International Journal of Mechanical and Production Engineering, ISSN(p): 2320-2092, ISSN(e): 2321-2071
Volume- 7, Issue-9, Sep.-2019, http://iraj.in

INDUSTRY 4.0 AND IT'S EFFECT ON SUSTAINABILITY IN SMART FACTORY, LOGISTICS, CPS, IOT

[1]KEVIN M MATHEW, [2]SREENADH T S, [3]MIDHUN PAUL

[1,2,3]Department of Mechanical Engineering, Federal Institute of Science & Technology, Angamaly, 683577, Kerala, India
E-mail:[1]kevinmmathew@gmail.com,[2]sreenadhts108@gmail.com,[3]midhunpaule@gmail.com

Abstract - The current trend in industrialisation is on the Industrial 4.0, which is the integrated working of a smart network of machines, cyber physical systems, Internet of Things (IoT) and individuals in the entire value chain ,ie., a smart factory and thereby reducing the wastage of resources. According to that, this paper conducts a comprehensive review on Industry 4.0 and presents an overview of the content, and the areas concentrated are smart factory, logistics, CPS, IoT. According to the efficiency of the resources, various technical, economical and environmental aspects in terms of smart production are discussed keeping the sustainable factors in industrial 4.0 as the key aspect.

Keywords - Industry 4.0, Smart factory, IoT, Logistics, CPS, Industry 5.0

I. INTRODUCTION

After the third industrial revolution which took place in 1970,a new trend focused in industrial value creation through new forms of microelectronic and robotic technologies which were introduced into the companies' production systems., which focuses it's development towards the fourth stage of industrialization known as Industry 4.0. Industrial value creation has gone through radical changes during the last 250 years. These changes can be determined by four stages, the so-called industrial revolutions. They have been characterized by the transition from human to machine work and an increase in productivity. This was accompanied by a first wave of increasing the level of automation in manufacturing and assembly . Computer Integrated Manufacturing (CIM) was introduced as a further technological evolvement of production systems . This so-called fourth industrial revolution (Industry 4.0), based on Cyber Physical Systems, cloud technologies, and the concept of the digital twin was based on electronics , Internet of Things(IoT) altogether in a proper manner for attaining a high level of automation in manufacturing. According to the Consortium II, Fact Sheet [11], Industry 4.0 is "the integration of complex physical machinery and devices with networked sensors and software, used to predict, control and plan for better business and societal outcomes." Henning and Johannes [9] define Industry 4.0 as "a new level of value chain organization and management across the lifecycle of products." Hermann et al. [10] define Industry 4.0 as "a collective term for technologies and concepts of value chain organization."

In the situation of the global environmental challenges, Industry 4.0 arises from the innovative digital technology and the demand by consumers for high quality and customized products .The main environmental pressure that digital technologies are suffering is related to the increasing trend in energy demand, and the urgent requirement of adopting low-carbon energy systems . It is understood that the Industry 4.0 principles were not initially focused on providing solutions to the ecological problems faced by production, but on increasing productivity, revenue and competitiveness. Other challenges are related to the pressure that growing digitization is putting on traditionally successful business models.

Nowadays, Industry 4.0 is focussing it's necessity of producing within environmental constraints in order to attain sustainability.

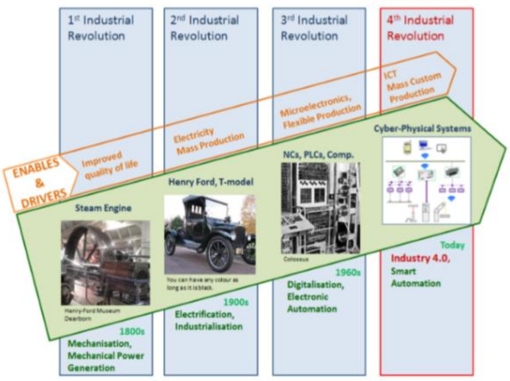

Fig. 1 Industrial Revolution

II. SMART FACTORY

The smart factory is a manufacturing cyber-physical system that integrates physical objects such as machines, conveyers, and products with information systems such as Manufacturing Execution System(MES) and Enterprise Resource Planning(ERP) to implement flexible and agile production. The main objective of smart factory production system is to process multiple types of products simultaneously so that process will be very fast compared to initial single line conveyor belt production.

