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A Conceptual Approach of Implementation of Lean Manufacturing Through Industry 4.0

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ABSTRACT

Industry 4.0 makes a factory smarter by applying advanced information andcommunication systems and future-oriented technologies.Lean Manufacturing is widely regarded as a potential methodology to improve productivity and decrease costs in manufacturing organisations. The success of Lean Manufacturing demands consistent and conscious efforts from the organisation, and has toovercome several obstacles.This paper analysesthe incompletely perceived link between Industry 4.0 and Lean Manufacturing, and investigates whether Industry 4.0 is capable of implementing lean. Executing Industry 4.0 is a cost-intensive operation, and is met with reluctance from several manufacturers. This research also provides an important insight into manufacturers' dilemma as to whether they can commit into Industry 4.0, considering the investment required and unperceived benefits. Individual researches have been done in various technologies allied with Industry 4.0, but the potential to execute Lean Manufacturing was not completely perceived. This paper bridges the gap between these two areas, and identifies exactly which aspects of Industry 4.0 contribute towards respective dimensions of Lean Manufacturing.

***KEYWORDS**: Industry 4.0, Lean Manufacturing, Integration of Lean Manufacturing& Industry 4.0, Cyber Physical Systems, Internet of Things*

1.0INTRODUCTION

Manufacturing in the current century witnesses enormous shifts and changes from its original version.Ever since the evolution of the first industrial revolution, the sector has been growing in all its facets,acquiring more and more technologies in the process. With the western world employing automation andcomputer-integrated technologies to improve its manufacturing, the Japanese industries devised acustomer-value focused method of manufacturing called Lean Manufacturing. Numerouschallenges produce obstacles in the effective path to attain Lean Manufacturing. So it is essential to find a route to solve these problems and aid theindustries in a non-traditional and employee-friendly manner throughIndustry 4.0. By advanced application of information and communication systems in manufacturing,the entire factory environment becomes smarter and enables mass customization. However, it is an inevitable fact that financial investment required for such high-end digitization is quite intensive. So not all SMEs are enthusiastic to dive into Industry 4.0. The approach used in this paper answers a significant part of this question, and illustrates that Lean Manufacturing and Industry 4.0 are not mutually exclusive; they can be seamlessly integrated with each other for successful production management.

2.0 FORMULATION OF THE CONCEPT

There are various definitions and perceptions exist in the field of researchers, it is formulated an appropriate definition is conceptualized for Lean Manufacturing. Then the authors formulated the term Industry 4.0 and discussed its current status along with the challenges faced by industries in its proper implementation. Then it has been suggested the solutions and represented according to the dimensions for implementation of Lean Manufacturing. The proposed methodology is illustrated in Figure No. 1.

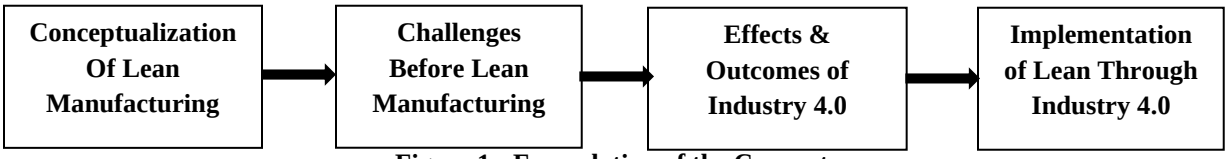

Figure 1 : Formulation of the Concept

3.0 CONCEPT OF LEAN MANUFACTURING

Lean Manufacturing can be described as a multi-faceted production approach comprising a variety of industrial practices, directed towards identifying value adding processes from the purview of customer and to enable flow of these processes at the pull of the customer through the organization.The main idea of Lean Manufacturing is to create a streamlined flow of processes to create the finished products at the required pace of customers with little or no waste. Some of the scientists performed a comprehensive, multi-step approach based study to identify the dimensional structure of Lean Manufacturing and developed reliable scales and to quantify the conceptual definition and measurement of Lean Manufacturinginto 10 different criteria as follows.

