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Industry 4.0 and Green Sustainable Manufacturing: A Smarter and Effective Process Management

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Abstract: Industry 4.0 (Fourth Industrial Revolution) and green process manufacturing are similar to each other and work closely as they are new concepts in manufacturing production & operations management. Today the need of expansion in businesses directly leads to adoption of new concepts of manufacturing and also making awareness of those used processes to ultimate consumers is needed. Industry 4.0 is related to the processes with latest technologies such as clean-green energy, automation, internet of things (IoT) and digitization, whereas, green manufacturing is almost similar like use of fewer natural resources, reduction in pollution & waste, reducing carbon footprints, recycle & reuse of material and moderate emission in processes. Country's sustainable growth right now is major among other strategies and every country is trying and working hard to incorporate the development process through adoption of these types of tools & techniques. Industry 4.0 technologies and green manufacturing relate to "Green Dialogue" and to some extent proving the object also. Now, introduction of Industry 5.0 is welcoming fully fledged automation of industries with green processes like G-IoT. However, climate health, consumers health and production & operation health is on priority to have healthier green clean sustainable development in the world. From the above title, the purpose of this study is to present the potential of the industries under new industrial revolution with the combination to eco-friendly manufacturing leading to knowledge of the updated technologies used for their respective ecological production & operation management. These concepts are considered to be new around the world and most of the developed countries are more active in accepting these sustainable concepts in their operations and production in industries. Developing countries like India are way behind in acquiring these concepts as manufacturing is aware but not willing to pay extra cost of production in advancing the operation & production process. Most of the top manufacturers of India have already started using this sustainable process as they have to prove their responsibility towards society at large by Corporate Social Responsibility (CSR) also.

Keywords: Industry 4.0, Green Manufacturing, Sustainable Manufacturing, Greening of Manufacturing Process, Green-IoT, Environmental Sustainability in India, Green Approaches with Industrial 4th Phase

Introduction

Industry 4.0 was coined by German industry to make production more efficient with the help of technology. This industry model is characterized by well planned, organized and controlled processes which contain excellent productive, procedural and pro-environmental processes with good performance outcomes. Manufacturing process system consists of many internal and external factors on which industries' whole management rely. Many new and already brands are opting for new models in manufacturing to support their production and operation to make it more sustainable in future. Industry 4.0 consists of technologies like

internet of things (IoT), Industrial Internet of Things (IIoT), Cyber-Physical System (CPS) and Green manufacturing which make industries smarter and more effective than earlier industry 3.0. Three previous industrial development models were mostly represented by human work, machines, tools and technologies, whereas industry 4.0 represents the uniqueness of technologies used to incorporate processes in accurate and precise manner.

Industry 1.0 was the phase of transformation from hand production to machine production methods which include steam and water power pressures. Weaving industries were the prime product producers and dominating industries who promoted this phase. Industry 2.0, phase includes mass production and the industries that grew at this point were chemicals industries, petroleum industries and automotive industries. Industrial 3.0, or digital revolution, include the adoption of automation and digitations by electronics and computer devices. Now mass production motives are converted to automation with accuracy of production and digital logic.

In Industry 4.0, traditional automation manufacturing and industrial practices are being processed by use of Internet of Things (IoT) are integrated for self-monitoring, improved communication, less scrap, accuracy and mass production without the intervention of humans. This phase is also into conscious use of natural resources and less waste to play the part of corporate social responsibility by effective environmental management.

Burning issues like prevention of environment and business activities which are more consumers oriented are most common these days. Industry 4.0 and green manufacturing deals with these two common problems at large and do suggest a good future for the environment and consumers green manufacturing. Whereas, introduction of Industry 5.0 refers to people working alongside robots and smart machines. It's about robots helping humans work better and faster by leveraging advanced technologies like the Internet of Things (IoT) and big data which also include G-IoT. It adds a personal human touch to the Industry 4.0 pillars of automation and efficiency.

