. Along with that it also expands relevant dimensions in the study of material feeding, and equipment selection. The prominent development in the 21st century in the industry 4.0 is enabling a protected and quick communication regarding tools, workers, machines and customers in real-time through internet with the help of actuators and sensors. They mentioned six characteristics of I 4.0, such as assembly control system, configured workstation layout, aided assembly line, late customization, traceability and intelligent storage system.

Logistics 4.0 and supply chain 4.0 in the automotive industry:

Markov, K., & Vitliemov, P. (2020). According to this paper, Blockchain technology and the visibility of the production process (Internet functioning along with the assembly line) are the essential values to the supply chain and the logistics. But these technologies also face problems in the form of faulty data and cybersecurity. The benefits that are received from the Industry 4.0 technologies are reductions in delays and costs, and improvement in performance. Around 20% of delays were reduced in the logistics process by implementing autonomous vehicle in the automotive plants. But there were some challenges faced in using the autonomous vehicles like safety regulations and higher costs for implementing the technology.

The role of wearable devices in meeting the needs of cloud manufacturing: A case study:

Helo, P & Hao, Y .(2017). Virtual Manufacturing plays a vital role in the Industrial 4.0 ecosystem. It is considered as one of the important tools of I4.0. and (Kusiak, A.2016) The idea of Virtual manufacturing in the beginning stages were to designing tools and testing purposes but due to various development over the years it went into production phase as well. It contains diversity of tools starting from computer aided design systems to rapid prototyping and other elements like VR and AR technologies. One of the biggest advantage of VM is that it helps in large of energy saving during pre-development stages especially in manufacturing stages. Since it can be used in designing tools in virtual environment most part of the pre-development can be covered or achieved . In product manufacturing stage , VM can be used numerous times in modelling(Masood, T.& Egger, J.2017).

Implementation of augmented reality in welding processes:

Stadnicka . D & Antonelli .D ,(2014). 3D printing technology has been used to develop some innovative products in the field of automobile industries . 3D printing has various applications in different stages including rapid prototyping , short runs and etc . . Because in metal tooling if one particular design is not possible the company cannot drop its order , but whereas in 3D printing it is possible to create new parts in an instantaneous manner. Hence it saves large amount of money apart from saving time and manpower .The manufacturing of tooling components plays a vital role in the field of automobile industry. On an average millions of dollars have been spent on these tooling components and it is noted that designing and manufacturing of these components results in significant amount of percentage in the overall productions costs. (Masood, T.& Egger, J.2017) Companies which follows or integrates 3D printing concept within their manufacturing ecosystem are able to decrease the cycle time by 75% along with improved part quality and reduction in overall production costs. The advantages of these plastics is they are light in weight and when it comes to lifecycle of the product it has longer durability compared to the traditional materials. They provide same of quality for the user. 3D printing has numerous advantages that help companies win over projects and proposals in the industry it gives the companies a competitive advantage over their rivals . Because with the help of 3D printing it is possible to reduce the time for producing a part as well as cost per unit can be reduced. It is next-gen technology with high potential to change the manufacturing sector over the decades.

A survey of product lifecycle models: towards complex products and service offers:

Klaus-Dieter Thoben et al2016). Global manufacturing is undergoing a fourth industrial revolution. It is based on the incorporation of IoT into manufacturing organisations, resulting in vertical and horizontal connected production systems. The factories that result are able to assembly purchaser needs in small lot sizes whilst incorporating innovation and automation. Policymakers in some nations have set up research and era switch plans to assist the enterprise in this conversion method and enhance worldwide competitiveness. The most important cognizance of those efforts is on cyber-bodily structures, which are physical entities (which includes machines, cars, and paintings gadgets) which can be prepared with technologies. They are distinguished by means of their ability to acquire facts about themselves and their environment, interpret and examine that facts and communicate with other structures and take movement.

Framework for the packaging supply chain of an automotive engine company:

Voroskoi, K & Borocoz , P.(2016). The effects of packaging are particularly essential to automotive manufacturing organisations, with an emphasis on cost effectiveness and environmental consciousness. In terms of the delivery of whole automotive engines, the packaging is not a well researched issue in the literature. However, because players sometimes have similar objectives and considerations, package selection and the corresponding development process in engine manufacture are among the most important aspects of the vast automotive sector.

As a result, decision-making and tactics for employing various packaging techniques and systems can be rather diverse. The reason for this is because each automobile manufacturer basically builds its own engines and transfers them to assembly plants around the world. To use, take-back, and recover their packaging, these organisations frequently adopt comparable logistical rules and supply systems. This is being pushed by company strategies as well as the need to decrease costs and improve supply chain efficiency.

