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Research paper

Make a Decision to use AHP for the Selection of Materials and Designs for Minimizing Environmental Impacts by the POPE Lawn Mower Manufacturing

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Abstract

The POPE lawn mower has turned out to be a standout amongst householder machines. This is because of many individuals are utilizing yard trimmers consistently to cut the grass in their home, open parks or road borderlines to keep up an excellent domain. In any case, this item has some negative effects on nature, for example, gases outflows and production of strong or fluid waste. Likewise, this item has a few issues, for example, corrosion on the materials of a few sections, and a wasteful and short life expectancy. The effects on the environment related with POPE lawn mowers are an outcome of the materials and configuration utilized as a part of the assembling procedure. Besides, the motivation behind this paper is to portray, analyse the POPE lawn mower segments, and propose how it could enhance the choice of new materials and designs used during the assembling procedure. The discoveries of this paper task will propose a few arrangements by utilizing the Analytic Hierarchy Process (AHP) to make a choice, which allows for a selection of new materials and designs for manufacturing the POPE lawn mower with less environmental impacts and greater efficiency. Finally , this study is encourage the organizations which fabricating the POPE lawn mower to enhance the lawn mawer by choosing new design , materials and making changes to the energy consumption to make this item more proficient with less ecological effects

***Keywords*:** Pope lawn mower, environmental impacts ,AHP

1. Introduction

In the recent years, the lawn mower has become essential household products. This is because many people are using lawn mowers every day to cut the grass in home gardens and public parks or on street verges to maintain a beautiful environment. Moreover, this product has lower costs as compared with other lawn mower models and is much easier to use. However, this product has some negative environmental impacts including gas emissions and the creation of solid waste. According to the Ministry of the Environment in Canada, during one season the POPE lawn mower emits nearly 48 Kilograms (106 IBS) of gas emissions [1]. In addition, [2] highlighted that the POPE lawn mower includes many kinds of materials that have less recyclability at the end of their lifespan, such as rubber. These materials become scrap and solid waste for the environment. The effects of lawn mowers on the environment are a result of the materials and design used during the manufacturing process. According to [3], the common materials applied in the manufacturing parts for lawn mowers are steel alloy, plastic, aluminum, and rubber. These materials have many effects on the environment, not only during manufacturing of the lawn mower, but also during the products' life cycle through to the end of its life. In addition, the designs decisions made for the lawn mower have several effects on the environment, such as methods of using fuel energy, which produce much emission gases [4]. Moreover, this product has design problems such as corrosion of parts and inefficient energy consumption.

Some research works have tried to improve the lawn mower manufacturing process by increasing the efficiency, extending the lifespan, making it easier to use and reducing the environmental impact to make it more environmentally friendly [1,5]. These researches tried to improve the lawn mower by reducing the environmental impacts by substituting some materials with new materials in manufacturing or by selecting new designs. Despite these research attempts, the lawn mower still has negative impacts on the environment. Therefore, this research will focus the minimizing of environmental impacts caused by a lawn mower.

Many experts have tried to decide on the selection of materials and design for the lawn mower manufacturing by studying its life cycle assessment (LCA) and analyzing each component of the product. [3,8] reiterate that using life cycle thinking (LCT) in design chain and analyzing all components of the lawn mower is important. Consequently, this paper will utilize the AHP capabilities to facilitate the decisions making during the design and material selection.

According to [5], AHP is one of the techniques that regulate ideas for decision-makers and therefore facilitate analysis and problem solving. It has helped decision-makers select the best solution from many options. In addition, an AHP method is present in many applications such as in operations research and design-for-six-sigma (DFSS) situations and quality engineering [6]. Moreover, the AHP can provide a means of reducing the problem into a hierarchy of subproblems, which makes it easy to

understand the problem and objectively evaluate [7,9]. Furthermore[10] AHP pairwise comparisons convert subjective evaluations into numerical values and be processed to rank each alternative on a numerical scale (Saaty Scale). Therefore, this paper applies AHP to facilitate the selection of materials and design during the lawn mower manufacturing that will reduce the environmental impacts.

