The Green Manufacturing: A Literature Review

Neeraj Lamba[1], Deepak kumar[2]
[1]Assistant Professor, Dept of Mechanical Engineering
[2]Dept of Mechanical Engineering
[1, 2] MRIU,Faridabad,Haryana.

Abstract-

Purpose:

The main purpose of this research paper is to gain knowledge about different industries production procedures,organisations technical performances including those related to fuel and semi finished products and processing and/or services ,ground work of raw materials,accessibility, equipment and plant different types of arrangements,process control and operations.

Design:

On the subject of green manufacturing we have a number of research works and surveys available which have been reviewed and proven methods to recognize the key factors for its development.These all research works show the present day conditions of green manufacturing in different strategies of companies and gives the idea of present day conditions of industries,data collection on environmental impact of GM,ways of reducing energy consumption,designing and controlling of production system and unification of products and the production system.It also unearths the obstructions in finalizing the decision system responsible for the green product designing and manufacturing.

In this paper we have all the information available is from the sources of internet,magazines,articles,previous research papers and research papers.

Finding:

In this research paper the problem of water,global warming,air and other wastage emission at the production time and suggests a solution to administrators in assessing the techniques of GM in the business and prioritizing the green manufacturing efforts.

Originality:

This potential literature review is to provide an overall possibility of performance techniques for green manufacturing practices in industries.It provides important information, new methods that will surely help in industries to help GM implementation.This research paper will fill the gap in the literature of green manufacturing on identification,validation of efficiency and establishment of GM industries.

Keywords- Resource usage reduction,safety,green manufacturing processes

Paper type: Research paper

The notion of sustainable manufacturing (SM) is becoming popular due to the focus on many of its research topics for a long time. This paper consists introduction of green manufacturing in present industries ,includes a literature survey on green manufacturing .The word manufacturing is taken from Latin word 'manufactum' meaning 'made by hand' from Italian word 'manufactura' and the green us between blue and yellow in the spectrum series which is colored like emeralds or grass.

Greening is shifted into a ore environmental friendly version of manufacturing that is related with a firm color often associated with the health ,life and fertility (Montly and Prakash 2013) .The huge pollution and environment degression due to chemical wastes throwing unused resources and $C0_2$ from industries and automobiles force us to think about green processes which take care of products from their producing stage to their final use degradation stage. This study will contribute in a more wider and clearer picture to move the current industries to go for GM. This paper shows that GM is the main key for Sustainable Development.

The aim of this research paper is to know the main drivers that helps in applying the GM in the industries .The large amount of CO_2 emission and the toxic waste generated from industries is one of the main reasons for environmental depletion which leads to dangerous situations like global warming, acid rain etc..Proper rules and regulations by the government are very important factors that help us to achieve the environmental ,economical and intangible performances. The data was collected ,analyzed and compared by the by the mean score of the survey. The economic growth at national and international level is achieved by implementation of these factors in the industries. The global development has an adverse affect on the natural environment such as . The Global warming which is continuing to increase GM systems that

aims to decrease the environmental impact of manufacturing processes and products are ever more important to sustain the future .It is estimated that even if all the factories,cars , aeroplane and power plants are shut down ,even then the mean global temperature will increase by 0.6^0C in this century . 'Green Manufacturing' or sustainable industrial methods is the need of the world and no more empty sayings. GM is a method of manufacturing that minimizes wastage and pollution. In this research paper the literature review of green manufacturing system has been studied.

I. INTRODUCTION

The belief on Green Manufacturing has been expanding in the minds of the environmentalists in the last few years. Large large of people are being aware of the worlds environmental problems such as decrease in non sustainable resources toxic substance emission and global warning .The government and administration has planned campaigns to make people aware about this concept.Different organizations taken care of these environmental problems by heading towards green methods, in their company like using the recycled papers for packaging and storing ,environmental harmless raw material and reducing the petroleum usage.

