International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Investigation of Manufacturing of Engine Group of 'Activa': Assessment of Environmental Impact Evaluation

Suman Sharma[1], Dr. Smita Manepatil[2]

[1]Professor, Department of Mechanical Engineering, TRUBA College of Engineering and Technology, Science, Indore-452001, Madhya Pradesh, India,

[2]Professor, Department of Mechanical Engineering, SGS Institute of Technology and Indore-452009, Madhya Pradesh, India,

Abstract: ***Every human activity has an impact on the environment in the form of emissions. The environment has some capacity to absorb these emissions so emitted to a certain level without lasting the damage. The manufacturing of a product produces emissions which may be detrimental to air, water and soil, during its entire life beginning from raw material extraction, manufacturing , assembly , transportation, usage to its final disposal. These emissions have harmful effect at local, regional and global levels. In order to have environment friendly engineering product, it is necessary to control the data which has prominent environmental impact during the various stages throughout its life cycle. It is important to identify processes and ingredients, which are major contributors to environmental impacts. Life cycle assessment (LCA) involves the evaluation of the environmental aspects of a product system through all stages of its life cycle. The primary objective of this work is to perform the investigations of manufacturing of Engine group of product 'Activa' for quantitative evaluation of its environmental impacts for various impact categories under 'cradle-to-gate' variant using Life Cycle Assessment (LCA) approach as per ISO14040. It has been carried out using the designed & developed software 'SSLCASoft'. The results presents the cumulative environmental impact of 'Engine Group' of 'Activa'' on various impact categories of EDIP-03. The major portion 'Engine Group' of 'Activa' having aluminium parts and the steel parts. The materialwise results show that the impact of steel parts is dominating. Subassembly-wise, the impact of Crank Shaft Piston (CSP) and Cam Shaft Valve (CSV) is prominent amongst all other subassemblies of 'Engine Group' for steel parts. Looking to the results, there is a major scope of improving the environmental impact arises during the manufacturing life of 'Engine Group' of 'Activa' at the design stage.***

Keywords: Environmental impact, Life Cycle Assessments, Life Cycle Inventory, Life Cycle stages, Impact Category, Impact Evaluation, LCA methods, Manufacturing Process, material, subassemblies.

1. Introduction

Civilization has been transformed due to the progress and advancement of industrialization. Every human activity has an impact on the environment in the form of emissions. The environment has some capacity to absorb these emissions so emitted to a certain level without lasting the damage.

Industrial activities contribute to these damages and a part of this environmental impact is derived from the products, starting right from its origin to the disposal. This has made the companies to investigate ways to minimize the effects on the environment. Many businesses have responded to this awareness by developing "greener" products and using "greener" processes. The environmental impact of products and processes has become a key issue now. Many companies have adapted environmental management systems and pollution prevention strategies to minimize their environmental impact.

The manufacturing of a product produces emissions which may be detrimental to air, water and soil, during its entire life beginning from raw material extraction, manufacturing , assembly , transportation, usage to its final disposal. These emissions have harmful effect at local, regional and global levels. A standard technique internationally known as 'Environmental Impact Assessment (EIA)' is used to identify the detrimental effect by evaluating the various product parameters. It is used to study the life cycle of a product and it helps to the reduction of emissions. Any particular engineering product has its own impact on the environment depending upon the materials and processes used for manufacturing and its use till end of its life. In order to have environment friendly engineering product, it is necessary to control the data which has prominent environmental impact during the various stages throughout its life cycle.

Life cycle assessment is used by the manufacturers for product development, product improvement, product comparison etc. It is important to identify processes and ingredients, which are major contributors to environmental impacts. It helps to compare different options for a particular process with the objective of minimizing the environmental impacts. Life cycle assessment (LCA) involves the evaluation of the environmental aspects of a product system through all stages of its life cycle.

