LIFE CYCLE ASSESSMENT OF NEEDLE ROLLER BEARING

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Abstract

Bearings are an important element to many machines, as they reduce friction between two objects, allowing moving parts to move more smoothly. Life Cycle Assessment is a useful engine of sustainability manufacturing and gives details of environment impact, created by human activity or product. Today's society is very concern about environment and they put pressure on manufacturing plants, to produce less environment damaging product. This paper aims to measure the effect on the environment created due to cage production of Needle Roller Bearing. This will be achieved through Life Cycle Assessment. It is performed from gate to gate i.e. only for production phase on GaBi software (version 8.7).

Keywords
Life Cycle Assessment (LCA), Bearing, Life Cycle Sustainability Assessment (LCSA) and GaBi.

1. Introduction

In recent year, LCA has become very helpful tools in evaluating the impacts on the environment caused by the product. LCA has performed for any product from cradle to grave i.e raw material acquisition to wastage disposal phase. LCA is interdisciplinary. It's copes with technical, social and natural systems and the relationship among them (Ekdahl 2000).

LCA has been used in many studies as a basic structure to create life cycle sustainability assessment (LCSA) to join the social, economic and environmental aspects of sustainability (Finkbeiner et al.2010, Halog et al. 2011, Hoogmartens et al. 2014, Jorgensen et al. and Weidema 2006). In this LCSA, the life cycle access use to detect the relying on of sustainable components in order stay away from the problem and load of shifting from one part of system to the other (Sala et al. 2013).

At present, the industry experienced the less environmental damaging product principle for producing consumer goods but they continuously pressuring their supplier. Now, the question regarding environment management system is slightly changed to more products related. Product related enhances the LCA tool work and LCA become very popular. LCA is defined as ‘‘a method of determining the total environment impact of a product during its entire life cycle i.e. extraction of raw materials, production, transportation, construction, demolitation and waste disposal and involves a board examination of the service life of the product-a holistic approach’’ (Consoli 1993).

LCA envisage a way which has futuristic outlook. Its objective is to look after the environment factors considering the manufacturing of products, operation of processes and the management of facilities in order to reduce its impact. According to the International Organisation for Standardisation (ISO), LCA consist of four different stages(ISO, 2000):

- Goal and scope definition, in this the intentional requisition and the area of the subject has to be revealed fully;

- Inventory analysis (LCI), where data about the product system is collected and applicable inputs and outputs are measured;
- Impact assessment (LCIA), it change the flows from the inventory into smooth indicators connected to the possible influence associated with it;
- Interpretation phase, the assumption made during earlier stage are evaluated, the final results analyzed and conclusion is drawn.

2. GaBi

GaBi is LCA tool software. GaBi is used for product system modeling (Harrmann and Moltesen 2015). It's a sustainability solution, next generation product with a strong LCA engine. It was launched worldwide in 1992 by PE INTERNATIONAL, Germany. This paper used GaBi 8.7 for product system modeling.

3. Materials and methods

Needle roller bearings consist of small cylindrical rollers and cage. The function of rollers is to reduce friction of a rotating surface and caged are used for supporting loads radial and rotational speed. A cage directs and holds the rollers. If we compare ball bearings and needle roller bearings, needle roller bearing tends to have a large surface area while being in contact with raceway of bearing journals. Bearings provide the rotational freedom and relative positioning while transforming the load (Parth D. 2014). Caged arrangement usually comes in single and double row arrangement, having a board variation of materials likes aluminum, steel and plastic.

In this paper, the LCA is done on single row steel cage of needle roller bearing. Steel cages possess excessive power and have a minimum weight with occupy small area and allow required supply of lubricant in the bearing (SKF 2001).

LCA is an organized research practice and it assembles the environment impact of product system from raw material procurement to waste utilization (ISO 14040 2006). The main objective is to quantity the environment impact created by cage of Needle Roller Bearing from gate to gate i.e. production phase. LCA of production phase of cage is analysis on GaBi software (version 8.7)

The functional unit is 0.008 Kg of a cage, which will undergo the different processes and cage is obtain from steel tube.

