A Review on Smart Manufacturing, Technologies and Challenges

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Abstract: *Smart manufacturing is a technique that enables interconnected machinery and equipment to improve productivity and quality while also optimising energy and working population requirements through the use of big data processing, machine intelligence, and industrial automation technology, as well as their interconnectivity. As a result, both large and small producers must carefully select and prioritise these technologies. Other enhancements may also be required in order to get the most out of the chosen technology. This paper gives a clear picture regarding the implementation of smart manufacturing and also some of the important technologies used here and also the challenges it widely faces. Focusing on agility, production, energy efficiency, and sustainable environmental yields benefits that go far beyond lowering volatility in the market. Creativity, time-to-market, and a speedier, broader study of the trade space are all influenced by agility. The introduction of smart manufacturing and latest technological infrastructure for manufacturers is motivated by all these developments, the factors driving it, and new network-based computing infrastructure that give unique insights and analysis.*

Key words: smart manufacturing; manufacturing; technologies; challenges; automated systems; intelligent manufacturing systems

1. Introduction

One of the most widely used words to define manufacturing in the future is "smart manufacturing. Research about smart manufacturing is becoming increasingly popular. Many focus on in-depth coverage of the issues affecting smart manufacturing in order to streamline and organize the increasing amount of research. Since the start of the industrial revolution in United Kingdom in mid-eighteenth century with the arrival of steam engines, through all the mass production starting from the early nineteenth century, the commercial potential of electricity, the advancement of Information and Communication Technology (ICT), and the rise of new of automation machines in the early twentieth century, the manufacturing industry has undergone innovative progress. Current developments in ICT technologies, such as hardware and software, are triggering a manufacturing renaissance or revolution. Smart Manufacturing could be the driving force behind the next revolution. It is a collection and approach of numerous technologies that, by combining employees, technology, and information, can inspire significant development in the present manufacturing business. While process improvement in the 1980s and 1990s aimed for cost savings through waste elimination, Smart Manufacturing is a potential development enhancer that aspires for long-term growth by managing and improving major manufacturing elements such as productive output, quality, distribution, and adaptability, based on technology interconnection and various components across communities, humans and the environment. The current era of manufacturing has its roots from last half-century. As software and machine technology has evolved, manufacturing has become more automated. Rather than manual processes, current machine equipment's are mostly controlled by software programmes. Automated material handling systems carry materials and components, which are then placed in automated storage and retrieval systems. Ever since 1980s, different terms have been used to describe automated manufacturing, differing from flexible manufacturing cells and flexible manufacturing systems to computer integrated manufacturing and smart manufacturing, depending on the needs and degree of automation of a shop floor and the execution of various functional manufacturing sites. At about the same time, Japan started investigating smart manufacturing, concluding in the establishment of the Intelligent Manufacturing System (IMS) Program in 1995 to aid industry research. It was understood that one country's industrial industry could not restructure on its own, and that global cooperation was essential. Large manufacturers from Japan, the United States, Korea, and Europe have started collaborating on the evolution of manufacturing, with Japan leading the way with its most active participants. The Next Generation Manufacturing Systems (NGMS) Program, which was created as a non-profit organization, has been responsible for much of the IMS work in the United States. The IMS Program was later expanded in smart manufacturing when the European Union began research operations.

Even as world moves closer to smart manufacturing technology, several of the world's most important nations have already disclosed their ambitions for the future generation of corporations. Industrial revolution 4.0 is a German initiative which has been recognized by a lot of nations as another solution for industrial growth.

2. Components of smart manufacturing

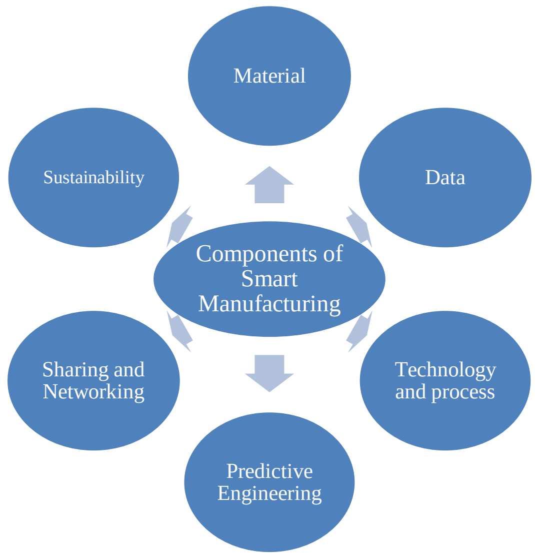

Figure 1- Components of smart manufacturing

The ideas developed primarily in the realm of computation have been applied to drive smart manufacturing. Manufacturing, on the other hand, will stand to profit from these and many other new innovations. The fundamental foundations will be established by future work, technological innovation, and uses. The final elements could be formalized in a number of methods, include clustering scholarly articles, industrial studies, and knowledge on technological advances utilizing text and data mining technique and algorithms. The six elements of smart factory include manufacturing processes and technologies, resources, information, predicted engineering, sustainable, and sharing of resources and networking. These six elements' names and relative significance have varied over time, but they're always involved in production. Data, for instance, has always been an important aspect of production. In the era of smart manufacturing, it has grown into large amounts of data. Forecasting engineering, which is based on statistical analytics, came before production planning and forecasting.