2. Literature Review

An environmental impact assessment is generally defined as an assessment of the possible positive or negative impacts that a proposed industrial project may have on the environment, associated with the natural, social and economic aspects.[1-4]

Environmental impact assessment (EIA) is a planning tool which is generally regarded as an integral component of sound decision-making. It provides the decision maker with an objective basis for proposed industrial product development. [5] By this process one can predict the environmental consequences of any activity of product development or industrial activity on the environment. [6] Therefore the processes of product development of the industrial activity have become a key issue that has lead companies to investigate ways to minimize their detrimental effects on the environment.

The present day trend is to develop an engineering product as *'green product'* as a strategy for enhancing the environmental performance for overall socio-economic development. That enhances the manufacturing capacity for international competitiveness. This green product concept has become very popular. So the procedure has been developed to completely study the life cycle of a product emphasizing the environmental concept to upgrade eco-efficiency. This approach is popularly known as 'Life Cycle Assessment' and briefly termed as LCA. In a life cycle assessment the life cycle of a product is usually divided into stages as procurement i.e. raw material acquisition, manufacture, use and disposal. The life cycle stages of a product can be illustrated with the help of figure 1.[7]

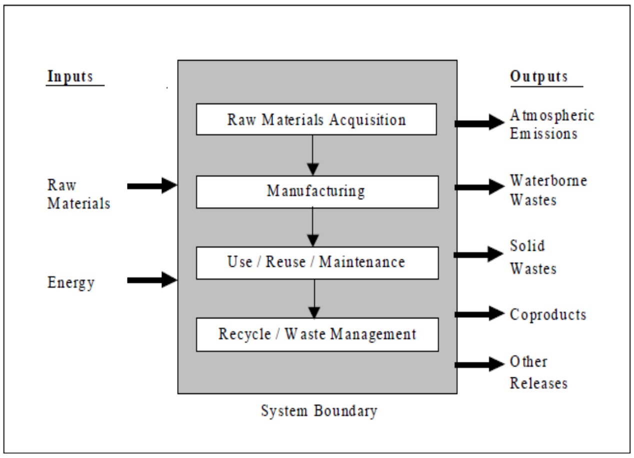

Figure 1: Life Cycle Stages (Source EPA, 1993)

Life cycle assessment is a method for assessing the environmental considerations of a product or service throughout its entire life cycle. A complete life cycle includes everything from raw material extraction, processing, transportation, manufacturing, distribution, use, re-use, maintenance and recycling to final disposal. [8] The environmental impacts as per LCIA are the consequences that could be caused by the input and output streams of a system on human health, plants, and animals, or the future availability of natural resources. Typically, it focuses on the potential impacts to three main categories: human health, ecological health, and resource depletion. [9]

3. Methodology of Investigation

The methodology adopted for the environmental impact assessment of the selected products is according to the standard practice of LCA. The actions carried out have been grouped according to the standard techniques as described below:

1. Product Selection and Analysis
2. Scope and Data Collection
3. Evaluation of Impact Assessment
4. Results and its Interpretation

The methodology for environmental impact evaluation using EDIP as LCA method under the defined boundaries of the typical engineering product is being explained here. [10]

- Selection of the Engineering or consumer Products or its components for investigation. The selected products may consist of assembly-group of sub-assemblies.
- In case of an assembly-group, identify the number of sub-assemblies, and further group it into sub-assemblies; the product selected for environmental impact assessment, is an 'Engine Group' two-wheeler scooter 'Activa' of Honda make.
- Study of the various design parameters of the selected Products or its components.
- Study and analysis of for various technical aspects of product for its sub-assemblies, subsequently their parts, design of parts, materials, manufacturing stages, weights etc.
- Study and analysis of the selected products for its life cycle stages and further the various materials requirement and the manufacturing processes used for its production as specified in Goal & Scope of the work.
- The next step is the collection of LCI data from the standards and references.
- The generation of the LCI data for various stages of life, according to set boundaries of life cycle of the Product, if the LCI is not available in the standards or references.
- Selection of the appropriate LCA Methods viz. FRED (ISO 14040), Eco-Indicator 99, and EDIP. In this work the LCA Method, i.e. EDIP (Environmental Design of Industrial Product) is used for this Investigation.
- Selection of various impact categories according to the selected method and requirement.
- The LCI filtration and the inventory processing of selected features of products for various impact categories has been done for Impact assessment.
- The evaluation and presentation of impact assessment for selected stages of life cycle of the product using the developed software 'SSLCASoft' as LCA tool.

