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Research on tightness loss of belt conveyor's idlers and its impact on the temperature increase of the bearing assemblies

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A R T I C L E I N F O

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A B S T R A C T

The temperature of idlers' bearing assemblies is the basic indicator of their technical condition. The main aim of this article is to present the impact of decreased tightness of the conveyor belts' idlers which results in the higher temperature of bearing assemblies, which in turn is the main factor influencing their level of durability.

This article includes research methodology of idlers, which was designed to determine the direct impact of lower tightness of bearing assemblies, at a determined load, on the temperature of bearing assemblies.

Research results are presented in the form of dependence of ΔT temperature increase, in t time function, and at the determined F radial load. The characteristics set during the tests included the temperature of bearing assemblies and were analysed in terms of the possible or potential risk of bearing assembly seizure.

The research carried out showed the significant impact of load on the temperature increase of bearing assemblies. Constant recording of temperature increases and the nature of changes allowed conclusions to be drawn concerning the seizure of bearings or idler's seals.

A thermographic (infrared) camera enabled pivotal areas located in the bearing assembly to be determined, which may indicate the seizure, and helped to present thermography images showing the distribution of the temperature in the idler which occurred during testing.

1. Introduction

A typical belt conveyor travel path consists of a load-bearing element, usually in the form of trestles, brackets, and idlers designed to support, carry and shape the hollows of the conveyor belt. Idlers are rotary structural elements divided into two basic types: carrying (upper) and return (bottom).

The bearing mounting in carrying idlers is based on proper inner-bearing mounting of the idler hub which rotates around a stationary axis. Ball bearings are mainly used for bearing mounting of idlers.

The durability of idlers (Antoniak, 2007) depends on numerous construction, engineering and operational factors. In practice, idler bearings are often damaged due to wear and tear, jamming or seizure. The main symptoms of damage to idlers include: the temperature increase of bearing assemblies (statistically the most common symptom), increased noise emissions and vibrations.

Durability of idlers largely depends on the seal of bearing units (Gladysiewicz & Helten, 2011, p. 2; Gładysiewicz, 2012). Currently, clearance non-contact seals (mainly labyrinth) and their varieties (Reicks Allen, n.d.; SKF Non-contract labyrinth seals, n.d.) are the most common product of this type on the market (Marcinkowski & Kondura, 2008). Fig. 2 below presents an exemplary design of a typical labyrinth seal.

The clearance seal used in the above project has a labyrinth design and is made of flame-resistant plastics. The labyrinth seal presented in Fig. 1 is comprised of two interlocking elements, indicated with red and green. The height of the troughs between the two elements generally ranges from 0.5 to 0.7 mm. According to the results of a test on idler sealing (Pytlik, 2014) carried out, for the certification of products, by the Department of Mechanical Devices Testing of the Central Mining Institute, the seals do not ensure proper water-tightness but, nevertheless they are sufficient for effective protection against dust, provided that a suitable coupling

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grease, which guarantees long-term adhesion to the labyrinth walls, is applied.

Other types of seals are also used, such as contact seals (e.g. lip seals) (SKF Contact seals, n.d.; SKF sealing solutions, n.d.). Lip seals are very sensitive to impurities penetrating the area between the axis of the idler and the sealing lip. This often results in significant idlers rotational resistance and a consequent increase in the temperature of the bearing assembly. In extreme cases, the excessive increase of the temperature of bearing assemblies may cause seizure and jamming of the idler, which in turn increases the risk of the self-ignition of a conveyor belt.

Other types include seals based on ferrofluids (Król, 2013) and a hybrid, labyrinth and lip design (Antoniak, 2007).

Fig. 2 presents a design of a three-element hybrid (labyrinth-lip) seal based on a model created by GIG, no. PL 67749 Y1.

It is comprised of a labyrinth seal (set in a hub) made of stainless steel (a), which at the same time provides protection to the outer lip sealing (b) filled with grease; the sealing lip directly interacts and operates with the stainless case (c).

As confirmed by studies, this construction stiffens and strengthens the bearing assembly improving its resistant to radial loads, and protects the lip sealing from deterioration due to the increased friction caused by corrosion products present on the idler's axle during operation.

The idlers whilst in use are subjected to the negative influence of pollution, aggressive water and variable loads that impact bearing assemblies, and are a cause of increased idlers rotational resistance, which directly affects temperature.

There are a number of papers concerning the research of idlers conducted both in laboratories and in situ conditions (Gładysiewicz, 2003; Gładysiewicz, Orzeł, & Noga, 2012; Król, 2013; Król, Jurdziak, & Gładysiewicz, 2008).

