GREEN MANUFACTURING: AN INSIGHT

[a]Sanjay Sundriyal, [a]Rupak Kumar Deb, [b]Iqbal Ahmed Khan, [c]Vinay Chandra Jha

[a]Mechanical Engineering Department, Lingaya's Vidyapeeth, Faridabad, Haryana, (India)

[b]Mechanical Engineering Department, Greater Noida Institute of Technology Greater Noida, Uttar Pradesh (India)

Mechanical Engineering Department,

[c] Mechanical Engineering Department, Kalinga University ,Raipur

ABSTRACT- It has been observed recently that sustainable development is the primary goal for any manufacturing industry globally. Green manufacturing is indeed needed because of its long term advantages such as low carbon emission or wastes by better production design and durability of the product. Green manufacturing not only provides unlimited opportunities for long term development but also eliminates the unpredicted risks involved at strategic level for manufacturing. The main objective of this study is to study the recent trends in green manufacturing. This article is emphasizes on the literature review related to green manufacturing and overall past research results and the identification of challenges in this methodology.

Keyword: Green manufacturing, sustainable, emissions, greenhouse gases.

INTRODUCTION

There are two important challenges in the 21st century identified as deficiency of resources and environmental shift. It was also shown by Keeling curve that there is rapid increase of CO_2 as compared to previous limit of emission of the polluting gases which will eventually result in increases greenhouse phenomenon [1]. Secondly as per national geographic source, there is sea level withdrawal which poses a threat to high density regions such as New York, Miami and Shanghai [2]. Another change we are facing is the increase in world population up to 100 billion at the end of this century [3]. This problem will be further worsened by the upliftment of living

standards in the developing countries. Productivity is merely not the criteria for success rate of the country, as there will be more requirements of facilities such car and fuel which will result in more emissions. In today's era, the industrialized countries enjoy affluent products such as

energy, food and other daily requirements but there are no prepatory efforts in order to eliminate the adverse effects of the environment by the regulating bodies such as local governing bodies and international organizations.

Therefore there are chances that there will be disasters to the human lives in the upcoming decade [4]. Therefore sustainable manufacturing is gaining more and more grounds these days. If we look at the current consumption of the world in terms of energy then the major portion of the energy is consumed by the industry (33%), temperature control in the building results in consumption of 28% - 39%. Other adverse effect by the energy consumption results in production of waste/ toxic material which negatively impacts the environment. Several studies have also been conducted in green product innovation and low carbon matters [5-14].

2. Methodology of Green Evolution

There are different abstracts available for evaluation of recent technologies such as Hype cycle which was published by Gartner Group which has given an insight of the emerging technologies and additionally it also shows the development stages and its pace in the trend [8]. There various assumptions taken into consideration such as trigger of innovation, inflated expectation peak, trough of disillusionment, slope of enlightenment and finally the plateau of productivity as shown in Figure 1. In the plateau region, the innovative technology matures and its profitable margins are determined. For example if we consider rapid prototype as case study in field of additive manufacturing which came into existence in 1980's. The rapid prototyping (RP) was at the peak at 2013 and even the laymen knew the technology due to the popularity but later on due the adverse effects of RP, the expectations were not met but eventually RP will still be in demand. There several examples of technologies which did not reach the maturity phase due the various adverse effects.

*Corresponding author: Dr. Sanjay Sundriyal
Assistant professor (Linagays Vidyapeeth)
E-mail- dr.sanjaysundriyal@lingayasvidyapeeth.edu.in
Mobile No- +91-7042320303