Objective of the Work

The primary objective of this work is to perform the investigations of manufacturing of Engine group of product 'Activa' for quantitative evaluation of its environmental impacts for various impact categories under 'cradle-to-gate' variant using Life Cycle Assessment (LCA) approach as per ISO14040. This work has been carried out with the scientific approach of life cycle assessment (LCA) using 'EDIP-03'.[7] It has been carried out using the designed & developed software 'SSLCASoft'. The environmental impact assessment for the selected products covers two types of damages, eco-system quality and human health. The corresponding 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 process of impact assessment is carried out using following steps, which are discussed in subsequent sections in detail.

1) Data input of product
2) Inventory processing
3) Impact evaluation

The data input has been carried out for the input of details of various sub-assemblies of 'Engine Group', such as Shroud Fan Cover (SFC), Cylinder Head Cover (CHC), Cylinder Head (CLH), Cam Shaft Valve (CSC), Cam Chain Tensioner (CCT), Cylinder (CYL), Oil Pump (OP), Right Crank Case (RCC), Left Crank Case (LCC), Left Crank Case Cover (LCCC), Crank Shaft Piston (CSP), Gasket Kit-A (GKA) and Gasket Kit-B (GKB). The various constituent materials used for manufacturing 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 2.

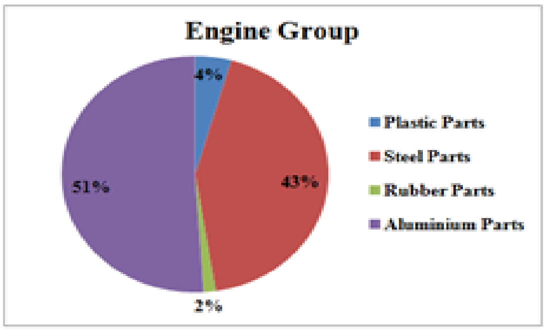

Figure 2: The proportion of parts of constituent materials in percentage

The Inventory processing has been carried out for the different combinations of various aspects of this product 'Engine Group' of two-wheeler 'Activa'. A sample of this inventory processing for one combination is described in the table 1.

Table 1: Inventory Processing of Shroud Fan Cover

Product: **Engine Group of Activa**	Stage: **LCS-03**
• Selection of Product	: Activa
• Quantity	: 100
• Selection of Assembly Group	: Engine
• Selection of Sub-Assembly Group	: Shroud Fan Cover
• Selection of Material of Part of Sub- Assembly	: Steel
• Selection of Sub-Material	: Rolled Steel
• Selection of Life Cycle Stage	: Part Manufacturing
• Selection of Process Group	:Casting and Machining
• Selection of Manufacturing Process	: Casting
• Selection of Compartment	: Air
• LCA Method	: EDIP-03
• Impact category	: Acidification

The Impact evaluation has been carried out for the different combinations of various aspects of this product 'Engine Group' of two-wheeler 'Activa'. A sample of this impact evaluation for one combination is described in the table 2.

