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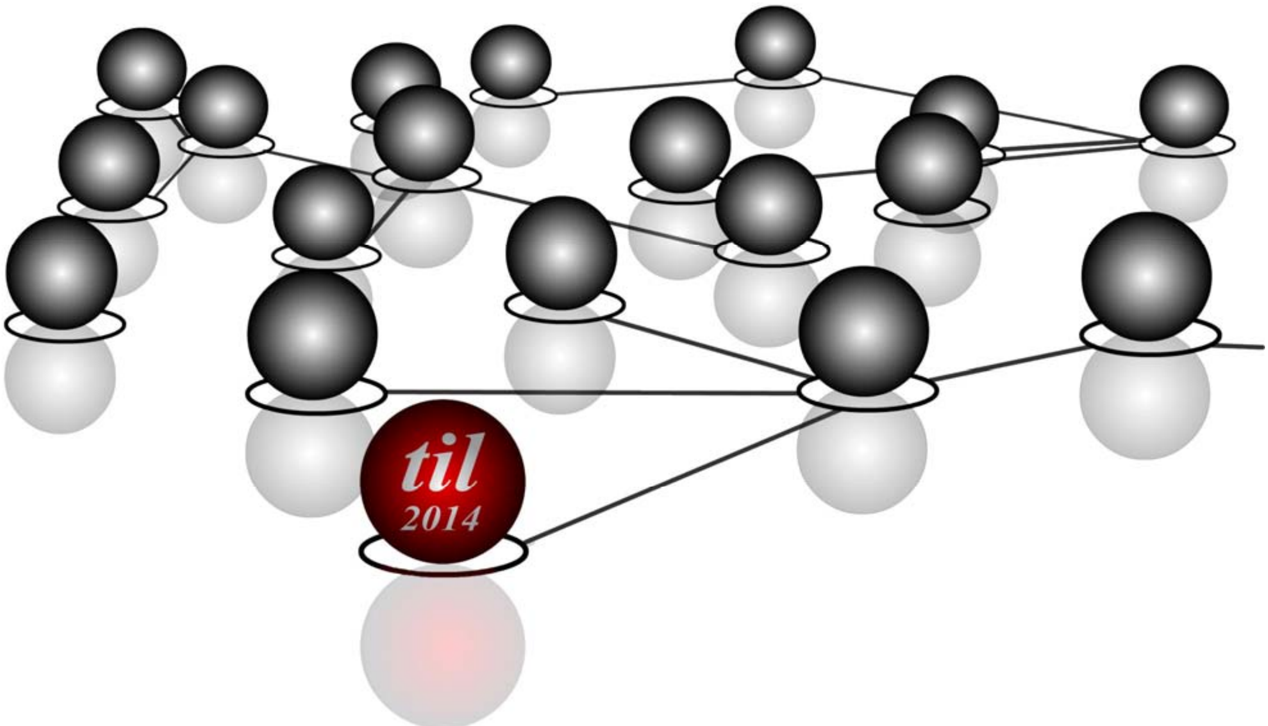

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SIMPLIFIED LIFE CYCLE ASSESSMENT OF BELT CONVEYOR DRIVE PULLEY

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Abstract

This simplified Life Cycle Assessment (LCA) of belt conveyor drive pulley is part of complete LCA study of belt conveyor and it will be used for establishment of methodology for conducting LCA studies of Bucket Wheel Excavator (BWE) or similar types of belt conveyors. Drive pulley as all other belt conveyor pulleys is considered as part of belt conveyor system that doesn't need electricity to fulfill its function. The only component of belt conveyor system that actually consume electricity is electric motor (EM). Drive pulley is analyzed with Ecodesign Assistant (EA) and Ecodesign PILOT (EP) software tools. Analysis had shown that drive pulley manifest the biggest impact on the environment in raw materials stage of its life cycle. Accompanying EP strategies suggested possible product improvements.

***Keywords**: Life Cycle Assessment, Bucket Wheel Excavator, Belt Conveyor Drive Pulley.*

1. INTRODUCTION

Purpose of this paper is to provide basis for conducting simplified Life Cycle Assessment (LCA) of variety of different pulleys as well as basis for their mutual comparison. Simplified LCA is conducted with Ecodesign Assistant (EA) and Ecodesign PILOT (EP) software tools. These software tools and terms such as life cycle, LCA and product types are explained in [1, 2].