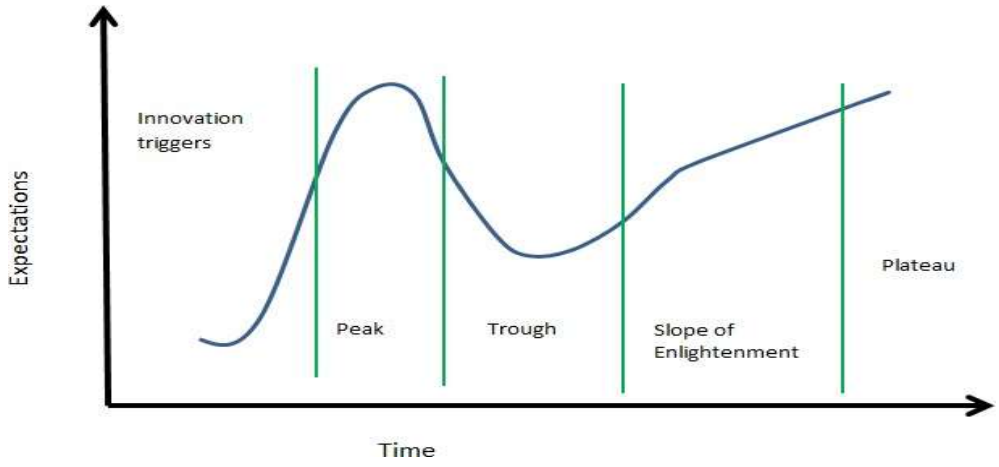

Figure 1. Hype Cycle

Recent study shows a comparison of average impact factors in engineering field related to environment and fuels technology and it has been observes that nowadays more journal papers related to greener technology is available as compared to research related to fields of manufacturing engineering and mechanical engineering as shown in Figure 2. The combination of manufacturing technologies and energy-environment technology provides adequate synergy effect for the green technology and also for the initiation of new engineering research journals covering those areas which are not yet discovered by the existing journals.

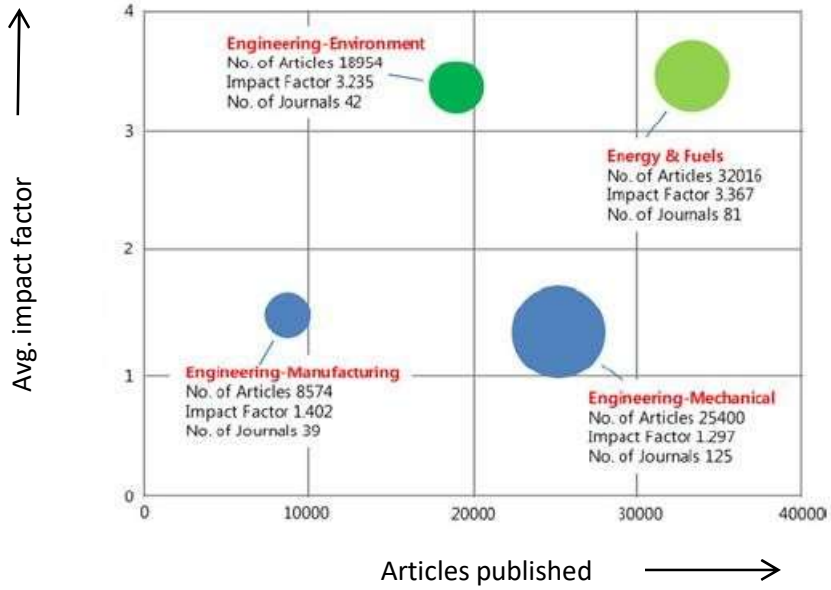

Figure 2. Comparative studies for different fields [15]

Establishment of sustainable methods as a key challenge when it comes to economic activity because it involves energy and climatic issues. Innovations in patterns of material flows for the least effect of ecological footprint of human economic activity are shown in Figure 3.

