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Life Cycle Assessment of a Bicycle Using Solidworks Sustainability

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Abstract: According to a case study, the life cycle assessment of bicycles today can be seen as various types of city bicycles that do not follow the procedure of design structure, that bicycles are not compatible and give effect to sustainability in terms of material use and the process involved, which can lead to environmental impact. Other examples include bamboo bicycles, which are cost-effective and innovative but not sustainable if mass-produced in large quantities. In terms of the product's manufacturing stage, processes such as process welding, extrusion, drilling, and others should be considered. The objectives of this project is a. To use SolidWorks sustainability analysis to evaluate a bicycle's entire lifecycle (cradle-to-grave analysis). b. To determine which bicycle components have the greatest environmental impact. c. To reduce the environmental impact of the component identified in (b) by improving its design. This study is being carried out to provide an understanding of life cycle assessment using SolidWorks software in the section of sustainability in comparison to current bicycle products. The process of analyzing design structure through the use of software tools. There are a variety of approaches that have been used to introduce undergraduate students to sustainability and life cycle assessment concepts, ranging from demonstrations to specialized courses. The selection of design is a component of a bicycle that can be put through its paces, similar to a traditional technique for introducing students to CAD software. In this part, we focused on the assessment of environmental impact and eco-sustainability of models created with CAD SolidWorks software. We assessed the material used to build the entire assembly in terms of efficiency, reliability, and environmental pollution, taking into account the carbon footprint, energy consumption, air acidification, and eutrophication. The best solution of this objective is the wooden oak where the material can reduce the environment impact and also the convenient financial sector. Lastly, the analysis of sustainability of Solid works is the beginning of the solution of this project and needs to be improved in sustainability tools to evaluate more complicated design and materials. During the construct the project, one of the recommended needs to apply during the project is have the bicycle design based on real company. This is because the analysis sustainability is more realistic to environments. Another recommendation is that selected materials need to be more

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specific to the component part of the design like skew, net, bolt, the special component part, etc.

Keywords: Life Cycle Assessment, SolidWorks Sustainability, Environmental Impact, CAD, Bicycle

1. Introduction

Governments and other sectors of society may be concerned about the efficiency of the transportation network for a variety of reasons, including economic and environmental concerns. In addition to high fuel prices, the externalities associated with pollutant emissions are becoming a growing source of concern for people around the world. When traffic is congested, it causes high energy consumption and pollutant emissions, as well as significant economic damage. It is also known that the average length of a trip for European drivers is between 9 and 22 kilometers per hour [1]. Therefore, cycling for transportation, particularly for short distances, is becoming an increasingly attractive option for many people today. There is also a greater interest in cycling today and efforts are being made to bring more attractive bikes to the market, including through the use of new and more sustainable materials, in order to improve well-being and the protection of the environment. However, understanding the impact of producing these new types of bicycles is important.

1.1 Problem Statement

According to a case study, the life cycle assessment of bicycles today can be seen as various types of city bicycles that do not follow the procedure of design structure, that bicycles are not compatible and give effect to sustainability in terms of material use and the process involved, which can lead to environmental impact. Other examples include bamboo bicycles, which are cost-effective and innovative but not sustainable if mass-produced in large quantities. In terms of the product's manufacturing stage, processes such as process welding, extrusion, drilling, and others should be considered.

1.2 Objective

The objective of this study is to use SolidWorks sustainability analysis to evaluate a bicycle's entire lifecycle (cradle-to-grave analysis). By determine which bicycle components have the greatest environmental impact. Finally, to reduce the environmental impact of the component identified in determination of bicycle components by improving its design.

2. Methodology

The process of analyzing design structure through the use of software tools. There are a variety of approaches that have been used to introduce undergraduate students to sustainability and life cycle assessment concepts, ranging from demonstrations to specialized courses.[2]

2.1 Defining Material

A particularly important aspect of this investigation is the material that was used. Aluminum, steel, fiber carbon, and other similar materials will be appropriate.

2.2 Manufacturing Place and Process

The manufacturing location and process involved will be assumed, for example, this bicycle product will be manufactured in Japan, and the process involved will be milled.

2.3 Environment Impact

After we have taken into consideration and counted all of the variables, we will have four major impacts, which are carbon, energy, air, and water. More specifically, they will demonstrate how they release percentages at the following points: material used, manufacturing, transportation, use by which country, and the end of the product's life cycle.

