Significance of Research in Green Design of product: An Overview

Abstract

Green design is not on work for waste prevention but also provide solution. This allow the people to produce products with less environmental impact. Electronic waste are now days becoming a bigger challenge in sustainable development. A environmental design process must be considered for pristine the natural resources and reusing the earth's scare resources, where energy and material consumption is optimized ,minimal waste is generated and output waste stream from any process can be used as the raw materials.There are so many methods to analyze the product like SWOT analysis used to analyze the strength and weakness of products market trends and for external factors affecting the success of product and Market Research Survey to understand the customer perspectives. 'Design for Environment' (DFE) isa designing approach focused on reducing the Environmental impact of product throughout its lifecycle.Design research empowers the designer to create better design for the users centric sustainable market.Evaluative Research Design is essential for the product success. It helps to validate the idea, that much particular product is satisfying the targeted consumers.

Key Words: Green design, zero emissions, blue economy , sustainable products,*Guerilla testing,* ,Life cycle analysis .

1.Introduction-

Since electronics are blooming in 20th century. A environmental design process must be considered for conserving and reusing the earth's scare resources, where energy and material consumption is optimized ,minimal waste is generated and output waste stream from any process can be used as the raw materials.

This is the process of addressing surrounding environmental parameters while devising plans, programs, policies, buildings, or products is called Environmental impact assessment or Environmental management. Life cycle Assessment is a kind of approach which helps in assessment of environmental parameter over the full life cycle of product.

Design for Environment (DFE) is another name of a United State's Environmental Protection Agency (EPA) program, created in 1992, which works for the prevention of pollution and the risk of pollution for human being and environment .EPA has given again a new name to this program " SaferChoice"in 2015.

The other instruments of EPA, by which EPA is working is Waste Management Act,1996, Protection of the Environment Act,2003 and Radiological Protection Act 2014 etc.

The intensions of EPA regarding product impact on environment is to support strategies to keep product materials for longer use, reuse , recycle and take waste to energy initiatives system. By setting the rules and regulation is to limit the release of hazardous emissions from designed product and provides tools to help consumers to make informed decisions about purchasing products with lower environmental impacts.The benefits of incorporating Design for Environment include: cost savings, reduced business and environmental risks, expanded business and market opportunities, and to meet environmental regulations[3].

When we design for the world , start with the identification of problems, explorative study about the problems, sustainable solution for the problems and then ensure that outcome would direct the challenges positively. Research in designing processes footing for the creation of user centered (UCD) design. It involves not only users requirement but also consider what consumers

Through the proper research , Environmental designer work with the objective of to create highly usable and accessible product. For example if researchers are going to design diamond jewelry , they focuses on current trends of diamond jewelry, critical design, business requirements together with users' needs, users feedback loop in product life style.

Designing research is a structural investigation of users behavior, motivation and context . Design research empowers the designer to create better design for the users centric sustainable market.

2.Literature Review-

The choices of raw materials , environmentally friendly disposal are during the synthesis and /6energy utilization during the production of particular product(Amit Kapur, Thomas E. Graedel, Encyclopedia of Energy, 2004). Researcher very frequently use the LCA and DFE methodology as a tool to find out the impact of designed product on the environment.(Zhang et al., 1999, Boks and Stevels, 2007, Grote et al.,2007) ,

Georgiadis and Vlachos in 2004 , presented a System Dyanamics Simulation (SDS) model to evaluate the long term effect of closed loop supply chain as an alternative of environmental protection policies in concern of take back obligation, proper collection campaign and green image effect.

Life cycle analysis (LCA) is also used to analyze the impact of product on theenvironment(MehmetAlilIgin, Surendra M. Gupta , Journal of Environmental Management,2010)

In 1990, the initial guidelines for the Design for environment approach were developed by East Meets West, a non -Governmental Organization based in New York. This effort quickly evolved into global movement focused on incorporating environmental objectives into design practices. The initiatives aimed to enhance product design by prioritizing sustainability and reducing the environmental impact throughout the product's life cycle.By incorporating eco-efficiency into

design tactics, DFE takes into consideration the entire life-cycle of the product, while still making products usable but minimizing resource use (D.E.Santos-Reyes, T.Lawlor-Wright,2001). The Key consideration of DFE is to improve the environmentally related attributes of designed product without conciliatingthe fundamental design aspects like specialty , reliability and market price.

A number of tools were also used to evaluate the designed product with respect to environmental impact. Green design Advisor (GDA) were proposed by Nicole M.Ardoin 2020, which considers metrics related to raw materials used in product formation, toxicity of product, recyclability of the product.

Lye et al. developed a computer based designed tool (ECoDE) to compare the environmental impact of component of products.

Wilhelm Griga in 2008 developed a new recovery-conscious design method for the quantitative analysis of recoverability of complex product.