(a) Supplier Feedback
(b)Just-In-Time (JIT) Delivery By Suppliers
(c)Supplier Development
(d)Customer Involvement:
(e) Pull Production
(f)Continuous Flow
(g)Setup Time Reduction
(h)Total Productive/Preventive Maintenance
(i)Statistical Process Control
(j)Employee Involvement

The research work provides a theoretical definition for the term ‘Lean Manufacturing’ and validated it by an extensive survey of lean practices in manufacturing industries. It provides an explanation of underlying principles and a clear definition for Lean Manufacturing in a socio-technical approach. This model of ten elements includes people and process elements, as well as internal and external factors, which had limited focus in past research. Hence these widely accepted ten dimensions of Lean Manufacturing are used in our research and are validated for attainability through Industry 4.0 technologies. These ten dimensions are grouped into four major factors, depending on the entities involved in each of the dimensions. These factors are shown in Fig. No. 2 which are as follows.

(A) Supplier Factors - The supplier factors are concerned about integrating with the suppliers in the business, and comprise thedimensions supplier feedback, supplier development and JIT delivery.
(B) Customer Factor - The customer factor is focused about involving customer into the business processes.
(C) Process Factors - The process factors focus on the operations and sequence of the processes, and consist of the dimensions pull production, continuous flow and setup time reduction.
(D) Control and Human Factors - The human and control factors, as the name suggests, are concerned about the controlling system and employees. Total productive/preventive maintenance, statistical process control and employee involvement fall under this category.

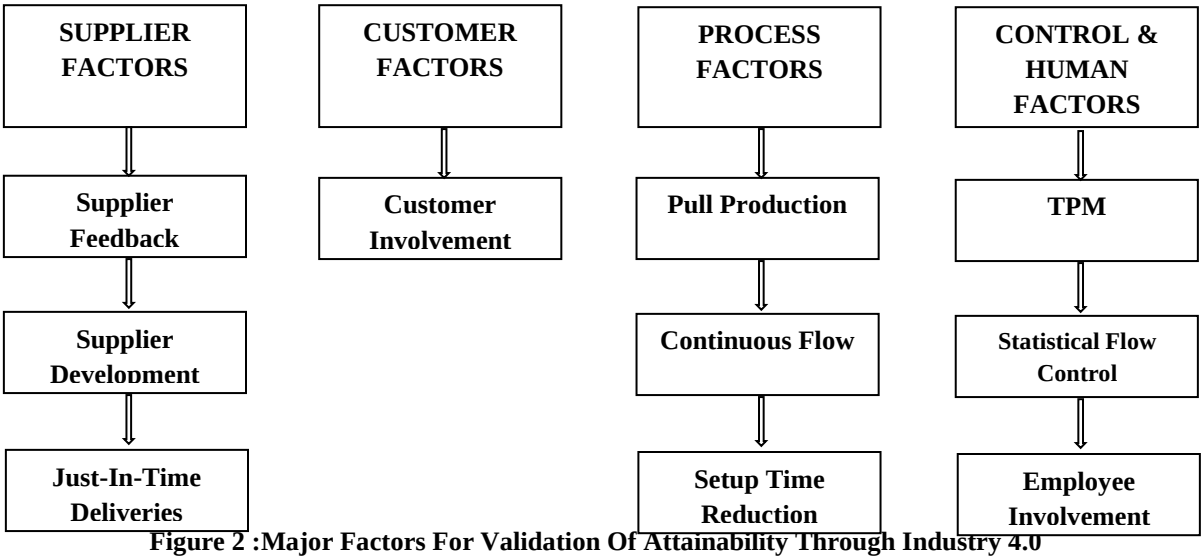

Figure 2 :Major Factors For Validation Of Attainability Through Industry 4.0

4.0 CONCEPT OF INDUSTRY 4.0

Digitization and intelligentization of manufacturing process is the need for today's industry. The manufacturing industries are currently changing from mass production to customized production. The rapid advancements in manufacturing technologies and applications in the industries help in increasing productivity. The term Industry 4.0 stands for the fourth industrial revolution which is defined as a new level of organization and control over the entire value chain of the life cycle of products; it is geared towards increasingly individualized customer requirements. Industry 4.0 is still visionary but a realistic concept which includes Internet of Things, Industrial Internet, Smart Manufacturing and Cloud based Manufacturing. Industry 4.0 concerns the strict integration of human in the manufacturing process so as to have continuous improvement and focus on value adding activities and avoiding wastes. Industry 4.0 is a strategic initiative recently introduced by the German government. The goal of the initiative is transformation of industrial manufacturing through digitalization and exploitation of potentials of new technologies. An Industry 4.0 production system is thus flexible and enables individualized and customized products. The aim of this paper is to present and facilitate an understanding of Industry 4.0 concepts, its drivers, enablers, goals and limitations. The current status of Industry 4.0 readiness of the German companies is presented and commented. Finally it is discussed about the conceptual approach of Lean Manufacturing through Industry 4.0 &if Industry 4.0 is really a disruptive concept or simply a natural incremental development of industrial production systems. The different phases of industrial revolution are shown in Fig. No. 3.

