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Efficiency and Lifespan Enhancement of Product with Dissimilar Material using Different Techniques

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Abstract

Objective: The objective of this study is to create ecological awareness in selection of different materials that go into a product through an organized method to achieve the satisfaction level of performance and product life cycle. **Method/Analysis:** Ecological collision of carbon dioxide, sulfur dioxide, phosphate, abiotic depletion fossil and dichlorobenzene was evaluated using Centrum Voor Milieukunde Leiden (CML) methodology during the product life cycle. The analysis was carried out on the impeller of a subassembly component of the product chosen. LCA software GaBi was used to estimate the emission levels and compared with the existing subassembly while arithmetical simulation test was carried out using ANSYS 14.5 to ensure the life time and efficiency of the product. **Findings:** The main focus of this study which is to assess the overall ecological collision through the CML/LCA methodology revealed diminution in pollutant emission and ecological collision was observed to have reduced by thirty eight percentage of carbon dioxide, thirty seven percentage of sulfur dioxide, thirty eight percentage of phosphate and six percentage of dichlorobenzene. With arithmetical simulation test it was found that material alteration to aluminum silicon carbide from brass increases the life span and efficiency with imperative diminution in stress, stress intensity and deformation. **Application/Improvements:** The results show that the reduction in pollutant emission levels helping in the reduction of the global warming and also allows the users and manufactures of various subassembly components in choosing better alternate material.

Keywords: CML Methodology, Dissimilar Material, Efficiency, LCA, Life Span

1. Introduction

Sustainable manufacturing concept is currently seen as product manufacturing using less collisioning production processes that are ecologically, socially and economically feasible. In the context of ecological sustainability, the initiatives should be to promote the conservation of natural resources and energy[1]. To estimate such liable surroundings, many modern tendencies like Life Cycle Assessment, etc. have appeared. Life Cycle Assessment is a method used to evaluate the environmental impact of a product through its life cycle, including extraction and processing of the raw materials, manufacturing, distribution, utilization, reuse and ultimate discarding[2]. Selection of suitable material or manufacturing processes is one way of attaining sustainability of a product by reducing its end of life collisions to a possible extent. But technological changes are unpredictable and so predicting future possible ecological collisions are highly difficult[3,4]. Skills, creating change agents, awareness, learning together, ethical responsibilities and synergy and co-creating principles to support design for sustainability in design education and practice were applied to attain consumer satisfaction with less resources activated[5]. Green design principles for material selection serves as an indicator and all indicators are ranked in order[6]. Eco design with creativity and innovation enhances the image of the firm in a positive manner and increases its visibility in the market and also it plays a very important role for attaining an ecologically sustainable society. Life Cycle Assessment (LCA) addresses the ecological aspects and potential ecological collisions during a life cycle of the product from raw material purchase, manufacturing, distribution, utilization, reuse and ultimate discarding. LCA is an appropriate tool to evaluate the ecological collisions related to a product or its maintanance[7].

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Bevilacqua, et al. evaluated the environmental impact of a household cooker hood throughout its life cycle using a cradle-to-grave approach and identified the phases causing the most pollution, to obtain the largest possible improvement by limited design reviews[8]. LCA methodology was used based on ISO recommendations to study the ecological aspects and potential collisions associated with the product[9]. Building material green index value has been suggested based on embodied energy, waste content, durability, maintainability, toxicity and safety during installations, local availability and energy requirements during its use which will help one to determine and compare the values of green indices of different materials for selection of most green material available in the market for building construction[10]. Numerical analysis was carried out for melting of a NePCM in a square cavity with different horizontal angles with two heat source-sink pairs flush-mounted on the horizontal sidewalls. Where the sources and sinks are separately placed on two horizontal sidewalls with 2% weight of Al_2O_3 nanoparticle has most liquid fraction ratio comparing to the other cases[11]. Green lean infrastructure system gives out a channel for the successful implementation of lean green best practices and achievement of corresponding green results in small scale industries to save the resources and earth[12]. Noroozi, et al. presented a model which can be used for allocating one or more new inputs between the DMUs in a way that some of the inefficient units have been modified to efficient units and allocates the new inputs between the DMUs in a way that the distance of new inputs from the fair allocation is minimized by applying the Chebyshev's norm[13]. The critical issues of lean execution and to assess their role of critical issues in organizational performance were recognized and the findings reveals that, both industrial and employees performance has found to be absolutely affected by successful lean implementation in Indian automotive industries[14]. This research work reveals the diminution of ecological collisions by taking into consideration the ecological factors by change of material for processing of components that increases the life-span and efficiency of product using life cycle analysis in CML methodology with ANSYS 14.5.

