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# APPLICATION OF DIGITISATION 3D-MEASURING EQUIPMENT FOR IDENTIFICATION OF FAILURE OF BELT CONVEYOR

# PRIMENA DIGITALNE 3D MERNE OPREME ZA IDENTIFIKACIJU OŠTEĆENJA TRANSPORTNE TRAKE

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**Abstract:** There is described in this paper a special measuring method of the FLEXOWELL belt conveyor in order to identify causes of a strong, excessive belt wear during current operation. There was applied an original measuring methodology based on application of 3D-measuring equipment, which is presented in this article.

**Key words:** FLEXOWELL conveyor, guiding cylinders, tension force, measuring process

**Apstrakt:** U radu je opisana posebna merna metoda na FLEXOWELL transporterima sa trakom u cilju identifikacije uzroka preteranog habanja trake u toku rada. Primenjena je originalna merna metodologija zasnovana na upotrebi 3D merne opreme, koja je i prikazana u ovom radu.

**Ključne reči:** FLEXOWELL transporter, pogonski bubanj, sila istezanja, merni proces

## 1. INTRODUCTION

There is a special category of belt conveyors, which enable transport of bulk material vertically. It is category of the FLEXOWELL conveyors (Figure 1). Conveyors of FLEXOWELL type are used for vertical transportation of the bulk materials in 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 (Jasaň et al. 1989). Most common transported materials are: ore, coal, fly-ash, gypsum, stones, gravel, sands, fertilizers, lime stones etc. (www.vvvmost.com).The conveyed material is protected against external impacts and dust nuisance related to conveyor operation is minimized, as well. The FLEXOWELL conveyor belts are designed for combined transport directions, i.e. for horizontal, steep inclined and vertical transport. Granularity of

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material, which is transported by means of the FLEXOWELL, is varying from powdery material up to several hundreds of millimetres large pieces. Bulk materials can be transported by means of this conveyor over 500 m in vertical lift using transport capacities from the lower capacity limit $1\,m^3h^{-1}$ to the upper limit $6000\,th^{-1}$. Application areas of such conveyors are wide-ranged, e.g. (www.contitech.de):

- coal and wood-chip fired power stations;
- underground mining (coal and ore);
- shaft conveying for tunnelling and underground mining;
- steel industry;
- ship loading and unloading, ship to ship loading;
- sand preparation in foundry plants;
- silo feeding;
- slope conveying in mining;
- waste recycling, soil purification and water treatment;
- handling of large material flows in the horizontal path.


**Figure 1** - The FLEXOWELL belt conveyor (www.meteoro.pt; www.vvvmost.com)

## 2. RESEARCH TASK AND SOLUTION

In the framework of a cooperation between our Department and industrial background we had to solve a special task originating in industrial practice: in a certain industrial plant, which is equipped with the FLEXOWELL conveyor, occurred a very serious problem concerning this conveyor, namely it was a rupture of the belt. The concrete task was to investigate a real cause of such very serious negative phenomenon. During a current operation of this conveyor arose an excessive wear of the belt after a relatively short time of running (Figure 2) and this fact led to the rupture finally.

After visual inspection it was observed a distinctive wear of running surface of belt, which is in permanent contact with guiding cylinders (called also "dumbbell"). In order to determine the exact cause of belt wear it was necessary:

- to perform detailed analysis of geometrical position of both guiding cylinders (accuracy of their geometrical set-up);
- to calculate tension forces in the belt (with regard to the belt strength limit);
- to verify quality of the belt jointing.

**Figure 2** - Strong wear of the FLEXOWELL belt

The carcass of belt consists of a high-strength steel cord placed in one plane embedded in the rubber and it is safeguarding the perfect joint between upper and lower cover layer, Figure 3. Such structure provides high performance and resistance of the conveyor belt.

**Figure 3** - Internal structure of the belt with steel cord (www.phoenix-cbs.com)

## 2.1. Measuring of geometrical position of guiding cylinders

One of possible causes of conveyor belt damaging is insufficient accuracy of their geometrical set-up. From this reason it was necessary to verify deviations of arrangement of both "dumbbells" in the conveyor supporting steel construction. There is illustrated a simplified scheme of the FLEXOWELL conveyor in the Figure 4, with marked position of concerned guiding cylinders, i.e. positions No.1 and No.2.

The main purpose of geometrical measuring of the "dumbbells" was determination of angular deviation of "dumbbell" axis in relation to the horizontal and vertical plane. After geometrical summation of both geometrical deviations is obtained a real position of "dumbbell" axis in the space. The ideal axis of rotation is situated in the horizontal plane.