One type of manufacturing system that is responsible for waste reduction that gained popularity i.e. Green manufacturing system during the end of the twentieth century and in the twenty-first century that reduce waste defined as having adverse environmental impact. Green Manufacturing play a vital role in sustainable development. The concepts,tools and techniques are very much tested and experimented before they are applied in companies .Waste consumes the companies' resources and doesn't add any value for productivity of the product. The aim of Green Manufacturing to terminate wastage from their systems and processes and extract maximum output from minimum input. There are seven kinds of 'muda' i.e. waste,that is addressed in the TPS are waiting,improper transport ,defects or correction ,unnecessary inventory ,inappropriate processing ,unnecessary motion and over-production .The ultimate goal of GM is the minimum wastage in the plant operation.

Green manufacturing starting from the buying of green to the integrated supply chain on setting from supplier to manufacturer and then to the customer and then the reverse logistics. Reverse logistics is related to the activities to the of different methods that are necessary for giving back the waste form the industries and to use goods to their manufacturer respectively that result into the full economic cycle as compared to the traditional uni-directional flow of economy.Closed loop economy indicates saving of energy and raw material from input side and land-fill capacity from output side, so that industries can improve their efficiency in economics as well as in ecology. This creates advancement towards sustainable manufacturing as well as the reduction in the cost for production for some or all the industries involved.

Manufacturing plays a vital role in the industries especially to maintain competition and improve the performance and efficiency of the manufacturing firms. Globalization manufacturing is itself transforming and evolving with the rapid changes in the technologies and customer needs.

The production system adopted in the early 19^{th} century was generally the mass production system which doesn't provided much weight-age to the green manufacturing.In 1970's the concept adopted was the Flexible Manufacturing System(FMS).

As the production system progressed the surrounding environment starts facing the problems of pollution that resulted in environmental degradation.To protect the environment from these toxic substance is the major challenge to these companies.So in the 20^{th} century the term Green Manufacturing was taken into account.Green Manufacturing can be understood in two ways :first is the manufacturing of green products ,especially which are used in the renewable energy manufacturing and clean technology equipment of all kinds and Second one us greening of manufacturing i.e. reduction of pollution and the wastage by minimizing conventional resources,recycling and reusing the waste and reducing waste emission.

II. GREEN MANUFACTURING

Green manufacturing is the method of minimizing the wastage and pollution which is accepted through research and operation design.GM is a method to produce products and/is services in a renewable way that don't harm us or the environment. Its main goal is also to conserve the natural resources for the future generations .The benefits of Green Manufacturing is to save useless cost and energy that promotes research and design.

The concept of Green Manufacturing was proposed as the manufacturing process that employs different strategies ,tools, and techniques to have more eco-efficient manufacturing. Strategies such as creating products or the services which consume less raw material and energy ,substituting input material,reducing unwanted outputs(wastage) and converting output to inputs (recycling).

Like the other manufacturing processes this manufacturing process is the outcome of the market strategies and technical drivers.More and more people are being aware of the environmental risks as a result of the new green movement is replacing the old manufacturing systems and fulfilling the customers requirements in many paces.In addition the involvement of green techniques with the new designs which are more eco-friendly together help in making realistic the green manufacturing practices.

Due to increasing interest in green manufacturing in research and industrial sectors,a clear description of what is meant by this term is becoming more important.There is much confusion and dilemma grows to describe ,its impact and implementation of green manufacturing at various level of production.We can say that more work is required so as to differentiate between the operational level,process level and system level of green manufacturing. Moreover the relation between sustainability and green manufacturing needs to be better explained so that mixing the two terms is avoided and at the same time drawing a clear relation between them.

This paper represents a system model for new green manufacturing processes.This model contains contains various planning and controlling activities required to move from a less green environment green environment to a greener and more eco-efficient manufacturing.This model explains green manufacturing in a better way and at the same time draw a qualitative road-map for green manufacturing realization.