3. Results and Discussion

In this part, we focused on the assessment of environmental impact and eco-sustainability of models created with CAD SolidWorks software. We assessed the material used to build the entire assembly in terms of efficiency, reliability, and environmental pollution, taking into account the carbon footprint, energy consumption, air acidification, and eutrophication. We considered the entire product life-cycle management, from raw material extraction to manufacturing, piece creation, assembly, and use until the end of its life, taking into account the mode of transport and distance between these points. The case study includes a virtual model of the product as well as the Sustainability Report.

3.1 Sustainability Design

Behind the idea of sustainable design is a whole theory of economic, social, and environmental responsibility that should be followed by any business, company, organisation, agency, or state institution. Sustainable design must take into account the climate and natural resources that are available to the society, as well as protect the environment from the harmful effects of development activities and use resources responsibly. Sustainable design considers how the production of your product, from cradle to grave, would impact four critical environmental factors: air acidification, carbon footprint, total energy consumed, and water eutrophication. Measuring these effects will enable us to create more environmentally friendly designs.[3]

To conduct the analysis, the design is taken from another resource which has been done and the design is a mountain bike as shown in Figure 1. This is to make sure the design is similar with reality used and it can make it easy to analysis for part bike as shown in Table 1.

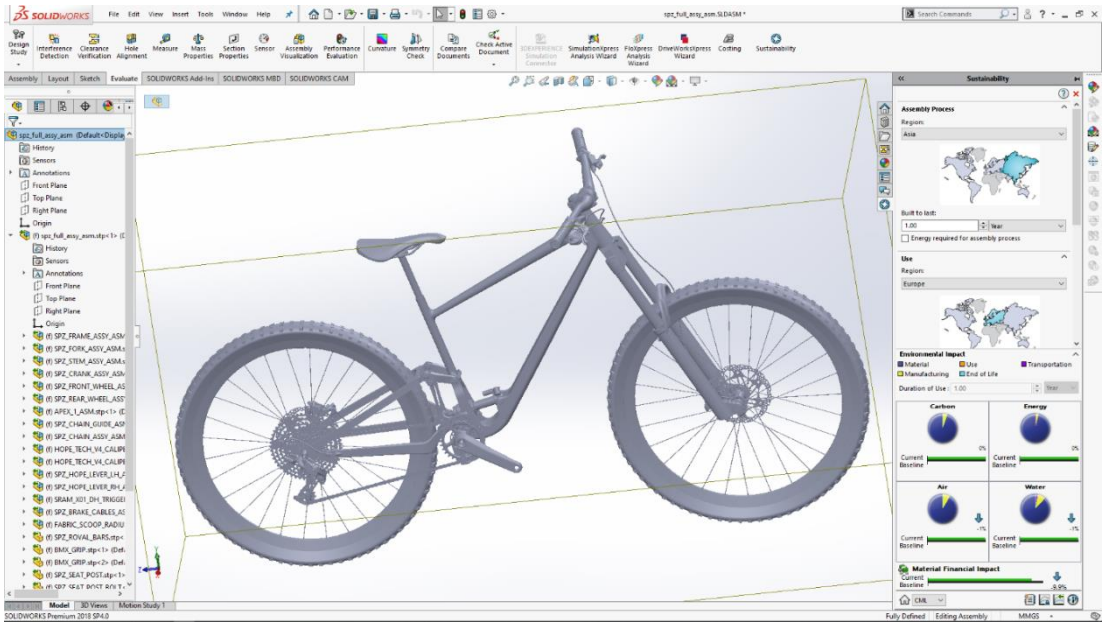

Figure 4.1: Design Bicycle [4]

3.2 Sustainability Analysis

During conducting analysis to get data, I presume to use 5 different types of material which is Steel, Aluminium alloy, Titanium alloy, Carbon fibre, and non-metallic material which is wood. All 5 types of material used are common aspects in making a bicycle (follow my second objective). I also try analysis of sub-material or specific materials which have different mechanical properties. This is to get into specific main material and can be compared between good or bad in sustainability (follow my third objective). The main material used in the world is used in making bicycles. Whole analysis in SolidWorks by sustainability tools count as my first objective to be archived.[5]

3.3 Summary Analysis of SolidWorks Sustainability

All the results of the analysis will be simplified to make final comparing all the main material selected and selected part components of the bicycle. This is also to make understanding the functional sustainability tools in Solid works. Besides that, the analysis was conducted to achieve the objective of this project and also to educate the people of using Solid works software in a good present. The table 1 showed the comparison of different materials in environmental effect in four areas.