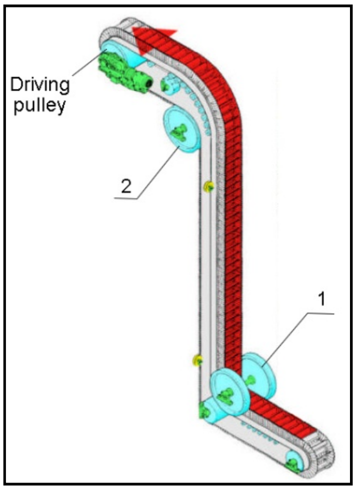



**Figure 4** - Scheme of arrangement of guiding cylinders (www.flexowell.pl)

In order to determine the angular deviations of "dumbbells" there was defined a spatial orientation of them related to the control room of plant, Figure 5. The beginning of the coordinate system "0" was situated on the left side of the "dumbbell" (in the place of bearing house middle point) and the *x*-axis is axis of "dumbbell" rotation.

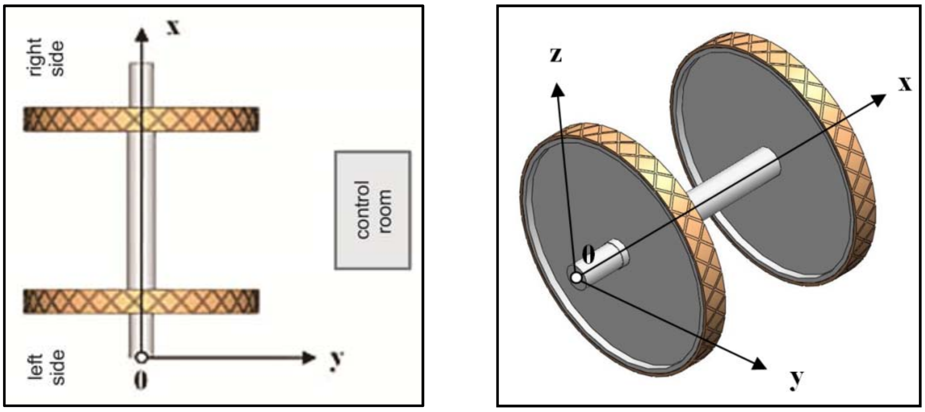
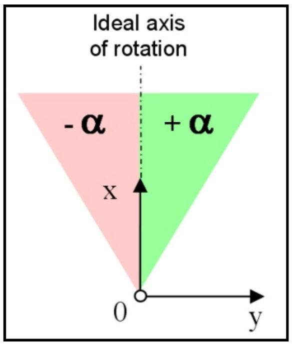
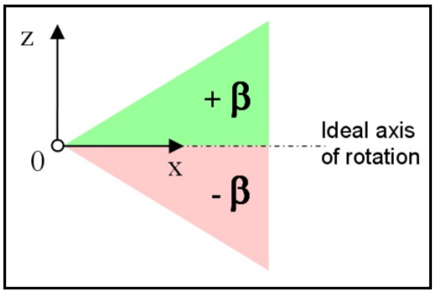



**Figure 5** - Arrangement of the coordinate system

There was defined a sign convention according to the Figure 6 for the given coordinate system in order to determine direction of angular deviation.




Angular deviations in horizontal plane




Angular deviations in vertical plane

**Figure 6** - Sign convention for angular deviations

The measuring process was realised by means of the 3D-measuring and digitalisation scanner 3D Creator with infrared data transmission (Figure 7). It is a product of the company Boulder Innovation Group, Inc. The measuring equipment was supplied also with special preparations designed for set-up of reference points and the laser distance-meter Leica DISTO. The described measuring methodology was applied for measurement of geometrical deviations of both guiding cylinders.

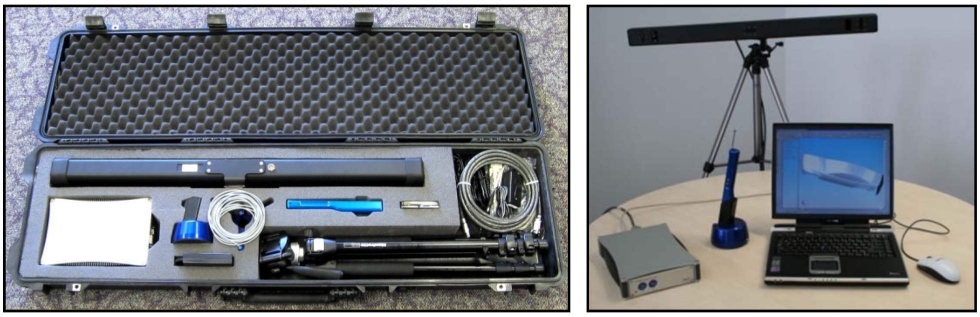


**Figure 7** - Measuring apparatus 3D Creator

An example of the measured deviation values of the "dumbbell" No.1 is presented in the Figure 8, where the 8a represents deviations of length in horizontal and vertical plane and 8b and 8c represent angular deviation in horizontal/vertical plane. Similar results were obtained in the case of the "dumbbell" No.2.