3.0 Design for Environment-

'Design for Environment' (DFE) is an umbrella term describing techniques used to incorporate an environmental component into products and services before they enter the production phase (Karl T. Ulrich and Steven D. Eppinger, 2012) .DFE seeks to discover product innovations that will meet cost and performance objectives while reducing pollution and waste throughout the life-cycle. A wide variety of techniques are available, and they fall into two broad categories.

a. **Waste Minimization Techniques** – This technique involves the reduction of waste during the production and if created involve reusing or recycling and minimizing scrap during production.

b. **Design for Disassembly**- These techniques involves the designing of product during production so that it be easily dissemble , repair or upgrade at the end of products life.

c. **Life Cycle Assessment-** This technique used to analyze the product's life cycle including raw material extraction , synthesis, disposal at the end.

d. **Modular Design-** By applying modular design technical approach one can replaced or upgrade the product without discarding the entire product.

e. **Green Chemistry-** By this technical approach one can focus on chemical and raw material that are environmentally benign and ensuring the environmentally safe synthesis process and designed product.

f. Carbon Capture, Utilization and storage(CCUS)- CCUS technologies capture CO2 emission from power plant before they released into the atmosphere, storing them underground and use them for other industrial operations.

Analysis tools can be used to identify broad environmental issues, but improvement techniques are needed in order to solve any problems identified.DFE strategies are sufficiently broad to be used at the product planning and problem definition stage of the design process. Concept demonstrators, on the other hand, are a tangible vision of the possible product of the future.

4.0 Methodology-To manyspecific methods and tools were used to validate designed product and to analyze end product information and its impact on environment .(Chetan Mehta & Ben Wang, 2007)

4.1 Zero Emission -

The concept of zero emissions is based on improving technologies and processes to the point of maximum resource productivity and virtually no waste.Zero emission Goals involves several strategies to reach–

I. **Net Zero-** It means not to emit zero emission at all but to stop unavoidable emmisions through compensatory actions.
II. **Transition to Renewable Energy-**This strategy involves the transition from fossil fuels to renewable energy sources to achieve zero emission goal.
III. **Electrification-**Electric grid transition to public transport (electric vehicle)and heating industries like electric furnaces may reduce the harmful emission and help in circulation of clean energy.
IV. **Innovation and Technological advancement-** This strategy to reach zero emission requires breakthrough in technologies as low carbon industrial process, advance battery storage, artificial intelligence to optimize energy system.

All of these are ways of eliminating wastes or turning wastes into profitable resources, while preventing harm to environmental and human health. Zero emissions may appear an unrealistic objective, yet it is a proven and profitable goal.

The "***Zero Emission Research Initiative***" (ZERI), developed at the United Nations University in Tokyo, by Gunter Pauli.It was a global network of creative mind focused on designing an innovative solution for sustainable development and has its goal to 'zero global emissions, zero water waste, zero solid waste, and zero waste in the air'.(Gunter Pauli, 1998)

The blue economy concept is also given by Gunter Pauli which was an extension of ZERI principles. Blue economy concept promotes the business model stimulated by natural

ecosystem where all resources are used effectively and no waste should come out. It also promotes the atom economy.

The concept of zero emissions has been developed into a methodology which is a comprehensive approach to create zero emission system by mimicking nature's efficiency, fostering the innovation and addressing the environmental challenges simultaneously (Rupert J. Baumgartner & Christian Zielowski, 2007). The basic idea behind the methodology is to transform the waste into opportunity. The key components of ZERI methodology, are as follows:

Biomimicry and Ecosystem Thought- The central idea behind this is, nature works in closed loop system where the waste from one organism becomes the energy source for others. ZERI applies this basic principle to many industrial processes to ensure that byproduct and waste can be repurposed in other industries as a raw material. In many countries the waste from a brewery are used to grow Mushrooms.

Holistic System Design- ZERI emphasized the need to understand the whole ecosystem in which process and product operates. Strategy behind this is to analysing the environmental,economical and social impacts due to product design and process.

Localization of Resources- ZERI emphasized the consumption of locally available resources to avoid transportation and related emission. As ZERI inspired project model might use the local agricultural waste for the production of energy thereby creating circular economy within community.

Value added Process- The central idea behind this is, instead of watching the waste as cost , ZERI views waste as an opportunity for value creation. The methodology focuses on addig value to waste products by finding the innovative uses for them.

Educational and Attitude shift- ZERI emphasizes that to achieve the zero emissions , it requires a fundamental shift in mental framework about wate resources and sustainability. Education and awareness among people works as important component of this methodology.6

ZERI collaborated with schools , universities and communities to educate people about practices and to adopt zero waste principles.

4.2 Research Design Methodology – Different research design methodologies use are as following types-(KassuJilchaSileyew, 2019)

a)Generative Research Design - It is computer aided research design system. This is AI to optimize the designing process. In this designers uses generative design software to iterate the design alternatives and then pick up the best design according to required criteria. This is widely use in automotive industries to design the auto parts, aerospace industries to design

with the objective of improved environmental impact and weight reduction, consumers goods for improved performance and lower cost .(Graedel T.E., Allenby B.R,1995)

b)Evaluative Research Design -It is kind of quantitative research , essential for the product success. It helps to validate the idea, that much particular product is satisfying the targeted consumers. Designers use different types of techniques to for the usability testing. Like-

Guerilla testing- In this designers head over to a public space as tea or coffee shop, mall, restaurants where the centered users hang out, designers ask the random users for their feed back.