2. DESCRIPTION OF THE PRODUCT

Bucket wheel excavator (BWE) 1201 belt conveyor drive pulley main components are drum, bearings and shaft, see fig. 1.

Fig. 1 BWE 1201 belt conveyor drive pulley

Drive pulley flange is not considered in this study. If it is necessary flange can be modeled as steel part and be aded to steel parts.

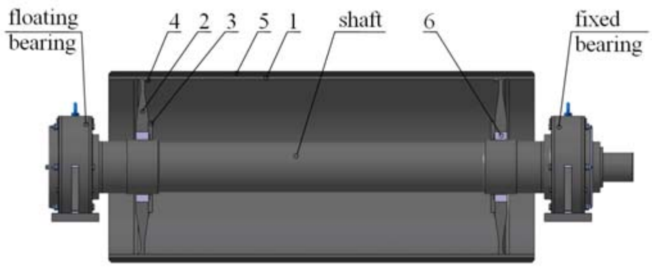

Fig. 2 Drum cross section

Drum assembly, shown in fig. 2 is consisted of 6 parts which are listed in table 1. Position numbers of the parts in table 1 are in correlation with fig. 2.

Table 1 Drum assembly parts list

Pos.	Part name	Mass [kg]	Material	Quantity
1	Rim	550.9	Steel (S335J2G3)	1
2	End disc	102.0	Steel (S335J2G3)	2
3	Ring	24.0	Steel (S335J2G3)	2
4	Positioning plate	0.3	Steel (S335J2G3)	6
5	Rubber lagging	156.8	Rubber	1
6	Flexible locking device	12.2	Steel	2

From aspect of ecodesign there is a small difference between fixed and floating bearing. Differences are in construction of bearing housing external covers, rotary seals and extra bushing in case of fixed bearing.

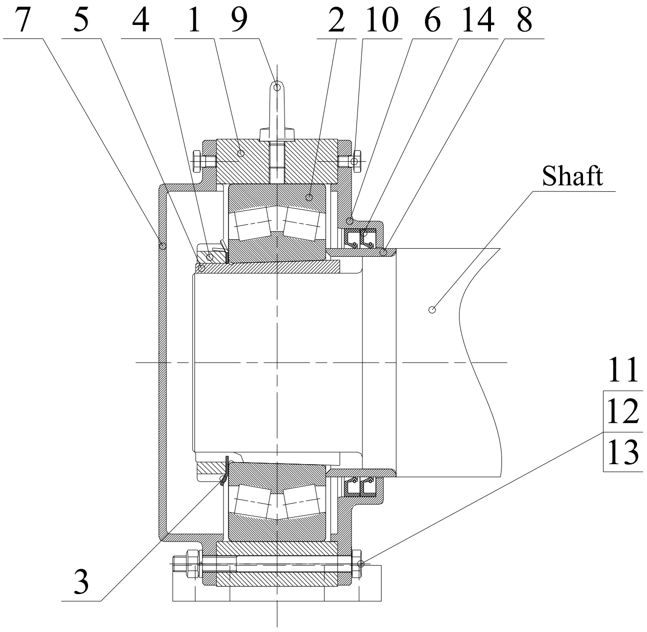

Fig. 3 Floating bearing

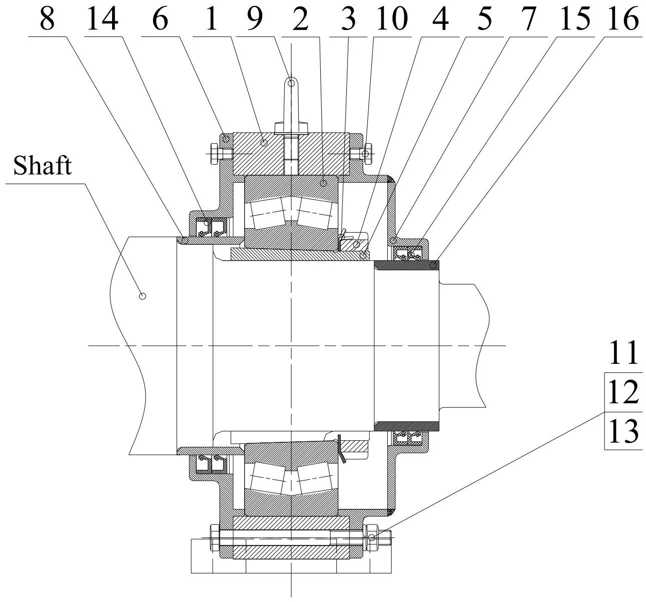

Fig. 4 Fixed bearing

Floating bearing shown in fig. is consisted of 14 parts listed in table 2. Lubricating nipple is neglected due to different lubrication method retrieved from [2].