It was already mentioned that visual inspection of belt discovered a distinctive wear of running surface of belt, which is in permanent contact with guiding cylinders and analogical wearing was visible also on the surface of running surface of guiding cylinders in the extension of half width of running area. This fact corresponds to the geometrical deviations of both "dumbbells" as a possible cause of additional and eccentric loading of the belt.

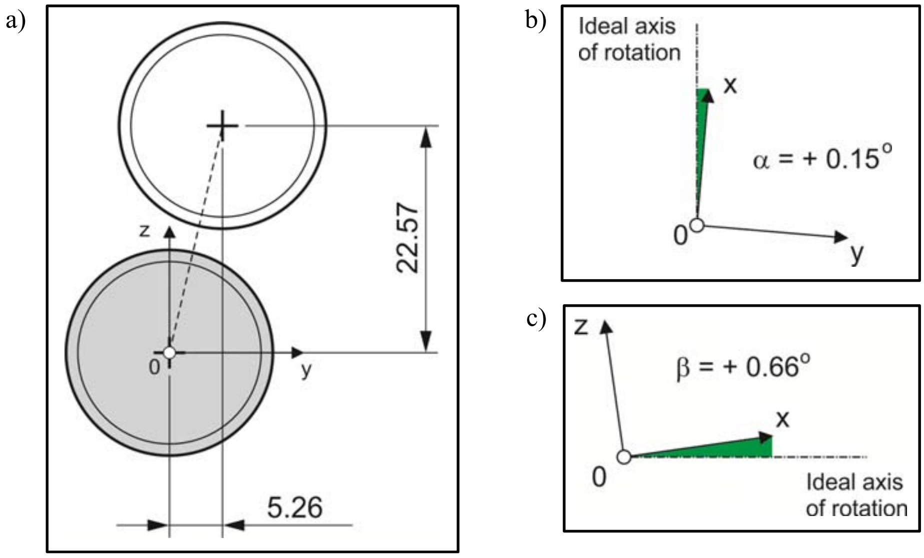
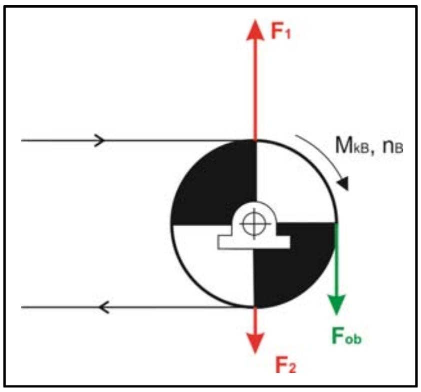



**Figure 8** - Measured deviations of the "dumbbell" No.1
a) Deviations of length in horizontal and vertical plane; b) Angular deviation in horizontal plane; c) Angular deviation in vertical plane.

## 3. CALCULATION OF TENSION FORCES IN THE BELT

The driving pulley is situated in the point of maximum tension force. Therefore the belt tension forces are analysed in the driving station, Figure 9.




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.

**Figure 9** - Force situation on driving pulley

There are known following relations among individual forces from the Figure 9:

$$F_{ob} = F_1 - F_2 \tag{1}$$

$$\frac{F_1}{F_2} = e^{f\alpha} \tag{2}$$

where are:
$f$ - coefficient of friction between belt and driving pulley,
$\alpha$ - angle of wrap around driving pulley.

Power output of driving pulley is:

$$P = M_{kB} \cdot 2\pi \cdot n_B \tag{3}$$

**Input data** 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: $P = 110$ kV
- 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,
- $\alpha = 180^{o}$,
- $\eta = 0.95$ (chosen efficiency of the belt drive).

Using the above-mentioned relations (1), (2) and (3) there were obtained results that are presented in the Table 1.

**Table 1** - Numerical results of driving pulley parameters

| $F_1$ [N] | $F_2$ [N] | $F_{ob}$ [N] | $M_{kB}$ [N·m] | $n_B$ [s$^{-1}$] |
|---|---|---|---|---|
| 56,428 | 8,046 | 48,382 | 30,239 | 0.55 |

Parameters of the FLEXOWELL belt are known from belt producer:

- tensile strength of the belt: $\sigma_p = 2500$ 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 $F_{max} >> F_1$ 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).

But the most relevant cause of the belt damage seems to be quality of the belt joint. According to the X-ray diagnostics of the join was evident a poor quality of joining process realisation and loss of contact between steel wire ropes and rubber covering layers.

## 4. CONCLUSION

There is presented in this paper an innovative method of a geometrical measuring realised by means of the digitisation 3D-measuring equipment. This measuring was performed on a special FLEXOWELL belt conveyor in order to determine accuracy of set-up of its guiding cylinders.

## ACKNOWLEDGMENTS

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