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Research Article

Industry 4.0: Implementation in Bearing Manufacturing

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Abstract

Industry 4.0 is the 4th stage of industrial revolution wherein technologies such as Internet of Things(IoT) and Cyber-Physical systems are adopted for better flexibility in production and overall profit maximization. In today's ever increasing demand for the consumer products, industries having manual interference are lagging behind in service. Thus automation of processes has become a necessity. Industry 4.0 takes the power of traditional manufacturing processes with the cutting edge technology and uses it together. Industry 4.0 mainly focuses on lean manufacturing with best possible quality in least cost of production. It also alarms the manufacturer about possible breakdowns beforehand. Continuous improvement with inclusion of least number of non-value adding processes is one of the goals of industry 4.0. Industry 4.0 is a concept wherein mechanical processes, cyber-physical systems and cloud computing go hand in hand.

Keywords: *Industry 4.0, Internet of Things (IoT), Cyber-Physical Systems(CPS), Lean Manufacturing*

1. Introduction

In the last two or three decades, we have seen a shift in our lifestyle as it is affected by computers. Information and Communication technologies are developing almost every month. This trend will find its way into industrialization, which will be beneficial to the industry in various aspects. In Germany this trend is known as INDUSTRY 4.0. It is a synonym for bringing a change into today's factories which are restricted to challenges like short product life, Products according to customer's desire and stiff global competition. It is not possible for manufacturer to satisfy the variable needs of the consumer. Thus to tackle this variation the must be a high degree of flexibility and speed in the production line which will be able to adapt itself to the changing needs. This cannot be achieved by traditional automation processes. Instead a virtual module of factory must be developed with the help of various sensors that will sense a number of parameters connected through Internet of Things which will be proven as the key elements that will help in overcoming the existing obstacles. But a challenge to this system is the number of vendors and automised coordination between material procured from them.

Basically, LEAN in industry language, means a system that achieves best possible output through continuous improvements. Toyota has been inculcating this practice in their system for a while now. It aims at reduction of waste and processes that need to be carried out that do not help the industry financially. The eliminations include-- Defect reworking, material procurement delay, waiting time ,etc. Nowadays it has its effects over various parameter right from product development to the distribution of finished product. It is a concept which has its complete focus on achieving highest quality, lowest cost, and shortest lead time. Internet Connected Technologies(ICT), Internet of Things(IoT), and Cyber-Physical systems play a very important role in this. These technologies are adapted to rapid data collection, analysis and transfer, This enables the operator to cope up with the changing trends of the market and keep his factory in pull type sector. This ultimately leads to lean manufacturing. Such industries where mechanical systems, control systems, cognitive and cloud computing are used for the optimization of production are called Smart Factories.

The components that that are the building blocks of industry 4.0 must be able to monitor some innovative sensing technologies for processing and analyzing the product history. Adaption of machine learning techniques can be used for improvisation in process control and quality management. The sensors should be able to create a virtual factory floors through smart modeling. The manufacturing data must be analyzes in real-time through intranet operations or cloud computing. New human-machine interfaces should be developed that will the distantly operated. Cyber-physical systems must be employed for design and operation of smart manufacturing facilities.

The characteristics of an industry where industry 4.0 is implemented can be as follows-

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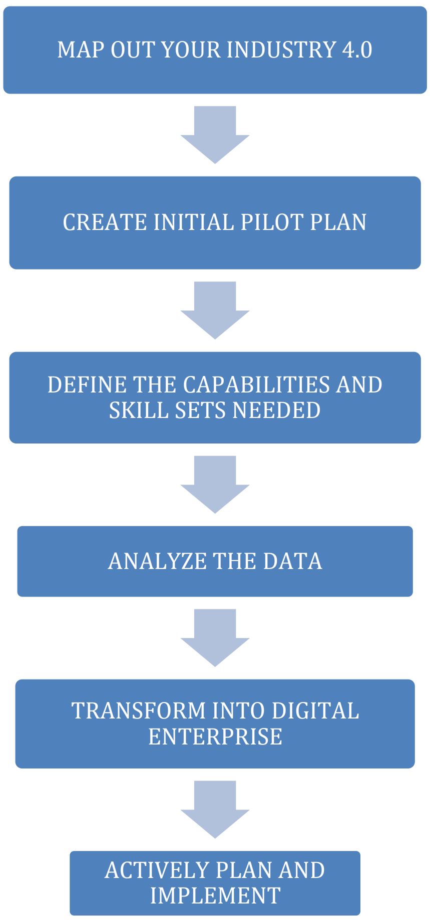
(1)Team-work in the organization with multi-skilled operators who have flexible work hours and their responsibility with respect to the output is high. (2)Active, real-time problem solving habits keeping kaizen as their main motive or continuous improvement.
(3)Lean processes, where difficulties are revealed and corrected by low inventories, TQM, prevention rather detection and problem solving, number of batches of small groups of workers, Just-in-time production. (4)Better relations with suppliers
(5)Frequent surveys for closer relations with consumers .