2.1 Manufacturing technology and processes

Manufacturing techniques and improvements are expected to evolve in the near future (29). Different materials, equipment, and products will be developed. Additive manufacturing is indeed an example of a modern technology that has changed product design and manufacture, as well as unlocked the way to modern innovations such as bio-manufacturing. Manufacturing machinery, such as equipment that can mill vertically and horizontally, grind and also drill has been designed to incorporate multiple operations. Novel hybrid technologies will emerge, including hybrids of conventional and additive processes, laser manufacturing, and total production. Implementation of various materials, product development, and manufacturing processes will be more prevalent, like the finding of a chemical substance that leads to the construction of a new medication as well as a method of delivery, as well as the production of the medicine and the device. Additive manufacturing would become more common in both small and large firms. A new group of low-cost robots would improve workplace automation. Modern manufacturing machinery will be substantially highly cognitive of the factory and beyond communication attributable to sensors and software capabilities.

2.2 Materials

Smart manufacturing does not directly urge the development of smart materials such as shape memory alloys or functionally graded composites. It's feasible that intelligent elements will arise spontaneously. To build innovative product, smart manufacturing can use any sort of material, including chemically synthesized materials and biomaterials. Recovery of materials from items at the end of their lives will become more important. Landfills could potentially become new mines for a variety of commodities. Some new materials will necessitate the development and integration of novel techniques into smart manufacturing. The hunt for new materials and their mixtures will be greatly aided by additive manufacturing alone.

2.3 Data

Manufacturing is experiencing a data revolution. Sensors, wireless connectivity, and developments in data analytics all played a role in some of it. Data is gathered from a wide range of sources, including several material attributes, process factors, clients, and suppliers. The data will be utilized to drive possible developments, such as predictive modeling. Additionally, that will be a perfect setting for preserving and recovering historical and modern industrial knowledge.

2.4 Predictive Engineering

Among the most recent additions to the area of manufacturing solutions which might contribute to a proactive and instead of reactive business is predictive engineering. In the manufacturing industry, information has typically been used for analysis, tracking, and inspection, like productivity evaluation, process control, and quality management. Six Sigma techniques and other data-analysis approaches have had such a significant influence on the quality enhancements in industrial goods and services. In contrast, traditional initiatives have sought to look to the past instead of the future of industrial systems and processes. Predictive engineering is a new way to generating large models (virtual representations) of events of interest. Such simulations would permit for said exploring of future locales, many of which are within in the realm of present tech and others who have not previously been observed. Today's modern models will be supplemented with both constrained models (e.g., supply chain behavior) and multi-system modeling (e.g., approaches that combine productivity, quality of products, energy, and logistics) to assist decisions about potential production and market conditions. Models with that kind of a large scope can aid in the restructuring of the manufacturing sector. Some companies may become widely dispersed, and some may become centralized. Products that really are cost-sensitive in terms of shipping, duration, or customized, for instance, could be made near to customers.

2.5 Sustainability

Sustainability will indeed be crucial in the industrial industry. The concentration of sustainability initiatives is on materials, production methods, energy, and emissions linked with production. Every real sustainability strategy begins with the item and the market. There would be little question that using sustainability targets to drive product and process development yields the greatest sustainability benefits. The below are some such instances: (1) sustainable product design would influence production; (2) sustainable manufacturing techniques will impact product development; and (3) sustainable materials, solutions, and methods will be developed concurrently. The second situation is additive manufacturing, which has led to unique component and item designs as a result of a technique. Sustainability is concerned not just with what is produced, but also with how it is produced. It is the impetus behind bringing remanufacturing, reconditioned, and recycling on par with production. The distinction separating manufacturing and service would remain blurry due to sustainability. Way of sharing a used item, for example, is not really a normal manufacturing activity, yet it may be included in current manufacturing jargon.

