Journal of Sustainable Mining 15 (2016) 57–65

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Journal of Sustainable Mining

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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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ARTICLE INFO

Article history:
Received 12 February 2016
Received in revised form
17 July 2016
Accepted 19 July 2016
Available online 25 July 2016

Keywords:
Belt conveyor
Idler
Dust-tightness
Water-tightness
Sealing
Testing stands

ABSTRACT

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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Peer review under responsibility of Central Mining Institute in Katowice.

http://dx.doi.org/10.1016/j.jsm.2016.07.001
2300-3960/

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:

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

where:

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

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

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

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,

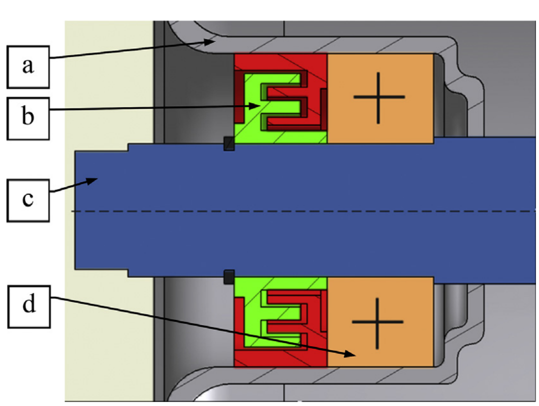

Fig. 1. An exemplary design of a bearing assembly with a double-sided labyrinth seal: a – idler's hub, b – labyrinth seal, c – idler's axis, d – ball bearing.

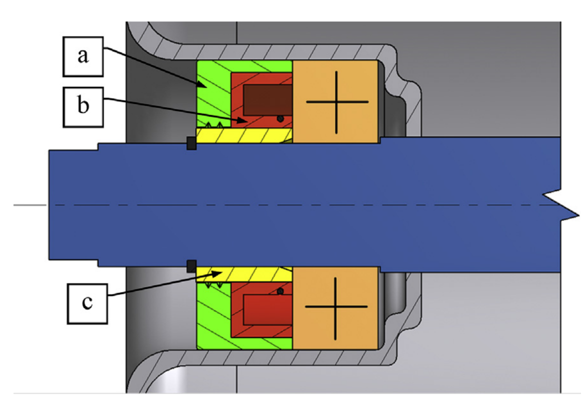

Fig. 2. Hybrid (labyrinth-lip) seal based on a model created by GIG, no. PL 67749 Y1.

Mišković, & Stamenić, 2014; Wheeler & Munzenberger, 2016), usually with the use of two research methodologies:

- with movable axle of idler,
- with movable mantle of idler.

Research carried out on idlers in GIG's testing stands is conducted according to the methodology based on a Polish standard (PN-M-46606:2010) and this research is mainly for product certification. In addition to standard tests of radial run-out, static and dynamic idlers rotational resistance, and water and dust-tightness, the test stands can also measure the temperature of bearing assemblies and examine the impact of rotational speed and variable load on an idler's durability (Pytlik, 2013, 2014).

The requirements of Polish standard (PN-M-46606:2010) for testing dust-tightness of idlers (testing time 72 h) and water (testing time 36 h), differ from the requirements of the German standard (DIN-22112-3:1996) which assume the testing time of 96 h for both tests, as well as standards developed in South African National Standard, 2012a; South African National Standard, 2012b). There are also differences in methodology. However, as the Polish mines require certificates of compliance with Polish standards, research which is the subject of the paper is limited to the Polish requirements.

The research methodology of the dynamic idlers rotational resistance, according to the requirements of Polish standard (PN-M-46606:2010), with its radial load of $F = 0.25$ kN, is very similar to the methodology described in the German standard. Such a low value of radial load, however, does not correspond to the actual loads which occur during operation in situ (Król, 2013). Both standards do not provide requirements for the allowable temperature rise of bearing assemblies during a test.

The literature provides methods of laboratory testing of rotational resistance of idlers using a special measuring apparatus developed at the University of Newcastle – Australia (Wheeler & Munzenberger, n.d.), using 'Rolling knife-edge' measurement system. The measuring system has a very wide range of work capabilities, both in the laboratory and field. Specially made measuring idler is built on a knife-edge support. While this allows the most accurate measurement of the rotational resistance, it requires a very high degree of precision, to exclude formation of idler vibrations caused by its lack of its centring in handles.

