Smart Factories -An Important Component of Industry 4.0

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Abstract

Industry 4.0 has had an enormous effect on the increasing growth and rise of science and technology. Amidst this Smart Factories was one of the biggest components for the development of Industry 4.0. Development of smart factories are important because it not only contributes towards a faster production rate but also ensure an optimal output production. In order to demonstrate some insights regarding the technology currently in use in the domain "A Smart Factory in Industry4.0." The evaluation about the available evaluations of the literature yields some significant findings and sheds some insight on the future of an individual smart factory and the rise of Industry4.0. This study report includes literature reviews, discussions of the methodologies and our approach to the findings, as well as the findings and analysis of our own investigation. The current activities and research connected to smart factories and Industry 4.0 are reviewed and analyzed in this article, which also identifies the key traits of such factories with an emphasis on sustainability. It also proposes a model on IOT driven smart factories. This research paper also suggests some techniques about the energy management on the concept of IOT.

Keywords
Smart Factories, Industry 4.0, Automation, Digitization.

1. Introduction
This concept was introduced for the reduction of human efforts and ease in manufacturing (Professor Kagerman, 2013). Later this concept was promoted by governments worldwide. But knowing that What exactly is Industry 4.0? Consequently, to address this query Industry 4.0 is essentially a concept that emphasizes minimizing human effort and having the best possible output in production. This might be accomplished with the aid of a variety of factors, including automation, ICT, robotics, digitization, and many more. Additionally, according to sources, the objective behind Industry 4.0 was to make Western European economies more competitive. but then Industry 4.0 was promoted so worldwide that its effect has been seen in the macro and micro markets (especially in the MSME sectors). Now, what exactly is a Smart Factory? So a smart factory concept was introduced to obtain the optimal output and thus manufacturing processes were made smart. This concept was named Smart Manufacturing or Smart Processes. (Sundermaeker, 2010, Gullimen, 2010) Technical Definition of Smart Factory: Through the efficient connection of

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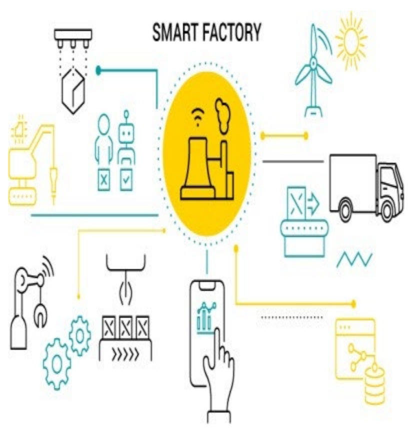
various processes, information streams, and stakeholders (frontline employees, planners, etc.), smart factories provide the chance to develop new types of efficiency and flexibility. Initiatives for the "smart factory" may alternatively be known as "digital factories" or "intelligent factories." The manufacturing industry is moving toward smart factories as a result of new market demands and emerging autonomous technologies like loT. (Elbourne, 2009).

A system where the products are enhanced with some hardware devices (RFld, tags, sensors, etc.) and made in network to the Internet is the foundation of the Internet of Things (loT). So, loT depends on both smart networks and smart things. Physical items are effortlessly incorporated to the internet network due to the Internet of Things (IoT), allowing them participating actively in trade operations, provides data about their status, the surrounding atmosphere, manufacturing process, maintenance schedule and even more. On the other hand, rise in energy costs, growing awareness about the nature, and shifting customer preferences toward greener products are pressuring the business man take decision to prioritize energy-efficient production and green manufacturing. Green products are those that were produced using as little energy as possible, not just those that require less energy when being utilized by the consumer. A smart factory today is a straightforward manufacturing operation that keeps on gathering and shares data through linked devices, instruments, and manufacturing processes. Then, decision are made on the basis of this information to enhance procedures and deal with any potential problems. Therefore, the growing market demand also supports the necessity for smart factories. Why are Smart Factories necessary? Although automation has made it presence since a long time, the concept of a smart factory has recently gained attraction and has come into existence as viable pursuit for manufacturers. The following are the component that has increased the attention towards:

