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IDENTIFICATION OF TECHNICAL STATE AND OPTIMISATION OF OPERATION OF TRANSPORT-HANDLING EQUIPMENT

Summary. This paper describes a real example from the practice concerning an analysis of technical state and operational optimisation of the given transport-handling equipment, which is installed in a trans-shipment station specified for transport and handling of bulk materials. By means of identification of a faulty technical state of this transport equipment there was determined the main cause of a damage process, which occurred during current operation. Consequently, it was possible to perform an optimisation of the relevant technical parameters in order to eliminate the negative phenomena.
Keywords: conveyor, measuring, optimisation.

OKREŚLENIE STANU TECHNICZNEGO ORAZ OPTYMALIZACJA PRACY URZĄDZENIA TRANSPORTOWO-ZAŁADUNKOWEGO

Streszczenie. W artykule przedstawiono realnie rozwiązywany przypadek z praktyki technicznej, którego podstawą była analiza stanu technicznego oraz optymalizacja działania konkretnego urządzenia transportowo-załadunkowego, zainstalowanego w przedsiębiorstwie przeładunku materiałów sypkich. Za pomocą identyfikacji pierwotnego stanu technicznego – uszkodzenie – wspomnianego urządzenia transportowego została ustalona przyczyna jego uszkodzenia, a następnie za pomocą przeprowadzonej optymalizacji właściwych parametrów technicznych zostały wyeliminowane negatywne wpływy podczas pracy.
Słowa kluczowe: transporter, pomiary, optymalizacja.

1. INTRODUCTION

There are two main subjects of this paper: identification of a reason, which caused a rupture of conveyor belt and description of the following performed optimisation procedures performed in order to eliminate the negative occurrences. The described conveyor represents a special category of the belt conveyors that are able to transport the bulk material vertically. Such special kind of conveyors are used for vertical transportation of the bulk materials in

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situations where is limited space for installation of classic belt conveyor or other kind of conveyor system. They are able to transport any type of bulk material: from very small grain size bulk materials to large piece ore, [1]. However, there are at disposal also other kinds of special belt conveyors designed for vertical transport of bulk materials, e.g. pipe conveyors, [2].

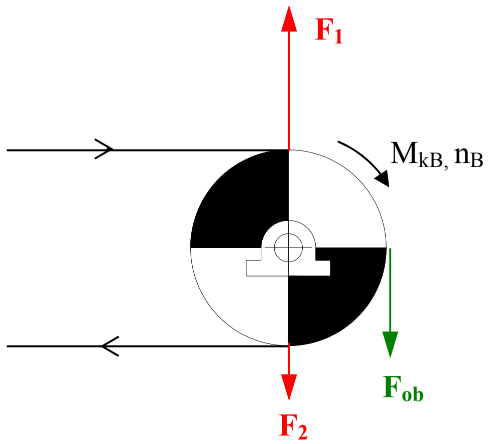
The subject of our interest was a special belt conveyor installed in a tranship centre, which deals with transport and handling of a granulation product.

The transport belt of this belt conveyor was worn-out excessively during a current operation and the final consequence of this negative phenomenon was rupture of the belt. The belt conveyor itself, together with its operational conditions, were analysed in detail.

A visual inspection of the rotating elements (i.e. the guiding cylinders) identified an excessive and eccentric wear-out in extension of 50% from the running width of the rubber coating, as well as an axial slippage of the belt from the guiding cylinder along the axis of rotation.

2. VERIFICATION CALCULATION OF TENSION FORCES IN THE GIVEN CONVEYOR

The first necessary step was a control calculation of tension forces in the belt conveyor. The driving pulley is situated in the point of maximum tension force. Therefore the belt tension forces are analysed in the driving station, according to the Fig. 1 [3].



Applied notation:

F_1 – maximum tension force,
F_2 – minimum tension force,
F_{ob} – circumferential driving force,
M_{kB} – driving pulley torque,
n_B – speed of driving pulley

Fig. 1. Force situation on driving pulley
Rys. 1. Stosunek sił w bębnie napędowym

Input data for control calculation are as follows:

a) according to the drawing documentation obtained from the belt operator there are given operational parameters:

- nominal power output of belt drive	$P = 110$ kW
- nominal speed of driving electric motor	$n = 1482$ min^{-1} (24,7 s^{-1})
- gear ratio of gearbox	$i = 44{,}49$
- diameter of driving pulley	$D_B = 1250$ mm

b) chosen parameters:

f = 0,62 for dry, clear, rubbered and grooved surface of the driving pulley,

α = 180°

η = 0,95 (chosen efficiency of the belt drive)

By the calculation there were determined the individual values according to the Fig. 1 that are presented in the Table 1.