Industry 4.0 is the fourth industrial revolution applying the principles of cyber-physical systems (CPS),internet and future-oriented technologies and smart systems with enhanced human-machine interactionparadigms. This enables identity and communication for every entity in the value stream and leads toIT-enabled mass customization in manufacturing. The term was first used in2011 followed by formation of a working group chaired by Siegfried Dais (RobertBosch GmbH) and Henning Kagermann (Acatech). The Internet of Things and Services enables tonetwork the entire factory to form a smart environment. Digitally developed smart machines,warehousing systems and production facilities enable end-to-end information and communicationsystems-based integration across the supply chain from inbound logistics to production, marketing,outbound logistics and service. Industry 4.0 alsoensures the creation of better co-operation between employees and business partners.

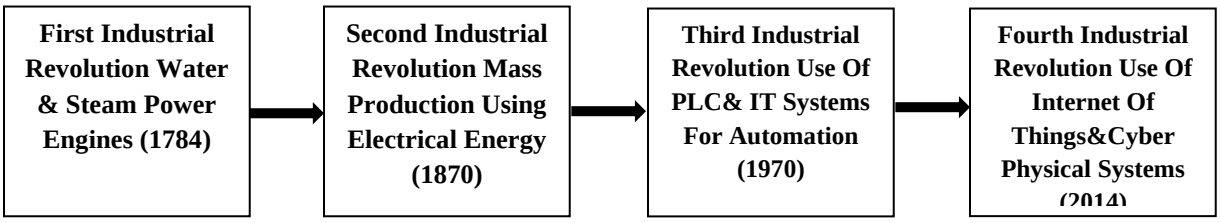

Figure 3 : Different Phases Of Industrial Revolution

Industry 4.0 significantly influences the production environment with radical changes in the execution ofoperations. In contrast to conventional forecast based production planning, Industry 4.0 enables real-timeplanning of production plans, along with dynamic self-optimization. Though embedded with latesttechnologies and intelligent algorithms, the smart factory allows itself to be built on the foundations ofthe classical. The introductionof information and communication systems into industrial network also leads to a steep rise in the degreeof automation. Intelligent and self-optimizing machines in the production line synchronize themselveswith the entire value chain, right from order or materials from suppliers to delivery of goods to customers. Simulation of inventory, logistics andtransport, and usage history of products also help to positively influence the production processes.

In Germany industries are evaluating their readiness towards implementing Industry 4.0. At least 42% of German firms are aware of this theme and have started some concrete initiatives. But it is along way to go and for some industries the topic is still unknown. This applies in particular to smallscale industries where 50% of them are unaware of Industry 4.0; on the other hand it is well known in larger companies, where only 17% are found to be ignorant of the term. There also exists a lag in implementation plans of Industry 4.0 between big industries and SMEs. Nearly 20% of original equipment manufacturers have solid implementation strategies, whereas even withthe huge volume of SMEs in Germany, only 17% are equipped with implementation strategies. These industries need to explore the possibilities and benefitsassociated in integrating all their factory operations. This does not only concern technical issues butalso raises important management questions. The initiative is widelyspread across the world, called by different names in different countries. Hence the findings of thisresearch are applicable to Internet of Things (IoT) based manufacturing control practices in anycountry.

The need of industry 4.0 is to convert the regular machines to self-aware and self-learning machines to improve their overall performance and maintenance management with the surrounding interaction. Industry 4.0 aims at the construction of an open, smart manufacturing platform for industrial-networked information application. Real time data monitoring, tracking the status and positions of product as well as to hold the instructions to control production processes are the main needs of Industry 4.0.

5.0 INTEGRATION OF LEAN MANUFACTURINGAND INDUSTRY 4.0

Integrating both the spheres of Lean Manufacturing and Industry 4.0 is an important research field to beextensively explored.With the advent of computer integrated manufacturing, there was a speculation thatfactories of the future would operate autonomously without the requirement of human operators.In the following sections, the ten dimensions of Lean Manufacturing from the four grouping factors are discussed and how the technologies and concepts of Industry 4.0 act as enablers to these dimensions is evaluated.