2. Methodology

The study and analysis started with literature review for reduction of atmospheric impact and suitable tool identification, selection of product, selection of material and processes for manufacturing, removal of subassembly made of brass and implementing CML methodologies to estimate the emission followed by selection of alternative material as aluminum silicon carbide. LCA software GaBi was chosen to estimate the emission and the results were compared with the existing subassembly. The arithmetical simulation test was carried out using ANSYS 14.5 on the proposed material of aluminum silicon carbide to ensure the life time and efficiency of the product. The limits of the system and the collision groups like global warming etc. help in assessing the collision over the environment.

3. Manufacturing State

The subassembly of the product, which is made out of brass material, is considered for the analysis of life cycle study within the limits of two states. The states are described in two different methodologies called 'orientation state' being the currently used processes and 'change of state' the other, with the suggested material for process and production.

3.1 Orientation State

Brass is used for manufacturing the subassembly in the orientation state. This is a very commonly used material which is easily available and preferred by the manufacturers because of its good quality. Casting is used during mass manufacturing of the subassembly components which are made up of the designed mould. The machining work such as turning, drilling, milling, etc. is based on design requirements because all the manufacturing work cannot be done by casting alone. Normally brass is a composition of molten copper and molten zinc. The weight of the subassembly under this scenario is 130.00 grams. Huge amount of energy is consumed during manufacturing process because of heating requirement for the molten metal and also material depletion during machining process after the casting procedure which is recycled. There is shipping in between each process for the manufacturing the subassembly from the raw material site to product subassembly. The distance in shipping and carrying materials is also accountable for the inventory analysis phase of LCA to find out the atmospheric collision of each process. The shipping distance details for the orientation state are indicated in Figure 1.

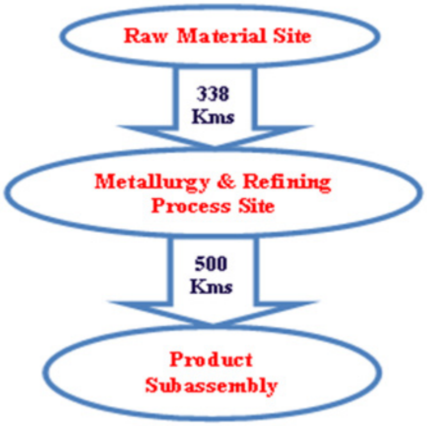

Figure 1. Shipping distance in orientation state.

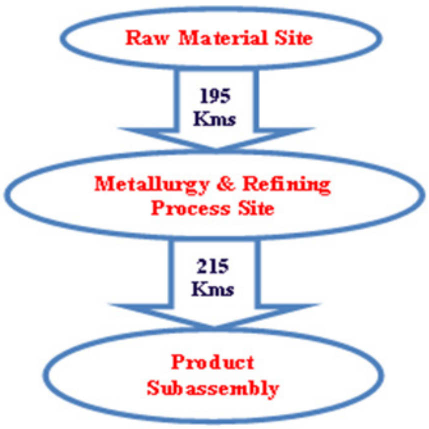

Figure 2. Shipping distance in change of state.

3.2 The Change of State

A change of material has been suggested in change of state being aluminum silicon carbide which is used for manufacturing the product subassembly. This aluminum silicon carbide used for manufacturing the subassemblies have more thermal conductivity, electrical resistivity, bending strength and elastic modulus as compared to the brass material and has a weight of 60 grams. Initially while manufacturing the subassembly, casting of billets of aluminum silicon carbide takes place. These billets are then processed based on the required dimensions in the appropriate machine. The process involves more use of energy on the whole billet structure and component machining and also the wastage materials are to be recycled. Here also, we consider the distance of shipping and carrying materials which are accountable for the inventory analysis phase of LCA to find out the atmospheric collision of each process (Figure 2).

Sources of Data

A change of material was fit for reducing the ecological collision of the product subassembly. The general working condition of product with its specification is taken as standard functioning state. The flow of inventory consists of inputs like transport, electricity and fuel. The creation of the model using the collected input and output data of all behaviors inclusive of supply chain must be within the system limit. Information from the product manufacturer and focused databases are used to access the necessary data set. The entire detailed process flow in the product subassembly is analyzed by using the software of GaBi. For orientation state the referred material is defined in U.S. life cycle inventory database of GaBi 5.0. For the formation of brass an industry furnace that could provide a thermal energy input of 0.192 Mega joules and an electricity input for the process of machining is 0.359 Mega joules is required. Shipping distances and loads are considered as per the details mentioned in the truck. As it is an electrically run product the subassembly assembled together as a product consumes electrical power for its functioning. To imitate the operation we assumed a life span of fifty months with a usage of two hours per day. The electricity consumed is 6384 Mega joules throughout its life span. We also assumed that 97% (126.10 grams) of the material used for the subassembly is recycled while the remaining 3% (3.6 grams) is considered as waste within the total weight of 130.00 grams of the subassembly.