- Rapid development of technological field.
- Increase in the supply and demand of the product worldwide.
- Growing competition from the different corners of the world.
- Use of IT and OT to develop the automation
- Increasing talent is a challenge



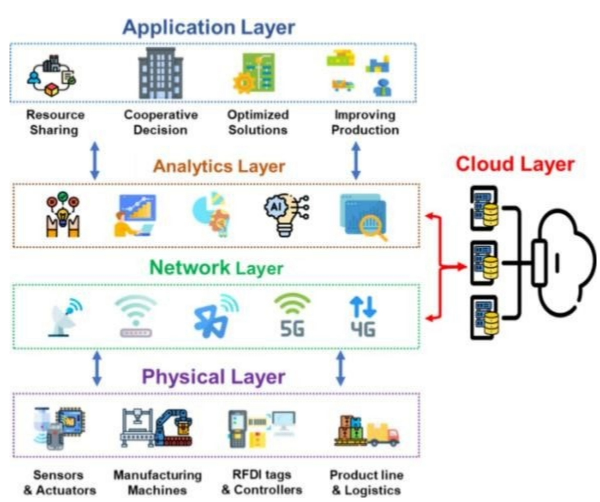


Figure 1. Image Courtesy: avsystem

Figure 2. Image courtesy: avsystem.com

The above given Figure 1 and Figure 2 both the images depict the working of smart factories and shows us some important component used for the development of Smart Factories and also contributing towards the Indutry4.0 development.

2. Literature Review

2.1 A review of literature on Smart Factory

By integrating and automating manufacturing system, connecting physical and IOT capabilities, and optimizing the output by increasing data power, including the use of big data evolution (Zuehlke, 2010), industrial operations are said to be improved in "smart factories". By implementing cutting-edge information technology, businesses launching smart industrial innovation hope to gain a competitive advantage. (Yoon, 2012) By utilizing IoT technologies, a smart factory can represent itself as it is in physical life in a simulator, monitor real-time machine operations in the manufacturing field, and eventually transition from a common control systems to new types of uneven, uniform and robotics control and operations. Numerous advantages result from this, including increased production, flexibility, and resource efficiency. In line with its significance to the business, research on smart factories has continued to rank among the most well-liked topics in recent years. (Yoon, 2012) Our survey of the literature specifically revealed three streams in which to divide the present research on smart factories. The first stream was primarily focused on designing and providing broad system designs for Industrial Management & Data Systems. In order to transform the notion of the smart factory into a technological reality, Industrial Management & Data Systems solutions are developed by analyzing the needs of the smart factory. Another body of study examined technological prototypes and pilot implementations of smart factories in certain sectors, including the production of cars and aero planes, petrochemicals, and green energy (Zuehlke, 2010). The third group of research made an effort to examine potential hazards and obstacles related to smart factories, but from a very specialized angle, such as problems with information security, information access, and business processes. In contrast to this abundance of technical research, socio-technical investigations of social, organizational, managerial, and human resource challenges in smart factories have received very little attention in the industry. This exemplifies the significance of socio-technical challenges in the development of the smart factory. The truth is that, while important technology is not the primary element in determining the success of IS projects in organizations, according to a number of past studies on information systems. The intersection and interaction of technology, organization, and users will have a considerable impact on the installation and usage of information systems in general as well as smart manufacturing. Thus, in order to realize the goal of Industry4.0, it is necessary to analyze smart factory-related challenges from a softer and IS viewpoint, which supports the thesis provided previously in this article (Zuehlke, 2010).

