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Analysis of Environmental Impact of 4 Stroke Petrol Engine by Using Eco Indicator 99 Method

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Abstract- This study presents the assessment of environmental impact of four stroke petrol engine. The assessment is done by using the Eco indicator 99 method & Eco it software. The assessment of environmental impact of whole life cycle of engine includes the impact assessment of Production phase, Processing phase, transport and packaging phase, use phase, disposal phase of whole life of engine.

For assessment, data are collected and then analyzed, during analysis the indicator point obtained from eco it software for particular material and process is taken. After the analysis the impact shows as indicator scores in milli-points, which phase have more indicator score have more impact on environment.

Index Terms- Eco indicator 99 method, Indicator point, Eco It software, Four stroke petrol engine.

I. INTRODUCTION

Every product has impact on environment in its whole life, some products have less impact and some product have more impact. This article involves a stepwise analysis of impact on environment of every phase i.e. production, processing/manufacturing, use, transport & packaging, disposal of 4 stroke petrol engine in its whole life by the use of Eco indicator 99 method. For assessment the environmental impact many methods can be use, in which most widely used method is Eco indicator 99 method. “The Eco-indicator 99 is both a science based impact assessment method for LCA and a pragmatic ecodesign method. It offers a way to measure various environmental impacts, and shows a final result in a single score.”This method uses indicator points to evaluate the impact of product on environment. The indicator points for different type of materials and processes can be obtained by the ECO-IT software. This analysis shows the impact in terms of indicator scores in millipoints, of various product life cycle phases, which phase have more points, it have more impact on environment.

Eco-indicator 99 Methodology: Operating instructions The following steps must always be followed to ensure correct application of the Eco-indicator:

Step 1: Establish the purpose of the Eco-indicator calculation.
- Describe the product or product component that is being analyzed.
- Define whether an analysis of one specific product is being carried out or a comparison between Several products.
- Define the level of accuracy required.

Step 2: Define the life cycle.
- Draw up a schematic overview of the product’s life cycle, paying equal attention to production, Use and waste processing.

Step 3: Quantify materials and processes.
- Determine a functional unit.
- Quantify all relevant processes from the process tree.
- Make assumptions for any missing data.

Step 4: Fill in the form.
- Note the materials and processes on the form and enter the amounts.
- Find the relevant Eco-indicator values and enter these.
- Calculate the scores by multiplying the amounts by the indicator values.
- Add the subsidiary results together.

Step 5: Interpret the results.
- Combine conclusions with the results.
- Check the effect of assumptions and uncertainties.

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• Amend conclusions (if appropriate).
• Check whether the purpose of the calculation has been met.

Indicator Point : Eco-indicator scores to express the environmental performance of a product as a single figure. The standard Eco-indicator values can be regarded as dimensionless figures. As a name we use the Eco-indicator point (Pt). In the Eco-indicator lists usually the unit milli-point (mPt) is used, so 700 mPt= 0.7 Pt.

ECO-it Software is a tool for product and packaging designers. Designers often work under time pressure, and cannot be expected to be environmental experts. With ECO-it you can work without detailed environmental knowledge. ECO-it is easy to use and gives instant results. For this reason, it is also the perfect tool for education.

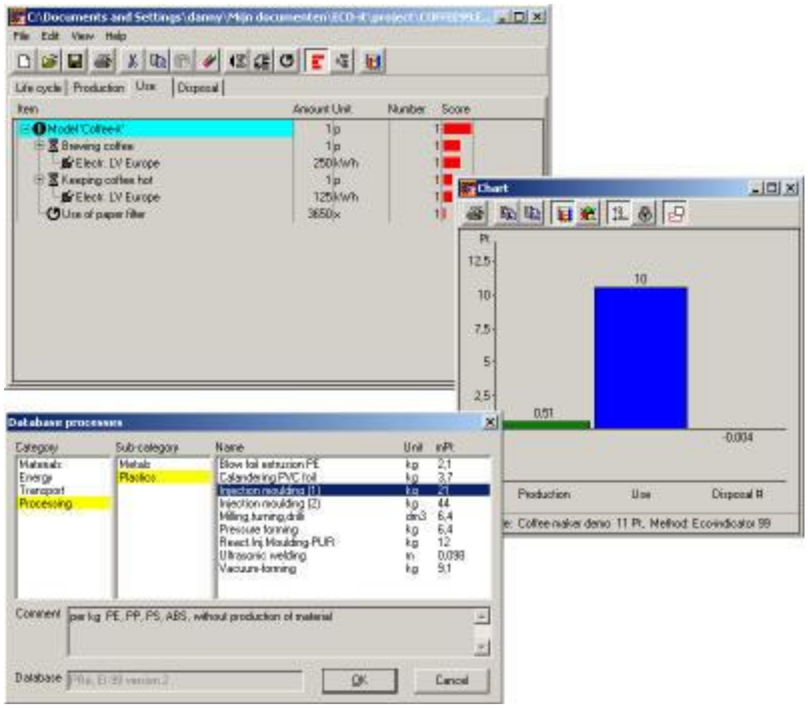

Figure 1 : Indicator points of process in eco-it software

ECO-it is easy to use, you can model your product in minutes and know its environmental impact.