Table 2: Impact evaluation generation of Shroud Fan Cover

Product: Engine Group of Activa: Shroud Fan Cover		**Material: Steel**
• Selection of Product	: ' Activa'	
• All Cumulative		×
Or Selection of Assembly	: Engine Group	√
• All Cumulative		×
Or Selection of Sub-Assembly	: Shroud Fan Cover	√
❖ All Cumulative	:	×
❖ Stage wise	:	×
❖ Material √	: Steel	
➢ Subassembly-wise	:	√
➢ Material -Stage-wise	:	×
• LCA Method	: EDIP-03	√
• Format of Results	: Comparative	×
	: Individual	
• Scale on Graph	: Normal Scale	×
	: Logarithmic Scale	√
• GetData	: OK	
• Get Chart	: OK	
• Export	: OK	

Similarly, the impacts have been generated for the various combinations of sub-assembly, material, life cycle stage, manufacturing process and impact category. The generated results can be exported to 'MSExcel' file.

4. Results and Discussions

1) Cumulative Environmental Impact

The graphical presentation of cumulative environmental impact of 'Engine Group' of *'Activa"* on various impact categories of EDIP-03 is as shown in the figure 3. It presents the environmental impact during the whole life cycle from 'cradle-to-gate'.

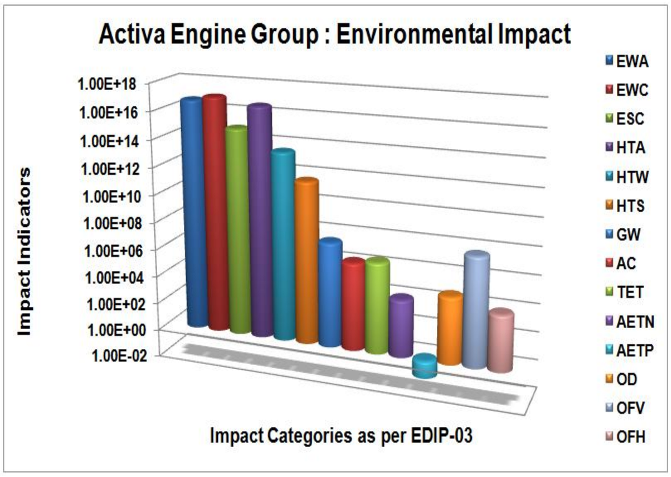

Figure 3: Environmental Impact of Engine Group-Cumulative

The impact of whole 'Engine Group' on various impact categories of EDIP-03 are described as below

- The impact on EWC is dominating as compared to the other impact categories. The second dominating impact categories are EWA and HTA. Both are very close to each other, almost equal. The next higher impacts are on EWS, HTW and HTS respectively.
- The impact on GW, AC, TET, and OD are quite less as compared to the impact on ecotoxicity and human toxicity

group. The impact on terrestrial eutrophication and impact on acidification is almost equal. The impact on OFV is slightly more than the impact on GW.

2) Assembly-wise Environmental Impact

The environmental impact of different assemblies of 'Engine Group' is presented graphically is as shown in the figure 4.