2.2 Overview of literature on applying big data in smart factories:

Big data is one of the most important components of Smart Factories and act as a primary step for the setup of a Smart Factory (Kang et al 2016). Numerous studies point to big data analytics as a potential fix for various issues with smart factories. In particular, Electrical and ICT driven facilities may assist in the real-time collection of a significant amount of production and machine data. The analysis of actual circumstances revealed by real time values and comparison with historical data may then be used to implement production automation control, predictive machine maintenance, as well as to detect and avoid possible issues. (Kamble et al. 2018) Along with supporting operations and decision-making in the production phase of a smart factory, big data solutions may also be utilized to help research and development, product sales, transportation, and stock, buying, and other general services. However, using big data solutions in smart factories is not an easy task and may perhaps provide a number of difficulties. The most common reported difficulty has to do with the technical capacity to interpret massive amounts of real-time data, draw conclusions from them, and adjust machine behavior accordingly. Information security and trust were also emphasized as additional significant issues that arose while using big data in smart manufacturing. Additionally, this new wave of industrial transformation may lead to adjustments in job responsibilities, a decrease in the workforce, and advances in organizational design, management, and operations. However, workers could be hesitant to embrace these upcoming operational and production adjustments. Previous studies have shown that while these are significant issues, they represent but a small portion of the main problems hindering the success of innovation brought on by cutting-edge information technology (Kanget al. 2016). Following a second assessment of the literature, it was discovered that there are currently relatively few studies examining the variety of socio-technical challenges and issues connected to the use of big data analytics in smart factories. As a result, it is challenging to infer useful ideas and recommendations from recent research to promote this data-driven smart innovation in manufacturing organizations. This article experimentally analyses several sorts of constraints that organizations face when applying big data analytics in the context of smart factories to fill this knowledge gap. The study contributes to the field by putting up a framework of obstacles in this situation using an empirical method.

Theory:

To some extent, automation has always been present in factories and even having high implementation of this

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automation is now normalizing (Professor Kagerman, 2013). Automation, however, means, conjures up the execution of a particular, distinct activity or procedure. In the past, instances when machines have "decided" to have been completely on automatic concept and linear, use of a pump valve according to the need. Automation now comprises more complicated optimization decisions than it ever did because of the growing use of Artificial Intelligence and the need for the cyber physical systems. The term smart factory simply defines the ease and reduction in human efforts at the work floor with the help of automation with IT/OT landscape. This has the potential to significantly alter production procedures and improve interactions with consumers and suppliers. (Rick Burke, 2017) This explanation makes it apparent that smart factories go beyond basic automation. Hence a Smart Factory is a system that can operate the entire production process automatically and increase its performance by itself over a big connection, and self-adaptation and learn from new situations that already exist. The four walls of a smart factory are not their only operating space; smart factories may also get connected to a wide network of related production methods and even to a greater supply network. Therefore, the digital supply network is crucial to the automation of things. The following are characteristic of Smart Factories:

1. Connected

- Continuously provides datasets with the help of sensors and location-based devices.
- All-time data-providing facilities to the suppliers and customers
- Inter-Connection between different departments

2. Optimised

- Reliable products, good production capacity
- Increased production efficiency and reduction in time
- Minimal human interaction and increase of automation in production
- Minimized cost of quality and increase in production

3. Transparent

- All time facilities for optimal decision making
- All time detailed analysis of customer’s demand and market forecasts
- Clear updates about the customer’s services

4. Proactive

- Advanced Identification and resolution
- Automatic restocking of goods and other needful products
- Fast tracking of quality and quantity issues
- All time safety provision

5. Agile

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- Easily changeable schedules and layouts
- Use of product changes to see affect in real time and do the market analysis.
- Simple factory layouts and availability of equipment's.

Sustainable manufacturing: Scientific studies show that digitization in manufacturing improves resource and information efficiency (Rick Burke, 2017, which benefits environmental sustainability. Applying industry 4.0 technology leads in a lower environmental impact, less dangerous power resources, minerals, and other chemicals reduced prices of production processes. Therefore, digital industrial innovation benefits not only your business but also the environment.

Benefits of Smart Factories: Not only optimal production and quality manufacturing but there are other benefits of smart factories. It increases the efficiency of the production. Also, some other benefits of smart factories are (Rick Burke, 2017):

- Asset Efficiency
- Quality
- Cost Reduction
- Safety and Sustainability.

