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Comparative Evaluation of Environmental Impact for Assembly Parts of Various Materials

Ms. Suman Sharma[a] Dr. Smita Manepatil[b]
Professor, Department of Mechanical Engineering,
TRUBA College of Engineering and Technology, Indore-452009, Madhya Pradesh, India,
Professor, Department of Mechanical Engineering,
SGS Institute of Technology and Science, Indore-452001, Madhya Pradesh, India,

Abstract: *In the race of industrialization and production of goods and services that enrich our life, it seems that mankind is usually unconcerned about the most valuable natural environment. The environmental impact of products and processes has become a key issue. The various materials used for manufacturing the parts of any product produces emissions during their manufacturing. The objective of this work is to perform the investigations of environmental impact during the manufacturing of parts of various material of Transmission group of 'Activa'. The work has been carried out for quantitative evaluation of environmental impacts for various impact categories under 'cradle-to-gate'using the scientific approach of life cycle assessment (LCA) through LCA method 'EDIP-03'. It has been carried out using the designed & developed software 'SSLCASoft'. The major portion of 'Transmission Group' of 'Activa' has steel parts, next is rubber parts and then aluminium parts. During the manufacturing (i.e. life cycle stages from 'cradle to gate') of parts of various subassemblies of 'Transmission Group', It has the prominent impact and more affected impact categories are ecotoxicity water chronic (EWC), ecotoxicity water acute (EWA) and human toxicity air (HTA). The subassemblies of 'Transmission Group' having rubber parts have prominent impact. This is just due to some substances only having higher impact values, otherwise steel parts having dominating impact indicators.This assessment concludes the comparative analysis regarding environmental impact of different materials used. There is a major scope of improving the environmental impact at the design stage by selecting the suitable material without affecting the functional requirement of the part/ subassembly.*

***Keywords**: Life Cycle Assessments, Life Cycle Inventory, Impact Category, Environmental impact, materials, Impact Evaluation, LCA methods, Transmission group, Manufacturing Process,*

I. Introduction

In the race of industrialization and production of goods and services that enrich our life, it seems that mankind is usually unconcerned about the most valuable natural environment that existed when the human civilization had begun. The environmental impact of products and processes has become a key issue now. . The various materials used for manufacturing the parts of any product produce emissions during their manufacturing. These emissions are detrimental to air, water and soil, during its entire life beginning from raw material extraction, manufacturing , assembly , transportation, usage to its final disposal. In order to have environment friendly engineering product, it is necessary to control the data which has prominent environmental impact at design stage only by the selection of proper material for part manufacturing without affection the functionality of the product. Life cycle assessment (LCA) involves the evaluation of the environmental aspects of a product system through all stages of its life cycle.

II. Literature Review

Environmental impact assessment (EIA) is a planning tool, it has both information gathering and decision making component which provides an objective to the decision maker with basis for proposed industrial product development. By this process one can predict the environmental consequences of any activity throughout the life cycle of product manufacturing. [1] Therefore the processes during the product development have become a key issue that leads industries to reduce the impact on environment.

The procedure has been developed to completely study the life cycle of a product emphasizing the environmental concept to upgrade eco-efficiency. In engineering, Life cycle assessment (LCA) has become a powerful tool to evaluate environmental impact assessment of a product.[2]

To initiate LCA, the work of Fava and Consoli et al. outlined LCA as four-step process. [3] It is a systematic, phased approach, broadly suggested four components.. The steps are briefly summarized as under;

i. Goal Definition and Scope: It defines and describes the product, process or activity. Establish the context in which the assessment is to be made and identify the boundaries and environmental effects to be reviewed for the assessment.
ii. Inventory Analysis: Identify and quantify energy, water and materials usage and environmental releases (e.g., air emissions, solid waste disposal, waste water discharges).
iii. Impact Assessment: Assess the potential human and ecological effects of energy, water, and material usage and of the environmental releases identified in the inventory analysis.
iv. Interpretation: Evaluate the results of the inventory analysis and impact assessment to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results. [2]

So all these above steps suggested are sequential and become iterative, if a change in one stage occurs. It will automatically affect other steps.