Therefore, in the test stand of the Central Mining Institute, it has been decided on a simpler solution, known in centre lathers, whose handles (lathe – fixed and rotary) allow for precise centring of idlers on the test stand, which reduces the idler vibrations to the minimum. Therefore, the following method of GIG does not provide a direct measurement of the idler rotational resistance, only its effect in the form of the temperature rise of the bearing units and sealing, the rotational resistance of lathe handles were omitted. As demonstrated by the tests carried out on the test stand, the degree of heating of the rotary live centres was negligible, because its nominal operating parameters allow us to test the idler with the radial force of approx. 10 kN, with a rotational speed of 600 rpm (maximum weight of the element fixed in lathe handle is 2000 kg) and the maximum radial rotational oscillation is 0.005 mm.

This article graphically presents the nature and level of changes in temperature which was based on ΔT temperature rise in t function of time with a radial load of $F = 1.5$ kN for $\phi 133 \times 465$ mm idlers, and with a load of $F = 4.6$ kN for $\phi 194 \times 750$ mm idlers. The characteristics set during the tests included the temperature of bearing assemblies and were analysed in terms of the possible or potential risk of seizure to the bearing assemblies. A thermographic camera enabled pivotal areas located in the bearing assembly which may indicate a seizure to be determined.

2. Methodology and scope of research

Research methodology of the idlers' tightness level and its effect on the temperature of bearing assemblies covers the following stages:

A. Idler's dust-tightness.

Methods for researching idlers' dust-tightness consist of a 72 h test conducted in a testing stand and illustrated in the diagram in Fig. 3.

– 1.5 kg of industrial talcum powder is poured in to a chamber with a capacity of 0.75 m^3.
– The chamber is closed and then the talcum is sprayed through the activation of the internal fan.
– After approximately a minute, the fan is turned off and the idler is inserted into the chamber.
– The compressor and the internal fan are turned on for 1 min. The compressor is turned on for 1 min every 4 h.
– The test is carried out for 72 h in two stages. In the first stage, the idler is rotated at a speed of 600 rpm for 48 h. During the second stage, the idler does not move for 24 h.

B. Idler's water-tightness.

Methods of research on bearing assemblies' water-tightness consist of a 36 h test conducted in a testing stand and illustrated in the diagram in Fig. 4.

– The tested idler is placed on the testing stand so that the idler's axis is placed between the centre points (fixed and rotary).
– The chambers with shower strainers which spray water are placed at both ends of the idler, inclined at an angle of approximately 45° to the idler's axis. The strainers should be fixed so that the distance from the head surface of the idler's sealing systems is approximately 200 mm.
– The test is carried out for 36 h in two stages. During the first stage, the idler is rotated at a rotational speed of 600 rpm for 24 h. During the second stage, the idler does not move for 12 h. The idler is rotated every 3 h by 90°, so that the main water stream affects the whole perimeter of the sealing system.

C. Disassembly of the idler after the water and dust-tightness tests (A and B stage). When disassembling the idler, particular care is taken not to damage the bearing units elements. Consecutive sealing elements are disassembled. Then, the degree of penetration of dust and water in the bearings and grease, and possible changes in colour and consistency undergo organoleptic evaluation and tests using a digital microscope (maximum magnification of 220×).

D. The tests of lower tightness of bearing assemblies and consequent temperature increase covers 4 h of research of the idler in the testing stand, as shown in Fig. 5.

– The idler's shell is loaded with F force (its value depends on the predicted idler's load in the belt conveyor) in the middle of its length.
– The idler's axis is brought into rotational motion at a rotational speed of 600 rpm for 4 h.
– The tests carried out also include the continuous measurement and computer recording of the temperature of the subject bearing assembly using a stationary pyrometer, with a minimum rate of $fp = 1$ Hz. Temperature measurement is carried out as close as possible to the bearing of the idler's axis.