3.1 Steel tube Production

Steel tube is made of raw steel and first this raw steel is cast into some workable form. For manufacturing cage, ST35 carbon steel pipe are used. ST35 carbon steel pipe has elevated content of carbon, where it is heat-resistant alloy, by means of excellent bending, corrosion resistance, welding performance, long-lasting organizational stability, high strength, cold deformation ability is exceptionally good.

3.2 Cage Production

In cage production, first operation is parting where steel tube cuts into required dimension (35X18) mm. After parting washing takes place, where steel tubes are washes with chemical solution. Chamfering is carried out on steel tube. Expansion takes place in steel tube with use of expansion hydraulic machine; this will give first shape of required cage. Most important manufacturing process for cage is piercing, where slots are created for placing needle. Next process is to make smooth finishing by giving face grinding and outer diameter grinding processes. After tumbling process, hardening process is carried out; this helps to increase the hardness of the cage. Again washing takes place. Tempering is used to increase the toughness of cage. Tempering is commonly done after hardening to reduce excess hardness. The last process is blackening; cage is placed in the solution of salt and water for half an hour to add mild corrosion resistance, for presence and to reduce light reflection.

The system boundary of Needle Roller Bearing is given on Fig.1

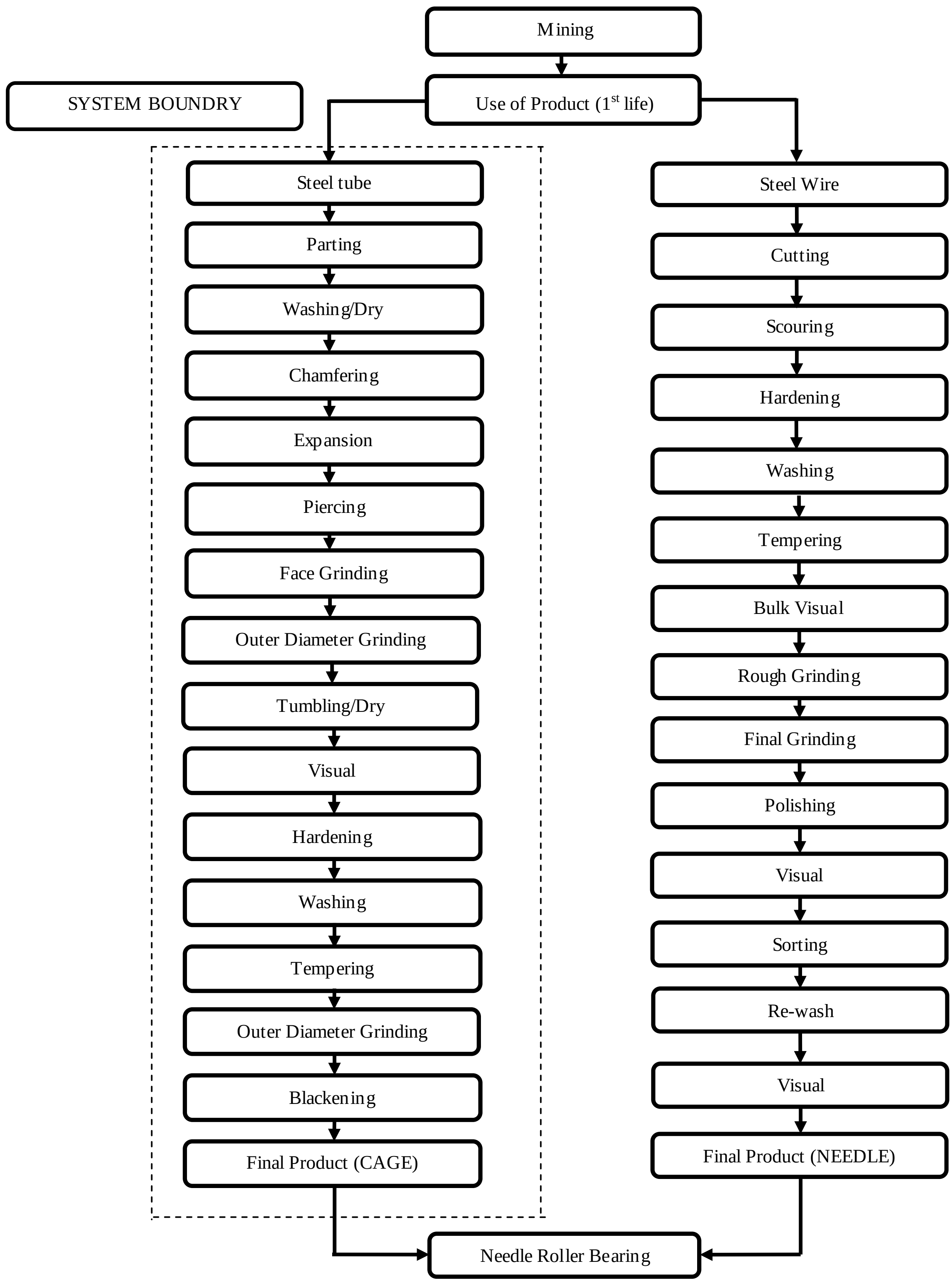

Fig.1:- System boundary of the Needle Roller Bearing
(System Boundary of cage production is marked in dash line)

Data are taken from industry for the system boundary of a cage production. Model has been established by using a GaBi 8.7 software system and chooses LCIA-CML 2015 for the calculation of global warming potential, etrophication potential and acidification potential result.

