

GREEN MANUFACTURING-A STEP TOWARDS GREENER EARTH

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ABSTRACT

Green Manufacturing refers to multidisciplinary approaches aimed at reducing the energy and material-intensiveness of manufacturing processes. One of the most challenging goals ahead is the use of only renewable energy sources to meet energy demands. The Green demonstrates that, by applying a combination of different

Environmental technologies, energy requirements could be reduced by between 60-70 percent. Apart from the innovative handling of energy demands, the Green manufacturing applies many other environmental technologies. In the not-too-distant future, environmentally benign manufacturing will become one of industry's greatest strategic challenges, not only from an engineering perspective, but from a business and marketing perspective as well. The purpose of this study is to gather information on research and development around the world aimed at developing alternative methods for materials processing with the purpose of minimizing toxic material generation and optimizing products and byproducts for sustainability and reuse characteristics.

Having considered **Green Manufacturing** as the most revolutionary step toward a "Greener Earth", this paper highlights various works going on in the field of green manufacturing in various countries. An analysis on its development and framework in India has been given. Moreover, a holistic review of green manufacturing, its definitions, background and current issues are represented here to offer appropriate options to the manufacturing systems for moving faster and safer toward a "GREENER" future.

KEYWORDS: Green Manufacturing, Green Energy, Green Product, Green Process.

I. INTRODUCTION

Since 1990s, series of problems concerning environment and resources have emerged with the development of industry. The adjustment of global industrial structure shows a tendency to a new green strategy [1]. The earth's ability to sustain life and the related economic activity is becoming threatened by the old processes of extracting, processing, transporting and disposing of the flow of products and resources which has led to the emergence of **Green manufacturing** [2]. This term was coined to reflect the new manufacturing model that employs various green strategies and techniques which are more efficient and environment friendly. This technique involves creation of product with less consumption of materials and energy, substituted input materials; reduce unwanted outputs or waste and also conversion of output to inputs by recycling [3]. It is a modern manufacturing pattern developed in recent years, which considers much on the effects of the manufacturing process on environment and resources with a goal to minimize its negative effects on the environment and maximize the utilization ratio of resources in the product life cycle which contains designing, manufacturing, packaging, transporting, using and disposing [1]. It is actually more of a philosophy rather than an adopted process or standard. It involves transformation of industrial operations in three ways, i.e., using **Green energy**, developing and selling **Green products** and employing **Green processes** in business operations [4].

Since the concept of green manufacturing was put forward in the blue-covered book on green manufacturing by ASME in 1996, green manufacturing is being paid much closer attention by the developed countries. Especially after International Standard Organization issued its No. 14000 series standards on the

Environmental management, green manufacturing is regarded as an advanced manufacturing model to realize the sustainable development of industries. At present, there are many decision-making problems which green

manufacturing is facing such as standards of green design, assessment model of green products, multi-objective optimization and decision support system (DSS). They are rather complex problems to be settled urgently [1].

II. METHODOLOGY

2.1 Framework For Adopting Green Manufacturing [4]

Even in tough market conditions, the business case for Green remains compelling. There is greater recognition of the imperatives of becoming Green and understanding that Green has to address all three areas Green energy, Green products and Green processes. However, companies face challenges on various fronts, most critically in providing leadership for such an effort.

This calls for a major transformation which to succeed, requires a systematic approach and a framework. Like any major transformational exercise, success in adopting Green requires companies to understand the full set of facts on costs and benefits, and the entire range of Green measures available to them. Once this fact base is developed, companies have to select their Green initiatives based on both, economic and strategic assessments of the choices they identify. An economic assessment is required for estimating the 'value' generated over the long term through these initiatives. It should cover all drivers of value creation- from quantitative metrics like pricing power and cost savings to qualitative ones like employee recruitment and engagement-otherwise. Performing an economic assessment is only one part of the story. Having made a viable case, companies need to make a strategic choice on how Green they want to be, and why. The choice of initiatives could vary depending not only on the underlying economics of the options, but also on the market context and opportunities for strategic differentiation. Potentially, companies can choose to be **Planet indifferent** (where the measures adopted are minimal), **Good citizens** (where they carry out a few isolated initiatives which are the bare minimum that customers demand or regulators stipulate) or **Green innovators** (where they try to stay ahead of the curve on sustainability and transform the issue from one of risk management to that of top line growth and a key business opportunity).

While the first two choices do not allow the company to fully leverage the potential of Green and are only relevant for a short term, the third commits the company to a comprehensive Green strategy and to getting the most from the initiatives.

Becoming Green is a long journey of transformation. To succeed, adequate attention is required on planning and execution of the initiatives. It calls for a fully committed top management, tight periodic reviews and constant internal and external communication. A simple three step implementation framework can be followed covering all three areas of action Green energy, Green products and Green processes.