5.1 Supplier's Factors

The supplier factors are concerned about the flow of goods and information from the suppliers to the manufacturer. It is necessary for every entity in the supply chain to get synchronized with the changes in business processes of the manufacturer. Accordingly, the dimensions supplier feedback, supplier development and JIT delivery are discussed, and the impact of Industry 4.0 on these factors is shown in Figure No.4.

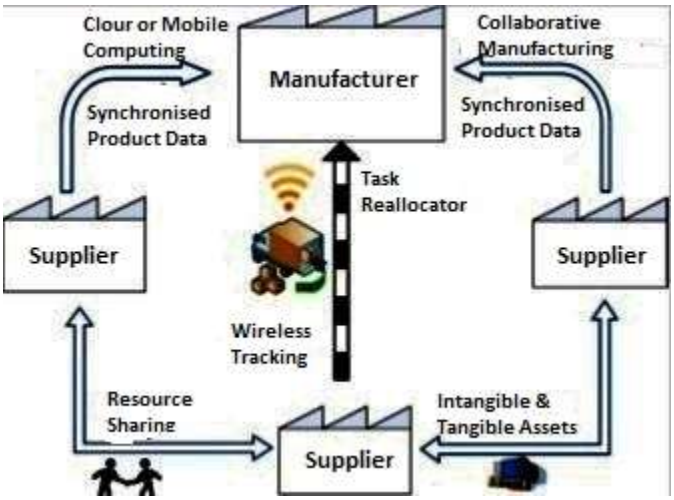

Figure 4 : Supplier's Factors

5.2 Customer's Factors

The customer factor focuses on catering to the needs of customer and integrating them with thebusiness process, in order to achieve Lean Manufacturing. No more can the old 'sell and forget' mentality be found in the minds of manufacturers. Business models are getting converted into providing products along with services. Enhanced services such as upgrade and refurbishment discover new customers while increasing experiences of existing customers. Industry 4.0 also employs intensive techniques for customer analysis and market research areas. Traditional analysis tools such as quality function deployment (QFD) have limitations on the quantity of customers' requirements and their relationship with product design requirements, besides the problem of acquiring exact needs of customers. Big Data facilitates extreme complex calculation and processing of relationship between needs and functions for large volume of data. Even the products developed and sold to customers are termed as being smart, which mean that they are integrated with devices which track usage data and send to smart factories. The manufacturer then collects and analyses data from these devices from different categories of customers, which enables him to better identify customers' needs and behaviours in order to provide more sustainable products and solutions.

5.3 Process Factors

The sequence of operations performed in the shop floor and the flow of products right from the stage ofraw materials to the finished goods are significant factors to be considered to implement lean & the impact of Industry 4.0 on these factors is shown in Figure No. 5.