2.1.Green manufacturing and sustainability:

The sustainability in green manufacturing is defined as: Meeting the requirements of the present generation without compromising the ability of the future generation to meet their needs '(World Commission on the Environmental and Development,1987)'.With the help of the definition all research ,methodologies and eco-friendly approaches to improve the environmental conditions and resources through waste reduction ,prevention or recycling can be categorized under sustainability .Sustainability can be seen as a process that has different implementation and interpretation at different fields.

Sustainability can be defined in the business language as "adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting,sustaining and enhancing the human and the natural resources that will be needed in the future" (in the Deloitte and Touche 1992).

Green manufacturing is concerned with the maintenance of sustainability in the social,economical and environmental related problems in the manufacturing domain.The author purposes the inter-relationship between the green manufacturing as a methodology and sustainability as a concept in the given definition of green manufacturing "Green manufacturing is a sustainable approach to the design and engineering activities involved in product development and/or system operation to minimize environmental impact."

2.2. Green Manufacturing and Efficiency:

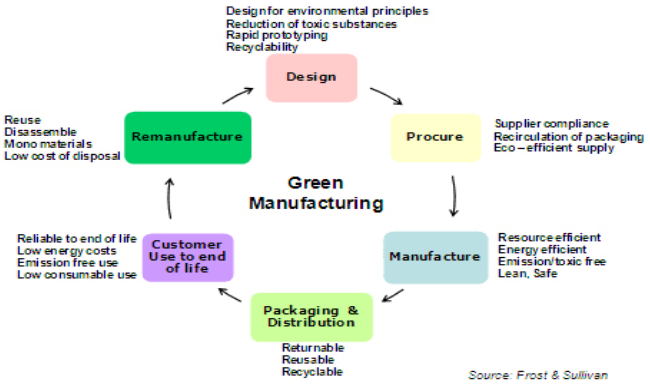
Everything we invest in a product is money i.e. time,energy,consumables,raw materials etc. all these concluded as money only.Using fever resources and energy for the preparation the same quality of the product compared to previous methods is a more efficient for production and earning money.In other words maximizing efficiency of production with minimum generation of waste is both eco-friendly and money efficient.In manufacturing process there are a lot of wastage levels that can be terminated in the process as well as in the product.

The available research and study on green manufacturing during its modern new context is not in the adequate amount. The review on green manufacturing can be divided into two subcategories ,first is the work that deals with the green manufacturing concept and second is the work that provided different analytical tools and models to realize green manufacturing at various levels.

The example of the first category of green manufacturing research works is that of the Monty and Deshmukh (1998) highlighting the significance of of green manufacturing as a competitive edge.They explained green manufacturing as the processes attempting to decrease wastage. They demonstrated various case studies with various waste elimination methods to highlight the strength green manufacturing can have on the overall production process efficiency.Naderi (1996) shown that green manufacturing is basically linked to waste management through elimination of driver factors . Jovane et al.(2003) suggested sustainable and green manufacturing as the future paradigm with business model based on design for environment friendly techniques using new material/nano/bio technologies. They have shown that the new paradigm will respond to the customer's needs of more eco-friendly products .Wang and Lin (2007) introduced a broad triple bottom line model to track and categorize sustainability data at the corporate level through a sustainability index.

2.3. System model for Green Manufacturing:

The main aim to develop system models for green manufacturing is to find out high-level framework to better understand some kinds of systems ,their subsystems and connections with related systems.So the motive of the suggested system model is to better understand it in the analyzing terms of the various works required to asses the current green level of the manufacturing system.Designing of the green transformation plannings and various tools and control metrics required in the available transformation.Describing how to sustain the achieved improvements and build on it to maintain more eco-efficient systems .



2.3.1 Design:

Green design also called the sustainable design.We can explain green sourcing or green design as finding environmental friendly resources.Green manufacturing is defined as the using environmental friendly methods to produce products and/or services.

Design for environmental principles,reduction of toxic substances,rapid prototyping and re- cycle-ability.

2.3.2 Procure:

Green procurement is the acceptance of environmentally responsible practices in business activities that are used to complete needs for goods, materials, utilities and services. The product life cycle and its ecological impact through operation, maintenance, production and disposal are all included in the green procurement.