Impact of Smart Factories on Manufacturing Process: The smart factory may be implemented in a variety of ways by manufacturers, both inside and beyond the confines of the factory, and it can be modified to alter when priorities shift or new ones develop. Agility, one of the key characteristics of the smart factory, really gives producers a variety of ways to use physical and digital technology in accordance with their unique requirements. (Rick Burke, 2017) For each firm, the precise effects of the smart factory on the production steps will probably vary. Deloitte (a US based company) has recognized a group of cutting-edge method that frequently make it easier to navigate between the real and digital worlds and exchange information. The smart factory is powered by these technologies, opening up new possibilities for the digitization of manufacturing processes.

Below Table 1 shows the step-by-step attributes and their equivalent solutions for the development of Smart Factories under Industry4.0. This table depicts the series of components playing an important role in the advancement of Smart Factories by using different technologies.

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Table 1. The table courtesy to Deloitte University Press.

Table 1. Processes within a smart factory

Process	Sample digitization opportunities
Manufacturing operations	• **Additive manufacturing** to produce rapid prototypes or low-volume spare parts • **Advanced planning and scheduling** using real-time production and inventory data to minimize waste and cycle time • **Cognitive bots and autonomous robots** to effectively execute routine processes at minimal cost with high accuracy • **Digital twin** to digitize an operation and move beyond automation and integration to predictive analyses
Warehouse operations	• **Augmented reality** to assist personnel with pick-and-place tasks • **Autonomous robots** to execute warehouse operations
Inventory tracking	• **Sensors** to track real-time movements and locations of raw materials, work-in-progress and finished goods, and high-value tooling • **Analytics** to optimize inventory on hand and automatically signal for replenishment
Quality	• In-line quality testing using **optical-based analytics** • **Real-time equipment monitoring** to predict potential quality issues
Maintenance	• **Augmented reality** to assist maintenance personnel in maintaining and repairing equipment • **Sensors** on equipment to drive predictive and cognitive maintenance analytics
Environmental, health, and safety	• **Sensors** to geofence dangerous equipment from operating in close proximity to personnel • **Sensors** on personnel to monitor environmental conditions, lack of movement, or other potential threats

Source: Deloitte Analysis. **Deloitte University Press | dupress.deloitte.com**

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3. Methodology
Research methodology: This study used a semi-structured interview as the data collecting method and an inductive qualitative strategy to accomplish the research goals stated above. The selected research technique is thoroughly justified in this part, along with a description of how it was used.

3.1 Data collection
This study used an inductive methodology since there was a dearth of theory and literature to perform a deductive investigation. It is well known that inductive research methods strive to develop theories based on evidence obtained making them ideal for investigations concentrating on novel subjects with limited thesis about the data related to the topic. Additionally, this study requires the collection of in-depth human views, reviews, consequences and impressions in order to analyze connected experimental activity in detail due to the complex structure of big data difficulties in our domain. As a result, this inductive study also included semi-structured interviews as a way of gathering qualitative data. The management and personnel of most user organizations might not have enough knowledge of the issue under inquiry because they are still in the early stages of integrating big data technologies into their brand-new smart factory efforts. Therefore, this study was deliberately conducted from the standpoint of an IS consultancy in the hopes that seasoned consultants may provide more in-depth views on both big data and the development of smart factories and therefore lead to more significant conclusions. 10 SAP project managers and consultants with at least five years of expertise in cutting- edge IT implementation projects (including big data, smart factories, CPS, and/or IoT) were consequently interviewed. The goal of conducting interviews with experts in diverse roles was to get a range of viewpoints on the difficulties in using big data in the context of smart factories. The purpose of the interview questions was to learn more about the consultants' prior expertise and experience with big data implementation in general and in the context of smart factories in particular. As a result, the interview was divided into three sections, each of which was composed of opening, closing, follow-up, and trigger questions. Understanding the interviewee's present position, history, and relevant experience was made easier by the first section. The needs for clients/manufacturing organizations to deploy the used or found data values and go through the implementation of smart factories were the subject of the interview's second section. Additionally, the interviewees were asked to recollect and describe the difficulties and adjustments faced by businesses implementing these solutions. The last part of the questionnaire was gathering the interviewee’s graphical representation of data. Each interview lasted 50 to 1.5 hours and took place in the participant's office at a prearranged time.