The work presented by Król et al. (2008) includes research results carried out by Riley which covers 10,000 idlers and a range of temperature monitoring based on an infrared measurement method. This work evaluates idlers according to the values of their operational temperature. If an idler's temperature is higher than the temperature of the environment by:

- 5 °C – the idler is assumed to be defective,
- 15 °C – the idler is considered unrepairable and should be replaced immediately.

Król in the same paper (2008) presents also the results of work carried out by POLTEGOR-Institute (Jonkisz et al., 1996) also provided results of diagnostic research on mining idlers. The research was carried out in KWB Turów and KWB Konin, open-pit lignite coal mines. The criteria for thermal evaluation of idler conditions are formulated according to $T_{allow,}$ allowable temperature:

$$T_{allow} = T_{amb} + 25, \,^{\circ}\mathrm{C}$$

where:
T_{allow} – allowable temperature, °C.
T_{amb} – ambient temperature, °C.

Allowable increase of idlers' temperature was presented by Gładysiewicz (2003):

$$T_{allow} = T_{amb} + 20, \,^{\circ}\mathrm{C}$$

Thermal emission tests using infrared thermometers (pyrometers) and infrared cameras are easy to conduct and effective. Thermography enables the monitoring of belt conveyors to be carried out and the detection of dangerous areas which may be the cause of fires, even in hard to reach places.

In practice, there are also other methods for monitoring belt conveyors and their components (Wick & Misz, 2009), such as those based on the reflectometric method of measurement (so called fibre optic measurement techniques) which are carried out by means of reflectometers (OTDRs – Optical Time Domain Reflectometry). Monitoring of the entire length of the conveyor significantly accelerates the detection of outbreaks of fire, and computer analysis enables the risk of their occurrence to be determined.

Data necessary to properly diagnose the outbreak of fire includes, inter alia, knowledge of the temperature characteristics of operating idlers with different loads of the belt conveyor.

Dynamic of the idler rotational resistance (Antoniak, 1990) is dependent on such key parameters as: the ratio of the diameter of the outer idler to the diameter of the bearing, bearing design and bearing assemblies (seals, applied method of setting the bearing on the axis, the quantity and quality of grease and the accuracy of the manufacture process), ambient temperature, the idler's load and its speed. It is also proved by research presented by other authors (Gładysiewicz, 2003; Król, 2013).

Numerous studies conducted at the Institute of Mining, the Wrocław University of Technology, have shown that measurements of temperature increase in bearing assemblies (Król et al., 2008) are proportional to the idlers rotational resistance enabling their empirical relationship to be determined. This allows the diagnosis of idlers both in a laboratory and in situ.

Laboratory tests of dynamic rotational resistance of idlers are performed by different research centres (Bukowski & Gładysiewicz, 2010; Furmanik & Kasza, 2014, pp. 41–54; Gładysiewicz, 2003; Gładysiewicz, Król, & Bukowski, 2011; Król, 2013; Mitrović,

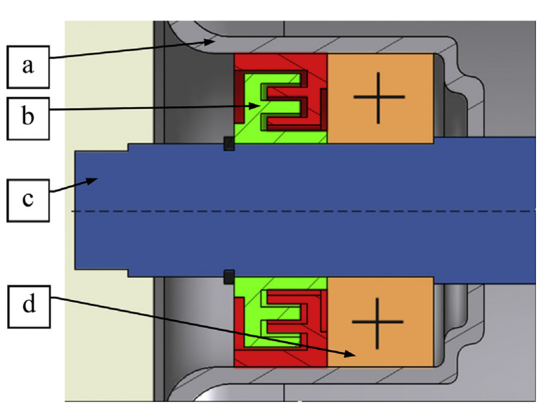

Fig. 1. An exemplary design of a bearing assembly with a double-sided labyrinth seal: a – idler's hub, b – labyrinth seal, c – idler's axis, d – ball bearing.

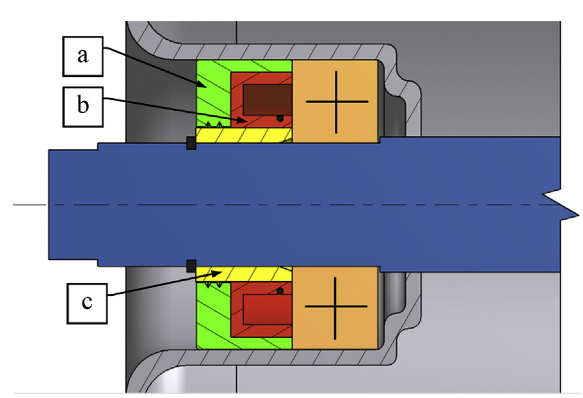

Fig. 2. Hybrid (labyrinth-lip) seal based on a model created by GIG, no. PL 67749 Y1.