Eye- tracking- Designers uses webcams to get the users look on the particular webpage or dashboard for the ease of analysis.

Session replays- Research designers records that how many times users use the particular app or search a particular product on the website.

c)Quantitative Research Design- Designers use systematic and structured approach to get better product. To conduct this research , designers are adhere to the following steps-

i) formulate a specific measurable objective questions about the product which has to be answered by consumers.
ii) They identified different types of variable relevant to questions that could be dependent (outcomes or responses) or independent variables (controlled or manipulated factors) .
iii) Based on research question ,they develop hypothesis (type of statements) make predictions about the variables.
iv) Researchers target the particular users for the sampling. Target population must be enough to calculate statistically significant results.
v) Quantitative research design is mainly based on numerical data collection, which could be done by any mean as surveys, experiments, secondary data analysis etc.
vi) Designers go through data analysis ,by descriptive statistics to summarize the data then inferential statistics to draw conclusion.
vii) The designers interprets the outcomes and draw conclusions on the basis of analysis which could be presented in form of Cancers or graphs.

d) **Qualitative Research Design -** In qualitative research design , designers typically involved the collection of data via different ways as interviews, observations on targeted groups and then analysis of documents. The different types of qualitative research design used are-

Phenomenological Research- In this research design ,designers try to understand the targeted users experiences towards particular products. They go through

explorative study in depth interviews or observation to understand their lived experiences.

Ethnographic Research- This research go through study of culture, practices, and social behavioural interaction of specific group or community in their natural home environment for a specific period of time . Generally done by interviews, participant observation and through document analysis.

Narrative Research- This research is based on personal stories and narratives shared by targeted users.Designers then examine the narratives to get insight that how an individuals absorb the meaning and make sense of their experience for the particular product.

Participatory Action Research (PAR)- This is a collaborative type of approach in which designers works together with participants to find out the social issues and problems. This type of research is use to empowers the targeted participants with actionable knowledge by the process of reflection, action and change.

Conclusion

Overall, design activity is definitely as important as research but uses different methods and goals. In cases where current engineering expertise and process technologies are not effectively work “breakthrough technologies' or system designs is initiated to work effectively. Design approach may reduce the impact of particular product on the environment. Design for environment would be able to provide the information regarding the safer chemical formulation. It would be a good practice to protect the environment and ecosystem from pollution and will help in reduction of resource usage, and minimize the economic cost of product throughout the product lifecycle.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

3

References-

1. Amit Kapur, Thomas E. Graedel (2004). Encyclopedia of Energy, "Centuary perspective of heavy metal use n Urban areas", Vol-1(3), pp-197-211 .
2. AliIlgin, Surendra M. Gupta ,(2010)."Environment conscious manufacturing"International Journal of Production Research, Vol-48(14) pp-4325-4326,
3. Graedel T.E., Allenby B.R., (1995), **'**Industrial Ecology', New Yersey, Prentice Hill,environmental management'.
4. ICER, (1993), **'**ICER Guidelines, Design for Recycling: General principles'.
5. Georgiadis and Vlachos (2004), " Decision making in reverse logistis using system dynamic", Yugoslav Journal of Operational Research.
6. Debabrata Das, PankajDutta,(2022), Product return management through promotional offers: The role of consumers loss aversion,"Int. J of Production Economics, Vol-251.
7. Karl T. Ulrich and Steven D. Eppinger,(2012) Product Design and Development, Chapter12,5th Edition, Irwin McGraw-Hill.
8. KassuJilchaSileyew, (2019), Research Design and Methodology, Book .
9. Chetan Mehta & Ben Wang, (2007)," Green quality Function Development III: A Methodology for developing Environmentally Conscious Products", J. of Design and Manufacturing Automation, Vol-1(1-2), pp-1-16.
10. Gunter Pauli, (2017), The Road to Zero Emission: More Jobs, more Income and No pollution, e-book published in , pp-224, ISBN-9781351282888.
11. D.E.Santos-Reyes, T.Lawlor-Wright,(2001), A design for environment methodology to support an Environmental Management system, J. of Integrated Manufacturing Systems,Vol-12(5) pp-323-332.
12. Mehmet AliIlgin, Surendra M. Gupta (2010) , Journal of Enviromental Management,.
13. Nicole M.Ardoin , Alison W.Bower, Estelle Gaillard,(2020) J. Biologial Conservation, Vol-241, 108224.

14. Lie et al, (2021)Virtual energy saving environmental protection building design and implementation, Int. J. System Assurance Engineering and Management, Vol-13, pp-263-272.
15. Rupert J. Baumgartner & Christian Zielowski (2007)," Analyzing zero emission strategies regarding Impact on organizational culture and contribution to sustainable development" J. Cleaner Production, Vol-15(13-14),pp-1321-1327.
16. Wilhelm Griga (2017), "Quantitative Research Design and Methodology" Managing Inpatriation, pp-73-91.