Cobots for the automobile assembly line :

Michael Peshkin & Ed Colgate (1999). In this paper the authors analyze how implementation of collaborative robots in industrial assembly has improved productivity and contributed to other benefits. The automobile assembly lines have completely been transformed into highly efficient systems by introducing these robots. Collaborative robots are designed to work alongside humans by assisting in menial tasks such as loading and unloading components and assembling parts (Jim Wells, 1999). The paper goes into detail on how worker safety has greatly improved by using robots as repetitive tasks are automated and error occurrences are greatly reduced. This allows operators to focus on other tasks that require human insight. Cobots are highly adaptable and able to replicate human hand movements with improved dexterity and bring an innovative edge towards the assembly line (Tom Pearson, 1999). The paper suggests a hybrid automation where automation and human intuition is combined to improve productivity and efficiency in the industry.

Flexible and assistive quality checks with industrial robots

Martijn Rooker & Michael Hofmann (2014). This paper looks into how quality control and inspections can be performed by robotic systems using Industry 4.0 technologies. Quality control and maintenance is vital for any industries and robots powered with vision based sensor systems are at the forefront when it comes to assuring efficiency (Andreas Pichler 2014). Technology has evolved to a great extent that even minute changes in surface area of parts can be detected which greatly exceed the capabilities of human operators (Gerald Fritz 2014). The robots can easily be reconfigured to determine quality of different parts thereby ensuring a flexibly quality measurement system.

Smart automated guided vehicles for manufacturing in the context of Industry 4.0:

Ray Y Zhong, (2018). This paper discusses in detail on how automated guided vehicles help in the transportation of raw materials in manufacturing process and offers insight on how they function. With emergence of smart factories due to rapid developments in Industry 4.0 technology, Automated guided vehicles are devices which are deployed in every smart factory to freely transport materials without human intervention (Mauludin Nawi 2018). There are fixed and flexible guided systems in industries. Fixed systems work like a line follower and follow the path laid out by magnetic or optic tapes. Fixed route systems are common and less expensive but in order to change routes tapes need to be applied again making this a time consuming process with little flexibility. Flexible route systems make use of GPS and RFID technology to navigate freely around the shop floor and collision detectors are placed to avoid accidents. (R.Y Zhong, 2018). Flexible systems implement computer reinforced learning algorithms to localize the surrounding environment and plot a feasible path for the machine to traverse along in the shop floor. These devices are expensive but their usefulness is becoming well known as lot of industries are implementing these smart systems which will raise the standards of quality and operational excellence in the future.

Theoreticalconcept	Impact on automotive industry
Cyber-physicalsystems (CPS)	Integration of physical and digital systems, enabling real-time data collection and control
Internet of Things (IoT)	Connectivity of devices and sensors, enablingdata sharing and communication
Big data andanalytics	Ability to collect, store, and analyze large volumesof data
Cloud computing	Provisioning of computing resources on demand
Artificial intelligence (AI)	Development of intelligent systems capable oflearning and decision-making

Process and assembly development:

Industry 4.0 in mixed assembly line of automobile industry:

(Lixiong Gong et al ., 2019)

The mixed assembly line is a principle based on the flexible manufacturing implemented in the assembly line production. In this process, different products are mixed and are assembled continuously, which is the main reason for applying this concept in automobile industry. Using this kind of assembly line, different automobiles can be produced and assembled in quick time. (Yuval Cohen et al., 2017)

The prominent difference that has to be noticed between the traditional assembly line and the modern mixed assembly line involving industry 4.0 is the usage of CPS computer system, which is a highly automated technology used make special characteristics of assembly and it also helps in the processing and the transmission of information that been processed.

The characteristics of CPS are:

1. **Equipment automation and interconnection**

a. The amount of data that are produced with the help of video, sensor is delivered to the intelligent expert systems.

b. They are interconnected among the analysis, mining and processing of data using various terminals that helps in monitoring quality assembly lines, logistics and vehicle transportation.

2. **Intelligent and configurable product**

a. The collected data were sent to the CPS home information centre system, where the data will be monitored and used for orderly production by scheduling the inventory availability.

3. **Modelling ability and advanced analysis:**

a. The product's life cycle is controlled and linked to CPS system, and the analyzed data is used to monitor and manage the analyzed design improving the production and the sales.

Assembly system 4.0 – Aided assembly:

(Marco Bortolini et al., 2017)

The assembly system 4.0 revolves around the implementation of IoT technology's application in the assembly process. It helps in collecting data regarding every piece of equipment, product, worker, storage location, workstation which is then sensorized in real-time specific data which is then been communicated to different departments. The **Assembly Control System (ACS)** helps in analysing the information and helps in implementing corrective structures and steps to monitor and control the assembly system automatically.