2.6 Resource sharing and networking

As manufacturing becomes more digitized and virtual, most of the innovation and judgment activity will take place in the virtual world. Whereas the digital realm is more accessible at times, the physical industrial capital and understanding will be protected. This separation of the digital and physical environment will enable for resource sharing across organizations, even competitors. Service and contract models have been introduced to the manufacturing business, and where the production of the items is outsourced to other facilities or vendors or third parties. Due to the obviously high price of innovation, low utilization, the level of difficulty, and ambiguity about the usefulness of the new tech, the rapid manufacture (Manufacturing process before 3d printing) emerged decades ago. Shared resource models have proven to be successful, and they are now spreading beyond carpooling to include Uber for transportation and Airbnb for lodging. These techniques will most certainly aid smart factories by allowing firms to share and make use of manufacturing equipment, software, expertise, and, most importantly, cooperative modeling and innovative space. While the technicalities of borrowing industrial machinery and distributing software packages may be imitated, sharing the creative environment is a challenge. Applying concepts such as Meta and Wiki to other elements of manufacturing will take many decades. Rather of real goods, all sharing transactions will take place in an area filled with digital models. Transport, in addition to production equipment, is an important resource that requires consideration. Internal transport, it makes use of specialist material handling machinery or several other stuff like tracks, and physical transport, which supports the supply chain management and distribution chain, which are the primary forms of transportation used in manufacturing [30]. Logistics, in addition to production equipment, is a significant resource that should be addressed. There still are two types of transportation in production: internal, which uses specialized material handling equipment or several lines, and outside, which supports the distribution and supply chain. In the field of manufacturing accountancy, transportation is frequently regarded as a non-value-added operation. This leads to the belief that shortening travel distances will not only reduce money but will also have a positive influence on the environment. Through greater autonomy and cooperation, robots and self-driving vehicles (from the land to the sky) have an impact on internal and external industrial transportation. Transportation will play a critical role in transforming the spatial arrangement of industry on a global and regional scale.

3. Smart Manufacturing Technologies and their roles

3.1 Additive Manufacturing

Additive Manufacturing (AM), often referred as 3D printing technology, opens up new opportunities for smart manufacturing. Customizable, rapid prototyping, generating spare parts rapidly, as well as on manufacturing are all possible with AM technology, which reduces a lot of time and money in terms of machine tool maintenance and raw materials. The significant advantage of AM in smart manufacturing is that it supports reverse engineering of almost any component or products using 3d scanner and enables customization in designing as well as speedy duplication for evaluation and confirmation. In addition to implantation in dentistry and orthopedics for the repair of broken body parts, AM technology is increasingly utilized in medical science. AM is used in civil and architectural engineering to prototype and analyze solutions for cost-effectiveness and satisfaction of customers [32-33]

3.2 Artificial Intelligence

Artificial intelligence has been used in the latest generation of manufacturing systems to improve human-robot cooperation and coordination and decrease the number of individuals working in dangerous surroundings, as well as to improve the servicing structure of the manufacturing systems and identify any errors inside the machinery and product. Self-optimization and autonomous reactions to physical changes such as altering production plans, stopping or operating any machining units, autonomous equipment tool replacement, and timely alerting of any unconstrained situations are all capabilities of the artificial intelligence system [34-36].

3.3 Virtual Reality

Virtual Reality (VR) allows users to interact with computer-generated graphics and films that simulate real world application. VR is wearable equipment with video, audio, location systems like GPS, remote communication to other devices, and technology that allows the user to feel physically present in a virtualized world built in simulations. VR has been used in manufacturing processes to train and educate engineers and technical graduates about industrial processes.VR is utilized in manufacturing structures to train and educate young engineers and technical graduates for handling industrial processes. The implementation of VR has become more effective than classroom knowledge in implementing young engineers and technical graduates to the manufacturing method, mechanization procedures, diagnostics, and maintenance technologies [37-39].

3.4 Augmented Reality

Computer simulation could indeed be used to generate an artificial experience in the material realm using devices and portable gadgets. They deploy a technique that mixes a real-world physical habitat with computer-generated images to depict artificially created components to an existing real environment for the objective of training, simulation, or verification of manufacturing models before they go into production. This combination of virtual computer images and real-world scenarios aids in the product's implementation in a real-world situation. When new worker training and product testing are conducted in an artificially enhanced environment with a variety of scenarios, they are proven to be more effective and time-saving [39-41].

3.5 Big Data Analysis

Data gathering and analysis from a variety of sources, ranging from production unit, the business, consumer feedback and product demand systems, and etc, aid in making real-time smart manufacturing decisions. Organizations increasingly desire consumers to share their views and opinions more about products they used and desire to use it because that they may concentrate on producing products that satisfy of a diverse set of consumers. Big data analysis will help the manufacturer describe the present state as well as induces of product breakages in real time, as well as drive customers to buy products by recognizing their purchasing habits and prerequisites and learning about facts and figures marketing's predictive manufacturing infrastructure [42-44].

3.6 Cyber Physical Systems

Industrial manufacturing engineers can successfully supervise and manage production process via the computer, allowing the control engineer to access the industry's monitoring system from anywhere via cloud technology. By utilizing data processing capabilities that really are easily available on the internet, the Cyber-Physical System (CPS) connects quantitative aspects to the physical universe and its recurring mechanisms. The CPS can also be defined as a cloud-based SCADA system, with higher layers of sensors, actuators, and hardware components and a cyber layer of programs, communications equipment, and data transfer via the internet. CPS is widely used in the aviation, automobile, transport, and roads and bridges industries [45-46].