Table 2 Floating bearing parts list

Pos.	Part name	Mass [kg]	Material	Quantity
1	Welded housing	131.8	Steel (S335J2G3)	1
2	Roller bearing SKF 22240 CCK/W33	42.5	Steel	1
3	Locking washer MB 40	0.293	Steel	1
4	Locknut KM 40	3.7	Steel	1
5	Adapter sleeve H3140	12.1	Steel	1
6	Housing cover – internal	14.1	Steel (S335J2G3)	1
7	Housing cover – external	15.6	Steel (S335J2G3)	1
8	Bushing	3.07	Steel (CK45)	1
9	Lifting eye bolt	0.3	Steel Zn (C15E)	1
10	Screw M12x16	0.03	Steel Zn	6
11	Bolt M16x180	0.32	Steel Zn	6
12	Nut M16	0.04	Steel Zn	6
13	Washer A16	0.01	Steel Zn	6
14	Rotary seal BA Simrit 230x270x16	0.1	Rubber	2

Fixed bearing shown in fig. 4 is consisted of same parts as floating bearing except diffrent constuction of external cover of bearing housing, aditional rotary seals BA simrit 180x210x15 and aditional bushing. Contituent parts of fixed bearing are listed in table 3.

Shaft is single material part made of steel 42CrMo4 and its mass is 751.30 kg. It is produced by forging. Steel 42CrMo4 is recognised as High Alloyed Steel in EA material class table.

Table 3 Fixed bearing parts list

Pos.	Part name	Mass [kg]	Material	Quantity
1	Welded housing	131.8	Steel (S335J2G3)	1
2	Roller bearing SKF 22240 CCK/W33	42.5	Steel	1
3	Locking washer MB 40	0.293	Steel	1
4	Locknut KM 40	3.7	Steel	1
5	Adapter sleeve H3140	12.1	Steel	1
6	Housing cover – internal	14.1	Steel (S335J2G3)	1
7	Housing cover – external	15.6	Steel (S335J2G3)	1
8	Bushing	3.07	Steel (CK45)	1
9	Lifting eye bolt	0.3	Steel Zn (C15E)	1
10	Screw M12x16	0.03	Steel Zn	6
11	Bolt M16x180	0.32	Steel Zn	6
12	Nut M16	0.04	Steel Zn	6
13	Washer A16	0.01	Steel Zn	6
14	Rotary seal BA Simrit 230x270x16	0.1	Rubber	2
15	Rotary seal BA Simrit 180x210x15	0.074	Rubber	2
16	Bushing	1.21	Steel (CK45)	1

Product life time is estimated to be 5 years, according to [2] and functional unit is defined as "transferring rotation of the shaft to translation of the belt at 3,9 m/s speed and load bearing".

3. ANALYSIS IN ECODESIGN ASSISTENT

Prior to conducting analysis in EA and EP simplifications similar to those made in [2] had to be done. All drive pulley parts are grouped according to table 4.

Table 4 Simplified parts list

Product Part	Mass [kg]	Material	Class
Steel parts	1252	Steel	III
Steel Zn parts	5.5	Steel Zn	IV
High Alloyed Steel parts	751.3	Steel High Alloyed	VI
Rubber parts	157.35	Rubber	IV