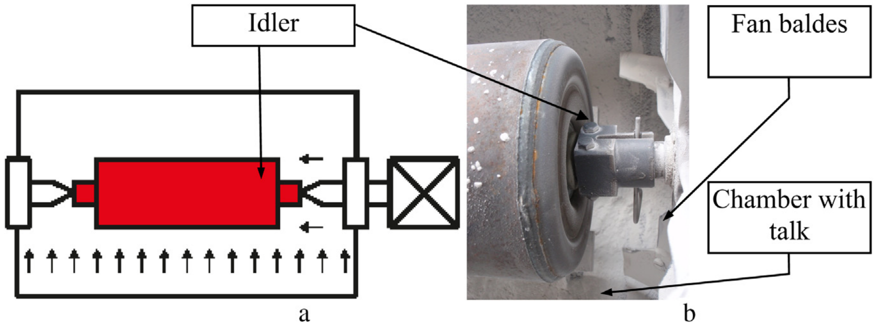

Fig. 3. A testing stand for testing an idler's dust-tightness: a – diagram; b – idler on a test stand.

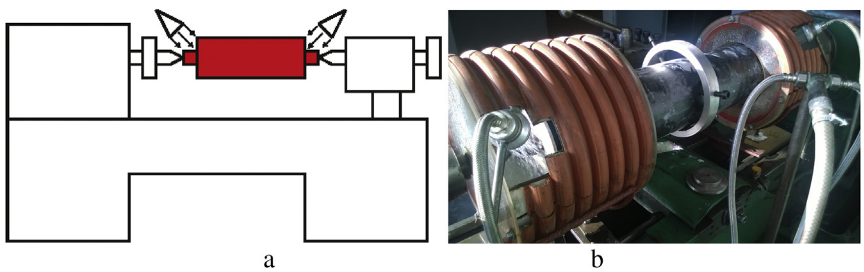

Fig. 4. A testing stand for testing an idler's water-tightness: a – diagram; b – idler on a test stand.

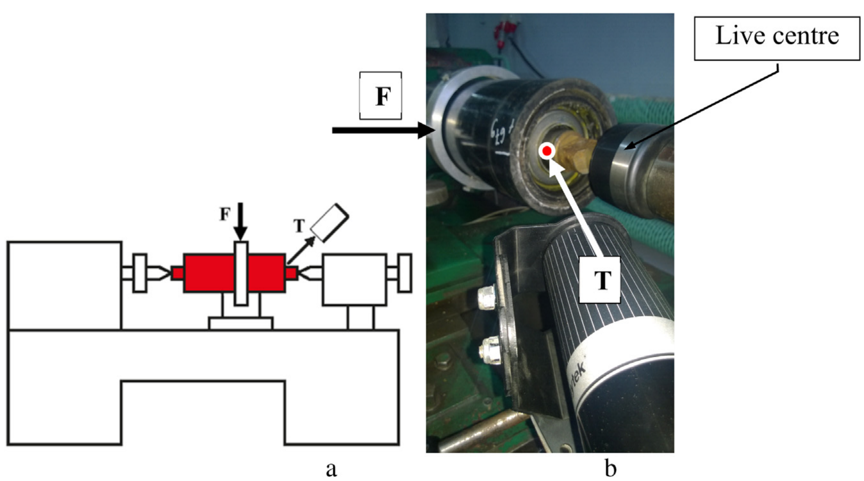

Fig. 5. A testing stand which tests the impact of the loss of water-tightness of bearing assemblies on temperature increase: a – diagram; b – temperature measurement (T) with stationary pyrometer and direction of radial load.

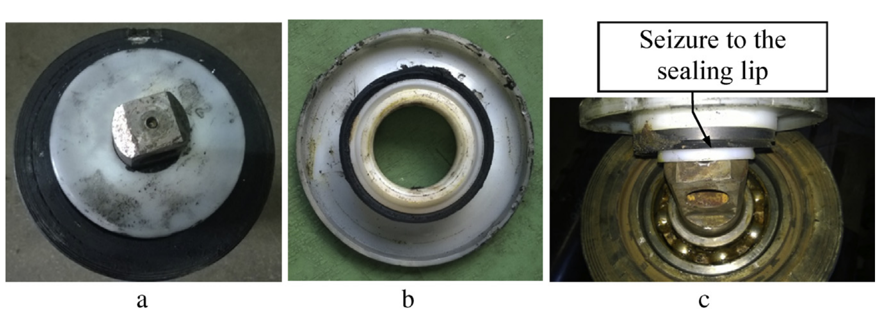

Fig. 6. The ϕ194 × 750 mm idler with its seals: a – the seal viewed from the side of the idler's axis, b – the seal viewed from the inner side, c – the seal viewed during disassembly, after water-tightness tests.