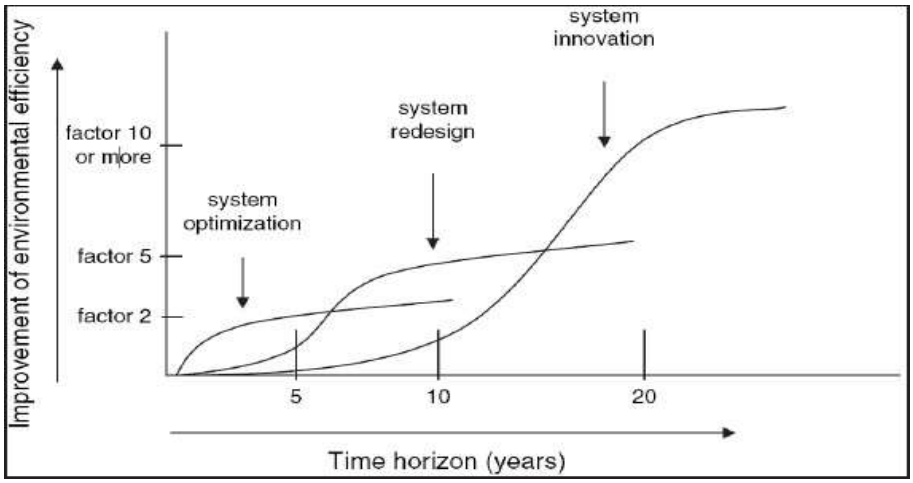

Figure 3. Innovations in patterns of material flows [16]

2.1 Energy-intensive industries for selective green technologies

2.1.1 Iron and steel industry

There are various steps in steel production process which can be categorized in different combination such as mixing of product, availability of raw material, and supply for energy and capital investment as shown in Figure 4. These characteristics can be mentioned in three routes:

- Blast furnace produces pig iron using iron ore and coke. Afterwards this can be converted into steel by using oxygen furnace. This is high energy intensive process as it involves sintering process by involvement of coke making.
- Scrap furnace uses scrap from iron input and this route uses considerably less energy intensive as compared to blast furnace due to coke omission.
- Finally there is process of direct reduced iron in which utilized scrap iron and this route is less energy intensive.

In recent years, increasing attention has also been paid to smelting reduction, which is emerging as a contender to the blast furnace process.

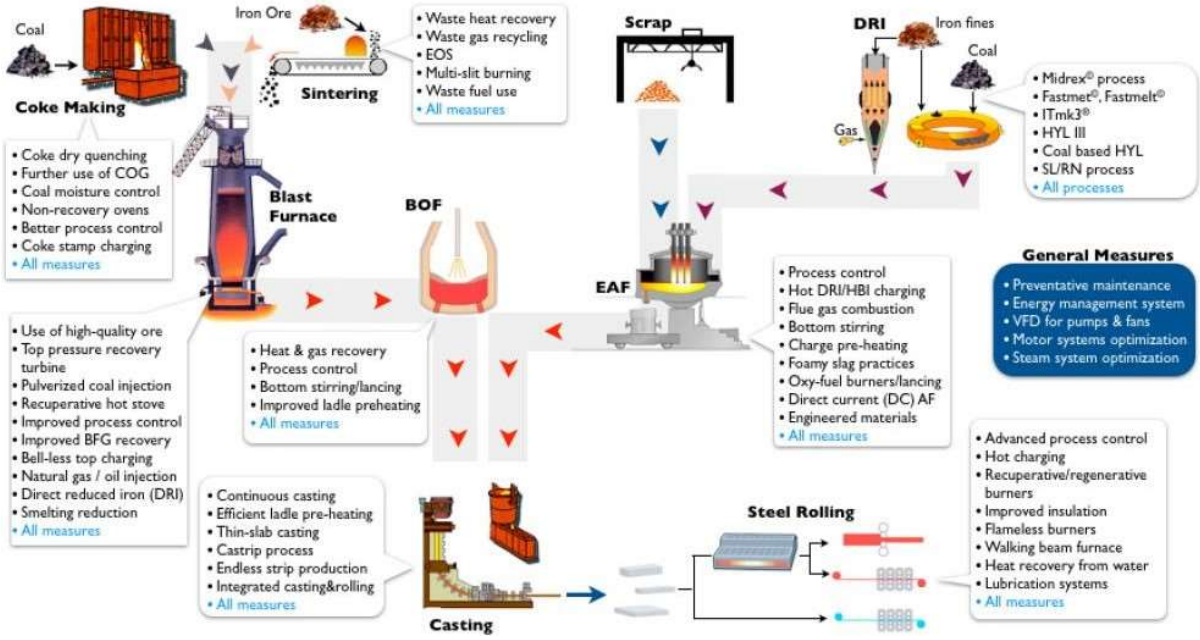

Figure 4. Source: Industrial Efficiency Technology Database, Institute for Industrial Productivity [17]