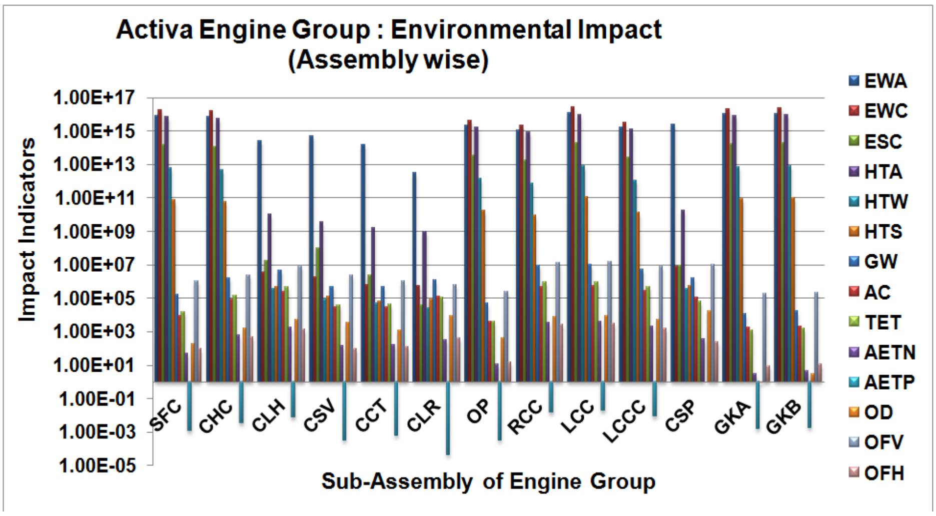

Figure 4: Environmental Impact of Engine Group-Assemblywise

- The impact of Left Crank Case (LCC) is prominent amongst all other assemblies of 'Engine Group'. The second dominating assembly is Shroud Fan Cover (SFC). The next dominating assemblies are Oil Pump (OP), Left Crank Case Cover (LCCC) and Right Crank Case (RCC) in reducing order. In these assemblies, the impact category EWC has prominent impact; the next affected impact categories are EWA and HTA.
- In case of assemblies Cylinder Head Cover (CHC), Cylinder Head (CLH), Cam Shaft Valve (CSC), Cam Chain Tensioner (CCT) and Cylinder (CYL), the impact category EWA is prominent and it has impact which is very large as compared to others. The next affected impact category is HTA.
- Other than ecotoxicity and human toxicity group, the GW and OFV are more prominent impact categories. The assemblies responsible for these are LCC, RCC, LCCC and CSP in reducing order.

3) Constituent Material-wise Environmental Impact

The figure-5 shows the assessment of comparative environmental impact of various constituent materials of the parts of *'Activa'*, i.e. plastic (P), steel (S), rubber (R) and aluminium (AL) on the individual impact category. 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.
- 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 for these groups.
- The next dominating material for ecotoxicity and human toxicity is aluminium and the plastic is the lowest material for 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. In case of OD, OFH, TET and AETN the impact of rubber is quite less.
- 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).

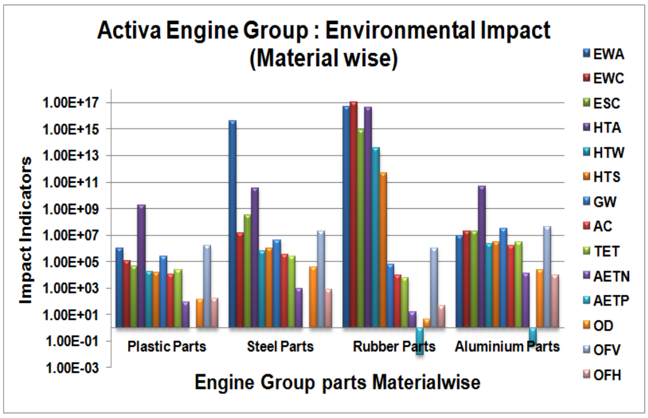

Figure 5: Environmental Impact of Engine

Group --Parts Materialwise

4) Life cycle stage-wise

Environmental Impact

The environmental impact of parts of 'Engine Group' at various life cycle stages raw material acquisition (LCS-01), material manufacturing (LCS-02) and part manufacturing (LCS-03) is presented graphically as shown in the figure 6.

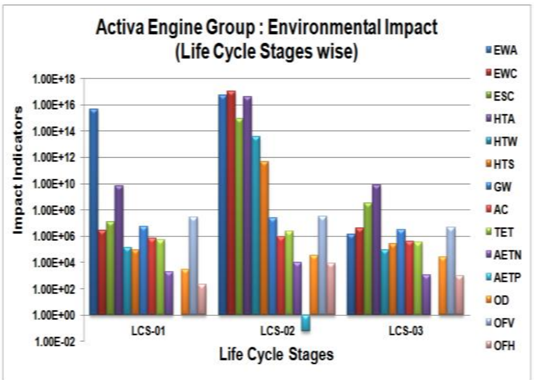

Figure 6: Environmental Impact of Engine Group -Life Cycle Stagewise

The impact is prominent at stage LCS-02 for all impact categories. The next dominating stage is LCS-03 for all impact categories except EWA, which is higher at stage LCS-01 as compared to LCS-03.