3.2 Data Analysis
Following the theme analysis technique, the research data was analyzed in five steps. In order to grasp the data obtained more thoroughly and look for potential trends, the process of analysis began by studying and becoming familiar with the researched data. In the next step of coding, a variety of codes were created in a coding system along with pertinent phrases. By mixing and merging various codes, the third phase of study focused on developing themes and subthemes of big data implementation issues. Therefore, some themes and subthemes were created from all of the discovered codes. The following data shows step wise description of process:

- Knowing the data: Knowing the data through the process of transcription, reading and researching the existing data.

- Developing the data developing coding scheme: All the codes from the data are organized systematically for analysis.

- Solving out codes and identify the themes: Connecting codes into existing themes, gathering all data for the development of existing theme.

- Analyzing themes and setting up a plan: Ensuring the working of themes in relevance to the coded quotes and the entire data set, Concept of map analysis gives us some important results.

- Reporting findings: Overall analysis of the gathered data and codes. Finding the implementation of data in the existing themes and drawing out conclusions for the development of the topic area.

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4. Conclusions

One of the most quickly evolving and extensively researched areas in response to the recent Fourth Industrial Revolution paradigm change is the smart factory. Understanding broad research trends will be necessary for the appropriate integration of interdisciplinary study characteristics and technological growth. In this work, we gathered research articles on "smart factories" and used LSA to extract the underlying themes. Additionally, using a regression technique, we examined the research patterns over time. The research has produced a number of significant findings. Results specifically showed that method to gather analyze, and utilize big data in smart factories is not a straightforward task and is complicated by many organizational, technological, and human factors. More crucially, the results revealed that in the reference in field of a smart factory, a large data barrier may frequently be the root of or a side effect of other barriers. These identified barriers may be particularly challenging to manage and address since they appear to be entwined and connected to one another. The findings of this study have significant ramifications for both scholars and practitioners.

Acknowledgement

We would like to express our gratitude to our university Pandit Deendayal Energy University, Gandhinagar to provide us a platform for our research work on Smart Factories. Also, we would like to thank Dr. MB Kiran sir to give us such opportunity for gaining knowledge with the research.

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Biographies

Saujanya Dave, a passionate student pursuing his Btech in Mechanical Engineering from Pandit Deendayal Energy University. He has his area of interest towards Manufacturing domain, Renewable Energy domain and the uprising domain of Industry4.0 and is working on some other research under the unmentioned domains.

Devang Desai is an aspiring undergraduate in Mechanical Engineering at Pandit Deendayal Energy University, he is always on the lookout for new challenges and ways to further his knowledge in fascinating industries. He had shown his curiosity in Automotive and well as Design Industries and hence took part in preparing Review report for subjects like Industry 4.0.

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Dr. M.B.Kiran, received his Ph.D. in the area of Surface Metrology from the Indian Institute of Technology (I.I.T), Madras, India, in the year 1997. He is a certified project manager (P.M.P. from Pennsylvania, U.S.A.). He has teaching, industry, and research experience of 25 Years. He has worked in many multinational companies. He has more than 15 years of post-Ph.D. experience. He is currently guiding five research scholars pursuing Ph.D. Dr. M.B.Kiran has been working actively in many academic and professional bodies. He has successfully completed many mission-critical projects for clients from U.S.A and U.K. Dr.M.B.Kiran has published many technical papers in National /International Journals/and conferences. He has conducted many training programs for practicing engineers pursuing P.M.P. certification.

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