Temperature distribution around the idler is monitored by an infrared camera or a pyrometer, with particular emphasis on areas where the seals are set.

The following types of idlers were included in the tests:

- ϕ194 × 750 mm, with a polyurethane shell, a steel hub and a contact sealing (cover made of plastic with rubber lip seal adjacent to the inner steel extruded protection of the bearing). Idlers of this type are applied in, for example, lignite mines.
- ϕ133 × 465 mm, with a steel shell, an extruded hub and a standard two-element labyrinth seal with a deflector. Idlers of this type are applied in, for example, hard coal mines.
- ϕ133 × 465 mm, with a steel shell, an extruded hub and a standard three-element hybrid (labyrinth-lip) seal.

The ambient temperature during testing was approx. 20 °C.

Temperature measurements were performed, depending on the availability of space where measurement was carried out using infrared camera by TESTO, portable pyrometer by FLUKE 572 type or stationary pyrometer by RAYTEK with continuous recording of temperature on the computer.

3. Test results

3.1. Test results of the ϕ194 × 750 mm idler

The ϕ194 × 750 idler is equipped with a contact seal which is presented in Fig. 6.

Two ϕ194 × 750 mm idlers were included in the test:

I. The idler was not tested in stage A and B (dust and water-tightness), the research team proceeded to stage D – research of temperature rise of bearing assemblies with a load of 4.6 kN.
II. The idler was tested according to the methodology: first, the test covered stages A and B (dust and water-tightness), and then the research team proceeded to stages C and D – research of temperature rise of bearing assemblies with a load of 4.6 kN.

Research results of the first idler are shown in Fig. 7, and Fig. 8 presents the test result of the second idler.

The analysis of $\Delta T = f(t)$ graph of bearing assemblies of the ϕ194 × 750 mm idler's (Fig. 7) which was not tested for its tightness level showed that the bearing assembly increases its temperature only by 10 °C at a load of $F = 4.6$ kN. Gradual stabilization of the temperature was observed, and the nature of the curve of temperature increase does not indicate the possibility of seizing the bearings.

The second idler passed the dust-tightness test but it did not pass the water-tightness test. The research team observed some level penetration of water into the bearing (as a result of local abrasion of a seal lip) that caused rust staining of the bearing grease (Fig. 9).

The second idler's bearing (Fig. 9) first showed results of seizure after approx. 1.5 h of axis rotation at a speed of 600 rpm, when the temperature of the bearing started to significantly increase, from 5 to 25 °C.

3.2. Test results of the ϕ133 × 465 mm idler equipped with a labyrinth seal and an N type defector

The test included two ϕ133 × 465 mm idlers equipped with a labyrinth seal and an N type defector:

I. The idler was not tested in stage A and B (dust and water-tightness) and the research team proceeded to stage D – research of temperature rise of bearing assemblies with a load of 1.5 kN.
II. The idler was tested according to the methodology: first, the test covered stages A and B (dust and water-tightness), and then the research team proceeded to stages C and D – research of temperature rise of bearing assemblies with a load of 1.5 kN.

Research results of the first idler are shown in Fig. 10, and Fig. 11 presents the test result of the second idler.

The analysis of the graph (Fig. 10) shows that the ϕ133 × 465 idler's bearing assembly's (at load $F = 1.5$ kN) temperature increased by 8 °C after 3 h, then the temperature rapidly increased by 11 °C, and stabilized after 4 h. No risk of seizure of the bearing assemblies was observed.

The second idler did not pass the water-tightness test. Water penetrated the bearing assembly.

The analysis of the graphs presented in Fig. 11 demonstrates that the idler's bearing assembly's temperature increased by 14 °C after approx. 2 h of operation (recorded on the idler's axis), and by approx. 45 °C after 4 h (recorded on the seal).

Because after approx. 1.5 h, the bearing unit temperature has stabilized, it was decided that the remaining 2.5 h of the test will be spent on checking the temperature rise of the sealing with stationary pyrometer. In view of the fact, that there was only one stationary pyrometer (with the possibility to record data on the computer), the temperature distribution of the idler was controlled by a portable pyrometer (FLUKE of 572 type).