3.7 Flexible and Reconfigurable Manufacturing Systems

Manufacturing mechanism that can adapt to any modifications in built-in priorities and processes as a result of competitive market demands or product reconfiguration. They are concerned with cost-effectiveness and the ability to respond quickly to system changes. It can produce small batches and can be easily repurposed to start producing a variety of products. Regular adaptability allows the production facility to produce new types of product in the same production line, whereas machine flexibility enables the production facility to organize the manufacturing schedules of various machining stations, distribute the machining activity respectively and automatically start replacing the machining parts. Functionality, adaptability, versatility, flexibility, and manageability are predetermined characteristics of FRMS in smart manufacturing [47-49].

3.8 IoT(Internet of Things) and IIoT(Industrial Internet of Things)

Smart homes, transportation systems, supply chains, healthcare, agriculture, human pets, and vehicle monitoring apps are examples of IoT applications, whereas IIoT concentrates on the industrial implementation of IoT, which integrates all material objects via the internet. The IIoT integrates tangible items like sensors, actuators, and the entire operational surveillance and control system to the internet cloud in the industrial world, enabling each component to interact and collaborate to achieve a common goal. These interactions between components help with resource, tool, and material optimization, as well as enhanced human-machine interface and smart control systems for resource, tool, and material enhancement. Customers can also view virtual demonstrations of products, procedures, and industrial plants for marketing and education using the IIoT [50].

3.9 Simulation

Factory simulations in the virtual environment to optimize machine settings for the earlier production process without evaluating in the reality would save time & expense in the verification process. Following upon the simulated results, a virtual model is created which may be used for production strategy and planning. Additionally, in recent years, simulation has been incorporated into SMS systems, which has aided in the examination of design errors, production schedule, manpower, and energy requirements for the entire supply chain, as well as the planning and preparation of cost estimation, profit loss evaluation, and bill of quantity preparation prior to moving forward with the real manufacturing process [51-53].

4. Material handling and transport of materials, components, products and people

Material handling and transportation, with lengths ranging from nanometers to kilometers, are essential components of the production chain. Both enable manufacturing and shipping activities to take place across several sites and throughout the world. The movement of items within a facility is referred to as material handling, whereas transportation refers to the movement of items, parts, and items through distribution networks that span districts, nations, and nations. Procurement and distribution can account for a significant fraction of the cost of a product; for example, transportation accounts for eight percent of the total of the cost of wind energy tower, although other components account for a greater percentage (e.g. 20 %) (Cotrell et al. 2014) [49]. Because of the growth of manufacturing, distribution of materials, parts, goods, and persons is expected to be a significant financial element in manufacturing. As a result, workers' transportation and usage expenses for maintaining hardware and software infrastructure across several production locations would be reduced. Job descriptions that are not yet available will be established in order to complete the intelligent production activities. Manufacturing professionals may travel in huge numbers utilizing various modes of transportation, such as vehicles, railways, and flights, in order to distinguish their goods. Human resources, like manufacturing resources, are prone to be affected in huge numbers, as mentioned later in this work. The cost of production is influenced by the efficiency with which resources, components, products, and people are transported. Global manufacturing connectivity is built on the foundations of transportation and communication. Transportation is expected to become an essential component of smart manufacturing independent of ownership due to: (1) growing dependence on the flow of resources, parts, goods, and service people driven by individualized demands, (2) durability, and (3) service levels. Limiting the sustainability consideration to the production envelope would result in a poor solution due to the interconnection of production with supply system exchange. Customer service quality is inextricably linked to inventory levels, production response times, and transportation.