(1) Plan: Green initiatives must be factored into the business strategy, future resource planning and budgeting exercises. A sustainability charter, based on short term and long term goals, must be laid out with Green targets and metrics. Companies should develop Green indices or scorecards quantifying the impact of the Green initiatives they have undertaken, set specific targets on those indices and track progress against those targets.

(2) Execute: With a robust plan in place and targets clearly defined and monitored, Green needs to be integrated across the value chain and made a part of the core business.

- **Green energy:** Manufacturing companies with high energy consumption need to shift towards using cleaner energy and plan for increasing the efficiency of its use.
- **Green products:** To move towards a Green product portfolio, companies should conduct an evaluation of their products based on (a) how Green are the resources and energy being used, (b) how Green is the product during the lifecycle of its use, and (c) how Green is the manufacturing process.

Companies need to gradually redesign business processes used in different parts of the value chain like reducing waste, increasing recycling, reusing resources and incentivizing all suppliers, channels, customers and employees to adopt similar measures.

(3) Communicate: Along with well thought-through implementation, a well formulated promotion campaign for Green initiatives is equally important to fully leverage their potential benefits. Customer education campaigns about Green product offerings and the Green orientation of the firm in terms of energy and

processes, can translate into increasing revenues.

III. MODELING AND ANALYSIS

3.1 Development Of Green Manufacturing In Various Countries

The motivation for adopting Green has varied across sectors. Some take it up owing to regulatory compulsions (e.g. power), while others see it as an opportunity to build a stronger brand with consumers (e.g. retail). All the governments over the world are trying to develop green manufacturing system applying different strategies. They are promoting the concepts of green mining, green purchasing/product, green business operation and green energy etc. Green purchasing is the concept which encourages environmentally conscious management and eco-product development through the market. To promote the green purchasing concept **Green Purchasing Network** was founded in February 1996 in Japan by the initiative of the Environment Agency. The mission of GPN is to promote the concept and practices of green purchasing and to provide guidelines and information necessary for practicing green purchasing.

European government is spending almost € 1 trillion/year for public purchasing which is over 14% of GDP. Various activities for promoting green purchasing are in practice like,

- Commission interpretative communication (2001) on the community law applicable to public procurement and the possibilities to integrate environmental considerations into public procurement.
- New public procurement directives (March 2004) clarify possibilities to integrate environmental considerations at different stages of a public procurement procedure Handbook on environmental public procurement “buying green”(August 2004)
- Status on green public procurement in EU; EU: 19%, Sweden: 50%, Denmark: 40%, Germany: 30%, Austria: 28%, UK: 23%.

US Federal government spends \$500 billion/year and State/Local government spends \$400 billion/year in greening activities like,

- Energy star program (1992).
- Comprehensive Procurement guidelines (1995) which promote purchasing recycled products and CPG supplier's database.
- Environmental preferable purchasing (EPP) program which based on “Executive Order 13101” (1998) which requires all the procurement officials to give preference to environmentally preferable products and Services.

Japanese government spent almost ¥14 trillion/year and local government spent almost ¥44 trillion/year, i.e., 17.6% of GDP. Japan green purchasing activities are as follows:

- Green purchasing network: 2800 members, 15 purchasing guidelines, award, training/seminars.
- Eco mark program: Since 1989 by JAPAN Environment Association and 5000 certified products within 45 categories.[6]

Indonesian Government is supporting the Policy of Green Mining. They developed the long term plan (2005-2025) with missions to

- Manage and utilize renewable and nonrenewable natural resources
- Protecting water and energy resources and diversity of local natural resources
- Capacity building in natural resources management and environmental management
- Control environmental pollution and degradation and also natural disaster management.[7]

These activities have led to an increment of 74% in sales of eco-product in these countries.

Green Manufacturing Agenda for India [4]

(a) **India's Green Challenge:** India's rapid economic and industrial growth, coupled with urbanization has come at the high cost of increasing GHG emissions, rising demand for scarce resources like water and increasing waste generation, particularly from urban centers. Today, India is the fourth largest economy and the fifth largest GHG emitter in the world. During 1990-2008, India's CO₂ emissions have increased by 150%,

placing it just behind China.

Rapid urbanization and industrialization generate massive amounts of hazardous waste. Apart from hazardous industrial waste and effluents which cause water and land pollution, e-waste is also becoming a major area of concern for India. Estimates suggest that only 3% of e-waste makes it to authorized recycling facilities, with the rest either going into landfills or being processed at informal recycling yards. The Indian e-waste market is expected to nearly double from 450 KT/annum to about 800 KT/ annum by 2020.