The test results of temperature increase of the bearing unit and sealing confirm the measurements of infrared camera shown in Fig. 13.

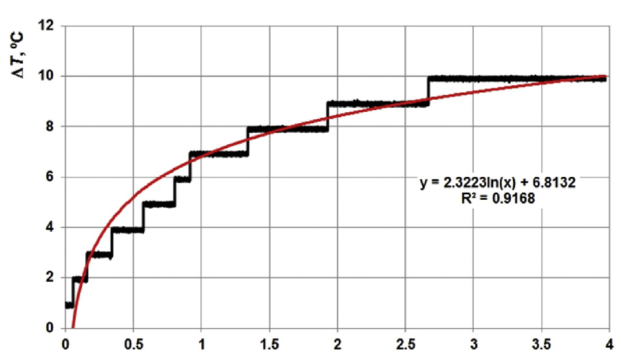

Fig. 7. The temperature of the ϕ194 × 750 (I) idler's bearing assembly during operation at 4.6 kN load.

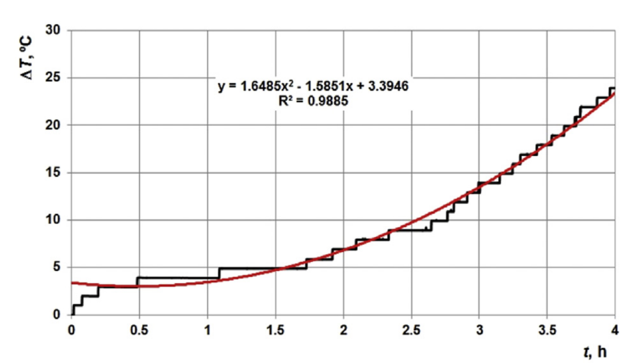

Fig. 8. The temperature of the ϕ194 × 750 (II – no proper water-tightness) idler's bearing assembly during operation at 4.6 kN load.

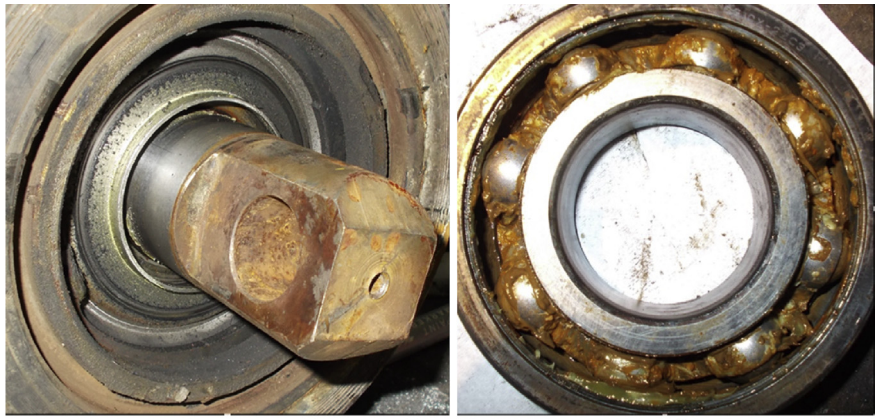

Fig. 9. The ϕ194 × 750 idler after the water-tightness test: a – not watertight bearing assembly; b – a bearing with visible rust staining of the grease.

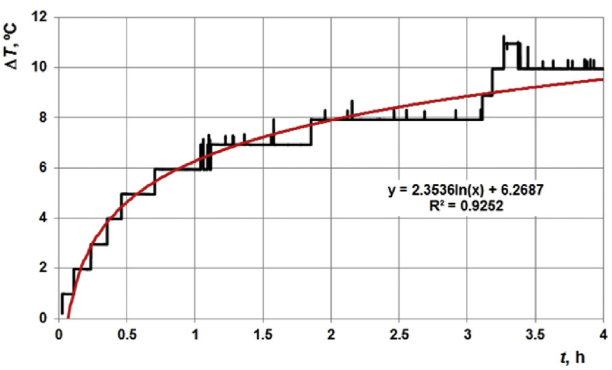

Fig. 10. The temperature of bearing assemblies of the ϕ133 × 465 idler equipped with a labyrinth seal, during operation at 1.5 kN load.

provides waterproof protection. The sealing lip did not suffer from any seizures thanks to proper operation with the stainless case characterised by low coarseness.