With the help of **Aided assembly**, all the activities are fastened and picked using various technologies that reduces their duration and also ensures safe working condition. When the product reaches the workstation storage location, the assisted picking device considers the final product needed for assembly and with the optimally programmed picking sequence, the workers' effort is minimized in picking the right component. During the fastening process, the worker is supported by the virtual augmented realty devices, which will suggest them with the sequence of processes to be carried out during the assembly process and to remain customizable depending upon the customer preference.

Main characteristics of assembly system 4.0

To ensure a significant amount of economic savings, **intelligent storage management** works on concerning the functions of material feeding. The level of inventory and the inventory requests on refilling to the main warehouse are monitored using many sensorized workstation storage locations. The system is so resilient that the unexpected customer consumption rates are met without any stock-out issues. The purchase department utilizes the intelligent storage management system to communicate about the out-of-date products or components that are involved in the assembly process to avoid unnecessary orders. And through the assembly control system, the inventory level of the components is maintained as less as possible with help of real-time acquired information that is received from the customer orders. **(Yuval Cohen et al., 2017)**

Using the information on the assembly product corresponding workbench dimensions and the assigned workers, the **self-configured workstation layout** helps in automatically adjusting the rack size, shelf length. The workstation structure is embedded with the sensors and actuators to help in automatically adjusting the length of the workbench as well as the depth and width of the shelves.

The **Process and process traceability** is completed by sensorized and fully connected assembly system entities. Any possible errors are monitored and detect in real-time for every assembly task. To track the position and movement of components that are assembled and the tasks' duration, workers' activity is monitored continuously. The tools and equipment are analyzed in real-time using sensors to detect the failures and control them.

The prominent feature of Assembly system 4.0 is the **late customization** of the assembled products. In the recent paradigm in the production processes, the customer is involved in all the processes right from the design phase to the final assembly process to tailor the products based on their own needs. To make sure of the essential flexibility required in the process of assembly, the assembly system 4.0 utilizes additive manufacturing machines and 3D printers to help in different stages of personalized configurations. And in addition to that, these pieces of equipment are manufactured based on the solid models that are personalized for the customers.

Logistics and material planning:

(Krasimir Markov and Pavel Vitliemov 2020)

The integration of IoT devices and other sensors were used in the production processes to help in the factory floor operations by providing data streams between departments. And with those data streams work along with "cyber-physical systems" will help in predicting the outcomes of future events or changes. Industry 4.0 has helped logistics in improving their connectivity to expand their network outside the factory floor – to suppliers, freight providers and transport networks.

The emerging growth shown in the internet of things applied in the industry (IIoT) has helped in introducing exciting opportunities in the field of logistics, that may help in solved using the growing technological developments such as: right products, right cost, at the right time, place, and quantity in the supply chain.

Logistics 4.0, the upgraded version due to Industry 4.0, has helped in improving the lean part of supply chain in storing raw material for a very long time before it is been used in the production process. Consider the inbound logistics system, where industry 4.0 help in providing high degree of connectivity that can help in sending data to the production control system.

It helps in gathering information on the incoming shipment timings, and then can be used to adjust the percentage of production that may help in reducing the inventory costs. Similar to that we can gather feedback regarding the outbound logistics which indicates the flow and position of a particular part or model in the flow; so that we can get to know whether the inventory is leaving the warehouse in time as expected (changes may happen due to demand fluctuations). With this knowledge you can study and alter the production quantity to meet the emerging supply needs.

Logistics 4.0:

(Krasimir Markov & Pavel Vitliemov 2020)

Interoperability: The internet of things has paved way for helping people to get connected and communicate with the machines, sensors, devices etc.

Information transparency: Contextualized information is created using the simulated version of the physical world with help of data gathered from sensors.

Technical assistance: The analytical systems in logistics have helped humans in making decisions and solving the problems in various supply chain problems. They have assisted us with more challenging tasks and works that are dangerous for humans.

Decentralized decision-making: With the help of cyber-physical systems, logistic and supply chain decisions will be made more autonomous as possible.

Demand capacity planning: Matching the total logistics capacity with the demand levels in the market by monitoring the inbound flow and outbound flow of goods in and out of the factory. This is done by digitizing and integrating the production flows into a data-driven planning environment.

Network optimization: Logistics 4.0 helps in stimulating any potential changes that may affect the nodes in the network, right from warehouses, hubs to delivery trucks, and can be used to determine the adjustments that need to be made in the logistics flows using the results from analysis.

Technology, its impact and uncertainties based on the IoT: Physical-internet:

- Improved efficiency, safety and transparency in supply chain (HBR Vishal Gaur 2020)

○ Blockchain technology which is a digital record maintaining technology has helped in creating a complete transparent flow of information about inventory, financial transactions.