5. Smart Vehicles

Many of today's product transportation and distribution vehicles communicate and exchange data. Transport connection will grow because more individuals participate in information sharing, such as automotive communication or automotive centre for diagnostics and repairs. In fact, machine tools are expected to use the same interface as condition monitoring systems and manufacturing. Transportation automobiles are classified by type of vehicle, fuel usage, and technology used. Automotive are characterized to use any combination of automotive type & technology used. An automobile, for example, may be both independent and rechargeable. Product handling equipment, private automobiles, trucks, and public transportation are all affected. Technology appears to be naturally evolving in the direction of combining the notions of transportation, energy, and sustainability. Technology appears to be naturally moving in the direction of tying transportation, energy, and sustainability to production. For example, an electric forklift, a vehicle, a lorry, or a long-journey train could all be self-driving. Vehicles could also be grouped together. Electric car batteries have previously been charged using power produced by conventional renewable energy power plants. Vehicles will be built for long-term durability, featuring fuel efficiency, and will run on power produced from renewable sources as turbines or gas. A more fuel-efficient vehicle will need less material and have a geometry that is shaped to reduce air resistance. When it reaches the decline stage, the majority of its components will be reprocessed and reprocessed [45]. Topic of dependable electric vehicle design has gotten little attention to date. Perhaps the car industry is unduly focused on gaining a foothold in the independent market. Vehicle accessibility is a topic that has been discussed for a long time. In the domain of public commuting, it has a long history. In the mass-transit domain, it was implemented in two ways: physical and data connectedness. A train is a mechanically connected automotive that communicates wirelessly or over the cables. Traditional connection advantages may be applicable to the next era of automobiles and goods handling systems. Vehicles, like industrial machinery, can be connected both online as well as offline. The digital connection can be established in a range of methods, from automotive-to-automotive communication to traffic control. The development of connected vehicles has resulted from advancements in transportation productivity, efficiency, and safety. The advancement of transportation productivity, efficiency, and safety has led to the development of connected vehicles. For example, in the same way that one operator may control several machines in manufacturing, having one driver for a large number of vehicles saves money. In the personal-vehicle arena, the concept of shared mobility has been around for a long time. The benefit for using shared transportation was usually access to a less congested highway lane. The vehicle's owner is usually one of the passengers. Transportation for small groups (e.g., six to ten persons in a van) to large groups (e.g., a mass transit system) is a well-established technique. Using our own vehicle for personal mobility is inefficient in terms of both energy and cost. Personal vehicles are typically underutilized. We don't think that way, though, when what we really need is a transportation service that doesn't require us to buy a car. Subscribing to the transportation service idea allows for better vehicle utilization and lower transportation expenditures. As a result of the increasing use, the number of automobiles on the road is reduced, which has a good influence on traffic congestion and the environment [45].

6. Smart Manufacturing Systems challenges

Although smart manufacturing technologies can handle a broad number of risks and difficulties faced by established companies, there are still a few hurdles to overcome during their deployment. Safeguards, a lack of systems development, a lack of return on investments in research and development, and financial problems are assumed to torment smart manufacturing systems during in the construction of the new production technology or the upgrade of existing businesses with smart manufacturing technology, according to various totally reliant variables. The sections that follow look at the challenges that smart manufacturing technologies confront, as well as possible solutions.

6.1 Security Concerns

The usage of a network system which is integrated in a production system for transferring data among production or processing units and end consumers is referred to as a smart manufacturing system. It requires network access for this purpose, which is arranged mostly through the internet. Data and information security are required at multiple stages across the system when transferring data over the internet, including world - wide unique identification and end-to-end data confidentiality. As a result, each network component should be safeguarded against attacks from the outside and data theft. When developing network infrastructure, such as smart manufacturing technologies, the most important aspect is to ensure the device's and overall network's security [46].

6.2 System Integration

Synchronization of modern technological devices with existing devices is another barrier in implementing a smart manufacturing system. Connectivity concerns between existing and new devices create a wide range of problems for smart manufacturing technology usage. New gadgets may employ a different protocol than old gear controlled by specified communication standards. Additionally, for machine-to-machine communications and system integration, more communication is required. In order to link more devices at the same time, IPv6 connection is essential in modern manufacturing processes [39].

6.3 Inter-Connectivity

Interconnectivity refers to a system's ability to understand and access the features of another system independently. This functionality allows them to exchange data and information despite of the hardware or software they use. Industry 4.0 has four degrees of connectivity: operational, systematical, technical, and semantic. CPS and Industry 4.0 are linked by operational interoperability, which raises questions about Industry 4.0's conceptual structure. Standards, recommendations, principle techniques, and models are all concerned with systematic interoperability. Technical interoperability defines tools and platforms for the technical and ICT environment, as well as related software. Information sharing across various levels of organizations and individuals is the subject of inter-connectivity. If communication techniques and rules are not correctly matched, interconnection may not even be possible. The system's inter-connectivity restrictions are determined by variations in communication range, operational frequencies, method of communication, hardware capabilities, and other considerations [41].

6.4 Safety in human-robot collaboration

A robot or lightweight robot; is a type of robot that can interact with humans in the workplace in a safe and physical manner, as well as collaborate by incorporating innovative methodologies from human-machine interaction (HMI) [53]. The International Federation of Robotics is a non-profit organization that promotes robotics around the world. Human-robot collaboration is defined as a robot's ability to work in tandem with humans in an industrial setting to complete complex operations the main focus must be on the occupational health and safety of individuals who work on the workplace; any potentially dangerous situation must be avoided, and essential occupational safety should be maintained [14]. When adopting the CPS framework or industrial robotic systems, the main focus should be on minimizing any mechanical, electrical, thermal, noise, vibration, radiation, and work environment dangers in the workplace [11].