Test results of the ϕ133 × 465 mm, with a steel shell, an extruded hub and a hybrid (labyrinth-lip) seal are presented in Fig. 15.

The analysis of the graphs presenting the impact of ΔT temperature increase in t time function indicated that the temperature of the axis of the ϕ133 × 465 idler equipped with the labyrinth-lip seal, at $F = 1.5$ kN load, increased by 22 °C after the first 2.5 h of rotation. Later, the temperature became stable and did not change. This proves that there is no possible risk of bearing seizure (Fig. 16).

4. Result analysis

The analysis of idler research resulted in the creation of waveform functions, $\Delta T = f(t)$, and showed that the tests can be applied

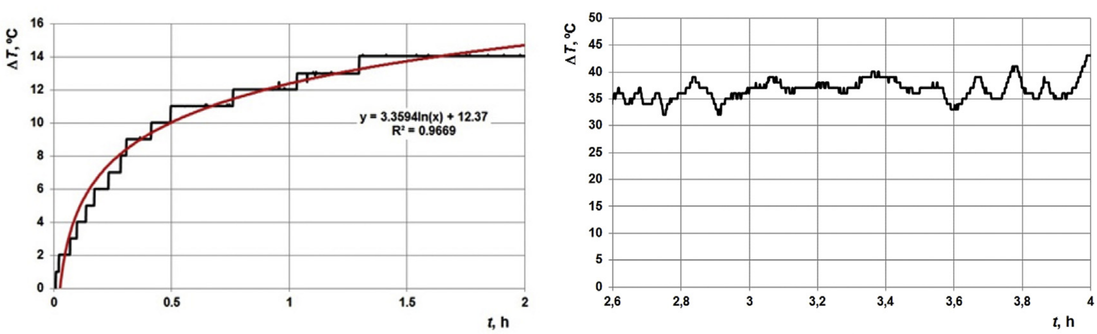

Fig. 11. The temperature of bearing assemblies of the ϕ133 × 465 idler equipped with a labyrinth seal, during operation at 1.5 kN load – after the water-tightness test: a – recorded on the idler's axis, b – temperature measured after approx. 2.5 h, on the seal (max. increase by approx. 45 °C).

Fig. 12 shows a photo of the ϕ133 × 465 idler (II) with a labyrinth seal and a deflector.

The temperature distribution registered by the infrared camera (Fig. 13) indicates the possibility of the seizing of the idler in the area where the seal is in contact. The temperature increased from 20 °C (before the test) to 65.4 °C after 4 h of the test.

3.3. Test results of the ϕ133 × 465 mm idler equipped with a three-element hybrid (labyrinth-lip) seal

The ϕ133 × 465 mm idler passed both dust and water-tightness tests. This idler has a contact-lip seal, shown in Fig. 14b, which

to determine the technical condition of an idler, and based on the nature of the change in temperature, the potential risk of jamming of the idler and its rotational resistance can be forecasted. This is confirmed by the results of tests carried out in the Mining Institute, Wrocław Technical University (Król et al., 2008), which allowed the authors to determine the basic relationships between resistance, temperature increase, and operation time of the idler. Obtained (Król et al., 2008) graphs of temperature with time function of the idler's rotation time are similar to graphs presented in this article, but they refer to properly operating idlers which were not damaged. An example of the changes $\Delta T = f(t)$ during the normal operation of idlers is presented below:

Fig. 12. The ϕ133 × 465 idler with a labyrinth seal and a deflector: a – the idler after the water-tightness test, b – inside of the hub, visible rust spots and mildew stains, c – the seal with the remains of washed out grease.

