A Study on Management of Artificial Intelligence in Green Manufacturing with Special Reference to TVS Motor Company, Hosur, Tamil Nadu, India

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Smart Manufacturing is a broad category of manufacturing that employs a computer based integrated manufacturing system with higher end of new adaptability and quick evolution in design structure along with digitization and effective workforce training. Industry 4.0 and the advent of industry 5.0 have given new dimensions in manufacturing along with sustainable and environment friendly manufacturing which is called Green manufacturing. Artificial intelligence (AI) if implemented with major environmental concerns can add a new dimension to the industrial revolution of this century. Imagining a set up of cell manufacturing and flexible manufacturing systems using low carbon emission standards with AI may one day make complex systems easy to operate and give a healthy environment to work. Less hazards and low carbon emissions particularly in chemical industries may make industries more environments friendly and thus save the life forms on earth from self destruction. Green Tech or Green manufacturing is an umbrella term which comes under the same branch in one way or other which is used in several technologies or the fields of science in order to bring up with products which Eco friendly. This article discusses as well as suggests remedies for AI systems to be more environments friendly and thus bring harmony with technology and its management with Mother Nature. This research article has data from secondary sources like reports / websites / professionals and a detailed model is prepared on it.

Keywords: Artificial Intelligence, Green Manufacturing, Environment, Carbon Emissions.

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1 Introduction

Smart production systems [2, 9] require innovative solutions to increase quality and sustainability of manufacturing activities while reducing costs. In this context Artificial Intelligence driven technologies leveraged by industry 4.0 key enabling technologies (eg. IOT- Internet of things, Advanced Embedded Systems, Cloud Computing, Big Data, Cognitive Systems, Virtual and Augmented Reality) are ready to generate new industrial paradigms. Green manufacturing in Industry 4.0 and upcoming Industry 5.0 has been a buzzword for some time now and is also gaining global acceptance as the world faces new challenges in living in harmony with nature and cutting down carbon emissions and green house gases for the very survival of life forms on earth.

Artificial intelligence (AI) [2, 4, 7] may play a crucial role in this by reducing working class to hazardous processes and meeting environmental standards. Cloud computing doesn't require physical servers and thus can reduce E-waste (Electronic Waste). AI technologies like bots on websites of companies reduced dependence on customer service cells and infrastructure for it which again generates E-Waste. Green manufacturing technologies will play an important role in this context , mentioning a few viz. AI , 3D printing, smart manufacturing, etc...Green technologies may be the way forward for future of manufacturing and living in harmony with nature.

1.1 Need for Research on Management of AI in Green Manufacturing

Since the most recent decade corporate organisations are getting intrigued by condition assurance and clients are requesting condition well disposed items/products. Green manufacturing is usually characterized as disposal of waste by recharacterizing existing generation procedure or framework. When AI comes in combination with Green technologies it adds a different dimension to manufacturing and thus can be used for environment friendly manufacturing techniques [10, 11]. The present scenario across the globe calls for more environment friendly practices as the effects of green house gases is evident in causing natural calamities and loss of life and monetary resources.

This paper strives to put green manufacturing as an important concept for the very survival of species on earth and managing AI as well as adjusting it with Green manufacturing may spell a whole lot of innovations in green technologies.

1.2 Scope of Study

The study is limited to Manufacturing industries and does not cover services sector. The samples for data analysis are taken from big and medium sized manufacturing units in Hosur, Tamil Nadu, India. Moreover the study specifically talks about AI and related fields with its management and alliance with environmentally friendly manufacturing / Green technologies [3, 10].

This work does not encompass the whole manufacturing sector in India or the world and an assumption is made that all units studied are progressive and are using Green technologies. The company selected (TVS Motor Company) is taking fast strides in Green technologies and this paper gives an idea about the progress of automobile industry in India particularly the company in question. The companies considered here in this paper are advancing and implementing the technologies and may become companies of future in India. Hence it can be said that this study has its limits and scope in some well known manufacturing companies in India and considers advanced technologies in local indigenous Industries.