2. Introduction to Industry 4.0

Use of information technology and communication started in 1970s. But the concept of Industry 4.0 was first brought up in Germany in 2011. To make a factory smart factory, it is important to achieve increased automation which is possible through Cyber physical systems and Internet of Things which can be employed for autonomous working. For this, interaction with physical environment is necessary which can be obtained through installation of microcontrollers, actuators, sensors and communication interface. But Internet of Things and CPS are introduced so that the tasks like product designing, planning, optimization, tasks of various machines is decided internally which paves the way for the 4th Industrial revolution.



3. Bearings

Bearing is machine element that restricts the relative motion between two moving/rotating parts to desired motion. Bearing are also used to reduce the friction and thereby frictional heat between two moving parts. It generally provides free rotation about a fixed axis of rotation. Rotary bearing or simply Ball bearing hold a shaft or an axle and transmit radial and axial loads. Bearing are mechanical components that transmit or bear loads of an excessively long shaft. The bearing have zero tolerance any angular misalignment. There are various types of bearings depending upon the type of load that needs to be transmitted. A simple ball bearing consists of Outer ring, balls/roller, cage, inner ring. Nowadays bearings are being used in numerous rotary operations right from ultra high speed dentist machines to Mars rovers. Some of the primarily used bearings in world are:

(1)Plain bearings consisting of a hole for rotating element
(2)Rolling element which consists mainly of [a].Ball bearing and [b].Roller bearings (3)Jewel bearing wherein the bearing surfaces are made of high degree of mirror like finish to reduce the friction.
(4)Fluid bearing which have fluids as the bearing element.
(5)Magnetic bearings wherein motion is supported by a magnetic field.

4. Linking of Industry 4.0 to Bearing Manufacturing

1) Bearings as a Smart Product

Keeping the principle of Kaizen and Just-in-Time in mind, it will help to pave a way to lean manufacturing. For manufacturing bearing as a smart product, it is necessary to collect and analyze the information about various parameters such as time required in material procurement with respect to demand, planned maintenance, raw material quality, unexpected failures, internal rejections, life cycle of the finished product, hours of service before first evidence of failure, etc. All this information will be collected by the sensors installed at the key positions. They have unique properties such as environmental awareness, ability to adapt, self-organized and ability to serve until completely scrap which enables them to be used for continuous improvement. Moreover, they efficiently create of visual picture of the shop-floor and allow the visualization of the manufacturing. This is extremely useful for planning business strategies. They can also alarm about an upcoming unplanned maintenance Through the processing of the vast data which is analyzed as long as they are working. In addition to this the manufacturer can also inculcate Kanban into manufacturing to keep the overall process Pull Type. This will ultimately lead to best raw material procurement least possible time, coordination with suppliers, less number of non-value adding processes, best quality raw material required for Bearings with maximum efficiency, less number of unexpected failures and notice about any failure in advance.

2) Smart Machines for Bearing Manufacturing

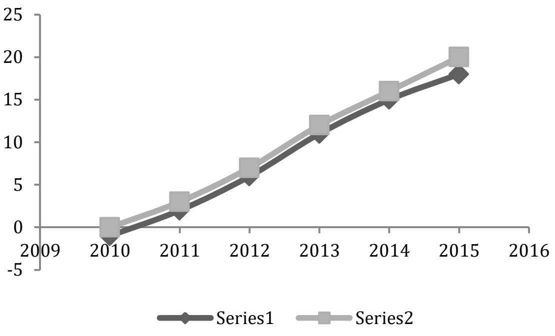
A smart manufacturing machine is one that has PLC and PID panel installed on it that uses Radio Frequency Identification. Such a panel will be proven useful while making use of Kanban cards that have radio frequency tags on them which will trigger the necessary process in the machine once the circuit is identified. It is assumed that the panel is programmed and will identify the card with 100% efficiency. This will force the machine to manufacture bearings only when needed according to the quantity that the card is programmed for. Except this, the machine will be adapted to constant improvement is various sections of a bearing where it was found to have failed earlier from the earlier survey. The machine can be developed with an alarm system that will go off if an unexpected event occurs. That will be sent to the concerned person through an addressing on mobile phones or public addressing systems or through electronic notifications. This data of each and every working component of a bearing makes it possible for the manufacturer to introduce Poka Yoke into the system and give better operational intelligence.