The aim of the project research is to develop an AHP model for material and design selection that will have adverse environment effects and improve efficiency. The objectives of this research paper are:

• To analyze all components for the POPE lawn mower

• To study the lawn mower life cycles (LCA) assessment

• To study the environmental impacts of a lawn mower

• To develop an AHP model for materials and design selection used in the lawn mower manufacturing process.

2. Research Design and Methodology

To achieve the aim and objectives of this research, the AHP is as the methodology of this paper. The methodology includes seven consecutive steps as following:

i. Analyses all components for lawn mower

This research started with a study of all functions and design of the POPE lawn mower and the materials used in the manufacturing of these parts.

ii. Study the life cycle of materials constituent for a lawn mower

In this task, the research study flowchart for LCA of all materials, which used in manufacturing the POPE lawn mower. The flowchart begins with raw materials and continues to the end of materials life cycle.

iii. Study the current designs for lawn mower

After finishing the study of the material constituent for a lawn mower, the study of various manufactured designs begins.

iv. Determine the effects of the lawn mower on the environment

When analysis of all materials and current designs are completed, this study then determines the environment such as calculating all possible gases emissions, solid waste, liquid waste, and other effects.

v. Develop the ahp model

From the findings of the literature review, seven experts with expertise in the environmental impacts of lawn mowers and lawn mower manufacturing were interviewed. These interviews assisted in the collection of information about the final selections of designs and materials for POPE lawn mower manufacturing. In addition, this information assisted to design the AHP model for the POPE lawn mower and to collection the AHP data that was entered into the Expert Choice software.

This AHP model enabled decomposition of the problem into elements according to their common characteristics and the formation of a hierarchical model with different levels. There are four levels: three major levels and one minor level. The first level includes the research objectives, firstly to reduce the environmental impacts of POPE lawn mower, and secondly to increase the efficiency of these machines. The second level considered the factors (criteria) of how the POPE lawn mower manufacturing affects the environment, which includes designs and materials. The third level of the AHP model named the parts of a POPE lawn mower, such as engine, blades, primer, tries, control system, and other body parts. The fourth level considered sub-criteria, which included the current designs and materials for the POPE lawn mower, and included the alternative of materials and designs that used in POPE lawn mower manufacturing to reduce the environmental impacts and increase efficiency. Figure (1) shows the AHP model for the POPE lawn mower.