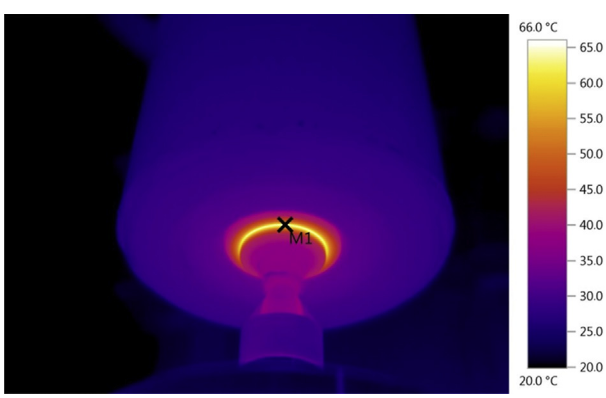

Fig. 13. The temperature distribution of the ϕ133 × 465 idler equipped with a labyrinth seal, during operation at 1.5 kN load – after the water tightness test (max. temp. = 65.4 °C measured on the seal).

The paper presented by Gładysiewicz et al. (2012) includes research results of idlers carried out in situ in the Sobieski and Janina Mines, which used infrared cameras to determine the technical conditions of the idlers. This study showed that the idler's temperature rise is directly proportional to the rotational resistance. The work does not determine $\Delta T = f(t)$ empirical relationships, but it provides differences in registered temperatures of bearing assemblies in standard idlers and bearing assemblies in the idlers manufactured by Küpper.

The results of maximum temperatures of bearing assemblies can be compared with the quantitative values of criteria for the performance evaluation of the technical condition of idlers, which are quoted in the introduction to this article.

If we assume that the allowable temperature (T_{allow}) of the bearing (Gładysiewicz, 2003), shall not exceed 20 °C above ambient temperature, then the technical conditions of the following two idlers would obtain a low mark: the 194 × 750 and ϕ133 × 465 idlers equipped with a labyrinth-lip seal. One of the factors triggering excessive temperatures is undoubtedly the idler rotational resistance which in turn is caused by the friction of the contact (lip) sealing.

The difference in the waveforms $\Delta T = f(t)$ is noteworthy.

In the case of the ϕ194 × 750 idler, which passed the water-tightness test, the nature of temperature change indicates a rapid increase in temperature, which during rotation of longer than 4 h may lead to bearing failure and consequently to jams. This was confirmed by visual inspection of the idler after the tests revealed corrosion of the bearing elements and changes in the consistency of the bearing grease.

The ϕ133 × 465 idler with a labyrinthine-lip seal passed the dust and water-tightness test, despite the fact that the temperature increased by approx. 20 °C after about 1 h of operation, and after 2.5 h the temperature increased by another 2 °C, and after a further 1.5 h, the temperature stabilized and no changes of the temperature were

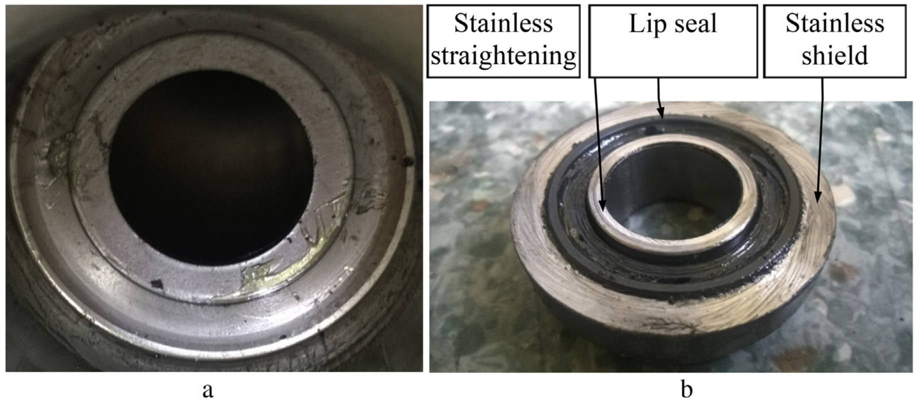

Fig. 14. The ϕ133 × 465 idler with labyrinth-lip seals: a – inside of the hub, no rust spots, b – the seal – grease without any visible changes in colour after the water-tightness test.

