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PRODUCTION TECHNOLOGIES AND ENGINEERING

SIMPLIFIED LIFE CYCLE ASSESSMENT OF A RETURN BELT CONVEYOR IDLER

Miloš Đorđević[1], Nenad Zrnić[2], Milorad Pantelić[3]

Summary: *Prior to conducting complete life cycle assessment of the bucket wheel excavator's belt conveyor, simplified life cycle assessment of its components has to be done. One of these components is return belt idler support 0°, which consists of idler support and three rollers. Simplified life cycle assessment of the idler roller is conducted with Ecodesign Assistant and Ecodesign PILOT tools. Conducted analysis has shown that the most significant stage of the idler roller life cycle is raw materials stage. Suggested strategies provide possible improvements towards more environmentally friendly and energy efficient idler roller design.*
Keywords: *idler roller, life cycle assessment, ecodesign assistent, ecodesign PILOT.*

1. INTRODUCTION

Bucket wheel excavators (BWE) are considered as the machines of great relevance for any open pit coal mining system. Since BWEs are large scale energy consumers any improvement in energy efficiency or energy saving is considered as significant contribution to sustainability. Refer to [1] for terms such as sustainability, sustainable development, energy efficiency and energy saving. Investigations of possibilities for potential improvements in energy efficiency of BWE are conducted using life cycle assessment (LCA). LCA is an analysis of environmental impacts based on entire life cycle of a product. In accordance with the 14040 series of ISO standards, life cycle of a product is consisted of 5 stages: raw material, production, distribution, product use and end of life. This research is focused on belt conveyor systems of the BWE SchRs 350. In order to perform complete LCA of the BWE belt conveyor, simplified LCA of its components has to be done. Main components of the belt conveyor are belt, drive, pulleys, carrying and return idlers, take-up device and belt cleaners. Return belt idler support 0° presented here consists of three rollers and idler support. Idler support is made of steel and is a part of steel structure of the BWE belt conveyor. Therefore, it will not be considered within this paper. Simplified LCA of the idler roller is conducted with Ecodesign Assistant (EA) and Ecodesign PILOT (EP)

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tools [2]. EA and EP are used to identify relative environmental impact of a product. Basic type of a product is determined according to the most significant stage of its life cycle. Relative to life cycle stages there are 5 basic types of the product: type A – raw material intensive product, type B – manufacture intensive product, type C – transportation intensive product, type D – use intensive product and type E – disposal intensive product. In adition, ecodesign measures with greatest potential for improving the product are provided by EP in accordance with identified product type. Purpose of this study is to establish methodology for different idler types analysis and guidelines for conducting complete LCA analysis of entire belt conveyor.

2. DESCRIPTION OF THE PRODUCT

Idler roller shown in Fig. 1 consists of 15 different parts, listed in Table 1. It's lifetime is estimated to be 5 years based on selected bearings, calculated working hours per year and required belt speed, refer to Table 2.

Functional unit of the idler roller is defined as: "Carrying and aligning conveyor belt at 500 rpm rotational speed for 30000 h".