Table 1: Comparison of material different material in environmental effect in four areas

Materials	Environmental areas	Environmental impact by base aluminium alloy as a baseline	Financial Impact
Aluminium Alloy	Carbon Footprint	Neutral	
	Total Energy Consumed	Neutral	Neutral
	Air Acidification	Neutral	
	Water Eutrophication	Neutral	
Steel	Carbon Footprint	Decrease	
	Total Energy Consumed	Decrease	Decrease
	Air Acidification	Decrease	
	Water Eutrophication	Decrease	
Titanium	Carbon Footprint	Increase	
	Total Energy Consumed	Increase	Increase
	Air Acidification	Increase	
	Water Eutrophication	Increase	
Carbon Fibre	Carbon Footprint	Neutral	

	Total Energy Consumed	Increase	Decrease
	Air Acidification	Decrease	
	Water Eutrophication	Increase	
Wooden Oak	Carbon Footprint	Decrease	Decrease
	Total Energy Consumed	Decrease	
	Air Acidification	Decrease	
	Water Eutrophication	Decrease	

Based on the table above Wooden oak and steel are very good in reducing environmental impact this is due to the manufacturing of made components that do not use large total energy consumption. It is also transported by ship which is slightly less environmentally friendly due to the large shipping container. Besides that, the financial impact also shows the decreases due to the main component part. However, the Carbon fibre showed the result slightly unsatisfactory because of the good decrease factors and the bad increase factors showing the material should be less produced of the bicycles in order to reduce environmental impact. Last but least, titanium has the most increased impact on the environment due to financial and four areas. This is why the production of this material needs to be very small due to reduced environmental impact.

The selected component's part bicycle needs to be analytic due to environmental impact which was the previous data. The table 2 shows the most component part of the bicycle in environmental impact.

Table 2: The most component part effect to environments

Name of component parts selected	Material used	Environmental impact
Main frame	Aluminium Alloy	Yes
	Steel	Yes
	Titanium	Yes
	Carbon Fibre	Yes
	Wooden Oak	No
Fork frame	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No

	Wooden Oak	No
Bar frame	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No
	Wooden Oak	No
Seat post frame	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No
	Wooden Oak	No
Chainstay frame	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No
	Wooden Oak	No
Rocker frame	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No
	Wooden Oak	No
Crank arm	Aluminium Alloy	No
	Steel	No
	Titanium	No
	Carbon Fibre	No
	Wooden Oak	No

Based on the Table above, I conclude that the main frame of the bicycle component has a greater impact on the environment. This is because it is the main part of the bicycle and it gives effect to all selected material except the wooden oak which is the effect is very less compared to others selected material. It also produces good production of the wooden oak based on the main frame bicycle.

Furthermore, the rest of the selected parts except the main frame do not give much of the environmental impact. This due to the production of that part needs less total energy and other types of process.

4. Conclusion

All the process projects are finished and the result has come up. Based on the objective project which is (1) To use SolidWorks sustainability analysis to evaluate a bicycle's entire lifecycle (cradle-to-grave analysis) is achieved during analysis sustainability. (2) To determine which bicycle components have the greatest environmental impact. This is where I conclude the main frame has the greatest effect on the environment. (3) To reduce the environmental impact of the component identified in (2) by improving its design. The improving factor is based on the main selected materials which are Aluminium alloy, Steel, Titanium, Carbon Fibre and Wooden Oak. The best solution of this objective is the wooden oak where the material can reduce the environment impact and also the convenient financial sector. Lastly, the analysis of sustainability of Solid works is the beginning of the solution of this project and needs to be improved in sustainability tools to evaluate more complicated design and materials.

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References

[1] EU, 2014. EU transport in figures, European Commission, Report ISBN: 978-92-79-28860-9.

[2] Hakamada, M., Furuta, T., Chino, Y., Chen, Y., 2007. Life cycle inventory study on magnesium alloy substitution in vehicles, Energy 8, 1352– 1360

[3] Popa, L. I., & Popa, V. N. (2017). Products eco-sustainability analysis using CAD SolidWorks software. MATEC Web of Conferences, 112, 0–5. https://doi.org/10.1051/matecconf/201711206002

[4] Free CAD Designs, Files & 3D Models | The GrabCAD Community Library. (2021). Grabcad.com. https://grabcad.com/library.

[5] Sustainable Bicycle Manufacturing at Tout Terrain. (2019, Septembre 9). Tout Terrain;ToutTerrain.https://tout-terrain.de/en/the-manufactory/news-stories/sustainable-bicycle-manufacturing-at-tout-terrain