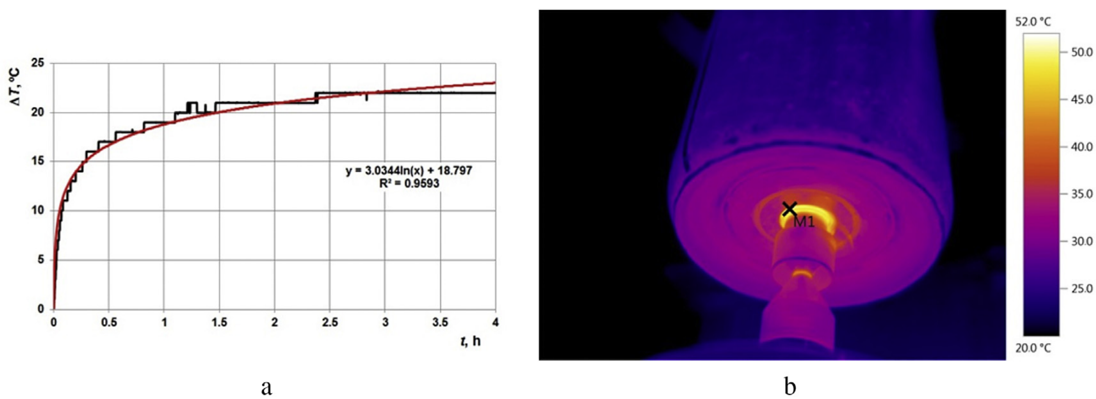

Fig. 15. The temperature of the ϕ133 × 465 idler with the labyrinth-lip seal at load of $F = 1.5$ kN: a – temperature changes, measured on idler's axis, b – temperature of the case's sealing – $T_{max} = 51.7$ °C.

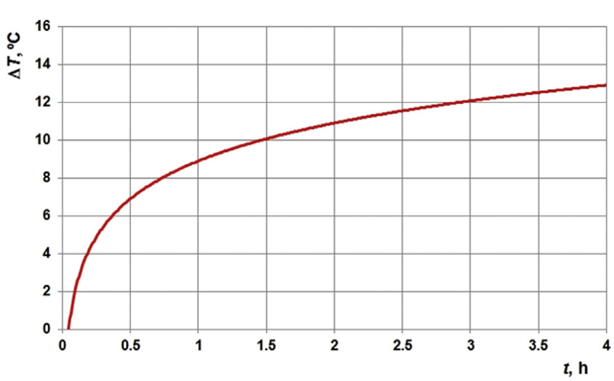

Fig. 16. $\Delta T = f(t)$ during normal operation of an idler.

recorded. This indicates the lack of a risk of jamming, but the most likely cause of an excessive increase in the operating temperature is excessive idler rotational resistance. The temperature distribution of the idler registered by the infrared camera shows that although the temperature of the axis of the idler increased by 22 °C, the temperature of the steel case (Fig. 2) increased only to 51.7 °C after 4 h. This is due to friction of the lips and the seal case. This, however, does not threaten the lip seal because the operation temperature stays within the limits allowed for the material of which it is made. The inspection carried out after the tests did not reveal any signs of corrosion in the bearing or changes in the colour or consistency of the grease, which proves the correct operation of the seal.

5. Conclusion

The research confirmed that the loss of water tightness of idlers' bearings is associated with a significant increase in the temperature of bearing assemblies, which can lead to seizure of the bearings. This is clearly visible in the graph (Fig. 8) which shows $\Delta T = 25$ °C temperature increase, $\Delta t = 4$ h, registered during tests on the ϕ194 × 750 mm idler. After the water and dust-tightness test, some seizures of the rubber contact seals of the idler were observed and this allowed water to penetrate the bearing.

In the case of the ϕ133 × 465 idlers with labyrinth seals, there was no rapid increase in the temperature of the bearing assemblies.

Research based on the use of an infrared camera and pyrometer showed that the area which is prone to seizure also includes seals, whose maximum temperature reached 65.4 °C (the ϕ133 × 465 mm idler with a steel shell, an extruded hub and a standard labyrinth seal).

The research conducted also showed the significant impact of load on the temperature increase of bearing assemblies. Constant recording of the temperature increase and the nature of changes allowed conclusions to be drawn concerning the seizure in bearings or idler seals.

The research methodology of idlers is used to compare different design of idlers and bearing assemblies, it will also be applied to improve the existing design solution for seals created by GIG, and it will help new designs of seals to be found, in order to minimize their resistance rotation.

The research presented in this article will be continued for a variety of design solutions of idlers and bearing assemblies and carried out at varying loads.

Acknowledgements

The article was prepared based on research and analyses financed from Department of Mechanical Devices Testing's assets (Central Mining Institute).

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