- The sustainable environment is improved – efficiently resources are planned(HBR 2020)

○ Big MNCs offer trainings on performing sustainability practices to lower tier level suppliers and help them out with incentives for implementing them.

Uncertainties:

- The ability of the sector to invest and its willingness in collaboration
- Whether the standardisation process is driven by the foreign bodies
- People's point of view towards the security and around privacy of data will change

Data analytics:

(McKinsey Shital Chheda 2020)

- Operational efficiency and the customer experience is improved in the operations

○ The successful improvement in in improving the customer experience is by trying to simplify the customer experience and provide a very simplified services or products to the customers rather than merely taking the existing product and trying to digitize it.

- Improved management in the visibility of inventory
- The Predictive maintenance is improved

○ The data revolving around the equipment provides detailed information about the functioning and its performance data. It will help in repairing the failure before it actually happens.

Uncertainties:

- Still the capacity involved in the processing of data and its development rate is not clear
- Strict rules will be imposed in security of data and privacy regulations may increase

Cloud computing:

(L. Barretoa, et al.,2017)

- Models related to Platform based business will be initiated to improve the efficiency.

○ With the help of anytime available cloud services helps us in providing resources that will help in sharing the services to supply chain. Since the information shared in the supply chain is mostly demand driven, it needed scalable distributed system.

Uncertainties:

- Physical data systems will be cheaper according to the certain scale but its costs are unclear

Blockchain:

(Pankaj Dutta et al., 2020)

- Enhanced supply chain security (reduction of fraud)

○ It enables you to eliminate the intermediaries in which it case it creates digital trust enabling peer-to-peer interaction and helps in exchange of data.

- Reduction in bottlenecks (certification by 3rd parties)

○ Its cybersecurity technology helps in reducing the bottlenecks like lack of tracking products in quick time and reducing the theft and fraud within the logistics and supply chain ecosystem.

- Documentation using papers will be stopped and the errors will be minimized
- Efficiency will be increased

Uncertainties:

- Problems will arise when many numbers of solutions to increase efficiency will come into play and to choose the best will be hectic process

Robotics & automation:

(Dimitrios Bechtsis et al., 2017)

- The workforce of human will be reduced and will in turn increase the efficiency in sorting and distribution centres like warehouse and delivery sectors

○ Robots can be used efficiently to do small and repetitive jobs in warehouse which will give time for the humans to take care of more complex jobs that requires more strategic thinking.

- Lower costs

○ They show direct improvements in productivity and efficiency by helping companies to save considerable time and money during the process.

Uncertainties:

- Speed of technology development unclear

Autonomous vehicles:

(Jéssica Bruna Perussi, et.al 2019)

- Reduction in human workforce

○ Many changes that we will come across in the workforce will be due to the available jobs and careers. New brand of jobs will be introduced which will be mostly related to service technician role.

- Increased efficiency in delivery processes

○ It helped in drivers to detect and were alerted regarding live traffic using the light sensors, ultrasonic sensors, LIDAR, GPS etc. which helps them in vehicle run down through inner-city with more congested traffic and without the help of human interactions.

Uncertainties:

- In the most countries, the regulation revolving the environmental issues is not in place
- Emergency situations still has no solution to their ethical questions

3-D printing:

(Helen Rogers, et al., 2016)

- Lower transportation demand

○ Logistics Service Providers (LSP), are entering into new business models of developing 3D printed hubs, 3D printed capabilities at the customers' site.

- Transported goods would mostly be raw materials

○ Most of the raw materials that were developed using 3D printing will be transported to the final channel of distribution and then succumbed to assembly and then transported.

Uncertainties:

- Customer industries are still unsure of the amount of uptake and their scope and speed of transporting goods

III. DESIGN AND TESTING

AR/VR and Computer Simulation:

The VR technology has grown over the years and the usage of VR tools is not only restricted towards tools such as computer aided design and rapid prototyping . The VR tool is combined along with other tool in the process of prototype testing . People argue about the virtual reality has become the new replacement and it has reached greater level of development . Hence because of these developments it provides great support to various fields.

The idea of making use of VR in prototyping has been experimented and the results have proven to be beneficial to various fields . Modelling in VR has been proved to be possible . Due to this it add great benefits compared to CAD systems which leads to higher customer satisfaction and increased creativity. Various obstacles will be removed due to possible addition of certain features which leads to higher activity . (Masood, T.& Egger, J.2017) In I4.0 conditions the process has evolved to a greater extent. Due to this magnificent change designers have started to become product development engineers which leads to higher benefits for the industry in general. (Helo, P & Hao, Y .2017)The importance of product simulation has increased over the course of time , and the amount of people involved in these areas of domain are increasing day by day . There is drastic and continuous decrease in the number of test engineers involved. Knowledge and exchange of data plays a crucial role in these processes. By proper usage of data and resources it is highly possible to increase the quality of the products at the same time reduction in development is also achieved.

