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Sustainable Design of Alternator Pulley for Locomotives

Fyzal Badarudeen [1] Sherine Y F [2]

[1] *Faculty of Mechanical Engineering, Higher Colleges of Technology, Al Ain Men's Campus, Al Ain, Abu Dhabi, U.A.E. Former Assistant Professor, Department of Mechanical Engineering, Younus College of Engineering & Technology, Kollam, Kerala, India.*

[2] *Former Associate Professor, Department of Electrical & Electronics Engineering, Younus College of Engineering & Technology, Kollam, Kerala, India.*

Abstract – *Sustainable Design represents the application of Sustainability principles to the field of engineering and design. In this study, the Sustainable Design of an Alternator Pulley for Locomotives has been analyzed using the Sustainability Tool in SolidWorks Software to review the life cycle of the design and the impact of the design on the environment. Life Cycle Assessment was carried out on the design and the environmental impact was calculated using an impact assessment methodology. Accordingly, the SolidWorks Sustainability Tool measured the environmental impact of the design across the product life cycle including the effect of material, manufacturing, transportation, product use and disposal.*

Key Words: **Sustainable Design, Sustainability, Life Cycle Assessment, Impact Assessment Methodology, etc.**

1. INTRODUCTION

Sustainable Design use the principles of sustainability in the design and development stage of both commercial and industrial product designs. Sustainable design takes into account the effect of the product design on the environment during the different stages of product life cycle starting from the raw material extraction, material processing, part manufacturing, assembly, transportation, product use and end of life[4]. Illustration of the concept of Sustainable Design is as shown in Figure 1.

Fig-1. Sustainable Design Concept[5].

SolidWorks Sustainability tool measures the following parameters to analyse the environmental impact of the product which can happen during the various stages of product life cycle during the design and product development stage itself [4]:

a. Air Acidification - It is the impact of acidic emissions like Sulphur dioxide, nitrous oxides released into air, which increases the acidity of rainwater, which in turn will adversely acidify land and water bodies. These acids will leave a toxic effect on plants, trees, vegetation and aquatic life, which depends on soil and water bodies to grow. Air acidification also leads to acid rain, which in turn can damage buildings and monuments in the long term. The impact of air acidification on the environment is measured in terms of kg Sulphur dioxide equivalent units or in moles H^+ equivalent units. Solidworks Sustainability tool uses kg Sulphur dioxide equivalent units to evaluate the impact of air acidification on the environment due to the product design.

b. Carbon Footprint - It is the adverse effect of carbon dioxide and other greenhouse gases on the average temperature of the earth. Burning of fossil fuels are the major contributor of these gases being released to the atmosphere leading to increase in the earth temperature that in turn leads to phenomenon like extreme weather conditions, melting of glaciers, increase in water level of water bodies, extinction of various species, etc... Carbon footprint acts as a substitute for Global Warming Potential (GWP). Solidworks Sustainability tool measures the Carbon footprint of the design in terms of kg Carbon dioxide equivalent units.

c. Total Energy Consumed - It is a measure in Mega Joules (MJ) of the total non-renewable energy consumed during the product life cycle. Total Energy Consumed is indicated in terms of the net calorific value of energy demand from fossil fuels like petroleum, natural gas, etc... The impact of total energy consumed not only considers the fuel or electricity used during the product life cycle but also the energy required to obtain and process these fuels and energy released from included materials if burned.

Solidworks Sustainability tool measures this parameter in terms of Mega Joules (MJ) of energy.

d. Water Eutrophication – It is the impact of the addition of excessive nutrients to the water bodies that results in the death of both aquatic plant and animal life due to depletion of oxygen in water. Nitrogen and Phosphorous from wastewater and agricultural fertilizers are the major contributors to this impact. Typically, this impact is measured in terms of either kg phosphate equivalent (PO_4) or kg nitrogen equivalent units. Solidworks Sustainability tool measures this impact in terms of kg phosphate equivalent (PO_4) units.

The environmental impact of the design is evaluated using the CML Life Cycle Assessment methodology[3] in SolidWorks Sustainability. Life Cycle Assessment (LCA) is a method of quantitatively assessing the product impact on the environment throughout its complete life cycle that includes design, raw material procurement, production process, packing, distribution, use, disposal and recycling of the product. The CML methodology is the most complete and widely used LCA assessment techniques [4] .

In addition, the Material Financial Impact of the product design has also been carried out by the Solidworks Sustainability study. Material Financial Impact is related to the material of the design only. It is calculated in terms of units of currency used. It is the product of design model mass and the financial impact unit (in terms of units of currency/units of mass).

1.1 Technical Features of the Alternator Pulley

The Alternator Pulley (V-Belt type) used in this study transmits 25 KW power, which is generated from the locomotive wheels. The locomotive wheels is fixed with an axle input pulley. The alternator pulley is keyed to the shaft and acts as the output pulley. Both the pulleys are connected by V-Belt. The alternator pulley rotates the alternator producing AC current, which can then be rectified to DC and stored in battery. This serves for lighting and air-conditioning in locomotive coaches. The technical features of the alternator pulley is summarised in Table 1.

Table -1: Technical Features of the Alternator Pulley[1]

Technical Feature	Details
Pulley Outer Diameter	235.4 mm
Pulley Inner Diameter	50.4 mm
Pulley Width	175 mm
Depth of V-Groove	20 mm
Pulley Material	Grey Cast Iron

1.2 Alternator Pulley Design using Solidworks

The alternator pulley is designed and modelled using the Solidworks modules of sketch and features. The section sketch is revolved about 360 degrees to obtain the base model. Four ribs were then created on the right side of the pulley. These ribs serves the purpose of clipping of the pulley for handling. Two ribs on the left side of the pulley is then created to complete the final model of the pulley which will then be used for the Sustainability study after applying the pulley material of Grey Cast Iron. Solidworks images of the alternator pulley design is as shown in Figure 2.

