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Enabling Industry 4.0 in Electrical Instrumentation Industries

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ABSTRACT: The vision of a futuristic industry that delivers high value to its growing base of customers around the globe, is using the most optimum and advanced resources. With the ever changing need of joining hands with industrial revolutions, the urgency for change is now feeding through from industrialists, business and academic thinkers, generating new ideas and techniques of manufacturing. Such rapid advancements in the field of manufacturing are also to be found in the ever growing field of Electrical Instrumentation Industries. Industry 4.0 being a visionary concept has started sowing seeds with help of realistic concepts like Industrial Internet of Things (IIoT), Smart Manufacturing, Testing of products with feedback systems. Industry 4.0 tries to integrate the involvement of human intelligence in the manufacturing processes in order to enhance productivity and avoid wastage. The purpose of this paper is to provide an outline of Industry 4.0, understanding the building blocks for implementing industry 4.0 and the practical implementation of its concepts.

KEYWORDS : Industry 4.0, Cloud based manufacturing, feedback system, cloud based data recording and energy management.

I. INTRODUCTION

As human civilization has been developing so are the requirements of the world surrounding us, changed. One such integral part of it is the industry that helps mankind fulfill its needs by means of various manufacturing technologies. It takes into account the changes in technology and means with which manufacturing is executed. The industrial practices and processes have evolved from the past years and these developments have proved to be life changing for mankind. During the end of the 18th century, the journey of industrial evolution-the First Industrial Revolution took place with the help of basic (natural) resources like water and steam to power gigantic mechanical machinery. Huge steam generating boilers and engine with the help of furnaces converted water to steam in order to haul processes. The boon of electrical energy and its generation methodologies helped paved the way of replacing labour from processes with machines heading towards efficient production by the beginning of the 20th century. The use of electrical energy to drive machines also helped to implement mass production of products. This increased the ratio of output of finished product to the power input. This not only changed the manufacturing processes, but also helped electrical energy to emerge as a prominent form of energy. This era was coined as “Second Industrial Revolution”. In the 1970s, new advancements in technology and the research and development of silicon based components introduced electronics in the industrial processes. Equipment and devices were made to be more compact and less power consuming. With the advent of time, information technology and computer intelligence in manufacturing processes started evolving. Systems and processes started running on computer based programs, making them more efficient and free from human error. Nevertheless, human involvement in these processes was crucial because these processes lacked feedback systems and were dependent on the intervention and control of humans.

As we travelled through time, the industrial processes evolved in terms of technology and practical implementations and so did the complexities too. Today, we are in an era of industries migrating to cloud based system where data from different nodes is collected, stored on the cloud, analyzed and given back to the control system so as to take necessary actions. It is an era of Cyber Physical Systems and is coined a “Industry 4.0”. The umbrella of Industry 4.0 is wide and comprise of various building blocks.

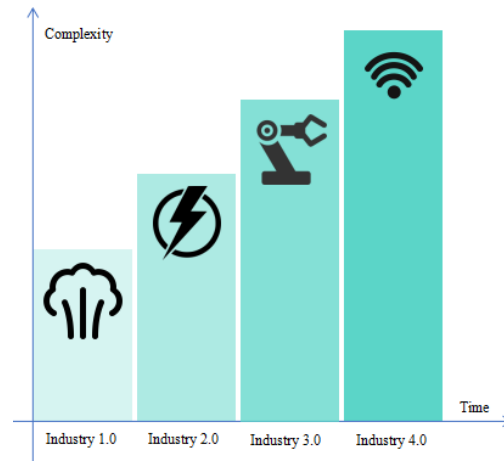


Fig. 1. History of Industrial Revolution

II. INDUSTRY 3.0 VS INDUSTRY 4.0

As understood earlier, the third industrial revolution talks about automation of industrial processes and incorporating information technology that involves electronic machines like computer systems, communication systems, and peripheral devices in order to receive and transmit data related to the processes. It would then involve human interaction to understand the data and take necessary actions when deviations or corrections are required in the process. One of the major differences between the third and fourth revolution is the incorporation of the feedback loop without human intervention in this stage. This means the devices, equipment and machines are capable of understanding, acknowledging and correcting data on their own. This can be achieved by making the processes smart and involving advanced technologies and concepts like Artificial Intelligence, data analytics, Internet of Things, robotics and the Cloud.

