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VERIFICATION THE DRIVE UNIT COMPONENTS OF BELT CONVEYOR FOR ORE T.109

Abstract

This paper presents the methodology for verification the reducer and couplings as the components of drive unit on the example of belt conveyor for ore with capacity of 2000 t/h at the open pit "Veliki Krivelj".

Analysis was done by calculation according to the manufacturer instructions of the Falk Company, and its results are indispensable for checking the reliability of functionality the drive unit components in the given operating conditions.

Also, the technical characteristics of these components are given, as well as their graphical representation.

Keywords*: belt conveyor for ore, verification of reducer and couplings, technical characteristics*

1 INTRODUCTION

The belt conveyor for ore T.109 was designed for transportation the primary crushed ore at the open pit "Veliki Krivelj" from the crusher (pos. T.102.100.2) to the open storage for ore [1]. To run the conveyor belt, two identical drive units are provided, each of which runs a single drive pulley. Each drive unit consists of an electric motor, a high-speed coupling, a reducer and a low-speed coupling.

Since the investor disposed of drive units with certain technical characteristics, it was necessary to check the functionality of drive unit components unit in the new operating conditions on the belt conveyor T.109, i.e. to do their verification.

2 TECHNICAL DESCRIPTION

The drive unit of the belt conveyor consists of an electric motor, a high-speed coupling between the electric motor and reducer, a reducer and a low-speed coupling between the reducer and drive pulley.

The reducer is of drive size 485 and type A [2] what means that it is with parallel shafts, horizontal and foot mounted, with solid low-speed shaft. Gears are helical and suitably machined to assure a full contact under load. The reducer is installed outdoors, and the position of reducer corresponds to assembly number 1. The reducer is with double reduction, nominal ratio 15.44 and actual ratio 15.24. The reducer is not equipped with any accessories what means that the reducer is cooled by natural circulation of ambient air. Since the transmission is through flexible couplings at both the high-speed and low-speed shafts, these shafts are not loaded with additional bending moments. The reducer image is given in Figure 1.

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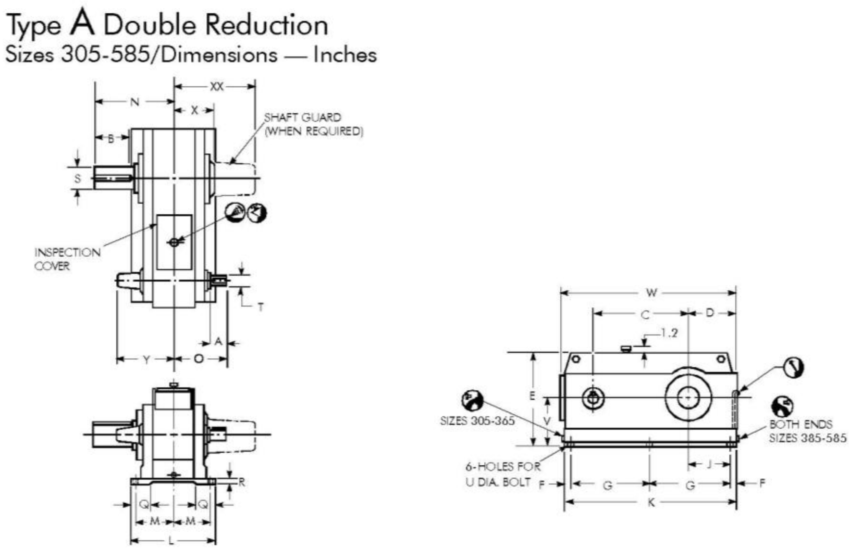
The high-speed coupling is 1110T10, and the low-speed coupling is 1180T10 [3]. The couplings belong to the group of Falk Steelflex Grid Couplings, type T10 what means that it is a double flexing, close coupled design for use in four bearings systems with horizontally split cover which allows for grid replacement without the movement of the connected equipment. View of couplings is given in Figure 2.

Technical characteristics of drive unit components are given in Table 1.

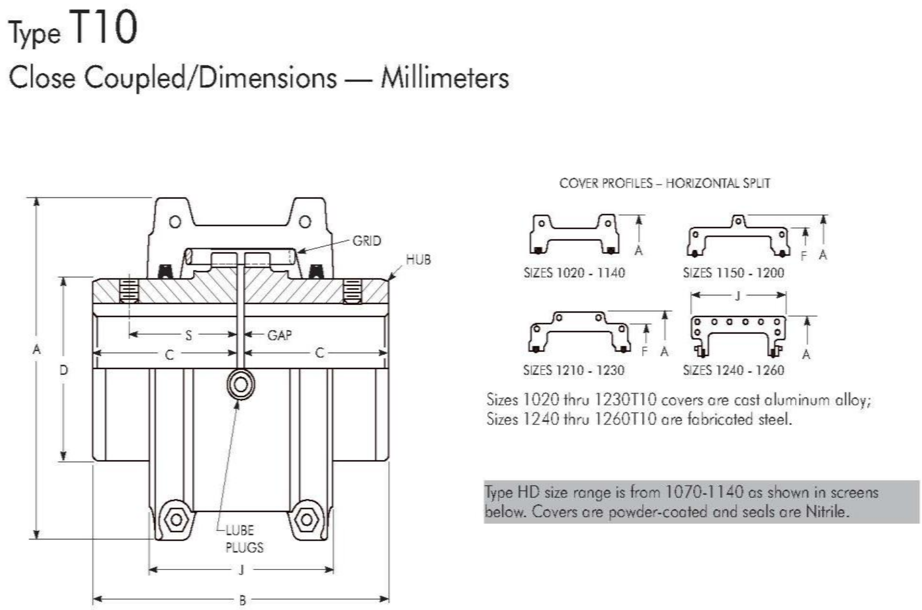
Table 1 *Technical characteristics of drive unit components*