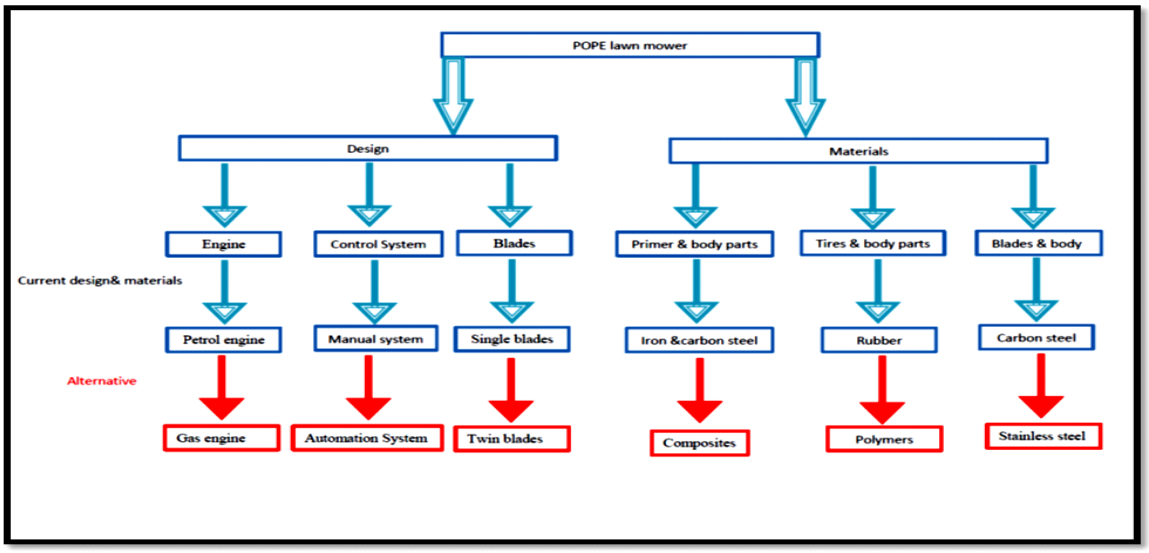

Figure (1): Final AHP model

vi. Pairwise comparisons

One of the necessary steps for the AHP is Pairwise comparisons and the judgmental matrix because this step compared the elements of a particular level with a specific element in the immediate upper level. How this compared depends on the opinions of different experts elicited for comparing the elements. In addition, these comparisons helped to make the decision for selection materials and designs for POPE lawn mower manufacturing with less environmental impacts and high efficiency. According to [5], "to make comparisons, a scale of numbers is needed, which indicates how many times more

important or dominant one element is over another element on the criterion or property with respect to which they are compared". How the elements are compared through pairwise and judgments on the comparative attractiveness of elements captured based on Saaty's 1–9 rating scale of comparative judgments. For this process, the responses of the experts for each question compared for the selection of new materials and designs for manufacturing the POPE lawn mower. Also, analyzed the reduction of the environmental impacts and increased efficiency using a Saaty's 1–9 scale. Whereby 1 indicates = 'Equal importance', 2 = 'Equal to moderate importance', 3 = 'Moderate importance', 4 = 'Moderate to strong importance', 5 = 'Strong importance', 6 = 'Strong to very strong importance', 7 = 'Very strong or demonstrated importance', 'Very strong to extreme importance', and 9 = 'Extreme importance'.

In addition, this comparison process repeated for all the criteria and their sub-criteria based on the definitions/explanations provided for each criteria/sub-criteria, to guide the expert's respondents. Following the completion of the interview, we used the information, which collected from the seven participants in this study with Expert choice program to find the result of pairwise comparison. Table 1 shows one example for the result of pairwise comparison from the Expert choice Software

Table (1): pairwise comparison from the Expert choice Software

Design	Gas engine	Automation System	Twin blades	Σ weight	Local weight
Gas engine	1	3	6	10	0.6
Automation System	1/3	1	1/4	1.58	0.1
Twin blades	1/6	4	1	5.16	0.3
Σ weight	1.5	8	7.25	16.75	1

Materials	Composites	Polymers	Stainless steel	Σ weight	Local weight
Composites	1	3	5	9	0.6
Polymers	1/3	1	4	5.33	0.3
Stainless steel	1/5	1/4	1	1.42	0.1
Σ weight	1.53	4.25	10	15.78	1

Moreover, by using AHP data, which collected from participants with Expert choice program, we calculated the local weight for each elements from AHP model of POPE lawn mower. Table (2) show the local weights all elements for the POPE lawn mower