Global economic system development and delivery to people more efficiently & perfectly is every country's priorities. Considering the ecological consequences, every industry dealing in research & development with Internet of Things (IoT) leads to extension of Green Internet of Things (G-IoT). Green Internet of Things (G-IoT) includes the network of things that are operated by sensors, software and technologies which are used to connect and exchange data over the internet with more energy-efficient machinery reducing carbon emission and less or no pollution. Industries are engaging in IoT innovations, for that reason consumers are also opting for green products for sustainable business growth worldwide.

Indian industries are also taking part in this industrial revolution but it’s very slow as compared to other developed countries. As we know that our resources in light of the internet technologies are very slow and low as compared to others. Fanuc India is an example of the development in the area of IoT. They provide their products and services in all applications of robotics across the industrial needs like painting, welding, drawing and modeling. They are also into all types of solutions to Computerized Numerical Control (CNC) around the country. Other industries dealing in CNC in India are Think 3D, Gemsons, Chizel, Raghu Vamsi, Anjali 3D, SrakPrestek and many more.

Review Of Literature

Industry 4.0 process was coined in Germany in 2011. This term was denoted for the transformation process in the global chains of

value creation at the Hanover fair. Klaus Schwab presented a report on the fourth industrial revolution at the World Economic Forum. He tried to include all the global industry processes that develop and uplift the production with information and communication technologies applying to internet technologies.

Global advancement and increase in competition is very high. If a corporation is not able to sustain its comparative advantage or not able to achieve goals in context with its potential competitors, they are way behind in the market (Dirisu et al.2013). Market orientation is very important in sustainable competitive advantage to create value by research and innovation. The alarm by global warming and excessive pollution has led the industries to think about environmental protection and sustainability and industries are adopting green business with IoT to make their production more effective and efficient. Industries who have declared that they are following the rules and regulation as per green industry have to abide and manufacture green products keeping the environment on priorities (Saxena & Khandelwal, 2010). Industries who want to grow at global level, they have to change and develop as per the need and should be adaptive in the era of Industrial 4.0. Industries to develop must have the resources which can create value of those industries that have these four features: resources which are rare, resources which are valuable, imperfectly imitable resources and non-substitutability. It's meant that industries should change themselves as per the requirements of that scenario and social cause should be always their like in Green IoT.

Objectives Of Present Study

1. To explore the meaning and concept of Industry 4.0
2. To elaborate the concept and relationship of Green Marketing with Industry 4.0 through leading companies' examples.
3. To know about the green manufacturing process under Industry 4.0
4. To know Environment management under Industry 4.0
5. Use of green approaches/green tools in manufacturing.

Green & Sustainable Manufacturing in Industry 4.0

Industries are facing the continuous pressure to be greener and hi-tech in this global competitive era. Being environmentally friendly and technology backed is the need of the hour. Green production processes influence green manufacturing and can lead to 6R's (Reuse, Recycle, Re-design, Re-manufacture, Reduce, and Recover) with the help of IoT and digitization. Green IoT in manufacturing also keeps an eye on e-waste, clean energy consumption and sustainable development of society.

Components of Green IoT which are being used in industry to interconnect smart and effective operations & productions on floor are:

- Green RFID Tags
- Green WSN
- Green Cloud Computing or Green Data Centre
- Green Machine to Machine communication

Green industries under IoT are doing their best to have modern and societal benefits. Use of machines which are operated by software and collection of data for minimization of scrap with accuracy of outcome is only possible under G-IoT. Green industries are on the way to full digitization where competent humans are recruited to operate CNC machines and software. CNC machines use the raw material efficiently as per the programming done and this leads to very less scrap/waste. Even the

scrap/waste can be reused or recycled with good planning under G-IoT. These types of machines are very hitch and do not produce any carbon or we can say that these use clean and green energy. This model under G-IoT is reliable and used for full optimization of resources with very less scrap or e-wastage.

Many companies worldwide are working on this concept of G-IoT to reduce their cost and be eco-friendly. One of the women's active wear "The Girlfriend Company" in 2015 proposed the ethical business through no child labor, fair wages and eco-friendly concept. They introduced girlfriend brand leggings made up of recycled plastic, water bottles and fishing nets. They collected the plastic from land-fields and oceans, processed them with the latest technologies and CNC machines approved and certified by Taiwanese government. This company has a highly automated processing system that processes the plastic into super fine usable thread that can be used to knit leggings cloth. They also use OEKO certified dye with the best possible advanced sewing R&D. Every day they produce 100 pairs of leggings with this G-IoT process management.