Parts made of same or similar material are treated as one part. Process energy needed for manufacturing each of the parts is taken into account. Material class for grouped parts is determined based on predominant material relative to classification of different materials provided by EA.
Roller bearing SKF 22240 CCK/W33, marked with number 2 in fig. 3 and fig. 4 is treated as a single part predominantly made of steel. Becides roller bearings steel parts obtain parts marked with numbers 1, 3, 4, 5, 6, 7, 8 and 16 in fig. 3 and fig. 4 and parts marked with numbers 1, 2, 3, 4, and 6 in fig. 2.
Steel Zn parts are consisted of parts marked with numbers 9, 10, 11, 12, 13 in fig. 3 and fig 4.
High Alloyed Steel parts are consisted of single part – shaft.
Rubber parts are consisted of parts marked with number 5 in fig. 2 and with numbers 14 and 15 in fig. 3 and fig. 4.
Main manufacturing methods of material processeing for this product are machining, forging, welding and injection moulding. Specific energy consumption (SEC) for these processes is obtained from [3, 4, 5]. Calculated energy for all of those processes was 9196 MJ. Waste genarated in production phase is estimated to be 10% of part mass. According to this assumption there is generated 113.6 kg of steel scrap and 15.7 kg of rubber scrap. Energy for heating and lighting is estimated as moderate. Percentage of external parts was 30-60%. Since all external parts are obtained from manufacturers situated in vicinity of the production facility, their hauling distance per unit is determined as "rather short".
Production facility is situated approximately 20 km from location of product's utilization. Chosen means of transportation is truck.
Use frequency of BWE 1201 belt conveyor drive pulley is defined as number of working days per year. According to data obtained from product user there are 325 working days per year. Electric energy input is not needed for drive pulley service. The only component of conveyor that consume electric energy is electric motor. Analysis of electric motor is not covered with this study. As in [2] FOR LPD 2 lubricating grease is treated as auxiliary material in product use stage. Amount of lubricant per use is calcualted and scaled according to [2]. It's calculated input per use was $8.4 \cdot 10^{-3}$ kg. Lubricant is consisted of Li-soap and mineral base oil. It is recognized as environmentally hazardous material and classified as material class V.
Drive pulley is being partially recycled at the end of it's life. Steel parts and High Alloyed Steel parts are being reused. Other parts are being disposed off or returned to the manufacturer.
Analysis carried out in EA identified idler roller as basic type A product, that is raw material intensive product. Following improvement strategies were recommended.
Main recommended strategies were:

- "reducing material inputs" and

Recommended strategies with lower priority which are to be realized later were:

- "selecting the right materials",
- "optimizing product use",
- "optimizing product functionality",
- "increasing product durability",
- "improving maintenance",
- "improving reparability",
- "improving disassembly" and
- "reuse of product parts".

One additional recommended strategy was "ecological procurement of external components".

4. ANALYSIS IN ECODESIGN PILOT

Improvement strategies provided by EA are further considered within EP. They are not presented in this paper particularly. Instead, they are discussed as tasks, measures and recommendations which are to be conducted in order to improve product's functionality and energy efficiency, as well as environmental performance.
As FOR LPD 2 lubricant is considered environmentally hazardous improvement of its environmental performances was considered and explained in [2]. There was recommended use of lubricants with renewable base oils and new concept of ionic liquid based lubricants. There was recommended use of energy-saving bearings and use of remanufacturing service for bearings also.
EP suggested possible utilisation of recycled steel for manufacturing steel parts of drive pulley. Having in mind that SEC for virgin steel production is much greater than SEC for recycled steel production, significant energy saving could be achieved by using recycled steel for steel parts manufacturing.
As steel parts are being refurbished or reused recycling rate could be maximised even more by recycling rubber parts.
Surface of the drum in contact with belt is exposed to soiling. To prevent formation of material buildup on the drum surface there can be utilised belt cleaners.
Since drive pulley components are locally available, transportation and its influence is reduced to minimum.

5. CONCLUSION

It has been shown that particular issues considered within this paper were already considered in [2]. Among these issues were environmentally friendly lubricants, energy saving bearings, material buildup and wear reduction, transportation of external parts and end of life options. Analysis in EP has shown that energy and consequently cost savings as well as environmental improvements could be accomplished by conducting provided recommendations. Conducting this type of LCA for different types of pulleys can provide significant base for analyzing environmental performances of the BWE conveyor pulleys in general. With more conducted LCAs there could be made pattern for analyzing pulleys in general and there can be recognized main issues which could occur during conveyor pulley utilization. Thus there can be suggested adequate solutions for these issues and achieved more energy efficient and more environmentally friendly utilization of conveyor pulleys.

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