III. BUILDING BLOCKS OF INDUSTRY 4.0

In order to gain the benefits that Industry 4.0 provides, it is necessary to understand the steps to implement Industry 4.0. These steps are building blocks and applicable to a myriad of types of industries.

The major building blocks can be as follows -

- 1. Tools to measure data:** Generation of data and capturing it is crucial for analysis and taking corrective actions. The first step is to measure the parameters that define the structure of a system. These parameters can be energy consumption, power factor, maximum demand, load currents, etc. while considering an energy management system or type of material, dimensions, applied pressure, emissions, etc. while working on a job in a process industry. Therefore, communication capable meters or gauges are required to be installed in these premises for capturing the data and then transmitting it to a central location for further requirement.
- 2. The Cloud:** The Cloud serves as a crucial link for communication of the nodes in the application area. This is to increase the speed of information sharing and keep it stored in a centralized system. The Cloud helps in conveying data to the centralized analytical system after collecting data from various decentralized locations.
- 3. Analysis of data:** The comprehensive data collected from various process equipment, devices and other nodes of data collection becomes a great tool for data analytics. The essentials of data analysis are to inspect, clean, transform and modify the data into a structure that helps define the system that is being monitored. Various tools for data analysis are provided for predictive data analysis. Real-time data from these resources prove to be beneficial for taking corrective actions in real-time and advanced analytics help in predictive maintenance or decision making.
- 4. Advanced simulation and control systems:** As stated in the difference mentioned in the erstwhile section, the pivotal element in the transition between the Revolutions is the incorporation of control systems and simulation

features with minimum or zero human intervention. This includes advance and emerging technologies like the Cyber-Physical Production Systems (CPPS) with its main objective of adaptability in processes. The CPPS are autonomous and work in response with the inputs received from sensors or the data collected from various decentralized resources. The term adaptability refers to a process or element that adjusts into existing conditions. It accounts, the use of feedback loops, the feedback coefficient takes care of the dynamics in the system by adding necessary input in the system.

IV. PRACTICAL IMPLEMENTATION

Due to the keen interest in the inspiring technology of Industry 4.0 and with the help of its building blocks, Rishabh Instruments Pvt. Ltd. (we) have tried implementing it to optimize and increase efficiency of our manufacturing processes. It is an electrical measurement (metering) device manufacturing industry and has been able to easily understand the exact need of monitoring, recording and transmitting data.

A smart manufacturing environment is practically implemented at the crucial stage of assembling discrete and surface-mount components on the PCB to the testing and calibration of final products. The feedback based manufacturing process and cloud based data recording system is thus being implemented practically in order to overcome challenges related to manufacturing and saving energy costs by managing it effectively.

A. Automated optical inspection of PCBs

On an assembly line the important stage is of soldering the components appropriately as well as to check for any defects in the soldering or incorrectness in placement of the SMT or discrete components. The involvement of a human intervention in such cases increase the time of inspection, chances of error or negligence. To avoid this an automated optical system AOI is installed. VISCOM S3088 Ultra 3D AOI is a high speed Automated Optical Inspection system. It detects soldering defects on PCBs. This 3D system uses one orthogonal and 8 angular cameras (optical sensors). Complex IC packages like PLCC, QFN can also be inspected on this AOI system. Machine detects faults like dry solder, weak solder junction, bridges (short circuits), displaced components, wrong polarity, missing components, lifted leads, etc. It can also read and verify values/part numbers printed on resistors, capacitors and ICs. It detects the faults very accurately and consistently.

It eliminates human errors and time required for manual PCB inspection. It also has a provision of providing feedback to the adjacent flow machine connected to it. It provides feedback related to settings of the right temperature in the flow machine so that soldering is done at the right temperature and no overheating takes place. Machine tests average size board of 100mm x 50 mm with high complexity within 15 seconds. Thus saving a large amount of time, generally 10 to 15 min depending on the size of PCB while manually inspecting the defects and correcting them.