6.5 Humans in smart factories

The field of human-robot collaboration (HRC) has recently attracted a lot of interest. Many research and professional institutions across the planet are exploring with human-robot collaboration. One of the key reasons is the increased use of robots. Robots are regarded to offer alternatives to several of modern social concerns (e.g., providing care, substituting humans in hazardous tasks).The framework for human-robot collaboration is shifting beyond separate human-robot interaction (in the past) to increased human access to machines (in the present) to close human-robot interaction (future). Another key concern with the deployment of robots, particularly in ambiguous situations (that is, outside of distinct, guarded zones), is the lack of reliable sensors. Sensor information is required for a robot to perform tasks such as responsive planning, movement controlling, visual servoing, defect diagnostics, and safety level maintenance. If the HRC equipment is intended for unorganized areas with unexpected human mobility, it must be equipped with a flexible sensor system that includes range, proximity, touch, vision, sound, temperature, and so on. Human-robot interaction will boost the versatility of automated industrial applications still further. Procedures will be enhanced by augmenting human cognitive and sensorimotor abilities with robot accuracy and fatigue-free work. These approaches do not necessitate a safe place from around robots, or even the safety zones are less than those required for regular robots. The intuitive design of the interface and operation of the robot, as well as the work instructions between the operator and robot, is a critical aspect for successful HRC.

6.6 Robots in smart factories

Robots in smart factories are equipped with sensors to enable for human-robot collaboration in a secure work place. When compared to conventional robots, so-called machines (cobots) have various advantages. These robots are human-safe and will provide the space needed by regular robots, that need a protective barrier. The safety features can be a mixture of different technologies, and the use of sensing devices to slow down the robot when individuals approach; force constraints to reduce threats to people or the environment; and the ability to detect human intent and maneuver accordingly. Aside from these safety procedures, several types of human-robot collaboration can be applied. Humans execute activities that require the most finesse, whereas robots perform repetitive, heavy, and boring ones. According to ISO 10218-2, a collaborative robot is classified as "a robot built for directly interacting with a person within a predefined collaborative workspace, i.e., work area within in the secured environment in which the robot and human can accomplish tasks at the same time during production operation." The primary premise is that robots do not harm people, and the tools to safeguard people are regulated force and velocity, separated monitoring, hand-guiding, and a safety-rated monitored halt.

6.7 Multilingualism

Smart manufacturing systems should be able to manage multilingual operations by translating any inputs provided in human language into machine language and instructing the machine to do the necessary operation [58]. It must be able to take commands directly from the controller, whether in speech or text format, to make smart manufacturing a reality and to combine machine learning, artificial intelligence, and sophisticated technologies into manufacturing systems.

6.8 Return of Investment in New Technology

When transitioning to a better technology in an established industrial system, the economic assessment and return on investment are carefully examined. The additional cost of implementing current technology is offset by manufacturing losses throughout the course of an upgrade, and the time it takes to recoup the capital with existing framework income determines the acceptance of newer technology [50].

7. Smart Manufacturing Systems

Many studies have extensively identified a number of Smart manufacturing(SM)-related characteristics, technologies, and enablers. Some of these attributes, technologies, and enablers have been mentioned specifically. Moreover, because this is not always the case, the authors conducted a thorough review of the relevant material to identify extra products that can be linked with these categories. Smart Manufacturing Leadership Coalition (SMLC) has proposed some SM platforms that take into account the integration of various technological advances in the system. The vertical and horizontal connectivity of manufacturing systems at the plant level is what SM is all about. As a result, an SMS should be aware of the status of its forerunners, successors, and parallel machines. In the literature, a computational-based learning system that integrates networked data, integrated automation, and intelligent information has been used to construct Smart Manufacturing Systems (SMS). The SMSs' scope is, however, confined to calculation in this situation. The (National Institute of Standards and Technology) NIST has presented a strategy model for SM that emphasizes agility as a goal and may be applied to different objectives.The categorization of SMS was based on three measurements: agility, asset utilization, and long-term viability. Other traits and technologies have been utilized to characterize SM in the same way. There are four steps to SM: (1) create areas where challenge descriptions can be addressed, (2) establish cyber-platforms, (3) data sharing, and (4) implement SM-friendly regulations. There is, however, no research that provides a full list of qualities, technology, and enabling variables that define a "smart" manufacturing system. The qualities, technology, and enablers that must be included in an SMS will vary. Enabling Technologies for Smart Manufacturing: Kevin Ashton originated the term "internet of things" in 1999. The Internet of Things (IoT) is a huge network of linked things that is expected to connect approximately 20.8 billion devices by 2020. It's one of the key enabling technologies for Industry 4.0 and Smart Manufacturing. The Internet of Things (IoT) is a network of things such as software, sensors, electricity, and physical objects. General Electric introduced the Industrial Internet of Things (IIoT) in 2012. (IIoT). Deep learning and big data, as well as sensor data and automation, are all used in IIoT to apply IoT to manufacturing.