1.3 Importance of Study

Adaptation and innovation are extremely important in manufacturing industry. This development should lead to sustainable manufacturing using new technologies. To promote sustainability smart production requires global perspective of smart production application technology. This study

strives to take home the concept of Green manufacturing and Green technology with management of AI is the future and is of prime importance for survival of species on earth and to reduce emission of green house gases.

Green technologies with well managed AI [5, 11] systems may add a new dimension to manufacturing processes and hope will redefine manufacturing processes when progressing towards higher heights in new millennium. This study in this context may be carried forward by more researchers for better and precise manufacturing processes while not harming the environment and with an environment friendly perspective.

1.4 Research Objectives

1. To study the role of AI (Artificial Research) and its application in manufacturing sector during industry 4.0 and industry 5.0
2. To suggest techniques of management of AI in the evolving scenario
3. To study and suggest better methods for Green manufacturing
4. To understand how Green manufacturing technologies when clubbed with AI will work.
5. To examine the Scenario of environment friendly manufacturing in TVS Motor Company, Hosur, Tamil Nadu, India.

2 Research Methodology

Nature of Research: Theoretical Research

Theoretical research also referred to as pure or Basic research focuses on generating knowledge regardless of its practical application. Here data collection is used to generate new general concepts for a better understanding of a particular field or to answer a theoretical research question. The question which this paper answers / suggests is how to generate solutions for environment friendly manufacturing using AI in the evolved scenario.

Data Collection: Secondary Data

Collected from various websites, research articles/papers, reports and contacting industry professionals. In all almost 150 research papers / articles on Green manufacturing and Green technologies are referred and about 50 have been selected and 6 of them after filtering have been selected for identifying research gap. The Research gap is identified and an effort is made to move forward with existing research data.

3 Data Analysis, Results and Interpretation

The concept is of Green Manufacturing by using AI and managing it. This concept can be vindicated by the current scenario of pollution not only air but water and other earthly resources. Only if steps are taken to reduce Green house gas emissions and reduce pollution of other resources, then all species on earth can survive and live in harmony with nature. The data [1-13] which was selected by filtering literature and research papers / articles from various platforms indicates that some work was already done but not enough and may define the future of species on earth and its very survival. This paper generates solutions for various problems yet facing Green manufacturing.

Table 1. Problem and solution matrix in Green manufacturing

Problem	Solution
Sustainable Practices	All present sources of energy should be replaced by renewable Eco friendly resources such as solar power stations, Hydro electric power, etc ...Effluent treatment plants in every industry to reduce wastage of water.
Waste not , Want Not	Making optimum use of resources and practicing techniques like lean management can reduce industrial wastage of resources.
What gets Measured gets Managed	Measuring industrial waste is critical which has to be managed so that new innovations can be done in energy management.
Technology and Innovation	Researchers should draw a line of where to stop when inventing and researching on new products or services. For example E-waste is a big problem; not to leave aside polythene. The solution is to do research and innovation to be environmentally sensitive and Eco friendly. A Good example is Eco friendly organic bags / Eco friendly composites used in manufacturing.
Production Processes	Eco friendly production / manufacturing processes to be designed for better health of employees and less usage of hazardous materials. Example: reengineering processes in chemical industries and the quest for Eco friendly materials used in production.
Storage of Materials	Systems like kan ban and inventory management techniques like JIT (Just in Time) may reduce overproduction and wastage of resources.
Artificial Intelligence and Automation	It can be put into practice so that interference of people in hazardous tasks in minimum and safe and responsible practices is put in place. For example CNC (Computerised Numerical Control) manufacturing and cloud data storage to reduce more reliance on physical hard disks. AI can give a new dimension to Green manufacturing.

Table 2. Application and Management of AI in Green Manufacturing

Present Application and Management of AI	Future of AI in Green Manufacturing
Cloud Computing	Modular Software
IOT (Internet of Things)	Reactive Machines
FMEA (Failure Mode and Effect Analysis)	Understanding defect Root Causes and Predictive Prototyping
RFID (Radio Frequency Identification) Tracking	Real Time Tracking and GPS (Global Positioning Systems)
Generative Design in Research and Development	ANSYS and enhanced effects in Software
Digital Twins	Virtual Reality and Augmented Reality
Robotics and Simulation	Better Precision in Programming and implementation of Automation