In the PDP process the usage of computer simulation tends to very high benefits compared to other methods. An industrial conveyor has been modelled using the computer simulation method which seems to be quite useful. Compared to the conventional methods the parameters designed by the computer simulation method seems to have greater efficiency in designing the parameters. (Stadnicka. D & Antonelli. D ,2014), It can be adapted to suit various processes such as product development , process development and testing as well . In engineering phase such as structural design, selection of raw materials and selections various parameters for the final design. Computer simulation can be used in the operations of a company in the forthcoming years. Basically the computer simulations try to imitate the real world features in a virtual reality based model. It can simulate things like machines , sensors and transducers. . (Helo, P & Hao, Y .2017) This flexibility allows operators to optimise the various parameters of a machine for successfully creating a virtual design for the model. Siemens proposed a virtual reality based solution , in that they claim that computer aided systems by making proper usage of data from the physical machine , it can produce better product which is achieved by nearly 75% reduction in actual machining time .

Visualization techniques are very useful in situations were the industry is highly client based approach towards product development. Industrial 4.0 makes use of two different types of technologies such as Augmented reality and virtual reality . (Helo, P & Hao, Y .2017) One is based on video based approach which involves the usage of camera which provides particular environment by making use of augmented information it is achieved by the user wearing a AR based gadget. A lot of processes gets benefitted by the usage of these technologies but the product design has the most significant advantage compared to other stages in manufacturing. An important element of these AR/VR compared to old school technologies is the constant presence of the user in the virtual atmosphere. It empowers the designs which are initially designed in the CAD and it allows to be developed in virtual environment so that it becomes the better version. (Kusiak, A.2016) This method provides better communication between the customer and hence it helps in achieving higher client satisfaction. AR technology is the process of visualization of an object against a spatial context , and the user can view the object in many possible ways so that it provides better customization in the process of product design.

Most of the computer simulations makes use of the two bundles named AR and VR which provides engineers and developers to design a better model with higher involvement of customer so that they can witness the development process along with engineers. This enables the customers to see the product before the final outcome. Another big advantage of these technologies is that it provides a great advantage to those companies from a marketing point of view which helps in building business relationships with their clients.

Tooling Design:

3D Printing :

The 3D printed applications is best for use under batch production process. Compared to traditional tooling methods , 3D printing can make different variety of tools with intricate design parameter and it can be used as a pilot tool . It is used for making highly customised components necessary for batch production. A lot of research and development has been done in the field of 3D printing to achieve greater efficiency in large scale production (Kusiak, A.2016).

3D printing technology has been used to develop some innovative products in the field of automobile industries . 3D printing has various applications in different stages including rapid prototyping , short runs and etc . (Stadnicka . D & Antonelli .D ,2014) One of the most significant advantage of 3D printing is , when a company receives a design change for an order for a small number of parts it can be easily customised and produced in short span of time using 3D printing . (Kusiak, A.2016) But this is not possible in the case of traditional methods like injection moulding. Hence it creates a competitive edge for the company . Because in metal tooling if one particular design is not possible the company cannot drop its order , but whereas in 3D printing it is possible to create new parts in a instantaneous manner. Hence it saves large amount of money apart from saving time and manpower.

3D printed tools for injection moulds with conformal cooling: With help of conformal cooling it is possible to make parts with intricate and highly complex designs in a efficient manner. It helps in quicker production of those of parts compared to traditional methods of tooling. Companies which follows or integrates 3D printing concept within their manufacturing ecosystem are able to decrease the cycle time by 75% along with improved part quality and reduction in overall production costs.

3D printed jigs: The most common way of manufacturing jigs and fixtures are done with the help of using metal or wood which results in serious design problems and high production time. The plastic used in 3D printing has been proved to be strong and better alternative compared to wood and metals. The advantages of these plastics is they are light in weight and when it comes to lifecycle of the product it has longer durability compared to the traditional materials. They provide same of quality for the user.