Objective of the Work and Method

The objective of this work is to perform the investigations of manufacturing of parts of various materials of 'Transmission group' of two-wheeler scooter 'Activa' for quantitative evaluation of its environmental impacts. The methodology adopted for the environmental impact assessment of the parts of selected materials is according to the standard practice of LCA. The work has been carried out for various impact categories under 'cradle-to-gate' using Life Cycle Assessment (LCA) approach as per ISO14040 and using LCA Method 'EDIP-03'. It has been carried out using the designed & developed software 'SSLCASoft'.

The impact categories ecotoxicity water acute (EWA), ecotoxicity water chronic (EWC), ecotoxicity soil chronic (ESC), human toxicity air (HTA), human toxicity water (HTW), human toxicity soil (HTS), global warming (GW), acidification (AC), eutrophication (terrestrial) (TET) and eutrophication (aquatic) (AETN and AETP), ozone depletion (OD), ozone formation vegetation (OFV) and ozone formation human (OFH) have been considered for this work.

The environmental impact evaluation has been carried out using the developed software "SSLCASoft". The process of impact assessment includes the steps such as Data input of product, Inventory processing and Impact evaluation.

The data input has been carried out for the input of details of parts of different constituent materials of various sub-assemblies of 'Transmission Group', such as Drive Face (DVF), Driven Face (DNF), Transmission (TRM), Front Wheel (FW) and Rear Wheel (RW). The various constituent materials used for manufacturing of various parts of these different sub-assemblies are plastic (P), steel (S), rubber (R), and aluminium (Al). The proportion of parts of constituent materials in percentage is as shown in the figure 1.

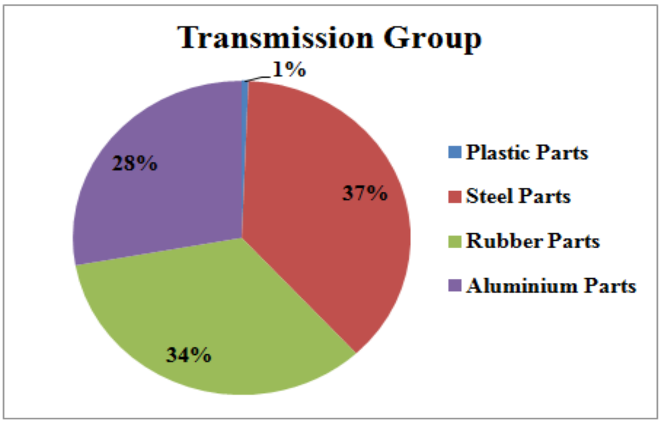

Figure 1: The proportion of parts of constituent materials in percentage.

By using the software "SSLCASoft", the Inventory processing and Impact evaluation has been carried out for all the parts manufactured by different materials of various subassemblies of this assembly group. It has been carried out for the different combinations of various aspects of 'Transmission Group' of two-wheeler 'Activa'. A sample of processing for one combination is described in the table 1.

Table 1: Inventory Processing and Impact evaluation generation of Drive Face Subassembly

Product: Transmission Group of Activa (Drive Face)	**Material: Steel**
• Selection of Product	: Activa
• Quantity	: 1000
• Selection of Assembly Group	: TRG Group
• Selection of Sub-assembly	: DVF
• Selection of Material of the Part	: Steel
• Selection of sub material	: M.S.
• Selection of Life Cycle Stage	: Material Manufacturing
• Selection of Manufacturing Process	: Rolling
• Selection of LCA Method	: EDIP-03
• Selection of Impact Category	: Global Warming

Similarly, the impacts have been generated for all the various combinations of part, its material, and its manufacturing process and impact category according to the selected LCA Method.