Table 2: local weight for each element of POPE lawn mower

NO.	AHP	Environment impact factor	Participant A	Participant B	Participant C	Participant D	Participant E	Participant F	Participant G
1	Level 1	material	0.2	0.4	0.2	0.1	0.1	0.1	0.1
2	Level 1	design	0.8	0.6	0.8	0.9	0.9	0.9	0.9
3	Level 2	Petrol engine	0.75	0.1	0.1	0.1	0.2	0.1	0.1
4	Level 2	Manual system	0.75	0.6	0.9	0.8	0.5	0.8	0.1
5	Level 2	Single blade	0.25	0.2	0.1	0.1	0.1	0.1	0.8
6	Level 2	Carbon steel	0.8	0.25	0.3	0.2	0.1	0.1	0.1
7	Level 2	iron	0.1	0.4	0.9	0.1	0.1	0.1	0.1
8	Level 2	rubber	0.6	0.4	0.8	0.8	0.5	0.1	0.7
9	Level 3	Gas engine	0.25	0.9	0.9	0.9	0.8	0.9	0.9
10	Level 3	Automation system	0.25	0.4	0.1	0.2	0.5	0.2	0.9
11	Level 3	Twice blades	0.75	0.8	0.9	0.9	0.9	0.9	0.2
12	Level 3	Stainless steel	0.2	0.75	0.7	0.9	0.9	0.9	0.9
13	Level 3	polymers	0.4	0.6	0.2	0.2	0.5	0.9	0.3
14	Level 3	composite	0.9	0.6	0.1	0.8	0.9	0.9	0.9

The results indicate that selection of new designs is more important than selection of new materials in manufacturing POPE lawn mower to reduce the environmental impacts and increase efficiency. This is because the average local weight for designs is higher than local weight for materials. Also, the best new design for the POPE lawn mower with less environmental impacts and higher efficiency is the design with a gas engine and double blades. In addition, selection some new materials can contribute to reducing the environmental impacts of the POPE lawn mower manufacturing and increasing efficiency such as stainless steel instead carbon steel for the blades and composites materials instead of iron or carbon steel for the body and some other parts of the POPE lawn mower. As we can see all this in table (2)

3. Results and Discussion

To make decisions on the selections of new materials and new designs for the POPE lawn mower to reduce the environmental impacts and increase efficiency for this product the 'Expert choice program' was used to arrive to the conclusion. A sensitivity analysis with various scenarios using the Expert Choice program was used. A test for the selection of new designs and materials with two scenarios (I) equal weight for the factors affecting the

environment (II) reverses weights for the factors influencing the environment. The scenarios were selected for two reasons:

i. The equal weighting scenario would identify the best design and materials for POPE lawn mower under balanced conditions, which is almost idealistic;

ii. These various scenarios will determine the study for selections of the best new designs and new materials for the POPE lawn mower under different conditions.

In addition, the expert choice program depend on AHP data which collected from participants' opinions which include selection best new designs for POPE lawn mower manufacturing depend on three factors affecting the environment (gases emission, nosey and efficiency). In addition, selection of the best new materials for POPE lawn mower depends on two factors influencing the environment (production of solid waste and efficiency). We can see the results for Expert Choice program as following:

3.1 participants A, B, C, D, E, F, G

Seven participants have subscribed in this study. By using the Expert choice program with three different scenarios which depend on the AHP data which was collected from participants**A,B,C,D,E,F,G**, the results for these two scenarios of equal weightage and reverse weightages for the factors affecting the environment will be discussed as below.
By using the first scenario of equal weightage for the factors affecting the environment (gases emission, noise, solid waste and efficiency) the results refer to the best new designs for POPE lawn mower manufacturing with less environmental impact and higher efficiency as the design with double blades instead of the design with single blades and a petrol engine. Also, the second best way to reduce environmental impacts from POPE lawn mowers is using composite material in manufacturing the body of the POPE lawn mower instead of using iron.
The results for the second scenario of reverse weightages for the factors affecting environment (gases emission, nosey, solid waste and efficiency) refer to the better solution to reduce the environmental impacts from POPE lawn mower manufacturing is selection a new design with Automation system instead of a manual system or select a design with double blades instead single blades. Moreover, the second best solution is to select carbon steel in manufacturing the blades of the POPE lawn mower and composite materials in manufacturing some parts of the POPE lawn mower body.