3. Results and discussion

3.1 Life Cycle Inventory

Table: 1:-Inventory of material and energy data.

Process	Input		Output	
Parting	Steel tube	0.017kg	Steel tube	0.016kg
	Lubricant	0.000096kg	Lubricant	0.000096kg
	Electricity	0.0036kWh	Steel chips	0.001kg
Washing	Steel tube	0.016kg	Steel tube	0.016kg
	Water	0.02kg	Water	0.02kg
	Sodium hydroxide	0.4kg	Sodium hydroxide	0.4kg
	Diesel	0.43kg	Diesel	0.43kg
	Electricity	0.75kWh		
Chamfering	Steel tube	0.016kg	Steel tube	0.0155kg
	electricity	0.0047kWh	Steel chips	0.0005kg
Expansion	Steel tube	0.0155kg	steel tube	0.0155kg
	CTC oil	0.01kg	CTC oil	0.01kg
	Electricity	0.125kWh		
Piercing	Steel tube	0.0155kg	Cage	0.01kg
	Lubricant	0.00259kg	Steel chips	0.0055kg
	Electricity	0.00358kWh	Lubricant	0.00259kg
Face grinding	Cage	0.01kg	Cage	0.009kg
	Lubricant	0.0009kg	Steel chips	0.001kg
	Electricity	0.0008kWh	Lubricant	0.0009kg
Outer diameter grinding	Cage	0.009kg	Cage	0.008kg
	Lubricant	0.0009kg	Steel chips	0.001kg
	Electricity	0.0008kWh	Lubricant	0.0009kg
Tumbling	Cage	0.008kg	Cage	0.008kg
	Water	0.02kg	Water	0.02kg
	Sodium hydroxide	0.4kg	Sodium hydroxide	0.4kg
	Electricity	0.75kWh		
Visual	Cage	0.008kg	Cage	0.008kg
Hardening	Cage	0.008kg	Cage	0.008kg
	Quenching oil	0.02kg	Quenching oil	0.02kg
	LPG	66.825kg	Water	10kg
	Methanol	2250kg		
	Water	10kg		
	Electricity	4.125kWh		

Washing	Cage Water Electricity	0.008kg 0.02kg 0.75kWh	Cage Water	0.008kg 0.02kg
Tempering	Cage Electricity	0.008kg 0.75kWh	Cage	0.008kg
Outer diameter grinding	Cage Lubricant Electricity	0.008kg 0.0009kg 0.0008kWh	Cage Steel chips Lubricant	0.007kg 0.001kg 0.0009kg
Blackening	Cage Salt Water Electricity	0.007kg 0.05kg 0.5kg 0.955kWh	Cage Salt Water	0.008kg 0.05kg 0.5kg

Table: 1 gives details data of the input and output for different process. This cage is produced from 14 different manufacturing processes.