2.1.2 Cement production

The main four process routes utilized in cement production is dry process, semi- wet process, semi-dry and wet processes. Although dry processes are more energy efficient but availability of the raw resources also plays an important part in its production. On the other hand, the wet process is more energy intensive process therefore it is being rules out in many countries such as Australia, New Zealand etc. There are several processes in involved in cement production such as sintering limestone, grinding raw material which require high demand of fuel. Therefore nowadays alternate blends for fuels, energy efficient technologies and other options are also emerging in the form of alternative cementitious materials which reduces carbon emissions and consumption of fuel. Figure 5 shows the schematic diagram for use of alternate efficient technologies in cement industry.

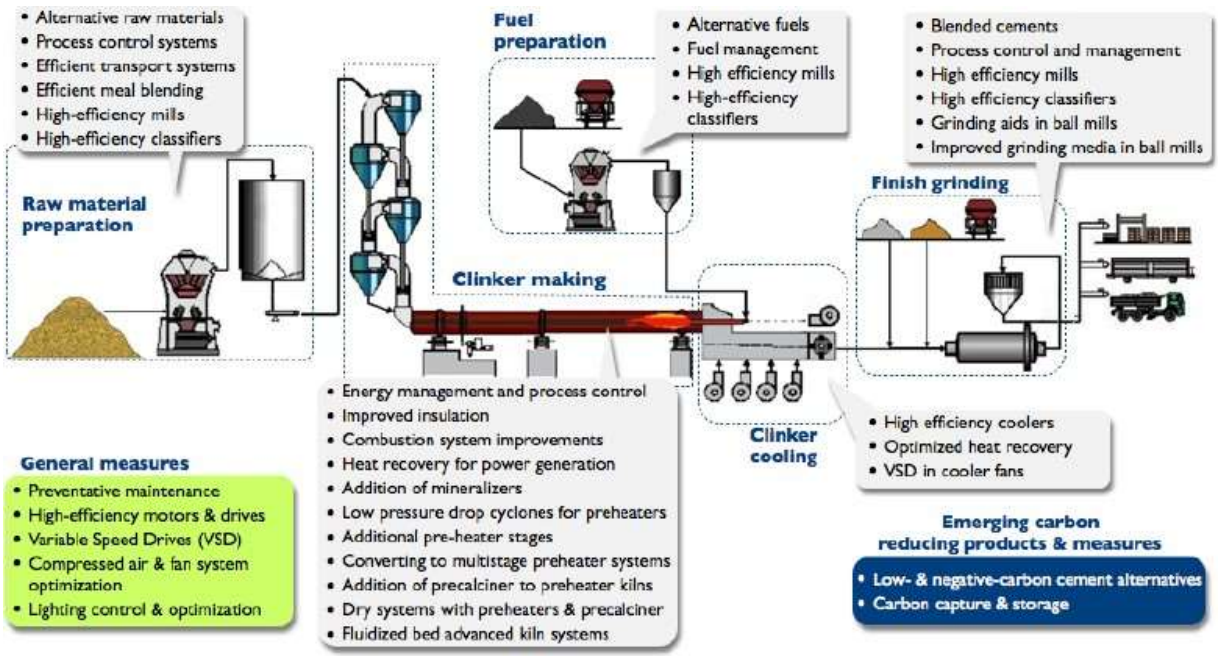

Figure 5. Cement production schematic, Institute for Industrial Productivity [17]