According to the results of the AHP data collected from participants in the Expert Choice program compared with the literature review, some solutions to reducing environmental impacts from POPE lawn mower manufacturing by selection of new designs and new materials for the POPE lawn mower manufacturing was derived: firstly, the results from all the seven participants in this study agree that the best solution to reduce environmental impacts from the POPE lawn mower manufacturing is selecting new designs. There were three suggestions for selection of new designs (design with gas engine, design with twice blades, and design with automation system). The results for six participants agree that the best design to reduce environmental impact from POPE lawn more is design with gas engine. This is because they believe that using gas engine instead petrol leads to reduce gases emission. In addition, the results for five participants believe that one of the better solutions for this issue is select new design with twice blade, which help to increase the efficiency and give higher quality for grass cute with less solid waste. In addition, the results from five participants do not agree on the selection of a new design with the automation system. This is because they believe that design of an automation system requires more equipment, which will lead to increase solid waste in the end life for this product.

Secondly, the result from all seven participants in this study believe that selection of new materials can also contribute to reducing the environmental impacts for POPE lawn mower manufacturing and increase efficiency, but this less important than the selection of new designs. There are three suggestions for select of new materials in manufacturing the body of the POPE lawn mower (stainless steel, composite materials, and polymer materials). The results from six participants in this study agree that the best solution to reduce environmental impact with increased efficiency for the POPE lawn more is to select stainless steel instead carbon steel in manufacturing blades. This is because stainless steel reduces corrosion and production of solid waste for the POPE lawn mower. Moreover, the results from five participants believe that one of the better solutions is to select composite materials instead of iron in manufacturing some parts of this product. This is because they believe composite materials have important properties such as hardness, recyclability and corrosion resistance, which lead to a reduction of solid waste. In addition, the result for four participants do not agree on the selection of polymer materials instead rubber in manufacturing tires because they believe polymer materials are hard to use in manufacturing tires and very expensive.

3.2 Data/Model Analysis

According to the results of the AHP and Expert Choice program, some solutions on how to reduce the environmental impacts from POPE lawn mower manufacturing while increasing efficiency by selection of new designs and new materials for POPE lawn mower manufacturing are discussed below:

1- Select new design with gas engine instead of petrol engine, which will help to reduce gas emissions

2- Select new design with double blades instead of single blades, which will help to increase efficiency for this product and give a higher quality grass cut with less production of solid waste

3- Select stainless steel instead of carbon steel to manufacture blade, which will decrease corrosion and solid waste from discarded blades.

4- Select composite materials instead iron in manufacturing most parts of POPE lawn mower body, which will lead to a reduction of solid waste at the end of this product's lifecycle because composite materials have higher recyclability.

4. Conclusion

Over the years, the lawn mower has become one of the most important and useful pieces of gardening equipment for households and small businesses. On a daily basis people, use this machine to maintain a beautiful environment in their gardens and verges. Efforts were made to make the lawn mower easier to handle, increase the efficacy, extend the life span and reduce environmental impacts. Therefore, it is recommended that:

The final model of the lawn mower manufacturing select new designs and new materials for the POPE lawn mower to reducing environmental impacts with increase efficiency as follows:

1- Select new design with gas engine instead of petrol engine

2- Select new design with double blades instead of single blades

3- Select stainless steel instead carbon steel in manufacturing blades

4- Select composite materials instead iron in manufacturing most parts of the POPE lawn mower body

• Marketers and manufacturers of lawn mowers support the future research works on sustainable designs changes and environmental friendly mowers, as these bodies can provide the time, equipment and facilities to carry out the simulations and Laboratory level or workshop level experiments are required to justify some of the suggestions produced by this project.

• Manufacturers are involved in producing the improvements. Manufacturers may have the component specific detailed information about mowers, customer feedbacks on the product and product failure case study details. This data can be used effectively for sustainable improvements and design changes.

• Moreover, there is a need to focus on how to reduce environmental impact for the lawn mower and increase efficiency by selection new materials and new design in manufacturing this product.

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