Fig. 2. Automated Optical Inspection System

B. Feedback based testing and calibration

There are various test and measurement equipment manufactured and they require testing as well as calibration in order to ensure their performance as per specifications. For this purpose, test and calibration set-ups are developed that are capable of testing and calibrating 5 digital multimeters at the same time. It utilizes a smart-loop system by using image processing cameras. During tests, the specified electrical parameters such as AC/DC voltage, mA current, capacitance of various specified test values are supplied to the device under test (DUT). The function of the DUT is to measure and display the supplied parameters correctly with mentioned accuracy. This is continuously monitored by the image capturing device, deviation in the displayed parameter is a cue that the instrument is either showing readings out of accuracy or needs calibration. A logic program is written in the system software that understands these signals and triggers the calibrator to act accordingly.

This process is completely automatized and involves zero human intervention, it successfully replaces the use of conventional system where-in the operator manually changes the output of the calibrator and calibrates the instrument. During each test & calibration cycle, an e-test certificate is automatically generated. This generated e-TC gets uploaded on the cloud and is made available to customers purchasing the multimeter, only a specified model no., serial no. of order confirmation is required to login to the system and obtain the test certificate.



Fig. 3. Image capturing using web cameras

This not only makes the system error free or free from human-intervention, but also helps reduce carbon footprints by using electronic media to provide test certificates.



Fig. 4. Closed loop testing and calibration



C. Cloud based data recording for energy management

There is an increase in the energy regulations and the cost of energy due to a reduction in resources for generating electricity. It has been proved that it is very necessary to implement energy management tools in any industry. Energy management is defined as a “Proactive, organized and systematic management of energy use in a building or organization to satisfy both environmental and economic requirements”. Implementing cloud based energy management is a more effective tool of managing energy in a given industrial premise.

The requirements of a cloud based energy management system are as follows:

1. Collecting the energy data and monitoring energy consumption
2. Using the cloud to store data for further processing
3. Taking actions to manage energy
4. Tracking the progress and ongoing improvement

With the help of various energy monitoring devices at different nodes in an industry, the data regarding energy consumption is transferred over the cloud.



Fig. 5. Energy monitoring devices installed in premises

A cloud based energy management software is implemented that retrieves the essential data and monitors it. Alarms, notifications and reports are generated as per thresholds fed in the software. This helps to monitor all essential electrical as well as other related parameters like temperature, fuel level, etc. to maintain the costs related to energy consumption.

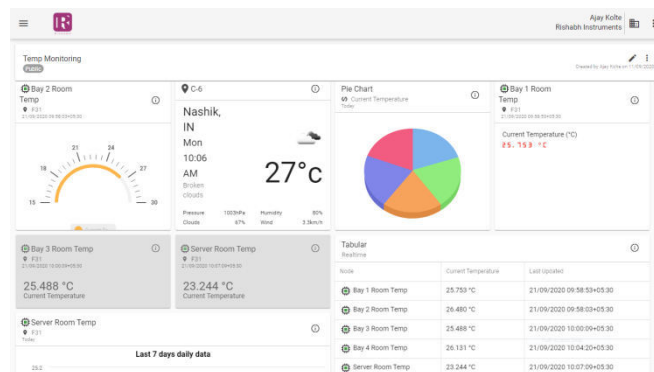


Fig. 6. Digital Shop-floor energy management system

Availability of real-time parameters over android application helps the maintenance incharge to keep record of the consumption pattern and act proactively.



V. CONCLUSION

The paper casts light on the concept of the fourth industrial revolution, i.e. Industry 4.0. The major building blocks like the field monitoring devices, data storage, data analysis and advanced control systems are also briefly explained by the context of its implementation in industries. Though the scope of Industry 4.0 is vast and it is a blooming concept which has various methods of its implementation in all types of industries, the approach is to try enabling Industry 4.0 in the electronic instrumentation industry using smart manufacturing concepts.

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