The phrase "cloud computing" was coined in 2006 to describe the delivery of computing services such as servers, storage, databases, networking, software, analytics, and more via the internet. Companies profit from CC because of its versatility, multi-tenancy, reliability, scalability, and other features. Professor Bo Hu Li invented the term "Cloud Manufacturing" (CM) in China in 2009. Manufacturing is referred to as CM. CM is a customer-centric manufacturing process that allows you to access a common pool of manufacturing resources on demand to improve efficiency and lower product lifecycle costs in response to changing customer needs. Every manufacturing resource is sensed and connected to the cloud in CM. IoT technology such as Radio frequency tags and barcodes can be used to automatically share and exchange data.

Lee et al. (2014) (23) the term "cyber-physical system" (CPS) was coined by the National Science Foundation in the United States in 2006. CPS is focused with the structure and operational attributes of software controlled systems, whereas IoT is concerned with internet connected physical devices. The majority of studies linking CPS to SM have proposed a 5C design of CPS for SM, with five levels: smart connection, data-to-information conversion, cyber, cognition, and configuration.

Smart Manufacturing and related issues: Lu et al. (2016) [22] "Smart Manufacturing is the capability to resolve present and future problems using an accessible framework that enables solutions to be adopted at business speed while providing favoured value," according to the SMLC definition.

The SM Ecosystem, SM capabilities (productivity, agility, quality, and sustainability), and SM standards prospects were examined, proposed a structure comprising four components as a data-driven strategy for SM (manufacturing module, data driver module, real time monitor module and the problem-solving module). Manufacturing benefits from a data-driven approach since it boosts production efficiency while also increasing product performance.

The world has steadily drifted away from SM in the last decade or two. Because of the various trans-disciplinary benefits of SM, research and development in the manufacturing area employing CC and IoT applications has risen significantly. The majority of SM research and development has been concentrated on one specific element of manufacturing. A few of the researchers developed a framework, while others proposed architecture for a future SM system. Many successful initiatives were tried on experimental levels from the standpoint of execution. The following research gaps have been identified based on a literature review: (1) the industrial use of SM is still in its early stages and it needs to be thoroughly tested in a large-scale setting. (2) Although SM is becoming better known, it is still limited to SMEs. (3) For SM service, the usage range and geographical location are critical. (4)Manufacturers are also concerned about connectivity and scalability. (5) Additive manufacturing is thought to be a better fit for SM adoption than subtractive manufacturing.

8. The future of smart manufacturing

Industry 4.0 has both advantages and disadvantages. Acceptance of the new manufacturing reality and transformation may be the most difficult obstacle. The next generation of low-priced artificial intelligence can support a replacement wave of trade automation. This alone can lead to the creation of latest 'cyber' jobs as critical ancient jobs. It is always difficult to change the conversion from blue collar employment to white collar. The "cyber" component of the smart factory is a separate business, with jobs to be created and a staff to be educated by educational institutions. Smart enterprise will work better if we have a better understanding of future needs (Kusiak 2017b) (59). The transition from today's manufacturing to tomorrow's manufacturing is a massive undertaking due to the unpredictability of the market and technology, hardly any business can be effective in accomplishing all responsibilities on its own and smart manufacturing is evolving, as well as its components will become apparent in the next few years. The following ten theories indicate some of the features of upcoming production. Each presumption is supported by a brief explanation. The hypotheses are intended to encapsulate the essence of intelligent manufacturing. Some of them could be proved, is much less relevant, and even be removed over time, whereas others evolve into new theories.

8.1 Digitalization of manufacturing

Manufacturing will become increasingly reliant on data, needing the collection of additional data.Many manufacturing industries are already making greater use of data. For example, the wind energy sector has adopted supervisory control and data acquisition (SCADA) devices that collect huge amounts of data on process variables from which manufacturing may learn. SCADA technology makes it simple to collect, store, and exchange process data (Kusiak 2016b) [57].

8.2 Growth based on simulation, optimization, and modelling

The growing size of the data in industry 4.0 (Hypothesis1) will almost certainly result in the delivery of products and services from the input data. Information representations will be increasingly popular since they enable the incorporation of factors from several domains (for ex, goods, service, and transportation) in simulations which would be difficult to construct using conventional methods e.g. Mathematical models. Fluid estimation methods will be widespread in smart manufacturing. Predictive models, as well as virtual and augmented reality, will become mainstream [35].

8.3 The phenomenon of materials, products, and processes

The number of occurrences in which a new material, procedure, and product are all developed at the same time will increase. Some of the most innovative ideas in the past occurred when a material and a procedure were developed at the same time. The advancement of materials, methods and products is expected to lead to innovations in the future [8].