(b) Setting the Agenda for Green Manufacturing: To overcome these challenges, or least to minimize their impact, the Indian manufacturing sector will need to take concerted action on all three areas, i.e., **Green energy:** Over past few years, both the Government and the industries have recognized the challenges posed to the country's environment by industrial growth and rapid urbanization. While India has had strict environmental protection laws, the implementation has been weak at times. This scenario is changing if one goes by some of the recent high profile cases, where companies were either denied permissions or given conditional approvals and had to commit to certain sustainability conditions. To supplement the impact of these laws, the Government has launched eight major initiatives as national 'missions' to promote Green, the most prominent of them being the Solar Mission to promote Green energy. According to a 'Global Trends in Sustainable Energy Investment 2010' report by the UN Environment Program (UNEP) released in July 2010 – India was ranked seventh in terms of investment in sustainable energy. Under the National Solar Mission, the Government plans to generate 20,000 MW of solar power by 2022. India is the fifth largest wind energy producer in the world with an installed capacity of around 11,500 MW and has a potential of about thrice. Similar aggressivetargets have been set for hydro and nuclear power generation. The 11th Five Year Plan set a target of increasing energy efficiency by 20% manufacturing sector. **Green processes in business operations:** Indian manufacturing is catching up with the long term benefits of Green processes to improve corporate brands, reduce costs and achieve compliance at the same time. Energy intensive companies are implementing lean processes to minimize waste and enhance energy efficiency which have reduced power consumption by nearly 35% in a short span of time. But there is still a long way to go in many sectors. In a bid to promote energy efficiency and reduce industrial carbon emission levels, the Government is evolving a PAT (Perform, Achieve and Trade) regime designed by the National Mission for Energy Efficiency under the Prime Minister's National Action Plan for Climate Change under which BEE would set energy efficiency targets for industrial units and issue them energy saving certificates or ESCerts. Energy audits plays a critical role in improving energy efficiency and the Government has mandated the appointment of an energy auditor for industries with high energy intensity. It is also important to address water consumption and waste generation as big levers of Green. It is possible to reduce water consumption by better control of processes, recycling water and embracing new water– saving technologies. Manufacturing plants can minimize waste generation by redesigning their press tools and machines to reduce the scrap they produce, and by improving scrap collection and recycling. Godrej Locks improved scrap recycling for all brass made products such as locks, by collecting the scrap and providing it to local smelters for recasting it into brass sheets and rods. Another effort is ITC's paper plant at Bhadrachalam which has been re-designed to consume less water than the industry average and at the same time convert pulpwood into crisp white paper much faster.

(c) Role of Technology in Enabling Green: Green technology is the common denominator across all the three areas of Green energy, Green products and Green processes. Companies can think about the role of these technologies in their business strategy in two different ways – building a new Green Business, and using technology to 'Green' an existing one. Building Green waste management businesses using new technologies such as aerobic composting and

IV. RESULTS AND DISCUSSION

Due to the recent global climate changes, humans have started to realize the vulnerability of nature and the disasters it may bring as a response of our negligence. Green house gas (GHG) emissions have increased rapidly in the recent past and their growth is further accelerating. Global temperatures have risen by 0.74°C over the last century—the fastest warming observed in the history of Earth. US, EU and Japan are by far the world's biggest producers of solid waste, with US at about 14 times that of Japan and the EU combined. At the current rate,

emissions will be doubled by 2050, compared to the 2000 levels (refer Exhibit 2). The rate of increase in atmospheric carbon dioxide between 1970 and 2000 is nearly double that between 1960 and 1970 (1.5 ppm vs. 0.88 ppm per year). Carbon emissions have increased by more than 1.5 times since 1970. This could mean a corresponding temperature rise of 4–6 °C over pre-industrial levels by the end of this century. This unprecedented change is expected to have a grave impact on the global ecosystem, hydrological system, sea level, crop production and related activities.

With ever increasing population and industrialization, the consumption of natural resources is rapidly increasing, with shrinkage in availability. This has led to periodic mismatches in demand-supply and high fluctuating prices, impacting both corporate margins and consumer spend. There is an urgent need to (a) adequately manage the use of these resources and (b) find and develop alternatives which are less scarce. Increased industrialization and urbanization have led to significant growth in waste generation which is potential danger to health, and its disposal without treatment leads to land and water pollution. The release of industrial effluents in rivers and other water bodies is destroying aquatic habitats. With increase in use of electronic products, e-waste is also becoming a major source of environmental pollution. It's high time to reflect and take environmental effects into consideration. Green Manufacturing sub-disciplines include scheduling and process optimization, advanced fabrication techniques, minimization of waste stream volume and toxicity and improved energy efficiency. As stated by Manufacturing & Technology News Green Manufacturing will become one of industry's greatest strategic challenges, not only from an engineering perspective, but from a business and marketing perspective as well [4] [5].

V. CONCLUSION

Green Manufacturing is vital in preserving our natural resources for future generations. Though some work has been done in this field a lot is yet to be done. Implementation of Green Technologies may be costly and requires a lot of determination but many companies have taken the initiative to go green. It is high time that other companies, be it large or small recognize their role in making the Earth greener and take up the Green Manufacturing challenge. The benefits are plenty especially if the company adopts Green Manufacturing now. As humans, we have the thinking capability which separates us from beasts. Therefore, we must start thinking of the consequences of our actions and begin fulfilling our most important purpose that is preserving the Earth from future destruction. The earlier, the better we understand it.

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