As per The Indian Express on 11th June 2021, Barbie international makers launched their first doll collection made up of ocean collected plastic and named them "Barbie Loves the Ocean". The collection features three dolls which are made up from 90% of recycled plastic collected from the ocean. Collected plastic includes water bottles, beach shacks and other plastic parts. The plastic collected is processed by the automated machines to have beautiful Barbie dolls. The price of the collection will vary from $9.99(Rs.730) to $19.99 (Rs.1460.81) and manufacturers are also aligned that their aim is to use 100% recycled material by 2030 with bio-based packaging also.

Advance Steel Tubes Ltd., Haridwar, Uttarakhand-India are into manufacturing of steel structures, ERW pipes & tubes, galvanized structure and swaged types steel tubular poles. They were into use of CNC machine purchased from China for fabrication of steel since 2010. In India at that time no one knew the concept of automation and no operators were there. Since then it's been 12 years and many industries have adopted the concept of IoT and getting smarter and effective day by day.

Green Approaches /Green Tools Under New Revolution 4.0

The concept of Industrial 4.0 has popularized the approaches and tool towards digital and eco-friendly. Frequent use of global registration and certifications provides this revaluation more strength and support. Organizations opt for smarter and an effective operations and management which include all the automated machinery, software to operate them and to assure quality registration for green labels. Basically eco-labels/eco-approaches are binding on industry by law to follow the respective guidelines in manufacturing of that specific product and also play a part of CSR by being environmentally safe. Adopting modern and eco-friendly approaches of manufacturing is the need and can sustain the environment

Green approaches are the trusted symbol of identity which makes manufacturers different and social from other manufacturers on which the manufacturer can claim such products are genuinely a smarter and more effective in eco-friendly performance than the conventional products available in the market. According to international organizations, adopting some eco labels are voluntary and some are mandatory to operate industry but organizations should also register in these voluntary certifications to create credibility among their mass customer and to acquire potential market.

For operation and production under Industry 4.0, the industry and governments should encourage

sound practice of environmental schemes, approaches, certifications and establishment of a department which can look after the prospective in line of this green certification which can give new promoting sustainable business methods also. These eco-labels are ISO 14001, BIS, FSSAI, energy efficient and many more. As per Eco-label Index, in May 2014, there were 448 eco-labels in 197 countries in different product categories and many would have been added since then.

Benefits of eco-labels are:

- Benefits to Consumers.
- Benefits Industries /Service providers/Suppliers.
- Benefits to Government
- Benefits to Environment

A consumer seeks these types of labels and tools for their decision making and industries are also benefited from them in long run. Eco-labels are smarter and effective tool to operate industrial manufacturing.

Suggestions And Conclusions

It can be said that Industry 4.0 phase is an integrated structure and all the technologies used under green manufacturing are sustainable and describe the future. Environmental management under Industry 4.0 by different green applicability leads to a smarter and effective present and sustainable future. Potential industries are looking to upgrade themselves as per the current revolution in every dimension. It can be said that Industry 4.0 is foundation to the future and environment management is an innovation & integration to uplift that foundation. Use of G-IoT and their development in industries will require less energy and resources consuming. It can also help in contributing social influence and sustainable development in the society. Collective awareness and laws should be imposed on industries for quality manufacturing and environmental balance by governments of the country also. Green Manufacturing is vital in preserving our natural resources for future generations. It may be costly and requires a lot of determination but many companies have taken the initiative to go green. With Green Manufacturing, companies that truly are green will prove the companies strength, capability and reliability. Green manufacturing basically is a process of innovation from traditional manufacturing. It pays attention to environmental aspects in all manufacturing activities, such as inputs, processes and outputs. It is considered as future development and sustainability in manufacturing keeping in mind social prospective also.

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