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Wide Scope to Sustainability in Industries through Green Design

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***Abstract*: Green design is also an important aspect of sustainable manufacturing to achieve real success in green manufacturing. Presently 3R standards (Reduce, Reuse, Reuse) is well-known for sustainable envelopment, but for the purpose of quickening green improvement, it ought to take after the 10R standards in green plan: Reduce, Reuse, Recycle, Renew, Recharge (or Refill), Repair (or Cure), Re-manufacture (or recuperate), Replace (or Replant), Re-clear (or Refine) and Remove.**

***Keywords*: Green design, green manufacturing, sustainable manufacturing.**

1. Introduction

Due to renewable resources for energy coming to extinct, made the essentiality to develop sustainable products, manufacturing process and its use. All these are achievable through Green Design. Basic concept in design is to develop a service or product through less complexity and end user easy interface to use that product. But, targeting only end user easy interface or sustainable product is not enough to save the mother Earth from pollution that we are facing currently. Even to develop sustainable product, sustainable design, and manufacturing along with process which will sustain with minimal to zero use of renewable sources.

Looking into design perspective, green design can be called as Design for Environment or Economic/ Ecological Design, Sustainable design and Development or E-Design. Green design will work on factors like satisfying service, Quality compliance and Cost/ Budget to the design. When less use of renewable resources and maximize the use of resources available can drive us to higher functionality and quality of the product/ service which automatically leads to lower cost. It will not be only green design put impact and lower the pollution on the earth, but it will also comes to manufacturing and its processes to be in green aspect for efficiency and sustainability which plays an important role in the market for industries to sustain with competitors [1].

Also, some industries not bothering about usage of non-renewable resources and use them freely, which will not bring cost effectiveness thus, compromising quality to increase quantity and using it to produce a product over and over will not bring efficiency, which impacting business [2]. For mass production of product, design as well as manufacturing processes must be in green approach and sustainable for effects to get highlighted, in perspective of business.

2. Postulates Behind Green Design

Always focusing on green manufacturing makes a huge difference to lowering the pollution and maximizing the sustainability of processes and product's life cycle but, green design comes into place to make even more efficient products, if green design used at the start/ source. Basics walks with green design are simple 3R's – Reduce, Reuse and Recycle. An entire world of green design lies in between these 3R's. Hence, these principles became globally known concepts to use in green design.

As design is the source of anything before production/ manufacturing of any prototype, the 10R principles mentioned in an abstract should be followed.

Reduce the waste or energy consumption, reuse the materials or resources and recycle the products or raw materials again and again with sustainable processes will immensely impacting in good manner, regards to the pollution.

Energy is the most essential thing to ensure sustainable development and the forward ongoing approach of human civilization. For over the last three decades, the consumption of energy has doubled the rate it was back in the last century [3].

As mentioned in introduction, for sustainable development, green design along with green manufacturing processes comes together, we can consider sustainable product development through design and manufacturing processes for example here, even with Carbon Fiber Re-enforced Composites (CFRC). As they possess advantages like high weigh-to-strength ratio, easy molding feature, higher tensile property which gives material a long life and of course, turned into the sustainable product [4].

Aviation industries using a top-notch sustainable approach for their component design and manufacturing proper engineering and placement of fibers, they can be tailored with directional properties as needed thanks to their inherent anisotropy in mechanical characteristics and strengths. These advantages along with the consistent development in the manufacturing process, availability of modern precision tools and equipment, have enabled their mass-scale usage in applications like Rocket and spacecraft (fuel tank). Over the past few decades, energy is the cornerstone of technology and economic infrastructure. Hence the costs of energy have been

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increasing exponentially worldwide [5]. Hence green design comes below 3 aspects, shown in fig. 1.

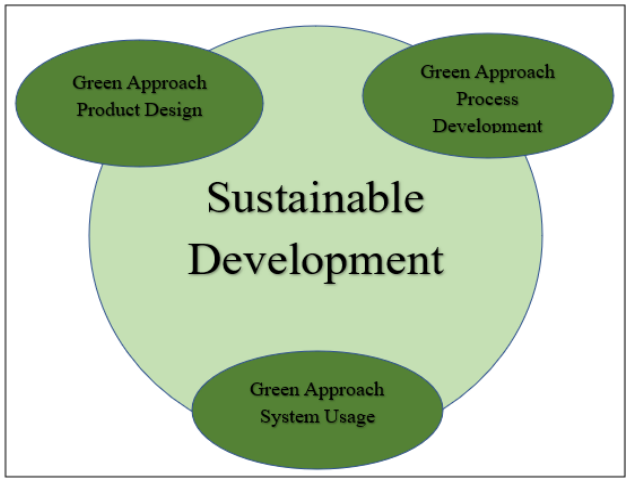

Fig. 1. Green/sustainable development

Sustainable development means not only manufacturing or design, but the research and development for the materials strength will contribute to sustainable development considerably.