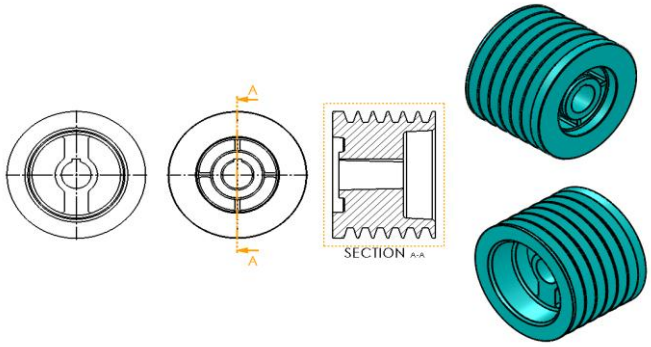

Fig-2. Alternator pulley design[2]

2. SUSTAINABLE DESIGN OF THE ALTERNATOR PULLEY

Sustainability study was conducted on the Alternator Pulley Design using Solidworks Sustainability tool after assigning the pulley material of Grey Cast Iron. The type of material decides the mass of the design as well as it is a key input, which will decide the various Sustainability parameters leading to environmental impacts due to the design. The Sustainable Design Study properties used for the study is as summarized in Table-2.

Table-2: Properties of Sustainability Study[5]

Properties	Details
Study Name	Sustainability
Model Name	Alternator Pulley
Material	Grey Cast Iron
Recycled Content	84%
Weight	18980.48 g
Manufacturing Process	Sand Casting
Surface Area	3.64×10^5 mm^2
Build to Last	10 year
Duration of Use	1 year
Transportation	Truck Distance Avg.1600 km
Material Unit Cost	0.60 USD/kg

2.1 Results of the Sustainability Study

The results of the Sustainability Study has been summarized in Table-3.

Table-3: Results of Sustainability Study[5]

Sustainability Parameters	Value
Scrap Rate	5%
End of Life	Recycled 8%, Incinerated 20% Landfill 73%
Carbon Footprint	52 kg CO_2e
Total Energy Consumed	520 MJ
Air Acidification	0.274 kg SO_2e
Water Eutrophication	0.035 kg PO_4e
Material Financial Impact	12.30 USD

The contributors to the various environmental impact parameters are as shown in Figure3. The Sustainability Tool in Solidworks has used CML Impact Assessment Methodology to do the calculations. Accordingly, the major contributor to the Carbon Footprint and the Air Acidification is the manufacturing process of sand casting. Material Processing consumes the major portion of the total energy. Product End of Life contributes more to the Water Eutrophication.

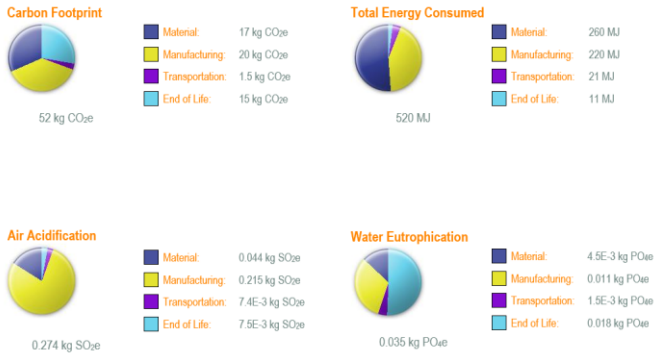

Fig-3. Environmental Impact Assessment[5]

3. CONCLUSION

Sustainability study has become a very important aspect of the design process of commercial and industrial products in determining the environmental impact of the design. Life Cycle Assessment looks at what impact the product will have on the environment throughout its complete life cycle that includes the production, use and final disposal of the product. Decisions on the material used, how it is manufactured, and other factors can result in very significant effects on the environment. Sustainability study shows these impacts of the product design on the environment and helps to improve it in a big way to protect the environment leading to a sustainable future.

REFERENCES

[1] Fyzal Badarudeen, Sherine Y F, "Modeling and Analysis of Alternator Pulley for Locomotives", International Journal of Engineering Science Invention, Research & Development, Vol.7, Issue 12, 2021, Pages 15-18.

[2] Fyzal Badarudeen, "Design Optimization of Alternator Pulley for Locomotives", International Research Journal of Engineering and Technology, Vol.9, Issue 1, 2022, Pages 1077-1079.

[3] Heinz Gabathuler, "LCA History: Centrum voor Milieukunde Leiden (CML)", International Journal of LCA, Vol.11, Issue 1, 2006, Pages 127-132.

[4] Rudy Ruggles, Asheen Phansey and Benjamin Linder, "Guide to Sustainable Design using SolidWorks Sustainability".

[5] SolidWorks 2020, "Sustainability Report".

BIOGRAPHY

Fyzal Badarudeen
Faculty of Mechanical Engineering
Higher Colleges of Technology, Al Ain
Men's Campus, Al Ain, Abu Dhabi, U.A.E.
Former Assistant Professor
Department of Mechanical Engineering
Younus College of Engineering & Technology

Sherine Y F
Former Associate Professor
Department of Electrical & Electronics Engineering
Younus College of Engineering & Technology
Kollam, Kerala, India.