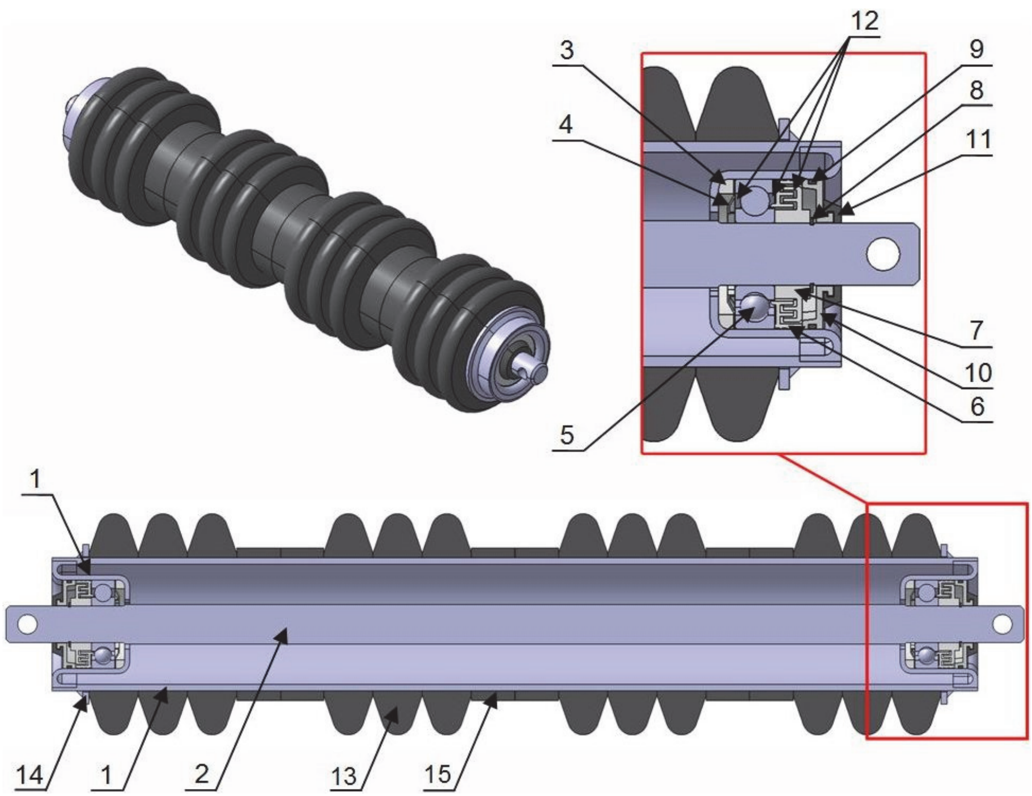

Fig. 1 *Return belt idler roller with containing parts*

Table 1 *Return belt idler roller parts list*

Part No.*	Part Name	Qty	Standard	Material	Size	Weight
1	Rollershell	1			Ø108x5x750	10.8 kg
2	Axle	1		C22	Ø32x825	5.05 kg
3	Distance Ring	2		PETP	Ø72/Ø58x7.2	0.02 kg
4	Seal ring	2		PA6	Ø72/Ø39x4	0.01 kg
5	Roller bearing	2	6306 C3 DIN 625	Precast	Ø72/Ø30x19	0.7 kg
6	Inner labyrinth	2		PP MA-4	Ø72/Ø45x13	0.022 kg
7	External labyrinth	2		PA-6 GF30	Ø65/Ø30x17	0.06 kg
8	Retaining ring	2	DIN 471	Precast	30x1.6	0.01 kg
9	O-ring	2	Int.Stand.PPT.FS1.0002	50 NBR 10.1	Ø67.2x3	0.02 kg
10	Cover	2		PP	Ø72/Ø30x15	0.05 kg
11	Rubber cap	2		Rubber	Ø53/Ø35x9	0.016 kg
12	Lubricating grease	2	FOR LPD-2			0.12 kg
13	Rubber ring	12		Rubber	Ø180x40	7.8 kg
14	Adjacent ring	2		S235JRG2	Ø130/Ø110x5	0.24 kg
15	Distance ring	6		Rubber	Ø124x35	0.84 kg

* For Part No. refer to Fig. 1

Table 2 *Bearing lifetime calculations data*

Belt speed	Working days/year	Working hours/day	Working hours/year	Calculated bearing lifetime [years]
3.5 m/s	325	20	6500	6.23
4 m/s				5.45

3. ANALYSIS IN ECODESIGN ASSISTENT

Prior to conducting analysis in EA and EP some simplifications had to be made. 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. Idler roller parts and groupped in accordance with material they are made of. Number of parts is reduced from 15 to 4, refer to Table 3. Material class for the new parts is determined based on predominant material relative to classification of different materials provided by EA.