5. Conclusions

The major portion of ‘Engine Group’ of ‘Activa’ having aluminium parts and then next is steel parts. During the manufacturing (i.e. life cycle stages from ‘cradle to gate’) of parts of various subassemblies of ‘Engine Group’, the impact categories-wise, ecotoxicity water chronic (EWC), ecotoxicity water acute (EWA) and human toxicity air (HTA) are affected more. The impact of steel parts is dominating. Subassembly-wise, the impact of Crank Shaft Piston (CSP) and Cam Shaft Valve (CSV) is prominent amongst all other subassemblies of ‘Engine Group’ for steel parts. Looking to the results, there is a major scope of improving the environmental impact arises during the manufacturing life of product ‘Engine Group’ of ‘Activa’ at the design stage.

References

[1] ‘Principle of Environmental Impact Assessment Best Practice.’ International Association for Impact Assessment, 1999. (webpage modified on 12 July 2011).
[2] Holder J., Christopher, ‘Environmental Impact Assessment: a comparative discussion of the elements of various domestic EIA systems’, Environmental Assessment: The Regulation of Decision Making, Oxford University Press, Prentice Hall, New York, II, Prentice Hall, Harlow, 2004.
[3] Jay S., Jones C., Slinn P., Wood C., ‘Environmental Impact Assessment: Retrospect and Prospect Environmental Impact Assessment’ Review, Vol.27: pp 287-300, 2007.
[4] Daniel S., Tsoulfas G., Pappis C., Rachaniotis N. ‘Aggregating and Evaluating the results of different Environmental Impact Assessment Methods Ecological indicators’, Vol.4, pp 125-138, 2004.
[5] Elliott M., Thomas I. ‘Environment Impact Assessment in Australia: Theory and Practice’, Federation Press, Sydney, 2009.
[6] Alan Gilpin, ‘Environmental Impact Assessment - Cutting Edge for the twenty-first century’, Cambridge University Press. (1995). hsrinivas@gdre.org
[7] Roger Bacon Drive Reston, Mary Ann Curran, ‘Life Cycle Assessment: Principles and practice’, Scientific Applications International Corporation (SAIC), National risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, EPA/600/R-06/060 May 2006.
[8] Jyri Seppala, ‘Life Cycle Impact Assessment based on Decision Analysis’, Dissertation for the degree of Doctor of Science in Technology, Department of Engineering Physics and Mathematics, Systems Analysis Laboratory, Helsinki University of Technology, (Espoo, Finland), FIN-02015 HUT, FINLAND, August 2003, www.sal.hut.fi/Publications/r-index.html
[9] Rolf Frischknecht, Niels Jungbluth, ‘Implementation of Life Cycle Impact Assessment Methods’, Swiss Centre for Life Cycle Inventory, Dubendorf, Data Vol.2.0, December 2007.
[10] UNEP, Environmental Impact Assessment Training Resource Manual, © UNEP, 2001-2003. Maintained by: meguedon@unep.fr
[11] Allan Astrup Jensen, Kim Christiansen, John Elkington, ‘Life Cycle Assessment, Environmental Issues Series, A guide to Approaches, Experiences and Information sources,(LCA)’, European Environment Agency of Sustainability , Denmark, United Kingdom, August 1997.
[12] Mark Goedkoop and Renilde Spriensma, Pre Product Consultant B.V., ‘The Eco-Indicator 99, Damage Oriented Method for Life Cycle Assessment’, Methodological Report, Amersfroot, June, 2001.
[13] T Lenau and N Bey, ‘Design of Environmental Friendly Products Using Indicators’, Department of Manufacturing Engineering, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering, Technical University of Denmark, Vol.215, Part-B, 2001. (referred on June 7, 2011) , http://www.sagepublications.com