Aluminum silicon carbide is used as the change material which is defined in US LCI Database of GaBi 5.0. For the formation of aluminum industry furnace that could provide a thermal energy input of 0.156 Mega joules and an electricity input for the purpose of machining is 1.95 Mega joules is required. With these attained details, we finish the production stage subsystem. Here also shipping distances and loads were considered as per the documentation maintained by truck operation. Energy input of 6384 Mega joules is utilized to the alternate state. Here, we assume that 97% (63.05 grams) of the material used is completely recycled and the remaining 3% (1.95 grams) as wastage within the total weight of subassembly which is 65 grams.

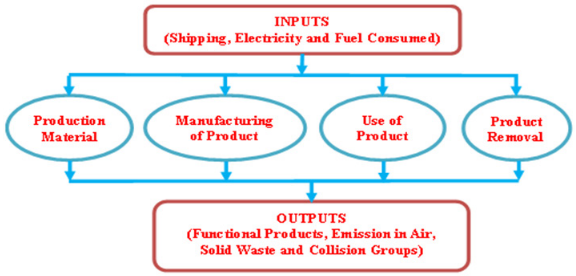

Figure 3. Product limit plan.

The selected subassembly product limit taken for this analysis extends with required inputs of shipping, electricity and fuel consumed and the outputs of functional products, emission in air, solid waste and collision groups. This includes production raw materials, manufacturing, utilization and removal of the product. The analytical limits of product subassembly are represented in Figure 3.

5. LCA Analysis

The main objective categories to evaluate overall ecological collision are described herewith. From this analysis, the product developers can be able to assess the ecological collision of their product and will be more alert on how to diminish it. Global warming is the reason for release of methane gases which is portrayed as equivalent to carbon dioxide produced by the burning of fossil fuels. Climate of the earth is directly propositional to the global warming because greenhouse gases soak up the emitted power by the ground changing it to heat energy. While producing the subassembly product it releases 527.12 kg in the orientation state and gained the emission of 327.16 kg in the alternate state. Acidification is based on the contribution of nitrogen dioxide, sulfur dioxide and other acidic emission produced during production process. The high-level collision is credited to the release of large amounts of sulfur dioxide during raw material processing and manufacturing process of subassembly. The computational analysis reveals that the emission is 0.820 kg for brass material and 0.520 kg for proposed aluminum silicon carbide material. The percentage of diminution in ecological collision for alternate state of product subassembly is 36.58%. Eutrophication is based on the contribution of phosphate during the production process, which responds to the totaling of natural or artificial matters. The percentage of diminution in ecological collision of phosphate in subassembly is 37.95% which is less when compared to the existing material. Abiotic depletion is nothing but natural resources like iron ore and crude oil, which are looked upon as non living materials. As per the analysis it reveals that only a small emission diminution percentage is recorded in the case of product subassembly. Human toxicity is caused by the emission of dichlorobenzene either by inhalation or ingestion. Also as per the analysis it is stated that the proposed subassembly material produces 5.81% lesser dichlorobenzene emission when compared with the existing material. The diminution percentage of ecological collision is given in Table 1.

6. Arithmetical Simulation Test

ANSYS 14.5 software was used in arithmetical simulation test carried out for both the existing and change of material. From the results it was clearly found that the stress is reduced by 21% and stress intensity is reduced by 25% while deformation is reduced by 5% in the selected alternative material of aluminum silicon carbide. It clearly proves that the physical properties of aluminum silicon carbide are better, when compared with the existing brass material. As the results have clearly concluded that there is a significant diminution in stress, stress intensity and deformation of the subassembly in the selected alternate material of aluminum silicon carbide, when compared with the existing manufacturing material of brass, it shows that the efficiency and the lifetime of the product stands improved.

Table 1. % of diminutions in ecological collisions between two states of impeller materials

Ecological Collision	Material for Orientation State	Material for Change of State	% of Diminution in Ecological Collision
Global Warming Probable	527.12	327.16	37.95
Acidification Probable	0.820	0.520	36.58
Eutrophication Probable	0.052	0.032	37.95
Abiotic Diminution Fossil	3958.16	3856.67	0.026
Human Toxicity Probable	0.172	0.162	5.81

7. Conclusions

Based on the above study and analysis the following conclusions were made:

- Life cycle analysis and sustainability analysis was carried out with CML methodologies for the selected subassembly of product.
- Sustainability analysis measures the ecological collision over the life cycle of the product in terms of carbon dioxide, sulfur dioxide, phosphate, abiotic depletion fossil and dichlorobenzene.
- Many efforts were made to reduce the ecological collision from the outlook of materials earlier and it was observed that the material change for subassembly had greater influence in reducing the stated emissions.
- This analysis clearly supports the influence for the change materials to the existing products and the significance of selecting the materials of low ecological collision for the new product development.
- The arithmetical simulation test results proved that the major diminution is obtained in stress, stress intensity and deformation as against brass which source increase in life time and efficiency of the product.

The research may further be extended to similar subassembly components of product along with suitable tools and techniques.

8. Acknowledgement

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