II. COLLECTED DATA AND ANALYSIS OF IMPACT

Step 1: In this study for Analysis of environmental impact of 4 stroke petrol engine, Bajaj caliber engine is taken.

Step 2 and step 3: The process tree is illustrated in figure 2. In this I determine exactly inputs & outputs during a whole life of product. The amount of material is also included which is found by weighting of every parts of engine in workshop.

Table I: Material used for manufacturing engine parts

Material for engine parts			**Total weight of material**
material	parts	amount	
steel	Piston ring	0.004 kg	1.3 kg
	connecting rod	0.175 kg	
	valves	0.044 kg	
	flywheel	0.64 kg	
	crankshaft	0.129 kg	
	camshaft	0.276 kg	
	Piston pin	0.018 kg	
	Wire shell of spark plug	0.0126 kg	
aluminum	Cylinder head	1.65 kg	2.173 kg
	piston	0.078 kg	
	Aluminum plates of cylinder	0.445 kg	
Cast iron (used for cylinder)			1.13 kg
Nickel (used for electrodes of spark plug)			0.0074 kg
Ceramic(used for insulator of spark plug)			0.006 kg

Table II: Process & heat energy used for manufacturing engine parts

Parts	**process**	**Heat energy used**
Piston ring	forging	0.26 MJ
Connecting rod	Forming, sintering, infiltrating, separating	11.375 MJ
valves	forging	2.86 MJ
flywheel	casting	41.6 MJ
Crankshaft	Roll forging	8.385 MJ
Camshaft	Sintering, heating	17.94 MJ
Piston pin	forging	1.17 MJ
Wire shell of spark plug	extrusion	0.819 MJ
Cylinder head	forging	381.15 MJ
piston	Forging/casting ,machining, turning, drilling	18.018 MJ
Aluminum plates of cylinder	Sheet forming, bending	102.795 MJ
Cylinder	Casting	41.81 MJ

Table III: Material used in packaging & transport of engine

material	**amount**
Polythene (PE)	0.004 kg
Polystyrene (PS)	0.01 kg
Packing carton/ cardboard/wooden container	0.5 kg
Transport by truck	3000

Table IV: product life cycle = 10 years, use of petrol = 2 litre/day , hence use of petrol = 720 Litre/year

Use engine oil = 1 Litre/servicing (in every 3 months)

Petrol (litre)	7200	2*30*12*10
Engine oil (litre)	40	1*4*10

Table V: Common product life cycles

Product type	**Useful life(years)**
Photographic film	1
Disposable dinnerware and hospital goods	1
Packaging	1-2
Construction film	2
Footwear	2
Apparel	4
Household goods	5
Toys	5
Jewelry	5
Saucepans	5
Sporting goods	7
Domestic applications	7-10
Luggage	10
Cameras	10
Furniture	10
Motor vehicles	10
Electrical goods	10-15
Hardware	15
Aircraft	15
Wire and cable	15-30
Construction	25-40
Machinery	30

After finding the life cycle & quantity (amount) of material, this quantity is multiplied by indicator point (find out from ECO IT software) for every material/process used in every phase and filled in the form (available in tabular format) to determine environmental impact of engine.

LIFE CYCLE OF 4 STROKE PETROL ENGINE – The process tree is illustrated in fig. In this we determine exactly inputs & outputs during a whole life of product. The amount of material is also included.