Artificial Intelligence Management:

1. Lean Management
2. Inventory Management and Tracking
3. Total Quality Management (TQM)
4. Quality Circles (QCs)
5. Decision Making Software using AI

The Future of Management using AI:

1. Management Decision Making using data Analytics Tools and Software
2. Precision Engineering

3. Business Analytics Management
4. Machine Learning and Related Fields
5. Prototype Simulation for New Product Development

(*Data collected from various websites and discussions with professionals both Indian and foreign and from engineering workshops and seminars)

*Following details of TVS Motor Company from its annual Report 2019-2020 give an idea about the progress of the company on AI and Machine Learning platforms:

*The Company continues to implement several projects to improve its efficiency, transparency and process control across supply chain from suppliers to dealers. Major focus areas are improvements at factory, retail management and improving customer experience at dealerships. Various initiatives on industry 4.0 are being adopted for improving quality, productivity, traceability and waste elimination. The company has adopted various machine learning tools for improving quality of its products and processes. Company has developed new products with connected technologies and developed skills to take them to the next phase. As part of continuous improvement and technology benchmarking, the company's IT systems were audited by external experts and recommendations were implemented. The company has enhanced information security by adopting new cyber security tools. Periodic audits are conducted by external experts and necessary control measures are taken.

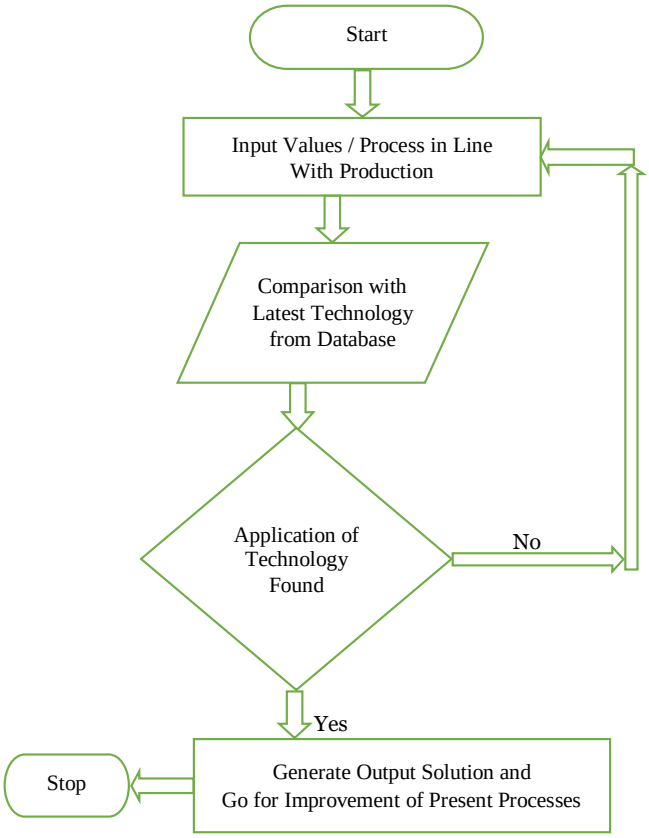

Fig.1. Flow Chart of implementing latest Production Techniques

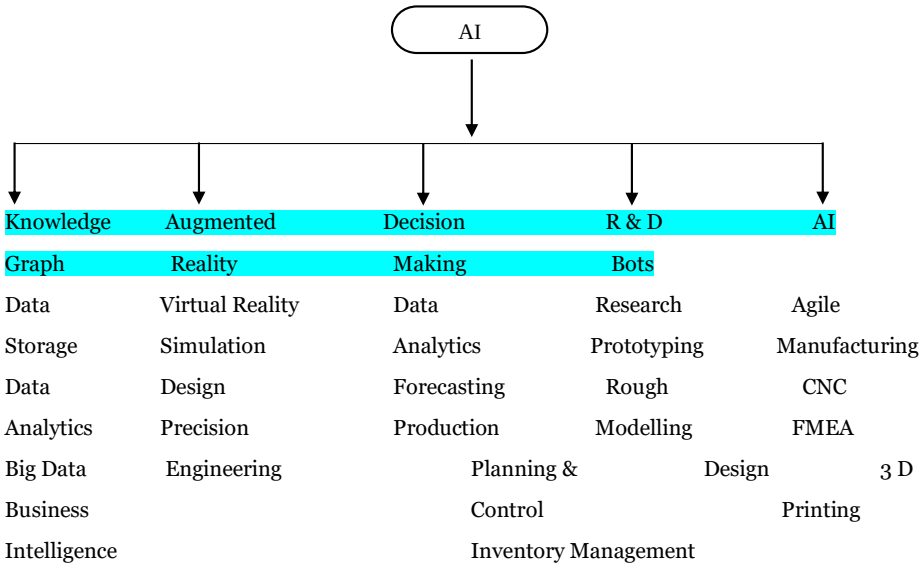

Fig. 2. The Role of AI in Green Manufacturing – Model and Application

From the above factors and discussion it's clear that green manufacturing is the concept of future and it has been successfully implemented in Industries. One of the examples is TVS Motors Company Limited, Hosur, Tamil Nadu, India. The following justifies its success:

- Reduction of waste by working in tandem with Green manufacturing techniques which is gradually implemented in TVS Motors
- Doing away with hazardous materials and providing safe ambience for manufacturing and assembling was instrumental in making TVS an ISO 14000 company
- Partnering with suppliers and sister concerns in implementation of Green manufacturing and use of AI and automation has reduced Green house gases emissions.

4 Findings and Suggestions

4.1 Findings

1. AI has a long way to go and is the future.
2. Managing AI may become difficult in future.
3. Role of AI in Green manufacturing is established.
4. There would be more advances in AI and Green technologies in future.
5. If industries don't adapt and practice Green manufacturing at the earliest it may spell doom to all species on earth.
6. Green technologies require huge investments but may prove profitable in long run.
7. The consumers of products are now looking for companies which have manufacturing techniques in harmony with nature and the new generation is more environments conscious.