Table 3 *Simplified parts list*

Part No.	Part Name	Parts included	Predominant Material	Weight	Material Class
1	Steel parts	Rollershell, axle, roller bearing, adjacent ring, retaining ring	Steel (low-alloy)	16.8 kg	III
2	Rubber parts	O-ring, distance ring, rubber ring, rubber cap	Rubber	8.676 kg	IV
3	Polyamide parts	Seal ring, external labyrinth	PA-6 GF30	0.07 kg	V
4	Polypropylene parts	Distance ring, inner labyrinth, cover	PP	0.092 kg	IV

Roller bearing type 6306 C3 DIN 625 is treated as a single part predominantly made of steel. O-ring is made of 50 NBR 10.1, where NBR stand for nitrile butadiene rubber. It is recognized as class IV material, along with other rubber compounds. Polyamide parts are predominantly made of PA-6 GF30, which is 30% glass fibres reinforced polyamide-6. Polypropylene parts are predominantly made of polypropylene (PP). Polyethylene terephthalate polyester (PETP) is recognized as class IV material, along with PP. FOR LPD 2 lubricating grease is treated as auxiliary material in product use stage.

Steel parts manufacturing included cold rolling, drawing, machining and welding. Data for such processes are obtained from [3],[4]. Calculated production energy for steel parts is 52 MJ. Rubber and plastics parts are injection molded. Most common machines used for injection molding are of hydraulic type with specific energy consumption (SEC) of 19.0 MJ/kg [5]. Production energy for injection molded parts was 168 MJ. Therefore, overall energy input for manufacturing one idler roller is calculated to be 220 MJ. Waste in manufacturing processes is estimated to be 10% of a product's mass. Energy for heating and lighting is estimated as moderate. Idler roller is being partially recycled at the end of it's life. Steel parts are being reused. Other parts are being disposed off or returned to the manufacturer. Production volume for new idler rollers was 80000 peaces/year and 20000 peaces/year for repaired idler rollers [6]. Percentage of external parts was 80%. 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 located about 10 km from the open pit mine. Manufactured idler rollers are being transported by truck. Use frequency of idler roller is defined as number of working days per year. Electric energy input is not needed for idler roller service. FOR LPD 2 lubricating grease is recognized as environmentally hazardous material. It's calculated input per use was $4 \cdot 10^{-4}$ kg.

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
- "recycling of materials".

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 already mentioned FOR LPD 2 lubricant is considered environmentally hazardous. Typical lubricating grease is contained of base oil, thickener and additives. This particular lubricant is consisted of mineral base oil and Li-soap as thickener [7]. Recent researches had shown that mineral oil based lubricant can be replaced with vegetable oil based lubricant resulting in similar or even better tribological and better environmental properties at the same time [8], [9]. New concept of ionic liquid based lubricants demonstrated superior tribological and environmental properties over conventional lubricants [10].

Idler roller bearing dynamic loads can be substantially reduced by carrefully choosing elastic and viscous characteristics of the damping components used in the support bearing design [11].

Another way to achieve energy savings is utilisation of energy-saving bearings, for example SKF E2 type [12]. They reduce frictional moment by 30% compared to SKF standard bearings. They also reduce lubricant use and therefore reduce negative environmental impact. Besides that, SKF provides remanufacturing services for their bearings which results in saving 90% of the energy used to manufacture new ones.

Steel parts are being refurbished or recycled. Recycling rate could be maximised by recycling rubber and plastics parts. The higher the recycling rate the greater the benefit for the environment and, what is more important, the higher economical efficiency of the overall process of refurbishing and/or recycling [2]. Having in mind that SEC for virgin steel production is 31 MJ/kg and SEC for recycled steel production is 9 MJ/kg [13], great energy saving could be achieved by using recycled steel for steel parts manufacturing. Demand on recources and waste production can be reduced by using recycled materials also. Components could be labeled to indicate remaining service life. That way it can be determined if component is or not suitable for reuse in refurbishing a product [2].

Return idler rollers are extremely exposed to soiling. Therefore, they are equipped with rubber rings for the purpose of preventing material buildup forming on the rollershell surface. Rubber rings are subjected to high wear. Thus, investigation of different materials antiwear properties might be wort of effort for the purpose of prolonging rings' life.

Since roller's components are locally available, transportation is reduced to minimum. The only component that is obtained from distant supplier is retaining ring. However it is shipped in a batch within the cardboard box packaging. Therefore, transportation influence per pair of retaining rings can be neglected.

5. CONCLUSION

Particular issues considered within this paper 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. Complete LCA analysis is needed to provide more precise data and better recommendations and solutions. Therefore, further research will be focused on investigation of different types of carrying and return idlers, belt construction, drive systems and accessories.

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