Now-a-days, automotive companies using lot of sensors for the various applications and data collection in the vehicle for durability, mileage, safety, and locations and many more. The more the sensors, less the waste. Most of the cars layout design made to sustainable, efficient for long term usage. Currently lots of automobiles employed with Fuel Monitoring System, Tire Pressure monitoring System, Engine Health Communication, Chemical Handling and Performance Parameters, which includes Micro-Electro Mechanical Systems (MEMS) sensors. MEMS are sensors are designed, developed and mass produced for more efficiency at first place [6]. These MEMS sensors application's use, widely increased day by day in many aspects because of its miniaturization and effective cost with more quality output [7], [8].

Basically, MEMS sensors are mixed of materials, electronic mechanical technologies integrated together for resiliency, efficiency, durability, sustainability for high level results. Also, currently, due to no-renewable energy resources are in crisis so the green development is so essential in all aspect of product life cycle. As Petrol, Diesel became so restricted to be available, biodiesel took place over them, which can burn almost completely and emits 85% less cancer-causing agents through the exhaust of any automobile using bio-diesel engine, this is an outline or approach of green development which requires green, sustainable design, along with manufacturing processes sustainability [9].

3. 10R's at a Glance

As design is the base of product development, but, when comes to green/ sustainable development, implementation of green design concept along with these 10R principles is must. Fig. 2 showing 10R cycle in product life cycle and its management. As mentioned, 3R principles such as Reduce, Reuse, Re-cycle are globally recognized principles in the green product development and life cycle, 10R becomes the children's principles of these 3R parents. 10R approach basically a most advanced approach in green development [10].

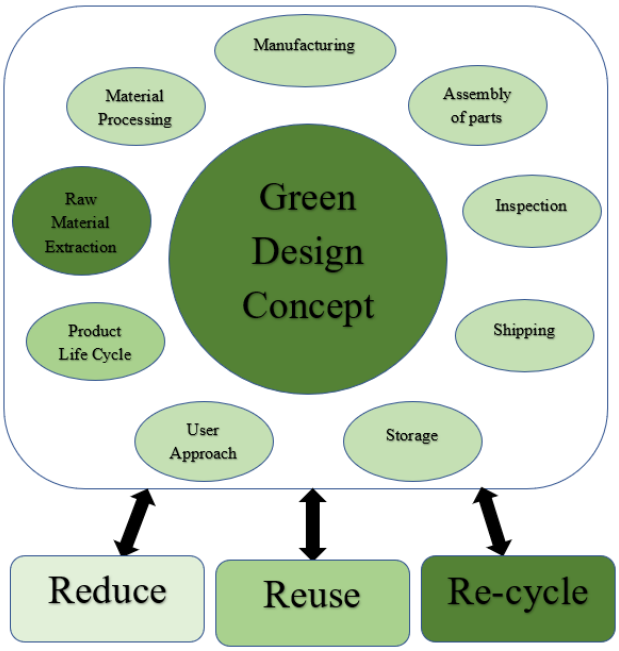

Fig. 2. 10R approach

A. Reduce

This term is nothing but reducing the emission wastes with the use of less resources at its potential. Design of product should be simple, portable, and durable with adaptability approach has to be consider while designing for product reliability.

For design, we use Computer Aided Design (CAD), for their analysis use of analysis tools like ANSYS (CAE) have been used for decades. But green design demands more and more intuitiveness while product life design. According to statistics, green design determines the consumption of 80-90% in the product life cycle [10], [11].

B. Re-use

This concept focuses on re-using the technology, products, processes, approaches for durability of product. Making products over and over, so make them much durable that they won't get wasted shortly. But, if business case comes in, have the various green approach design for every purpose that people will buy the product for different applications which has durability.

C. Recycle

Recycle can be done in many ways but, focused on 2 approaches commercially. Primary recycling approach gives an idea to use same product after its full life cycle to produce raw material for same new product whereas, secondary approach highlights the use of product recycled for another product's recycling. Its best strategy to use recycled materials at its optimum level and no use of non-recycling materials at first place of product manufacturing to lower the toxicity created in an environment.