PACKAGING

Due to the intense competitiveness of supply chains, cost effectiveness has always been a significant concern in corporate practise throughout the last decades, but it is also becoming increasingly essential in the field of packaging. The goal of a company's packaging choice is to find and select the optimal and ideal packaging functions and costs. This decision primarily concerns the technique for deciding between disposable and reusable packaging methods. (Voroskoi, K & Borocoz, P.2016) One-way packing can only be used once. Reusable containers are packed with products and sent to their final destination, after which the empty container is returned to supplier and refilled containing products, and the cycle is repeated. The biggest issue with one-way packing is the trash generated after use, despite decreased production costs. In the case of returnable packaging, however, transportation and maintenance expenses are an important consideration. Naturally, environmental considerations are becoming a part of these critical operations, such as waste minimization during production. Furthermore, when considering the elements of sustainability and economy, improving packing efficiency is a key strategic goal for organisations. Companies have also been pushed to reconsider their packaging operations as a result of legislation. Many actors in the automotive supply chain employ returnable packaging techniques because of this (ASC). Returnable packaging materials are categorised as Returnable Transport Items (RTIs) and are typically used in a closed loop supply chain (CLSC). The characteristics of the ASC, the typical packaging supply chain, and the packaging supply chain of an engine manufacturer are discussed in this study. The pricing structure of returnable packing is also reviewed and divided into categories, as it is one of the most important components of choosing the correct car packing.

TYPES OF AUTOMOTIVE INDUSTRY PACKAGING

In automotive industry there are two types of packaging is done

EXPENDABLE PACKAGING

Expendable packaging is containing of materials such as wood, plywood, paper, or cardboard and is meant to be thrown away. These items are commonly thought of as one-time packing solutions that are recycled or discarded once the vehicle element has arrived to final vacation spot. A everyday fabric disposal technique must be carried out into the packaging system' lifespan.

RETURNABLE PACKAGING

Packaging that can be returned has been intended to be reused in production and distribution networks. The requirement for throwaway packaging, which must be recycled or sent to a landfill, is decreased or removed entirely with this type of packaging.

Reusable racks, dunnage, containers, pallets, and hand-held containers are examples of returnable packing. Plywood, steel, plastic containers, and pallet collars are also popular packing options, and they offer a number of advantages.

IV. INDUSTRY 4.0 APPLICATIONS IN PACKAGING

NANOTECHNOLOGY

Given the protection issues involved with packaging, nanotechnology is predicted to play a significant position in the near destiny. A vital opportunity (Majid et al.2018) is the need for development of acceptable and safe revolutionary packaging materials. These materials can be utilised in reference to sensors integrated inside the machine to control the discharge of lively substances.

INDUSTRIAL INTERNET OF THINGS

Internet of Things (IIoT) is a concept that objectives to create a international network structure for connecting devices to the cyberphysical surroundings. It permits control and trackingl of sensors and actuators-equipped devices.(Dirk & Wai ,M cheung.2018) Packaging products with RFID tags, as an example, can be easily monitored manufacturer to consumer. In the case of e-trade offerings, UPS estimates that 1% of products are lost or broken. UPS gives you round four.6 billion parcels every yr, which equates to 4.6 million shipments damaged every 12 months. As a result, the incorporation of packaging has the capacity to significantly minimise UPS parcel loss. Other home equipment which includes food packaging, fixtures, boats, production machines and factories will become a part of the Industrial Internet of Things (IIoT) by way of 2025, further to mobile telephones, pills, laptops, and personal computer systems.

CYBER SECURITY

Despite the various new possibilities and growing technology, cybersecurity stays a massive fear. Existing technology are beset with the aid of information privacy concerns, which can pose critical troubles. (Drik & Wai, M cheung. 2018)If these problems aren't nicely addressed, clever packaging's complete capacity the most thrilling utility domains in Industry 4.0 might also never be realised. Attacks which can be many, evolving, fantastically quick and really sophisticated characterise the present Internet protection scene.

Preventive security agencies face substantial hurdles as a result of these qualities. As a result, in order to establish successful defence in depth tactics and resilient systems, approaches that enables detection and response to intrusions should be used in tandem with prevention tactics. Not just for smart packaging, but for all cyber-physical systems.

PRODUCTION SYSTEM IN AUTOMOTIVE INDUSTRY

INTRODUCTION

The linking or harmonisation of several stages and technologies to increase operations efficiency is known as smart manufacturing. Although there are various typical types of devices used in the field, it does not necessarily refer to a certain technology or type of equipment. Sensors for the Internet of Things are a good example. Plants in the auto industry typically feature a variety of systems that operate together to produce a s car.

Conventional production processes, on the other hand, treat these systems as independent entities. They've been divided or isolated off from each other. Smart manufacturing will connect these components of the plant using contemporary data-sharing technology, increasing efficiency, lowering costs, and increasing output.

Additionally, the technology may be used to track exact adjustments during manufacturing process, resulting in a more personalised consumer experience. Consider clients getting a vehicle through digital marketplace and selecting specific upgrades or options rather than the traditional bulk package choices.