8. The evolving technologies may put forth new challenges for researchers and industry professionals.

4.2 Suggestions

1. For Management of AI better management techniques on man machine interface management, understanding behavior of machines and related areas have to be studied and philosophies have to be developed.
2. The Era of knowledge worker and automation of repetitive and clerical jobs has arrived and companies should be future ready with coming in terms with technology.
3. Green technologies have to be researched and more action has to be taken by companies as very survival of species on earth is under question.
4. The challenges posed by evolving technologies have to be researched and more has to be done from human species in this regard.
5. Devices largely used in storing data, managing machines and related areas are posing a challenge (like E-waste) and material science should evolve with environment friendly products which are bio degradable .
6. Chemical and pharmaceutical companies should come up with environment friendly processes in production and better material handling of hazardous chemicals.
7. Green manufacturing is future for survival on earth and AI can play an important role.

5 Discussion and Future Implications

The future in green manufacturing depends on how AI is handled and managed. There is enough scope for studies and improvements when the matrix shown above for future of AI is considered. This study examines and suggests future course of action but a lots of unexplored areas and dimension are still available for study and research. AI, Machine learning, Big Data, Business Analytics using machines is the future of industry 4.0 to industry 5.0 and a lots will depend on how its managed. This paper gives a rough picture of future and the solutions for some of the vast areas for scope of improvement.

6 Limitations

1. Time of study is a major constraint.
2. AI is fast evolving and its management is a big challenge in future and the study only encompasses the present developments in AI.
3. Green manufacturing has its own limitations on investment costs in technologies, infrastructure, equipment and other related matters.
4. AI clubbing with Green technologies will take its own time and the present market demands has to be met and hence R&D should be done separately.
5. Management of AI may not be in sync with the present technologies and management techniques and needs a very fresh approach and thinking.

7 Conclusions

Here are some of the Conclusions which can be done from the study:

1. AI management in Green manufacturing may require better expertise and hence the planning for future of Green technologies is important.
2. Green technologies are evolving and it's the future of manufacturing for industry 5.0 and beyond.
3. Sustainable development is the key for survival of all species on earth.
4. Green technologies paired with AI may make manufacturing processes less hazardous but maintenance and management would be a problem.

5. AI may evolve into new dimensions and can be effectively managed only when more research is done on it.

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