2.1.3. Paper production

Generally in paper production industry, pulp production and its conversion to dry paper are the main energy consuming processes which need to be reduced by better technologies. Therefore integrated mills are being encouraged these days for balancing the energy consumption as they are more energy efficient as shown in Figure 6. The major energy consumer in the industry is the process which involves production of pulp and its conversion to dry paper. Efficient Integrated mill have significantly have reduced the impact of pulp mills and other integrated mills. Kraft chemical is the most favourable material uses in pulp industry although it needs large amount of heat energy for its processing but it can be compensated by the by-products such as black liquor. Another chemical used is sulphite which also involves high energy consumption but large part of energy can be met by its by-products too. Although weaker fibres are produced by mechanical pulping but due to the high yield of the fibres, the energy demand is considerably lower. Innovative technologies such as thermal –mechanical process for pulping are being used because a large portion of heat is recovered at different grades.

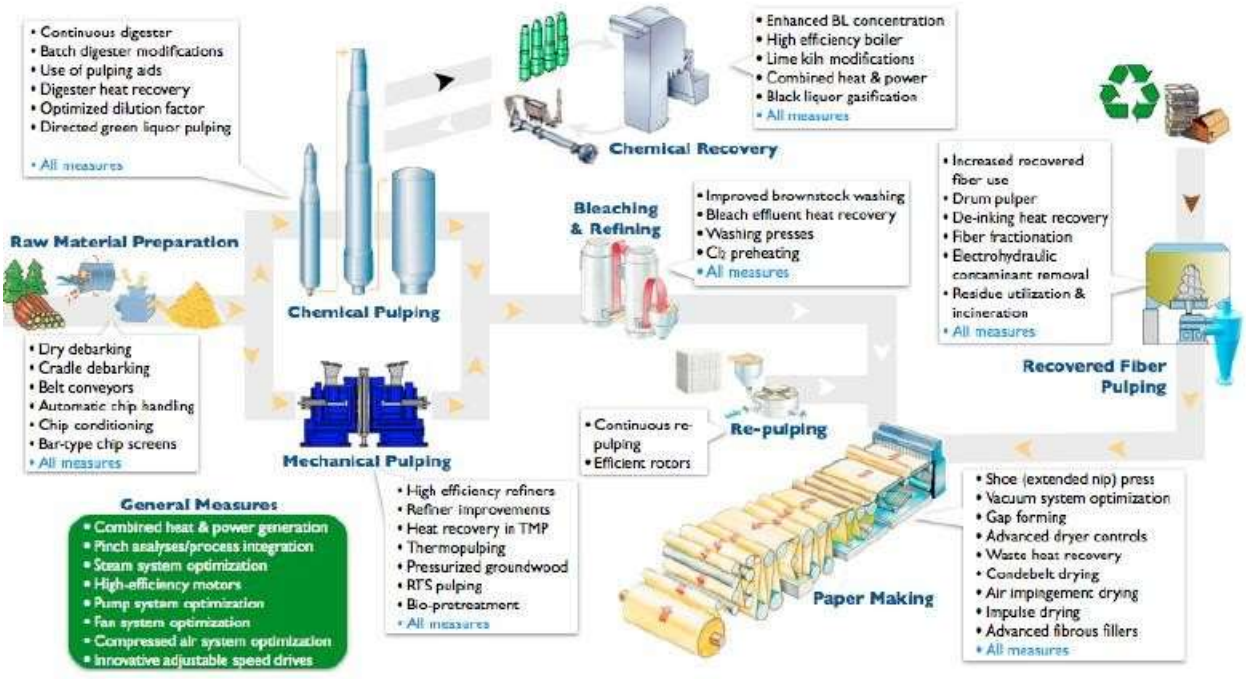

Figure 6. Paper production schematic, Institute for Industrial Productivity [17]

2.2. Less Energy Intensive Industries for Green Technologies

Electrical motors convert electrical energy into mechanical energy and are motor driven system. These motor driven systems find application in applications such as conveyor belts, fans, pumping, handling of mechanical equipment's and processing. As we know that most of the electricity is consumed by the motor parts but if we consider the overall efficiency then the overall electricity consumption is often limited. The main reason attributed to this fact is that the system components of motor driven system such as valve pipes, pumps, and ducts have affect on mechanical power of the entire system and all the other losses incurred during the delivery of the power have large impact on overall consumption of energy. Therefore it is much more important to adopt an optimized system in way to reduce the overall energy consumption. The advanced solution and technologies are very much responsible for improving the overall design of the system. In most cases, improving the efficiency of a motor-driven system involves the following parameters such as making use of energy efficient motors, selection of core components such as fans, compressors, speed drives with high efficiency as shown in Figure 7.