Re-circulation of packaging, eco- efficient supply, supplier compliance are all procurement in GM.

2.3.3. Manufacture:

Green Manufacturing can be understood in two ways: The green product design ,specifically those used in sustainable energy and clean technology equipment of all kinds,and the 'greening' of production -reducing pollution and waste by depleting natural resources use ,recycling and reusing the waste products,rand reducing of emissions of toxic substances.Resources efficient,energy efficient,emission of toxic free waste.lean ,safe.

2.3.4. Packaging and Distribution:

Green package also known as "ecological package" or "environmental friendly" package is defined as which is completely produced of natural plants and ecology ,it is hurt-less to the environment and to human body and livestock's health .In short,green manufacturing is the appropriate packaging that can be reused,recycled or degraded and doesn't cause pollution in humans and the environment in the whole production cycle.

Returnable, reusable and recycle-able.

2.3.5. Customer use to end of life:

End-of-life (EOL) is used with respect to product delivered to customers indicating that the product is in the end of its useful life ,and a vendor /distributor stops marketing ,selling,or rework related to it.

Trust-able to end of life ,low energy cost emission, free use low consumables use.

2.3.6 Re-manufacture:

Re-manufacturing is "the rebuilding of a product and having the specifications of the original manufactured product using a combination of new parts,reused, and repaired ". The EPA defines rebuilt vehicular parts as "vehicle parts that have been re-manufactured, reused parts in their original form". Mono materials,reuse, disassemble, low cost of disposal.

2.4 Green Manufacturing VS Tradition Manufacturing:

Factors	Green manufacturing	Traditional Manufacturing
1.Energy	Coordinates with energy conservation through green manufacturing material and processes.	Exploits the energy sources and the process to get the desired output.
2.Water	Predominantly saving is done through conservation and recycling.Production of potable water also promoted through alternate sources like desalination of sea water.	Water also wasted like other energy sources not much caring its recycling or storing in a safe place.
3.Environmental, pollution devices and services	Includes compliance auditing and inspection and engineering,testing and consulting.	No such care is done,main motive is to get the desired output from the industries.
4.Engineering, Architecture and design	Created change in product design,industry design,processes design,factory automation to increase efficiency.	Works on the traditional engineering designs and architecture, doesn't change much to reduce environmental pollution.

III. LITERATURE REVIEW

The literature review on Green manufacturing taken into account the wider methodology of sustainable development and finds out how and why organizations should be concerned with environmental and social issues related to supply chain. The review shows that this is generally done due to pressure from stakeholders and to improve the company reputation and efficiency as well as for competitive advantage reasons. Most common benefits of GM in achieving sustainability are as follows increased operational efficiency,cost reduction, enhanced value for customers and competitive advantage. The present trend in recent literature reviews also indicates that a more cooperative model of green manufacturing helps the environmental and social dimensions.

Literature review shows that the various investigations have proposed different approaches to implement Green Manufacturing.

Following are the literature review papers of 10 years which are carried out on Green Manufacturing:

S.No.	Paper	Author	country	Description	Year	Ref. No.
1.	Green manufacturing:Solutions for Indian climate change commitment and make in India aspirations.	Nikhil Sudhir Kothawade	India	Various perspectives of green manufacturing have been identified. Green manufacturing implementation framework explained in paper provides inputs for industry to shift to green practices.	2017	i
2.	Green supply chain management in production sectors and its impact on firm reputation.	Shantanu Kumar Ghosh	India	This research has verified the significance of green purchasing, green manufacturing, green distribution/marketing to firm reputation.	2017	ii
3.	Barriers of Green Supply Chain Management: A Review	Neeraj Lamba, Priyavrat Thareja	India	Barriers present in Indian manufacturing sector have been identified based upon the literature and consultation from the experts.	2016	iii
4.	Implementation of green manufacturing in industry - A case study	Swapnil V. Ghimmire, Dilip I. Sangotra	India	To protect the environment and the earth appropriate methodology should be adopted by the industries to minimize the detrimental effect on the earth.	2015	iv
5.	Study on innovation, research and recent development in technology for green manufacturing.	Prakash Kumar Sen, Shailendra Kumar Bohidar, Yagyanarayan Shrivas, Chandan Sharma and Vivek Modil	India	the relationship between green product innovation, firm performance, and competitive capability. It showed that green product innovation is generally positively affects firm performance and competitive capability	2015	v
6.	A Review on Evaluating Green Manufacturing for Sustainable Development in Foundry Industries	Prof. Shailee G. Achary, Dr.Jeetendra A. Vadher, Dr. G.D. Acharya	India	Green manufacturing is the step to move towards sustainable development. And it is the best practice to achieve Sustainable foundry.	2014	vi
7.	Green Manufacturing: Case Study using AHP and Grey Relation	Abhishek Kumar Singh, Shubhanshu Shekhar Shukla, Jaideep Dutta	India	With the help of relation matrix,established a correlation between various industries in the context of green manufacturing .	2013	vii
8.	Green Manufacturing in Foundry	P.Kumar & Dr. N. Mohan Das Gandhi	India	Lean system infrastructure serves as a catalyst to the successful implementation of Green best practices and the achievement of corresponding Green Results	2013	viii
9.	Infusing a sustainable green manufacturing course into manufacturing/mechanical engineering Technology programme	Dr. Devi K. Kalla, Metropolitan State College of Denver Prof. Aaron Brown, Metropolitan State College of Denver	Denver	Highlighted the importance of infusing sustainability into current mechanical/manufacturing engineering technology curriculum in order to address current unsustainable practices in industry and society	2012	ix
10.	Green Manufacturing (GM) Performance Measures: An Empirical Investigation from Indian MSMEs	Abhishek Kumar Singh 1, Sanjay Kumar Jha 2, Anand Prakash 3	India	Provide a mechanism for the transition of basic research on green manufacturing to industry and government for finding manufacturing solutions to enable a sustainable future with verifiable data.This research has utilized data from India which is one of the emerging economies, and has proposed six important factors of GM practices, namely, Green Product Design, Green Design of Raw Materials, Green Process, Green Technology, Green Packaging Material, and Green Packaging Design.	2014	x
11.	A system model for green manufacturing	Ahmed M. Deif Regina, SK,	Canada	presented a system model approach to realize green manufacturing.An open mixed architecture for the design, planning and control of green manufacturing activities was developed.	2011	xi
12.	Barriers in green supply chain management: An Indian foundry perspective.	Balaji M, V. Velmurugan, Manikanda, Prasath K.	India	This article seeks to find the ten important barriers of implementing GSCM in Indian foundry industries. ISM technique was applied on these barriers and was found that lack of government regulation, lack of knowledge and financial implicitly are to be addressed immediately.		xii
13.	In implementing GSCM in construction industry.	Elizabeth Ojo, Charles Mboun, Esther T. Akindh	Africa	In this article various barriers in implementing GSCM in African industries were identified like top level management commitment, government rules and regulations, etc., were found to be critical.	2014	xiii
14.	A hierarchical framework of barriers to green supply chain management in construction industry	Sreejith Balasubramanian	India	The aim of this article is to identify and classify the barriers as external and internal barriers to organization which help policy makers to focus on specific barriers important to adoption of GSCM in UAE construction sector.	2012	ivx
15.	Barriers to implement green supply chain management in automobile industry using interpretive structural modeling (ISM) technique – An Indian perspective	Sunil Luthra, Vinod Kumar, Abid Haleem	India	A structural model on barriers of green supply chain management in Indian automobile industries was developed.	2011	xv