III. Results and Discussions

Constituent Material-wise Environmental Impact

The comparative environmental impact of the parts of 'Transmission Group' manufactured by various constituent materials, i.e. plastic (P), steel (S), rubber (R) and aluminium (AL) on the individual impact category of EDIP-03 are presented as shown in the figure-2. The impact of all four constituent materials on various impact categories is described as below

- The dominating material is rubber in case of ecotoxicity group and human toxicity group. It has very high values of impact with respect to other materials. The impact of rubber parts is prominent as compared to steel parts just due to one or two substances which has very high emission value. Other than this, the impact of steel parts is prominent.

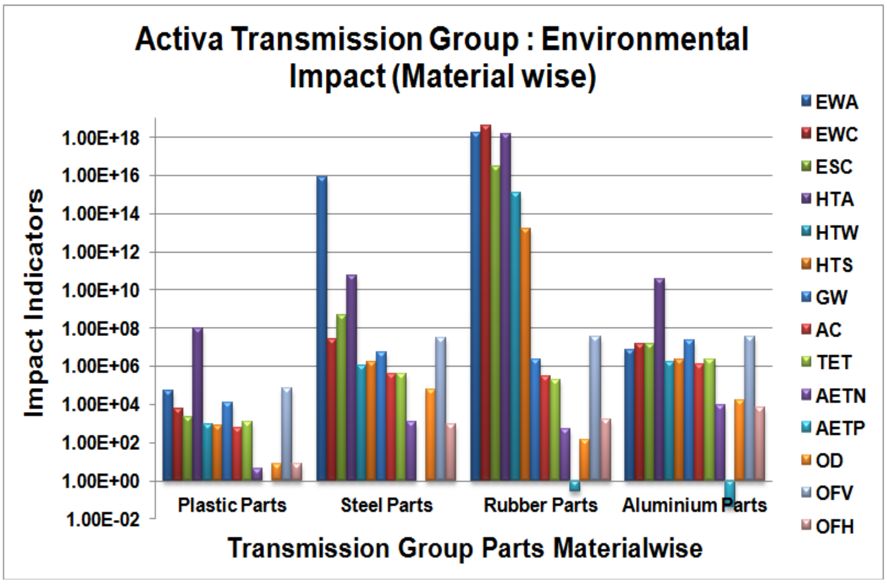

Figure 2: Environmental Impact of Transmission Group Parts Material-wise

- The second dominating material is steel in ecotoxicity and human toxicity group. In case of EWA it is very much dominating as compared to others. The next dominating material for ecotoxicity and human toxicity is aluminium and the plastic is the material has lowest impact on the same.
- In case of GW, TET, AC, OD the steel is dominating the other materials. The next material having higher impact is aluminium. The impact of rubber and plastic is having slight difference, almost equal to each other in case of GW, TET, ATEN, AC, OFV and OFH.

- The impact on global warming (GW) is prominent in steel and aluminium both, very near to each other, in case of plastic it is least and in case of rubber it is more as compared to plastic. The impact on OFV is increasing in the order as plastic, rubber, aluminium and steel (i.e. prominent one). The impact on ozone depletion (OD) is increasing in the order as rubber, plastic, aluminium and steel (i.e. prominent one).

IV. Conclusions

The major portion of 'Transmission Group' of 'Activa' has steel parts, next is rubber parts and then aluminium parts. During the manufacturing (i.e. life cycle stages from 'cradle to gate') of parts of various subassemblies of 'Transmission Group', It has the prominent impact and more affected impact categories are ecotoxicity water chronic (EWC), ecotoxicity water acute (EWA) and human toxicity air (HTA).

The Front Wheel (FW) and Rear Wheel (RW) subassemblies of 'Transmission Group' have prominent impact for rubber parts. This is just due to some substances only having higher impact values, otherwise steel parts having dominating impact indicators.

It has been concluded that, there is a major scope of improving the environmental impact arises during the manufacturing of parts with different materials.

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