Shiyong Wang et al.[2] affirmed that the industrial network collects massive data from smart objects and transfers them to the cloud. This enables system –

wide feedback and co-ordination based on big data analytics to optimize system performance. The self organized and reconfiguration and big –data-based feedback and co-ordination define the framework and operational mechanism of smart factory. The smart machines, conveyors, and products communicate and negotiate with each other to reconfigure themselves for flexible production of multiple types of products.
Shiyong Wang et al.[2] sorted out that the complete manufacturing process, ie., the smart production system reduces the waste, overproduction and energy consumption.The pull principle is utilised in the smart factory which means that raw material or semi-finished production material is requested on demand. The production system of the manufacturing company orders the material or parts automatically from its suppliers when needed. Fewer raw materials are ordered when the sales is low and this adds to the industrial sustainability.

T Stock et al.[1] presented the case study for Retrofitting a tool. The objective of this use case has been the development of a retrofitting solution for a desktop machine tool within the laboratory of sustainable manufacturing of the Collaborative Research Centre 1026 at TU Berlin. The situation analysis includes the definition of the list of requirements. In this case, the retrofitting solution is supposed to monitor the existing operational states of the equipment: shut on/off, idling, processing and fault. It also should be easy to install as well as cost effective.
Thu usage of minimum energy in handling the case is a typical example of sustainability concept in 4.0 industries.

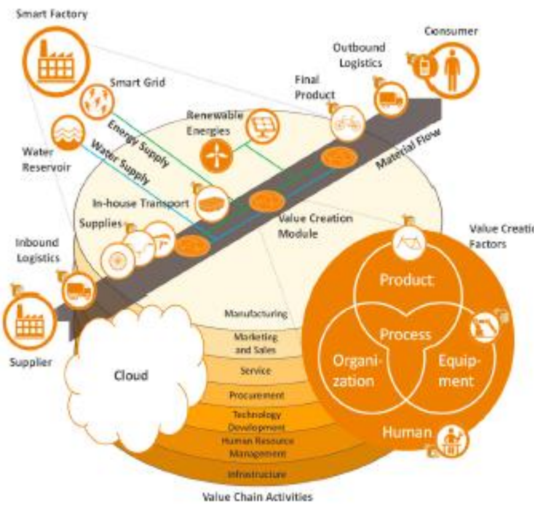

Fig.2 Micro perspective of Industry 4.0

The figure explained by T Stock [1] typically shows the microperspective of Industry 4.0 . It is basically the horizontal and the vertical integration within smart factories, and is a part of the end to end engineering dimension. The author aims in creating values on lower aggregation levels such as manufacturing lines.Smart factories will increasingly use renewable energies as part of a selfsufficient supply in addition to the supply provided by the external smart grid .This adds to the sustainability. The factory will thus become an energy supplier and consumer at the same time. The energy management system of the smart factory will have to be able to handle the dynamic requirements of energy supply and feedback. The logistics activities are carried in an agile manner, automation from starting to end. The supplies and products contain identification systems, e.g. RFID chips or QR codes. This enables a wireless identification and localization of all materials in the value chain.
This basically describes the intelligent crosslinking of the value creation factors: product, equipment and human, along the different aggregation levels of the value creation modules from manufacturing stations .The value creation module in a factory corresponds to an embedded Cyber-Physical-System. The manufacturing equipment, e.g. machine tools or assembly tools, are using sensor systems for identifying and localizing the value creation factors, such as the products or the humans, as well as for monitoring the manufacturing processes, e.g. the cutting, assembly, or transport processes. Depending on the monitored smart data, the applied actuators in the manufacturing equipment can react in real-time on specific changes of the product, humans or processes. The communication and exchange of the smart data between the value creation factors, between the value creation module and the transport equipment, as well as between the different levels of aggregation and the different value chain activities is being executed through the cloud.This is the microperspective view of the author on smart factories.