16.	product management	Rogers and Tibben-Lembke		Green operation ensures quality and environmental conformance, preventing negative corporate reputation by environmentally negligent products.	2001	xvi
17.	Cost and efficiency of production in an organization	Porter	Germany	Organizations can reduce production costs and increase economic efficiency by applying environmental related initiatives.	1991	xvii
18.	Green practices in organiasation and its adoption	Lin and Ho	China	Organizational encouragement exhibit significant influences on the willingness to adopt green practices.	2008	xviii
19.	Implementation of GSCM in textile enterprises	Fengfei Zhu	US	Implementation of GSCM in textile enterprises in which modern management mode consider the environmental influence and resource utilization efficiency	2009	ixx
20.	Green transportation costs in supply chain modeling	Benjamin	US	All these previous studies use subtly different constructs to measure or identify the external and internal drivers/benefits of environmental management or some aspects of GSCM.	2010	xx
21.	Comparison between the Lean and the Green manufacturing concepts.	Glenn Johansson, Mats Winroth	Swedish	They are complementary and to some extanct overlapping. Both concepts deals with the removal of waste while manufacturing. Reduction of waste in terms of inventory, rework, etc as augmented by the Lean concept contributes to resource productivity.	2008	xxi

IV. CONCLUSION

Literature review has been done and in future various barriers and drivers affecting the implementation of green manufacturing in Indian manufacturing industries can be identified through literature review, survey etc. And can be prioritize through multi- criteria decision making techniques like interpreter structural modeling, Analytic Hierarchy Programming , TOPSIS etc.

REFERENCES

[1] Green manufacturing-Solitions for indian climate change commitment and make in Indiaaspirations Nikhil Sudhir Kothawade,India.

[2] Green supply chain management in production sectors and its impact on firm reputation Shantanu Kumar Ghosh,India

[3] Barriers of Green Supply Chain Management: A Review Neeraj Lamba, Priyavrat Thareja, India

[4] Implementation of green manufacturing in industry - A case study Swapnil V. Ghinmine, Dilip I. Sangotra ,India

[5] Study on innovation, research and recent development in technology for green manufacturing. Prakash Kumar Sen, Shailendra Kumar Bohidar, Yagyanarayan Shrivas, Chandan Sharma and Vivek Modi,India

[6] A Review on Evaluating Green Manufacturing for Sustainable Development in Foundry Industries Prof. Shailee G. Achary, Dr.Jeetendra A. Vadher, Dr. G.D. Acharya ,India

[7] Green Manufacturing: Case Study using AHP and Grey Relation Abhishek Kumar Singh, Shubhanshu Shekhar Shukla, Jaideep Dutta ,India

[8] Green Manufacturing in Foundry P.Kumar & Dr. N. Mohan Das Gandhi,India

[9] Nfusing a sustainable green manufacturing course into manufacturing/mechanical engineering Technology programme Dr. Devi K. Kalla, Metropolitan State College of Denver Prof. Aaron Brown, Metropolitan State College of Denver,Denver

[10] Green Manufacturing (GM) Performance Measures: An Empirical Investigation from Indian MSMEs Abhishek Kumar Singh 1, Sanjay Kumar Jha 2, Anand Prakash 3,India

[11] Barriers in green supply chain management: An Indian foundry perspective. Balaji M, V. Velmurugan, Manikanda,Prasath K.,India

[12] A system model for green manufacturingAhmed M. Deif Regina, SK,Canada

[13] A hierarchical framework of barriers to green supply chain management in construction industry Sreejith Balasubramanian ,India

[14] A hierarchical framework of barriers to green supply chain management in construction industry Sreejith Balasubramanian India

[15] Barriers to implement green supply chain management in automobile industry using interpretive structural modeling (ISM) technique – An Indian perspective Sunil Luthra, Vinod Kumar,Abid Haleem,India

[16] product management Rogers and Tibben-Lembke

[17] Cost and efficiency of production in an organization Porter Germany

[18] Green practices in organiasation and its adoption Lin and Ho China

[19] Implementation of GSCM in textile enterprises Fengfei Zhu US

[20] Green transportation costs in supply chain modeling Benjamin US

[21] Comparison between the Lean and the Green manufacturing concepts. Glenn Johansson, Mats Winroth Swedish

[22] www.sciencedirect.com

[23] www.newtheory.org