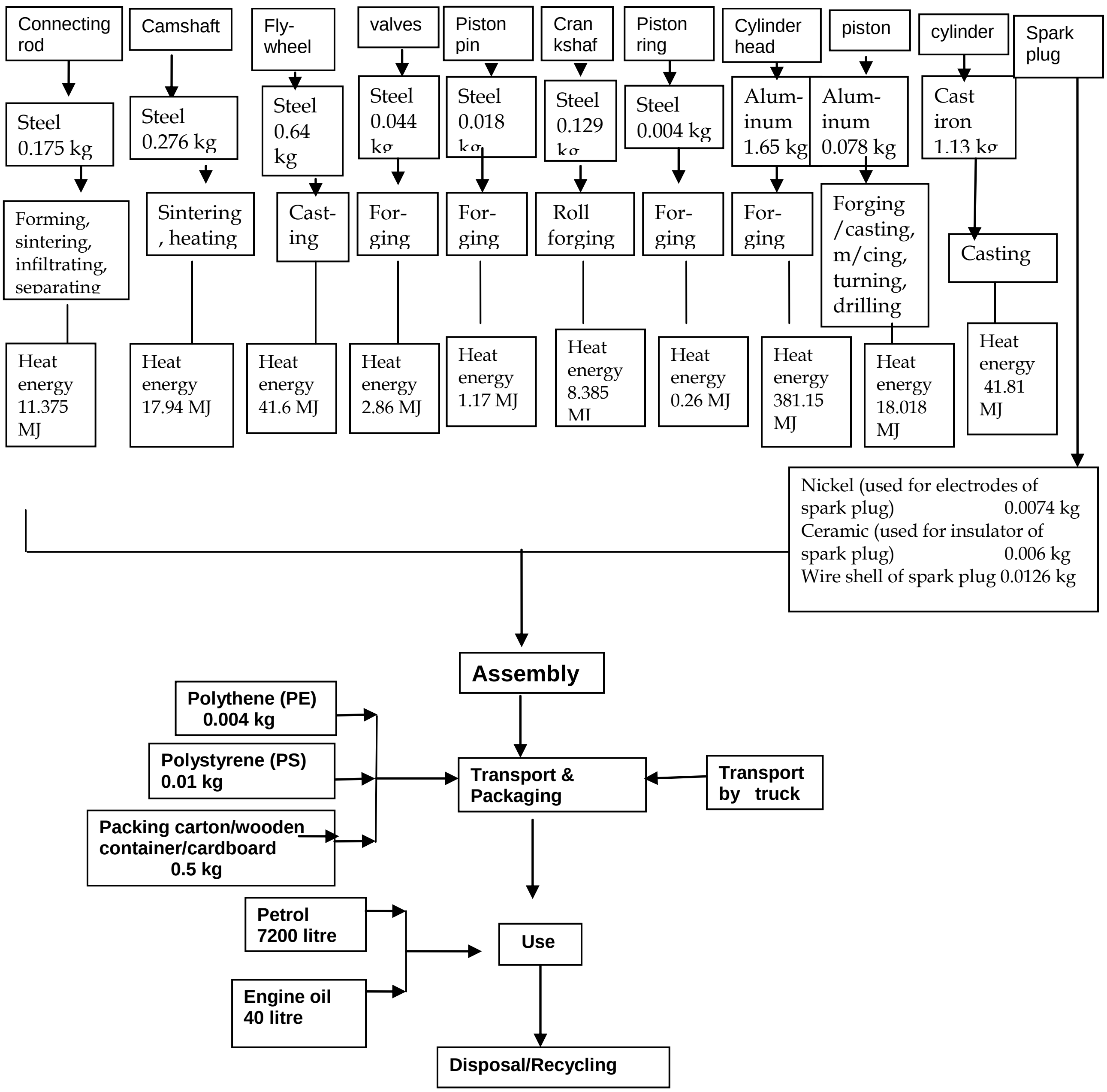

Figure 2: Process tree for engine

Product or component
4 stroke petrol engine

Notes about analysis
Assumption: Product life of 10 years, uses petrol 2 litre/day & its mileage is 83 km/l

Production
Material used in production of product

Material for engine parts			**Total weight of material (Q)**	**Indicator (I)**	**Result (Q*I)**
Material	parts	amount			
Steel	Piston ring	0.004 kg	1.3 kg	86	111.8
	connecting rod	0.175 kg			
	valves	0.044 kg			
	flywheel	0.64 kg			
	crankshaft	0.129 kg			
	camshaft	0.276 kg			
	Piston pin	0.018 kg			
	Wire shell of spark plug	0.0126 kg			
Aluminum	Cylinder head	1.65 kg	2.173 kg	780	1694.94
	piston	0.078 kg			
	plates of cylinder	0.445 kg			
Cast iron (used for cylinder)			1.13 kg	240	271.2
Nickel (used for electrodes of spark plug)			0.0074 kg	5200	38.48
Ceramic(used for insulator of spark plug)			0.006 kg	28	0.168
Total impact of production phase (in mpt) A = sum of all results in this phase					**= 2116.588**