III. LOGISTICS

L. Barreto et.al [4] defined that under Industry 4.0, Logistics 4.0 encompass a range of technical components as Cyber-physical systems, software and human support. Thus, Logistics 4.0 paradigm can be summarized as the optimization of inbound and outbound logistics which must be supported by intelligent systems, embedded in software and databases from which relevant information is provided and shared though Internet of Things (IoT) systems, in order to achieve a major automation degree. Additionally logistics can be seen as a network where all processes can communicate with each other, as well as with humans for enhancing theirs analytical potentialities throughout the supply chain and there by making the process faster and increasing it’s value.
Erik Hofmann et. Al[3] focused his work on implications of Industry 4.0 in the field of logistics management. But his explanations were limited to

only 2 logistics concepts: .Kanban, JIT/JIS,logistics. Kanban is basically the system of supplying parts and materials just at the very moment they are needed in the factory production process so that those parts and materials are instantly put to use, just like the pull principle.For efficient production, management should be capable of providing production systems with the needed inputfactors at the righttime, in the right quality and in the right place. With respect to Kanban, an improved demand assessment, dynamic and more efficient milkruns as well as shortened cycle times can be expected. As far as JIT/JIS systems are concerned, reduced bullwhip effects, highly transparent and integrated supply chains as well as improvements in production planning are among the potential benefits. Both these concepts contribute directly to the concept of sustainability by increasing the efficiency in milk run and reducing bullwhip effect.

IV.CPS

Jay Lee et al[4] presented a 5C architecture for Cyber-Physical Systems(CPS) in Industry 4.0 manufacturing systems. It provides a viable and practical guideline for manufacturing industry to implement CPS for better product quality and system reliability with more intelligent and resilient manufacturing equipment.A cyber twin is created from the sensory data at each stage of operation and is used for comparison and for determining future tasks. Further at the final stage (production system), aggregated knowledge from components and machine level information provides self-configurability and self-maintainability to the factory. This level of knowledge ensures a worry free and near zero downtime production, which provides optimized production planning and inventory management plans for factory management, which adds to the sustainability of that particular plant.

N Jazdi et al.[6] typically explained a prototype that supports the concept of CPS in Industry 4.0.

An industrial coffee machine, an embedded system was made in Institute of Industrial Automation and Software Engineering (IAS) of the University of Stuttgart. A microcontroller board was used as a gateway to the cloud for the extension. The coffee machine was connected to the cyber world with the help of hardware add-ons. Various services such as remote diagnostics or a software update can be realized via the cloud then. Benefits of the transformation of a coffee machine to a CPS arise during maintenance. Thus, it is possible to remotely determine which component is defective or which ingredient has been used up, so as to bring the appropriate spare parts or ingredients for maintenance. The configurations can also be changed remotely in this way. Products can also be customized. Thus, for example, the temperature and the strength of the coffee are automatically customized to the needs and preferences of the user when ordering via an app. There will also be a Facebook page for the coffee machine and others of its kind in the future, so as to network the coffee machine with the cyber world even better. In this way, it will be possible to find the nearest coffee machine, which can deliver the desired product. This is a typical case study of CPS, through which defective components can be replaced as soon as they are found to be inefficient and sufficient quality at least cost with user’s desire can be accomplished and this phenomenon ends with achieving sustainability.

V. THE INTERNET OF THINGS

The idea of Internet of Things (IoT) is formulated in 1999 and is introduced by a British entrepreneur Kevin Ashton. IoT can be defined as the concept which describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices. It is not only used for objects but also for the processes, people and atmospheric phenomena etc. Internet of Thing plays an important role in Industry 4.0.

Ray y Zhong et.al [7] identified that within the IoT enabled manufacturing environments, human – human, human – machine and machine – machine connections are realized for intelligent perception. So that IoT can enable efficient resource sharing by the application of IoT technologies in manufacturing. It can be considered as the modern manufacturing concept under Industry 4.0 and it has a great influence in the manufacturing sector. The main feature is the real time data collection and sharing among various manufacturing resources such as machine materials and jobs. Radio frequency identification (RFID) or wireless communication standards can be used for real time data collection. There are several real life cases of IoT enabled manufacturing like RFID-enabled real-time production management system for a motorcycle assembly line etc.