8.4 Physical assets and cyberspace can be separated vertically

The physical layer and the logistic layer in many smart organizations will be designed for ease and speed of connecting and disconnecting from one another. The vertical reparability will be largely ascribed to the necessity for physical asset reconfiguration.New system architectures will emerge as a result of the increased have to further meet shifting demands, new system architectures will arise, which will be supported by rising digitization and standardization. The ease with which the physical and cyber layers of a company may be separated vertically will define the future architecture.

8.5 Enterprise dichotomy

Contrasting cloud computing market models are likely to arise: being with strongly integrated assets and services, or one with architectural separation between the two levels. Reasoning: In accordance with Hypotheses 3 and 4, strong directional connectivity or directional reparability designs (a dichotomy) may emerge [4].

8.6 Horizontal connectivity and interoperability are becoming more important

Smart manufacturing businesses will have greater horizontal information exchange and connectivity. This will be prompted by the need to reorganize physical and logistical assets both within and between businesses. In both tiers, standardization will act as a facilitator. The growing amount and pace of information coming through a contemporary company will eventually drive the adoption of services that address enhanced horizontal information exchange and connectivity [15].

8.7 Resource sharing

Production and transportation assets would be exchanged throughout manufacturing chains on a regular basis. The unprecedented lateral interconnectedness of clever firms paired with price movements would allow sharing of manufacturing equipment, transportation, and other resources [23]. Organizations may acquire technology with the express assumption it'd be exchanged, which might aid in the development of industrial equipment.

8.8 Autonomous equipment monitoring, diagnosis, and repair

Equipment problem analysis and forecast can become commonplace in industrial automation. In some circumstances, restore may be possible. Equipment monitoring creates data that is used to support diagnostic models that are used to evaluate and forecast the status of devices and facilities. It will become routine practice to prevent problems from happening and to predict future faults.

8.9 Collaboration and standardization

Collaborative standard development can organically evolve that suit the rising demands of organizational commitment and interdependence. The demand for standardization and coordination will be fueled by the increasing dependency on data, resource sharing and the need for vertical reparability and horizontal connectivity and interoperability. Due to the difficulty of the challenges at hand, collaboration will probably certainly improve [34]. Metric standards that demonstrate a company's competence for horizontal and vertical connectivity and interoperability would be beneficial. A company may be assigned a class based on these qualities; for example, a Class 4 (out of five classes) firm might readily do business with any other Class 4 or lower firm. Organization switching and interoperability would be substantially improved with such a standard.

8.10 Cyber security and safety

Cyber protection will remain a concern that must be tackled on a regular basis. Growing data volumes and dependency make cyber security critical to industry. Advances in Industry 4.0, as well as increased data volumes and reliance, make cyber security critical .Advances in Industry 4.0 and the Economy [6]. This is particularly essential because information systems are becoming a more relevant determinant of a company's market value. The necessity of human and machine safety will grow as automation and system autonomy increase. Equipment and radar will become increasingly important. In reality, the similarities between equipment diagnosis and cyber security solutions could be investigated.

8.11 Need of smart manufacturing transformation

A potential approach of boosting the productivity of the industrial revolution is large-scale collaboration on the primary concerns related to the industries with the largest social implications. The construction of an accessible software platform embracing key industries could facilitate such collaborations, including the development of data-driven models. Without a doubt, public platforms will be realized at diverse scales. In study on joint manufacturing networks, the significance of tools in joint international projects has been demonstrated. Increasing the scale and scope of collaborative modelling work, on the other hand, makes the effort worthwhile. In every collaborative effort, considerations of trust and information transparency must be resolved [54].

Gaining better insights into trust on smaller platforms will be the first step towards addressing sharing information and expertise. To bring small and large businesses to a unified platform for collaboration, modelling at multiple scales is essential. It is critical, in fact, to ensure that small and medium-sized enterprises are seated simultaneously as large corporations. Around the world, the extent to which small and medium-sized businesses are active in designing the enterprise of the future differs. While small business entrepreneurship programs are more prevalent in the United States, Asia and Europe showed a strong interest in small business difficulties [54].

9. Conclusion

Automated manufacturing was planned and proven decades ago. The industry has shifted away from pursuing the ideal of 100% automation for sound business reasons. Without a doubt, some smart factories will be highly automated. Smart manufacturing, on the other hand, is about the manufacturing firm's independence, development, simulation, and optimization, not the level of automation on the factory floor. The scope and time span of the simulation and optimization will be dictated by the data and technology available. The level of smartness of an organization stands will be determined by how well the physical sector has been mirrored in virtual worlds. This article presents a smart manufacturing vision. Its essence was concentrated in six components that set it apart from traditional production. Ten hypotheses describing smart manufacturing were used to support the components.

10. Declarations:

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