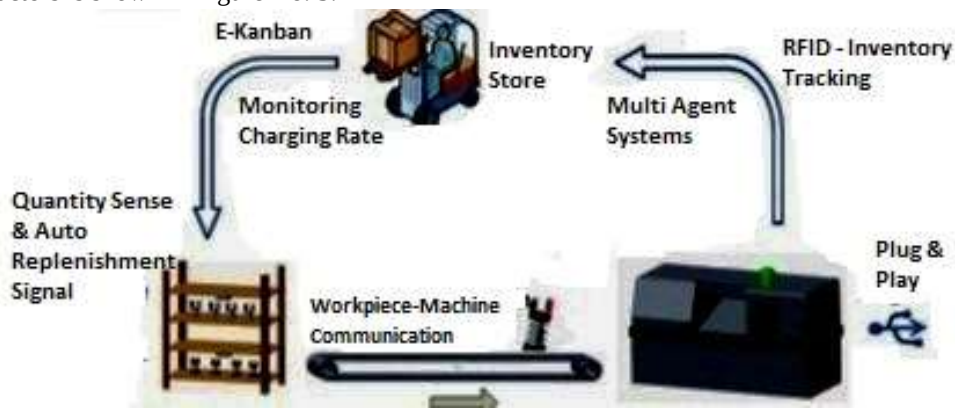

Figure 5 :Process Factors

5.4 Control And Human Factors

The factors responsible for control of quality and equipment along with work environment areconsidered in this category. Control and human factors consist of the dimensions total productive/preventive maintenance, statistical process control and employee involvement. With more advanced analytics and big data environment, machines are equipped to be self-aware and self-maintained. Such machines assess theirown health and degradation and utilize data from other machines to avoid potential maintenance issues. The ability to anticipate potential breakdown and identify root cause needs tobe developed in the control systems. In the scenario of Industry 4.0, smart products come with details about theoperations to be done on them. The sequence of operations to be performed on a product is alreadyloaded onto the carrier of that product. This information is already passed on to the machine forautomated operations, and shown with better visualization interfaces for manual operations. Improvedman-machine interfaces also present information in a more appealing manner, and avoid possibility ofmaking mistakes in the production processes. The smart feedback devices, worker support systems and improved man-machine interface facilitatebetter empowerment and involvement of employees in the organisation. The concept is as shown in Fig. No. 6.

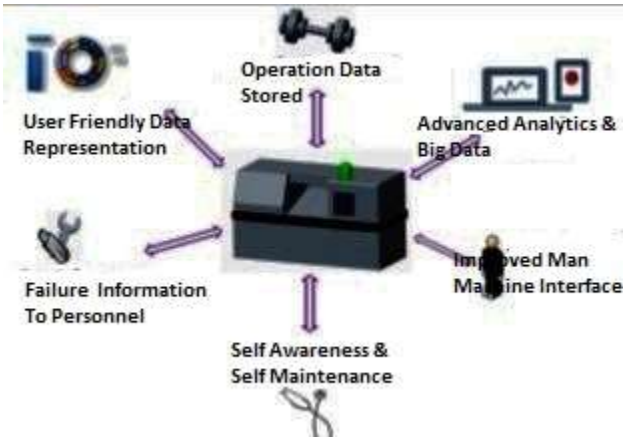

Figure 6 : Control & Human Factors

6.0 SUMMARYOF INTEGRATION OF LEAN MANUFACTURINGAND INDUSTRY 4.0

There is a positive co-relation between Lean Manufacturing& Industry 4.0. Every problem for implementation of Lean Manufacturing from the perspective of integration has a solution in the technologies associated with Industry 4.0. Executing these technologies solves these barriers in all factors – supplier, customer, process and control & human factors. Hence the research clearly confirms that by embracing Industry 4.0, industries are capable of becoming lean without the need to maintain conscious and persistent 'striving-for-lean' efforts. Conception, operation and maintenance of a manufacturing industry are improving considerably through the technologies ofIndustry 4.0. With advanced information and communication systems in place along with a lean operatingstructure, an industry has the potential to expand into new horizons at ease. As per the conventional aspects of Lean Manufacturing, it is a well-accepted fact that as a factory becomes lean, the flow strengthens, and the non-value added activities or 'waste' decreases. Decrease in waste means decrease in costs as well. So any effort to decrease this waste pays off in terms of reduction of operating costs. Now this effort comes through digitization and integration of resources, in the name Industry 4.0. By implementing Industry 4.0, besides the stated benefits of making the factory smart, financial benefits would be realized as well due to the reduction or elimination of redundant wastes. Hence though cost-intensive, enforcing Industry 4.0 proves to be worth the investment for its unforeseen benefits, and the research affirms that reluctant industries can positively venture into this fourth industrial revolution.

7. CONCLUSION

Industries across the world strive to achieve Lean Manufacturing, but not every organisation is successful in perfectly implementing and achieving the benefits of it. It wasconceptualized initially for manufacturing industries, but later the same techniques were used for service and maintenance sectors. This paper presented and evaluated how Lean Manufacturing can be implemented through the technologies of Industry 4.0. Through Internet of Things, the shortcomings of conventional practices can be overcome to improve productivity and eliminate wastes. It implies that industries now have the combined benefits of real-time integration of the entire factory along with assurance of minimal waste generation. The research alludes that SMEs in Germany can positively commit into Industry 4.0 with the perspective of making their production shop-floors lean. This technique will further enhance with the increase of computing power and decrease of size. Improvements or adaptations of evolution of these new technologies need to be analyzed over their influence on Lean Manufacturing. Instead of simply theoretical approach through certain mathematical model, an application oriented research need to be developed in this regard. Future research needs to be focused on creating a conceptual framework and cyber physical working system, integrating these parameters in a fully functional production environment.

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