SMART MANUFACTURING

He Department of Energy and the National Institute of Standards and Technology have coined the word "smart production." "A records dense utility of data technology (Klaus Dieter et al.2016) at keep ground and higher to enable shrewd, green operations," Wallace and Riddick outline smart production in a nutshell. While more complete definitions exist , they all emphasise using records ,communique era and superior facts analytics to optimise production operations at all degrees of the supply chain, whether on the shop floor, within the factory, or inside the supply chain. Some authors took it a step similarly and applied the smart manufacturing paradigm to areas apart from production, emphasising the life cycle view.

APPLICATION 0F INDUSTRY 4.0 IN SMART MANUFACTURING PRODUCTION SYSTEM

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Robotics:

Industrial robots have greatly improved manufacturing process in many industries especially in the automotive sector. The best example of this is Toyota, the largest automobile manufacturer which is well known for its operational excellence and embracing Industry 4.0 technology in their factories. They are able to pump out thousands of cars in a day while still maintaining quality standards. Industrial robots are able to assist workers in the shop floor and are generally used to perform repetitive tasks that require high precision. Using these robots improves manufacturing and assembly time while reducing bottlenecks. Robots unlike humans do not face fatigue so it is possible to maintain production cycle times all day and output has substantial increase. Some jobs are hazardous for workers in automobile industry and robots are perfect solutions to address this safety concern. Robots have now become a vital part of many industries

Robotic Applications in the Automotive Industry:

Robots are used for a wide range of applications in automotive industry which are given below:

Assembly using Cobots: Cobots also called as Collaborative robots are design to aid and work alongside with humans and other robots. Normal Industrial robots are big in size and have a safety cage surrounding them to prevent injury to humans but collaborative robots have a small footprint and are specifically designed for safety which is possible with the help of sensors and they are able to assist workers safely (Colgate & brown,1994). They replace the strenuous and high precision tasks in the industry. They are convenient for material handling tasks and so they are used in car assembly lines. Automobiles have a wide variety of components that need to assembled and these robots are programmed to do that quickly and efficiently. They are able to handle bulky parts as they have high payload making wheel mounting and windshield installing tasks much easier. (Michael Peshkin,1999) These robots do not replace human workers completely instead they help them to achieve greater output. Toyota believes that having both robots and human interaction is important for their factories.

Robotic Painting: Human workers cannot match the precision and quality that industrial robots have when it comes to painting automobile body parts. The robot arm is attached with spray painters and programmed to spray specific quantities of paint at set intervals of time. (Tarig Faisal,2012) Quality is consistently maintained and more automobile parts are painted which cannot be achieved by human workers. Paints may contain certain fumes and chemicals which cause problems for workers if inhaled and robots greatly reduce waste as they only use right quantities of paint and this is the reason why every automobile factory uses robots for painting.

Robotic Welding: Welding requires high levels of accuracy and skill which is difficult to maintain consistently for manual operators. Robots having six axes are flexible and their arms have a long reach making them capable of welding intricate automobile parts. In welding, the weld beads need to be maintained uniformly and should have proper thickness to have a good finished look. Robots are able to maintain this by controlling the weld temperature. (Tang Sai Hong, 2014). Different automobile components use different types of welding such as arc, resistance and spot welding and a single industrial robot can be easily programmed to do any of these varied types just by replacing the welding tool. So, it is more cost effective and time saving than hiring professional welders. (Weria Khaksar, 2014). Similar with painting, welding also pose some safety concerns for works as they interact with hot sparks and high temperatures which can cause injury if precautions are not followed. So, robots are also able to excel in welding automobile components.

Material removal and polishing: Automobile parts may have inconsistent rough surfaces with scraps of metal sticking out so removing and polishing the surface of parts is important. Industrial robots have different tools designed for material removing applications such as trimming, cutting, deburring and grinding (Alosio Pina, 2010) Based on the material and process that is to be done tool can easily be change and robot can be programmed to remove unwanted material from components. Robots are able to achieve smooth surfaces when they are used in polishing edges and surfaces.

Machine Tending: Robots are convenient for material handling tasks and so they can load and unload components to other machines like CNC. (Bjoem Mathias, 2006) They can be used to handle hot moldings that are harmful and they are able to consistently maintain cycle times in the production process.

AGV systems: Automated guided vehicles are mobile robots that are able to travel around the factory carrying raw materials and parts required for manufacturing. They are transport systems that don't require operators and can travel short to medium distances. They usually follow same defined path that acts as a guide line for them. (Ray Y Zhong, 2018). This path is marked by magnetic tapes which sensors fitted on the robot can detect. They also use motion planning algorithms and once the path has been marked and mapped properly, they follow it repeatedly and maintain constant speeds. They make use of 3D mapping technology to navigate the plant. The main advantage that AGV's have is that they replace manual vehicles such as forklifts which are normally used to transport materials. It also optimizes the entire work flow process and they are designed to detect and avoid collusion while reducing damage to the carrying product or part. (Mauldin Nawi,2018). Labor costs may increase or decrease but AGV costs once installed are easily manageable and they have cost efficiency in the long run. Toyota is well known for using lot of AGV's in their big factory.