Figure 7. Equipment of motor systems, Institute for Industrial Productivity [17]

2.2.1 Renewables and Smart Grids

Renewable energy sources are considered as one of the possible solution for manufacturing industry but only for short duration of time because these renewable resources are not a mainstream for fields like industrial manufacturing and applications as these continuously demands innovation in technology. This renewable energy finds application in generation of electricity by utilizing wind energy or photo voltaic source. Similarly small batch of power units in an approximate power range of 20-30 KW can be utilized for medium heat generation for industrial purpose. In building, small units of solar panels can be utilized for temperature control in building and offices. Other source such as bio-waste and bio genetic material further can also be used for power generation and oil based chemistry respectively.

3. Conclusions

- Several developments have taken place in previous two decades related to green manufacturing. Different innovations role has been played at different strategies ash shown in Figure 8.

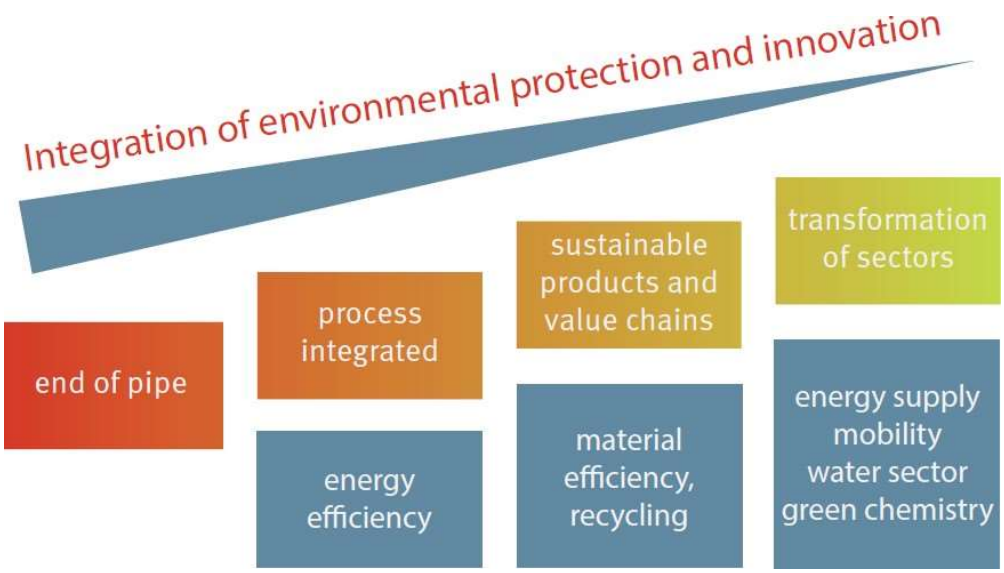

Figure 8. Various innovations in environmental technology [18]

- Initially end of pipe solutions were followed but these solutions do not provide any modification in the manufacturing process. This strategy was focussed on reducing pollutants.
- In other stage process integration came into existence which used policy of efficient energy and at the same time lower emissions. Quality production and economic productivity were of utter importance along with environmental benefits such as use of electrical efficient motors in steel making industry.
- Thirdly use on non-toxic material was encouraged for product design and development. Recycling of end products and life cycle assessment was focussed in this trend.
- In this study it was concluded that various efforts have been made in order to attain sustainability and there is complete transformation of industry in the global level. Secondly carbon free economy is the need of the hour without any further delay in the future.

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