3) Augmented Operator of Bearing Manufacturing

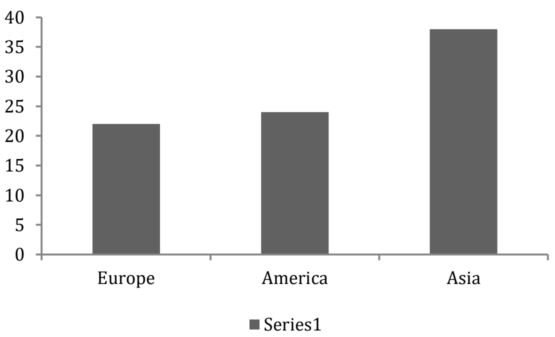
The operator is assigned to reduce the time between two tasks. In an automated bearing manufacturing process, the outer ring is expanded in the elastic limits of the material and then the balls, cage and the inner ring are inserted. This process as a whole takes about 6 seconds according to the SKF survey. The augmented operator has the responsibility to decrease this process time to as minimum as possible. The expansion of outer ring is checked by a sensor installed in the system that continuously analyzes and tries to reduce at least the time taken for this specific process. In this way, sensors installed in the system are assigned this task ultimately. All this optimization processes are handled by the augmented operator. An augmented operator is the brain of the whole system whose aim is to make the system automised to its maximum potential. The Operator is also responsible for the errors that occur during the process. All these errors are recorded in the database/memory for further studies as a part of continuous improvement. In addition failure will be immediately detected by the sensors and the fault repairing actions will be started by the cyber-physical system.

5. Graphical Representation of Results

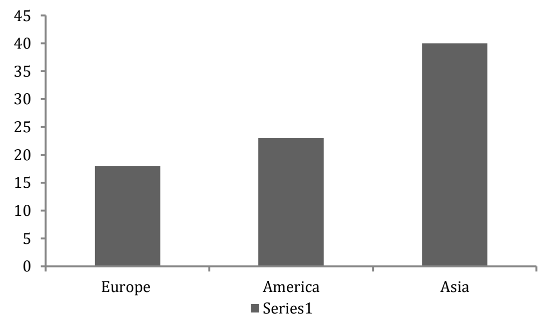
Following graphs show the results of various parameters after implementation.



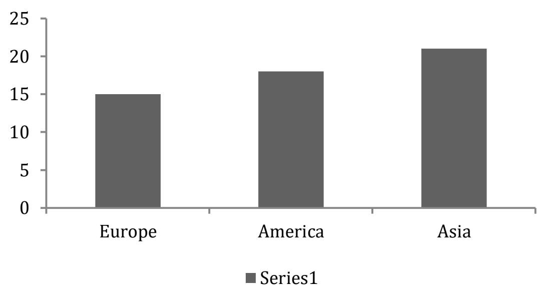
Graph 1. Increase in manufacturing jobs and increase in production output per year where Series1 represents Manufacturing Jobs and Series2 represents Production Output.



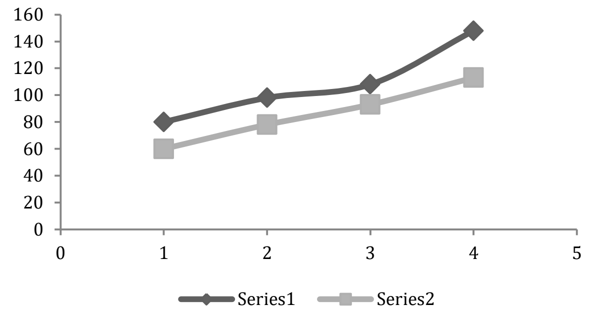
Graph 2. Efficiency gains(%) in different continents where Series1 represents Percentage Efficiency Gains



Graph 3. Relative Cost reduction in different parts of the world where Series1 represents Cost Reduction in million USD



Graph 4. Additional revenue requirement in billion USD where Series1 represents Revenue



Graph 5. Increase in productivity per decade in USA Increase in output per decade in USA where Series1 represents Increase in Productivity per Capita and Series2 represents Increase in Output per Capita.

Conclusions

Industry 4.0 is a revolution that is going to change the concept of manufacturing all over the world. Implementation of Industry 4.0 in bearing manufacturing has brought about a dramatic change in the overall efficiency of the factory. It can be answer to great flexibility of the manufacturing process knowing that the process and the supply chains are very complicated. In order to achieve maximum output in minimum cost of production it is necessary that various engineering braches work together. In the presented review paper review about Industry 4.0 and its implementation in bearing manufacturing using various quality control tools was presented to link the different engineering domains. The examples were provided for Bearing as a Smart Product, Smart bearing manufacturing machine and Augmented Operator of Bearing Manufacturing. Industry 4.0 is a revolution wherein mechanical engineering forms the foundation of the process, Electronics and Control Engineering are the pillars to support the upper level formed by Computer Support ultimately contributing to the manufacturing of bearing with 100% efficiency through fully automised manufacturing processes.

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