Quality inspection using robotic vision: Robot vision was developed so that robots could check quality requirements themselves and to do process smartly without the need for constant human intervention. It uses a mix of camera hardware and complex learning algorithms that helps robots to understand and interpret visual data. (Martijn Rooker,2014) The camera is attached to the wrist of the robotic arm and programming is done. Reinforcement machine learning algorithms are used that is the robot is constantly fed images of parts with desired quality levels and of parts that do not match quality standards. The robot learns by constant monitoring of many images containing large volumes of data. The robot is able to learn to an extent that it can even detect minor offsets that are not easily caught by the human. The longer these robots are used on the shop floor the better they are able to perceive defects. (Michael hofmann,2014) Robotic vision has become a valuable tool for the automotive industry and highlights the big change that Industry 4.0 has brought.

Hence, Robots have made a lot of positive changes and improved a lot of processes in the Automotive industry. Robotics and Automation has had a big impact and lot of new systems making use of Artificial intelligence are emerging. Though installation costs of robots are high in industry the changes and quality that they bring are very high in the long run. (Markus Ikeda, 2014) They are cost effective and a good way to ensure that operational standards and times are met in any factory. There has been a belief that robots will replace lot of jobs and while this may be true it will also bring in a lot of new roles where human innovation is needed. Robots are the future that will replace menial work and industries are embracing this technological change.

Manufacturing systems- 3D printing:

Industrial 4.0 has bought many changes to how manufacturing is done and 3D printing has made a great impact. Computer aided design software was already available but with arrival of 3d printing, Models made using computers can be made easily using the printer. It is a form of additive manufacturing that can design and print any complex shape. (Cephas Maware,2014). 3D printers are especially useful in the automotive industry. Before making a car, designers usually make a lot of prototype models that convey both style and ergonomically friendly to the consumer. They always try to bring new design implementations in each of their model lineups and 3D printing helps with this. 3D printing offers a flexible and optimized design process allowing Designers to make miniature prototypes of cars in order to pitch it to upper management. This acts as a reference model and they make many such models and choose the best designed one for the next manufacturing process. (Budmen & Rotolo, 2013) Variety of Customization can be done to automobiles through 3D printing. Before automobile prototyping used to take many days and if errors occurred it cost a lot of money for the company. But now 3d printing achieves rapid prototyping and though initial investment is high. The long-term benefits

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generate a lot of profits and saves time. Also, spare parts have always been a challenge in the automotive industry. By using the CAD software, the complex designs for multiple parts can be digitally stored in the system meaning inventory space is reduced. Customer demand always fluctuates and 3d printing can solve these problems and make parts whenever the customer orders for it. Some people have vintage cars whose parts are very old and expensive to manufacture as they are not available in industry. (Hyman, 2011).3d printing can successfully reengineer automobile parts used 50 years ago by making digital scans. This is a big step towards being always able to meet demand requirements in the automotive industry. 3d printing also saves considerable time in the assembly section. Instead of assembling 6 or 7 individual car components they can be easily combined into one printed component. This part is expensive compared to other parts but as it reduces the assembly time companies benefit cost efficiency and less inventory space. 3d printed components also help to reduce the overall weight of the car and improve fuel efficiency. (Merril,2013) Automobile manufacturers strongly believe in the future of 3d printing and they have started to design entire 3d printed cars. The 'Blade' was marketed as the first 3d printed super car with a great design and many other manufactures are trying to step into this new field of manufacturing. These 3d printed cars still need to be tested extensively before releasing as a model and manufacturers believe achieving this level of efficiency will be a true success for the automotive industry.

V. CONCLUSION

Emerging trends in Industry 4.0 are considered to be assets to the automotive sector, as it offers wide range of opportunities to create, develop, and enhance great services for comfort and betterment of the users. With time, Industry 4.0 has significantly grown and evolved through wide variety of automotive applications. Detailed examination of the advantages and the challenges that connected with the use of Industry 4.0 applications were discussed with identifying the present and upcoming technological changes in the automotive industry. Additionally, our study shows various connectivity types involved and linked them with the connected applications to show technical changes for upcoming automotive advancements. Industry 4.0 has the capability to offer many new and innovative insights within manufacturing processes. It allows the organisations to exchange data's among systems and enable them to use this information more efficiently and effectively in future decision-making opportunities. The promising future of this technology can be understood by addressing new research challenges and the outline of efficient technology with low cost and efforts.

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