D. Renewal

Products should be from renewable materials. Use of degradable materials, renewable energy, sustainable processes, and finally environmentally friendly design (modular designs) is the criteria for refurbishment of any product. Best example can be considered as microbial degradation or processing which will not demand for energy to consume.

E. Refill/Recharge

Energy or product can be re used after refilling its energy or refueling. As we everybody knows that Elon Musk founded SpaceX company in 2002 for space exploration programs and research. So, in that company, launch vehicles for rocket were used multiple times, whereas traditional vehicles were of one-time use. Electric vehicles now-a-days are in boom, which can get recharge and con be consider as renewable source of energy which basically transfer to transportation purpose.

F. Remedy/Repair

To achieve repairment or remedies of existing part of products, at first place, design considerations should be made in such way that, an entire product can made of modular components and easy to dismantle. Hence, once the part is wear, we can change that specific part or if approachable to repair, can get repaired to make the product working.

Design will automatically a green design, when considerations were made to make the product with self-check feature on its health, modular combinations of sub-components, simplified designs, adaptation of universal materials and parts and toxic materials sealing leads sustainable development at the first place in product life cycle and its management.

G. Recover/Remanufacturing

This term is very helpful in heavy duty equipment manufacturing industries like, Cummins, Caterpillar, Volvo and many more. Design the product in such modular way that, after full life cycle of that product, few to lot of parts can be interchangeable and use of cleaning, recovering, replacement techniques, product can bring back to its new life. This will save energy, material, resources, and less pollution obviously.

Use of self-healing carbon fiber, Carbon Fiber Reinforced Composites for various applications like front, rear grill and bumper of vehicle which usually gets damage at first place in any incidents, these carbon fibers can heal itself to most of its life and need not get new one, saving in all aspects will be the result.

H. Replace

This is one of essential design consideration in green development and green design approach. Inputs and outputs of a system or product or processes should flexible and universal, standardized and interchangeable which allows an organization to use those for variety of products.

Use of conjunction systems or features such as vehicles with generator system like Ford's F-150 pickup truck has and this can be useful in case of immediate power outages [10].

I. Refine/Re-clearing

Refine itself justifies the process. Refinement improves the quality of process and products to some extent. High tech cleaning like laser cleaning, electrochemical cleaning, ultrasonic cleaning, and Electro Discharge Machining can be helpful and effective. It is preferable to choose a cleaning method that requires fewer changes to complete the cleaning structure, which can simplify the cleaning process.

J. Remove

On the earth, before manufacturing industries comes into scenario, CO_2 concentration was 280 ppm and now it reached to ~ 408 ppm in an environment, which is almost double, we can say. To remove CO_2 from an environment means, use of low carbon emission technologies to be in use and need of development for it. Also, nanotechnology derived from natural resources or synthetic ones can be helpful. Use of carbon nanofibers are making their way to this field, aiming to improve the modern and next-gen batteries by increasing storage efficiency and durability [13], [14]. For lowering the emission of Chlorofluorocarbons (CFCs), need of thermophysical properties improvement is must by altering nanoparticles volume concentration like nanoparticle concentration on water based TiO_2, SiO_2, TiC, and SiC nanofluids. The dispersion effects of 1-4% nanoparticle on the single-phase forced convection heat transfer performance can be improved, and helpful for lowering carbon emissions from the process [15].

For nuclear reactor, much heavy-duty cooling systems are required, which has drawn lot of power to use of such appliances to cool down the facility, here nanofluid can be used for enhancing significant cooling technology and its sustainable durable performance along with safety [16], [17]. More to this, from available resources like sun light, heat from sun, we can use in multiple forms such as environmentally friendly, solar powered ammonia water absorption refrigeration system, which can be used as alternative to CFC emitted traditional refrigeration system [18].

It will be okay to use some forms of plastics but, those should be life long and sustainable and made from renewable raw material by combination of Low-Density Polyethylene (LDPE), Polypropylene (PP), High Density Polyethylene (HDPE) by compression injection molding to improve tensile strength, yield strength and maximum elongation [19].

4. Conclusion

Now it becomes mandatory to develop a green design due to the product sustainability and the impacts on environment from pollution.

Green design will consider all above aspects of design in 10R approach, giving a sustainable design for which again becomes essential to develop sustainable manufacturing processes, eventually save the mother earth from pollution and extinction of some animal, plants species which are required for maintaining biodiversity in an environment along with energy conservation.

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