Processing
Heat energy used in production

Parts	**Process**	**Heat energy used**	**Total heat energy (E)**	**Indicator (I)**	**Result (E*I)**
Piston ring	forging	0.26 MJ	628.182 MJ	4.2	2638.36
Connecting rod	Forming, sintering, infiltrating, separating	11.375 MJ			
valves	forging	2.86 MJ			
flywheel	casting	41.6 MJ			
Crankshaft	Roll forging	8.385 MJ			
Camshaft	Sintering, heating	17.94 MJ			
Piston pin	forging	1.17 MJ			
Wire shell of spark plug	extrusion	0.819 MJ			
Cylinder head	forging	381.15 MJ			
piston	Forging/casting, machining, turning, drilling	18.018 MJ			
Aluminum plates of cylinder	Sheet forming, bending	102.795 MJ			
Cylinder	Casting	41.81 MJ			
Total impact of processing phase (in mpt) B = sum of all results in this phase					**= 2638.36**

Transport & packaging material used in transport & packaging			
Material	**Amount (T)**	**Indicator (I)**	**Result (T*I)**
Polythene (PE)	0.004 kg	2.1	0.0084
Polystyrene (PS)	0.01 kg	370	3.7
Packing carton/ cardboard/wooden container	0.5 kg	69	34.5
Transport by truck	3000	22	66
Total impact of Transport & packaging phase (in mpt) C = sum of all results in this phase = 104.208			
Use Material, Transport, Energy and possible auxiliary materials			
Material	**Amount (U)**	**Indicator (I)**	**Result (U*I)**
Petrol (litre)	7200	210	1512000
Engine oil (litre)	40	99	3960
Total impact of use phase (in mpt) D = sum of all results in this phase = 15,15,960			
Disposal Disposal process for used material			
Material	**Amount (D)**	**Indicator (I)**	**Result (D*I)**
Municipal waste PE	0.004 kg	-1.1	-0.0044
Municipal waste PS	0.01 kg	2	0.02
Municipal waste aluminum	2.2 kg	-23	-50.6
Municipal waste steel	1.48 kg	-5.9	-8.732
Packing carton/cardboard	0.5 kg	-3.3	-1.65
Total impact of disposal phase (in mpt) E = sum of all results in this phase = -60.95			
Grand total [millipoint] all phases (A+B+C+D+E) 15,20,758.206			

III. RESULT SUMMARY

Life cycle phases	**Score in milli points**	**% of total damage**
Production phase	2116.588	0.14 %
Processing phase	2638.36	0.17 %
Transport & packaging	104.208	0.0069 %
Use phase	15,15,960	99.8 %
[Use of petrol]	1512000	[99.6 %]
[Use of engine oil]	3960	[0.20 %]
Disposal phase	-60.95	-0.004 %

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The result shows that the use phase has greatest impact. The number of points is many times higher than the totals for the production, processing, transport, & packaging & disposal.

Use phase have greater damage % than other ,that is 99.8 % including use of petrol 99.6 %, use of engine oil 0.20 %. Hence petrol have greatest impact on environment than others, the design team should concentrate on the use of petrol. Instead of petrol alcohol or mixture of both can be used.

Use of alcohol			**Use of petrol**		
Amount	**Indicator**	**Result**	**Amount**	**Indicator**	**Result**
10% = 720 Litre	99	71280	90%=6480 Litre	210	1360800
20%=1440 Litre	99	142560	80%=5760 Litre	210	1209600
30%=2160 Litre	99	213840	70%=5040 Litre	210	1058400

Hence,

Amount of alcohol + petrol	**Score in mpt**	**Total impact**	**% of total damage**	**Result**
10 % alcohol + 90 % petrol	71280 + 1360800	1432080	94.2%	Impact reduces by 5.8%
20% alcohol + 80 % petrol	142560 + 1209600	1352160	88.9%	Impact reduces by 11.1%
30 % alcohol + 70 % petrol	213840 + 1058400	1272240	83.7%	Impact reduces by 16.3%

Then, order of impact –

Petrol > 10 % alcohol + 90 % petrol > 20 % alcohol + 80 % petrol > 30 % alcohol + 70 % petrol

Hence when amounts of alcohol increases the environmental impact reduces. Hence pure alcohol will give minor environmental impact. But it requires more practical work.

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IV. CONCLUSION

Every product damages the environment to some extent. Raw materials have to be extracted, the product has to be manufactured, distributed and packaged. Ultimately it must be disposed of. Furthermore, environmental impacts often occur during the use of products because the product consumes energy or material. If we wish to assess a product's environmental damage, all it's life cycle phases must therefore be studied. The result of this study shows that the petrol has greatest impact on environment than others, the design team should concentrate on the less use of petrol. Instead of petrol alcohol or mixture of both can be used, when amounts of alcohol increases, the environmental impact reduces.

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