3.2 Life Cycle Assessment Result

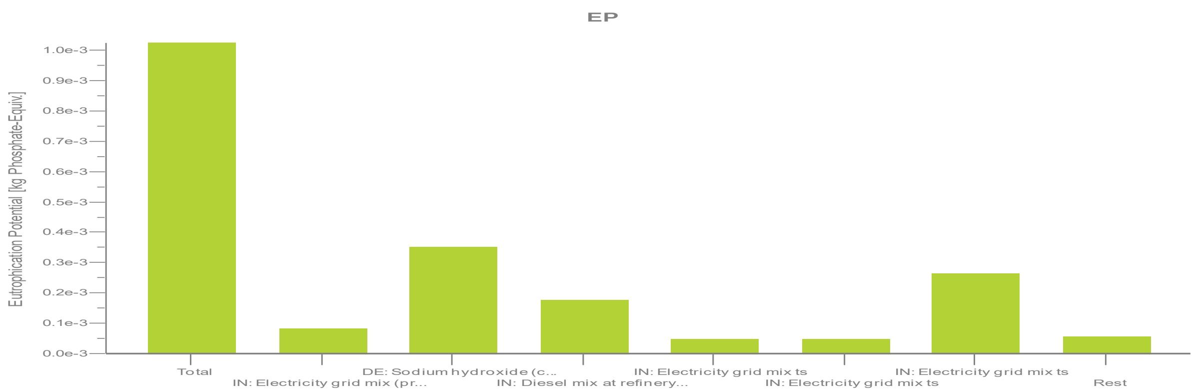

Fig.2:-Etrophication Potential

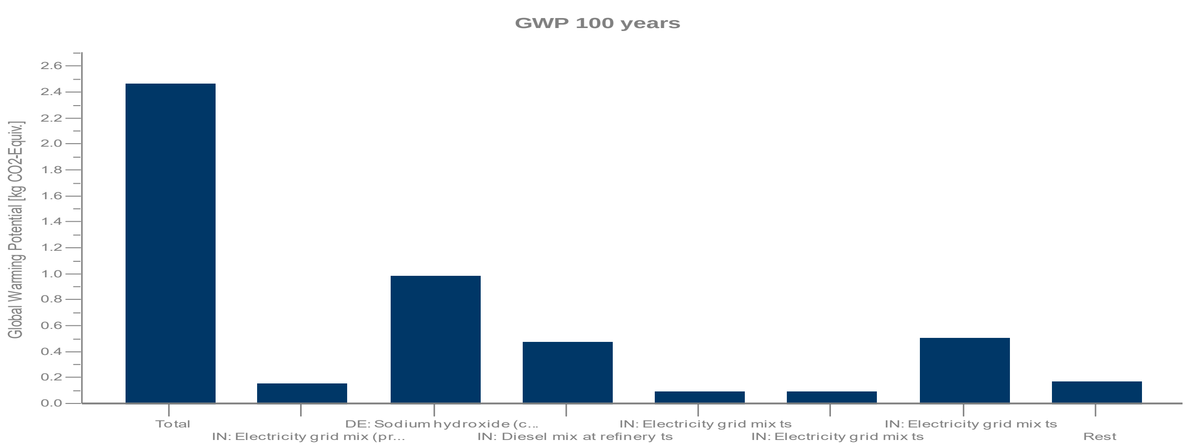

Fig.3:-Global Warming potential

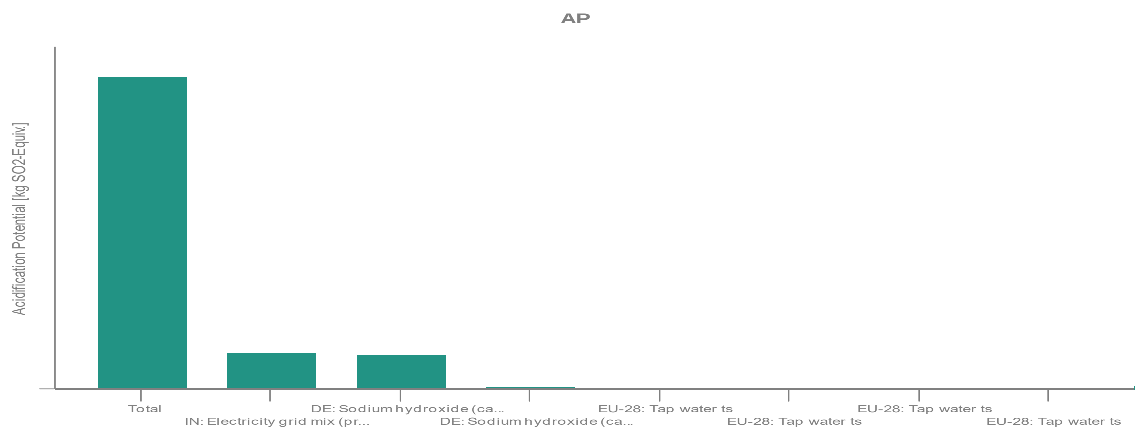

Fig.4:- Acidification Potential

Table: 2:- Result Analysis

	Life Cycle Cage Inventory Impact (Absolute Value)	Sodium Hydroxide (Absolute Value)	Life Cycle Cage Inventory Impact (Relative Contribution)	Sodium Hydroxide (Relative Value)
Flows	**1.32E004**	**3.84E003**	**100%**	**29.1%**
Resource	**6.56E003**	**1.89E009**	**49.7%**	**14.3%**
Deposited goods	**8.21**	**4.43**	**0.0622%**	**0.0335%**
Emission to air	**48.9**	**24.7**	**0.371%**	**0.187%**
Emission to fresh water	**6.57E003**	**1.92E003**	**49.8%**	**14.5%**
Emission to sea water	**4.49**	**2.42**	**0.0341%**	**0.0184%**
Emission to agricultural soil	**-1.14E-006**	**-1.09E-006**	**-8.68E-009%**	**-8.23E-009%**
Emission to industrial soil	**9.78E-006**	**8.96E-006**	**7.41E-008%**	**6.79E-008%**

Table: 2 gives complete result details. The main environment impact contributor is indicating in red colour. Cage production give negative impact to the environment due to the quantity of the chemicals used in washing and tumbling process, chemical such as NaOH, Na_2CO_3, C_2Na_2.
Two flows i.e. resources and emissions to fresh water are major source for negative impact to the environment. They Contribute 99.5% for complete cage production process. The main source for resources and emission to fresh water for creating environmental damage is sodium hydroxide, 29.1%. of total contribution.
For calculating global warming potential, etrophication potential and acidification potential result, we take LCIA-CML 2015 and the result gives:

- Global Warming Potential, total amount is 2.46 kg CO_2 equivalent.
- Etrophication Potential, total amount is 1.02e-3 kg phosphate equivalent.
- Acidification potential, total amount is 0.0169 kg SO_2 equivalent.

The main affecting factor for global warming potential and etrophication potential is caustic soda that contains 0.985 kg CO_2 equivalent for global warming and 0.356e-3 kg phosphate equivalent for etrophication potential. Affecting factor for acidification potential is electricity that contains total of 0.00626 kg SO_2 equivalent.

4. Conclusion

This research work presents a complete LCA of cage production, using GaBi 8.7 LCA tool software. The results show various environmental impact factors. The major roll for negative impact on environment is sodium hydroxide, which is directly discharge into fresh water. Washing and tumbling process is the main responsible process that contain major portion of sodium hydroxide, after coming out form these two process the solution of sodium hydroxide must go in waste water treatment plant before discharging into fresh water.

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