Hugh Boyes et.al[8] defined the Internet of Things which is relevant to Industries as group of infrastructures, interconnecting connected objects and allowing their management, data mining and the access to data they generate” where connected objects are “sensor(s) and/or actuator(s) carrying out a specific function that are able to communicate with other equipment”. On the basis of this author introduced a new term Industrial internet of things which is the application of IoT in Industries especially in manufacturing sectors. The function of IoT devices is: to monitor, collect, exchange, and analyse information so as to enable them to change their own behaviour, or else instruct other devices to do so, without human intervention.

VI. DISCUSSION AND CONCLUSION

Industry 4.0 increases the digitization of manufacturing with CPS, in which connected networks of humans and robots interact and work together with information shared and analyzed, supported by big data and cloud computing along entire industrial value chains[7]

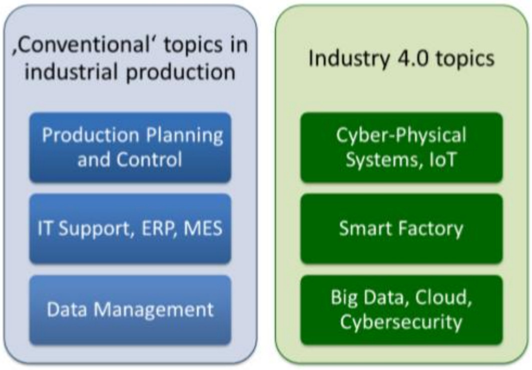

Fig.3 Comparison between 4.0 and conventional manufacturing.

The Industry 4.0 concept aims in achieving a complete value chain from providers to customers and all enterprise's business functions and services. The Industry 4.0 assumes broad support of an entire life cycle of systems, products and series, distributed both spatially and organizationally. The smart products are not only smart during the manufacturing process but they continue to provide the data about their state also during their lifetime. These data can be used for preventive maintenance; it can provide the manufacturer useful information about lifetime and reliability of their products. The corresponding concepts such as Automotive 4.0, Logistic 4.0 and Education 4.0 have in common with original meaning of Industry 4.0. It is expected that enterprises to become stable in the global market in the current scenario, 4.0 concept has to be implemented in a sustainable manner, so that resources are utilised in an ideal and agile manner, thus reducing the wastage and enabling efficient material handling through automation and in future, may chance lead to artificial intelligence of machines along with Big Data interpretation of the enterprise leading to Industry 5.0 concept.

REFERENCES

[1] T. Stock, & G. Seliger, Opportunities of Sustainable Manufacturing in Industry 4.0, (2016) 536-541.
[2] Shiyong Wang, Jiafu Wan, Di Li and Chunhua Zhang, Implementing Smart Factory of Industry 4.0: An Outlook, (2015) 1-10.
[3] Erik Hofmann, Marco Rüsch, Industry 4.0 and the current status as well as future prospects on logistics, (2017) 23-34.
[4] JayLee, BehradBagheri, Hung-An Kao, A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems, (2015) 18-23.
[5] D. Wee, R. Kelly, J. Cattel, M. Breunig, Industry 4.0-How to Navigate Digitization of the Manufacturing Sector, McKinsey & Company, (2015).
[6] N. Jazdi, Cyber Physical Systems in the Context of Industry 4.0, IEEE International conference on automation, (2014).
[7] Ray Y.Zhong, XunXu, Eberhard Klotz, Stephen T.Newman, ‚Intelligent Manufacturing in the Context of Industry 4.0, (2017) 616-630.
[8] Hugh Boyes, BilHallaq, Joe Cunningham, Tim Watson, The industrial internet of things (IIoT): An analysis framework, (2018) 1-12.
[9] WW Henning Kagermann, J. Helbig, Recommendations for implementing the strategic initiative Industrie 4.0, (2013).
[10] M. Hermann , T. Pentek , B. Otto , Design principles for Industry 4.0 scenarios, (2016), pp. 3928–3937.
[11] Consortium II. Fact Sheet, 2013. Available from: http://www.iiconsortium.org/ docs/IIC _ FACT _ SHEET.pdf

★★★