Table 1

Numerical results of driving pulley parameters

$\mathbf{F_1}$ (N)	$\mathbf{F_2}$ (N)	$\mathbf{F_{ob}}$ (N)	$\mathbf{M_{kB}}$ (N.m)	$\mathbf{n_B}$ (s^{-1})
56 428	8 046	48 382	30239	0,55

Parameters of the conveyor belt are obtained from belt producer:

- tensile strength of the belt σ_p = 2500 N/mm
- belt width B = 1400 mm
- tension safety coefficient of belt k = 10

Thus, the maximum permissible force F_{max} in the belt is 350 000 N. So it is evident that $F_{max} \gg F_1$ thanks to high level of tension safety coefficient of belt. The belt is over-dimensioned more than six-time and its tensile strength is sufficient enough.

However, according to eccentric wear of running surface of belt, which is in permanent contact with guiding cylinders, it can be expressed a judgment about negative impact of “dumbbells” misalignment on the belt loading (i.e. additional eccentric loading).

3. MEASURING AND A OPTIMISTAION OF GEOMETRICAL SET-UP OF GUIDING CYLINDERS

It was possible to postulate preliminary the incorrect geometrical set-up of the guiding cylinders as one of the probable causes of the occurred undesirable situation. In order to confirm or to reject this hypothesis it was necessary to verify the geometrical position or the geometrical set-up accuracy of the guiding cylinders.

The diameter of the investigated guiding cylinders is approx. 1600 mm and their length is more than 2000 mm. Taking into consideration the operational conditions it was not possible to disassembly all components, which are surrounding the guiding cylinders.

Thus, there was actual a question how to perform the required measuring with the necessary accuracy. Taking into consideration all the relevant facts there was selected an innovative sensing method using the 3D scanner. It was applied a contact scanner with the infrared data transmission between the measuring probe and the sensing camera 3D Creator, which is a product of the company Boulder Innovation Group, Inc., Fig. 2.

Fig. 2. Measuring device and operational radius of the 800 mm scanner sensor
Rys. 2. Urządzenie pomiarowe oraz promień działania 800 mm czujnika skanera

The first step, which has to be made before starting of the measuring process, is to define the measuring position, as well as to establish the individual axes of the spatial coordinate system. The sensing process in the sensor reach area was practicable from one side only with regard to the measuring principle.

From this reason it was necessary to develop a new sensing methodology by means of the exactly positioned reference point, which was situated in the range of the measuring sensor. This arrangement was applied for the bilateral sensing of the bearing house and running diameter of the guiding cylinder so that the sensing sensor was moved from the left side to the right side of the given surveyed object without a loss of accuracy. The output from the measuring performed by means of digitisation equipment is illustarted in the Fig. 3.

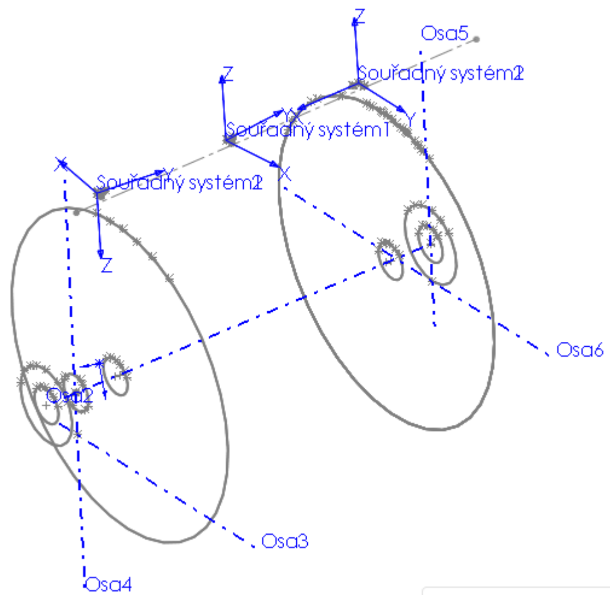


Fig. 3. Display of measured data from the equipment 3D Creator
Rys. 3. Przedstawienie wartości zarejestrowanych przez urządzenie 3D Creator

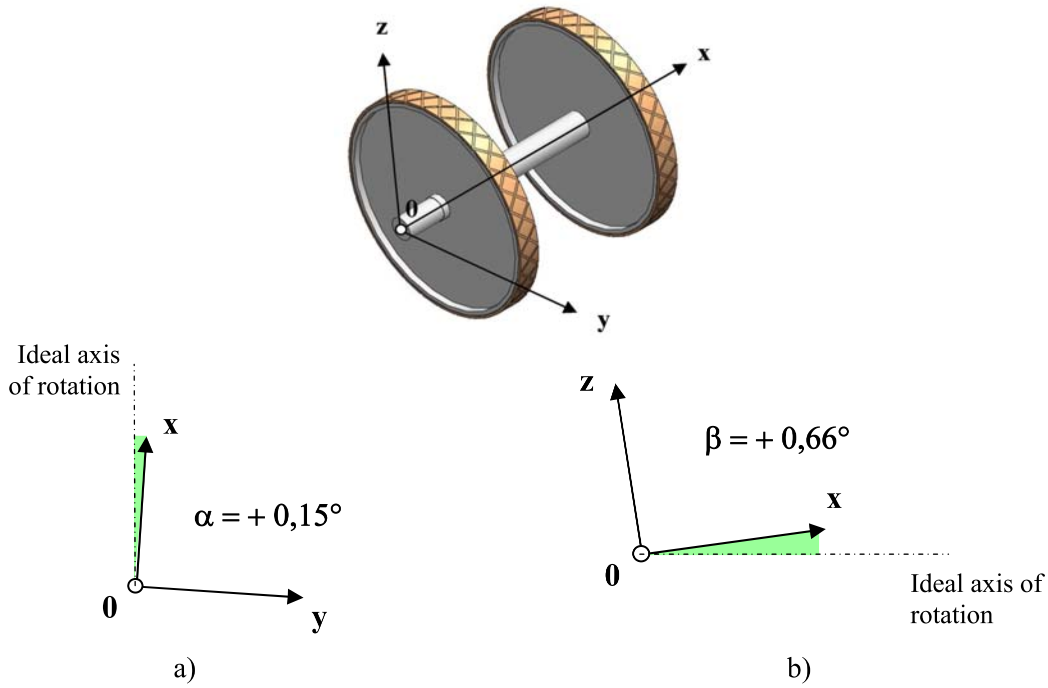


Fig. 4. Measured angular deviations: a) angular deviation in horizontal plane, b) angular deviation in vertical plane
Rys. 4. Zarejestrowane odchylenia kątowe: a) odchylenia kątowe w płaszczyźnie horyzontalnej, b) odchylenia kątowe w płaszczyźnie wertykalnej

According to the measured data there was identified a relevant deviation in the vertical direction. This deviation value was 23 mm of the height difference between the bearing houses.

4. CONCLUSION

The visual inspection of the running surfaces of the guiding cylinders corresponds with the results obtained from measured of the conveyor geometrical disposition. The wear out of the guiding cylinder running surfaces was eccentric due to an incorrect geometry of the guiding cylinders set-up.

Another negative impact is quality of conveyor belt joining with regard to the belt tension strength.

Finally, it is possible to say that the chosen measuring methodology, together with the applied measurement equipment, was very effective for solving of the given task. According to the measured values of the angular deviations the original geometrical position of two guiding cylinders was corrected by means of bearing plates that were placed under the bearing houses, Fig. 5.

It is possible to say, according to the information obtained from operator of the given conveyor, concerning the following operation after a half-year of standard running, that all the relevant parameters were improved and, consequently, the initial negative phenomena were eliminated. Thus, the original methodology, which was developed by our team and described in this article, proved good and successfully.

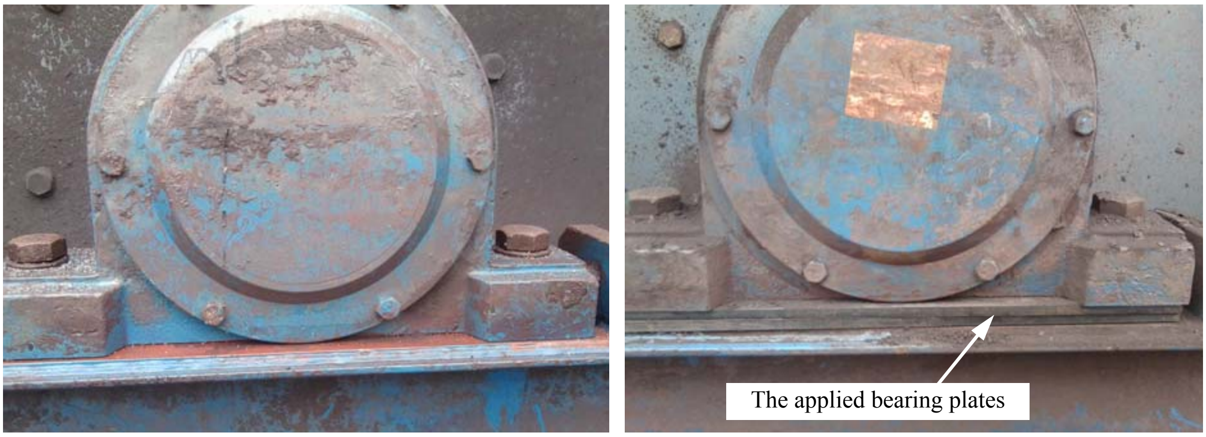


Fig. 5. Elimination of the angular deviation in the vertical plane
Rys. 5. Przeprowadzona modyfikacja odchylenia kątowego w płaszczyźnie wertykalnej

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