Item	**Electric motor**	**High-speed coupling**
Technical characteristics	- Manufacturer: Sever Subotica - Label: ZPN 6170 - Power: $P = 450\ [kW]$ - Speed: $n = 982\ [min^{-1}]$ - Mass : $m = 4200\ [kg]$	- Manufacturer: Falk - Label: 1110T10 - Torque rating: $M_n = 9320\ [Nm]$ - Maximum speed: $n_{max} = 2250\ [min^{-1}]$ - Bore diameter: $d = 42 \div 120\ [mm]$
Item	**Reducer**	**Low-speed coupling**
Technical characteristics	- Manufacturer: Falk - Label: 485-A2 - Power: $P = 788\ [kW]$ - Ratio: $i_n = 15.44\ [-]$ - Mass: $m_{red} = 2857.6\ [kg]$	- Manufacturer: Falk - Label: 1180T10 - Torque rating: $M_n = 103000\ [Nm]$ - Maximum speed: $n_{max} = 1100\ [min^{-1}]$ - Bore diameter: $d = 153 \div 300\ [mm]$



A	B	C	D	E	F	G	J	K	L	M	N	O
9	14.88	30	19	35	2.5	22.5	15	58.5	33	14.4	30.7	23
		Low-speed shaft		High-speed shaft								Mass in lb
Q	R	S	Key	T	Key	U	V	W	X	XX	Y	
8	1.5	8.5	2x1.5x13	4.5	1x1x8	2	18	61.12	14.36	31.24	23.9	6300

Figure 1 *Reducer 485-A2 with assembly dimensions*



Size	A	B	C	D	F	J	Gap
1110T10	269.7	259.0	127.0	160.3	...	161.5	5
1180T10	629.9	483.6	238.8	393.7	554.7	321.1	6

Figure 2 *Couplings T10 with assembly dimensions*

3 CALCULATION

3.1 Calculation of Reducer

Calculation of reducer has for a purpose of verification the technical characteristics of reducer in given operating conditions and it is given according to [2]. The reducer is selected according to the required ratio of reducer and equivalent power which has to be less than the power rating of reducer. Checking the thermal rating of reducer is done according to the application adjusted thermal rating which must be greater than the actual power transmitted by reducer.

3.1.1 Reducer low-speed shaft rpm required

$$n_2 = \frac{60 \cdot v}{D \cdot \pi} [min^{-1}] = 64\ [min^{-1}]$$

Where:

$v = 3.8\ \left[\frac{m}{s}\right]$ –conveyor belt speed

$D = 1{,}132\ [m]$ - lined drive pulley diameter

3.1.2. Reducer ratio required

$$i = \frac{n_1}{n_2} = 15{,}34$$

Where:

$n_1 = 982\ [min^{-1}]$ - reducer high-speed shaft rpm

3.1.3 Reducer equivalent power

$$P_{EQ} = s_f \cdot P_{EM}\,[kW] =$$
$$= 675\,[kW] < P_{RED} = 788\ [kW]$$

Where:

$s_f = 1.5$ - service factor for heavy duty belt conveyors working over 10 hours per day

$P_{EM} = 450\ [kW]$ - electric motor power rating

$P_{RED} = 788\ [kW]$- reducer power rating

3.1.4. Application adjusted thermal rating

$$P_{TA} = B_1 \cdot B_2 \cdot B_3 \cdot B_5 \cdot P_T\,[kW] =$$
$$= 395\,[kW] > P_{EF} = 329\,[kW]$$

Where:

$B_1 = 0.822$ - ambient temperature factor for ambient temperature $t = 40[°C]$ and for reducer with or without shaft or electric fan

$B_2 = 1.00$ –altitude factor for altitude above sea level $H = +350{,}00[m]$ and for reducer with or without auxiliary cooling

$B_3 = 1.90$ –ambient air velocity factor for sustained ambient air velocity $v > 3{,}683\ \left[\frac{m}{s}\right]$, outdoors installed environment and reducer without shaft or electric fan or cooling tubes

$B_5 = 1.00$ - duty cycle factor for operating time per hour of $E = 100[\%]$ and for reducer with or without auxiliary cooling

$P_T = 253\ [kW]$ –basic thermal rating for reducer type A, AR and AXV with double reduction, for nominal ratio 11.39÷20.93, reducer size 385÷585, high-speed shaft rpm $n_1 = 982\ [min^{-1}]$ and for reducer with no auxiliary cooling

$P_{EF} = 329\ [kW]$ - actual power transmitted by reducer for belt conveyor drive [4]

3.2 Calculation of Couplings

Calculation of couplings has for a purpose of verification the technical characteristics of high-speed and low-speed coupling in given operating conditions and it is given according to [3]. Couplings are selected according to the torque rating of specific coupling which has to be greater than the minimum coupling rating obtained by multiplying the service factor and system torque rating, having in mind coupling dimensions and maximum speed.

3.2.1 System torque rating of high-speed coupling

$$T_{HS} = \frac{P_{EF} \cdot 9549}{n_1}\ [Nm] =$$
$$= 3199{,}2\ [Nm]$$

3.2.2 System torque rating of low-speed coupling

$$T_{LS} = \frac{P_{EF} \cdot 9549}{n_2}\ [Nm] =$$
$$= 49087{,}8\ [Nm]$$

3.2.3 Minimum coupling rating of high-speed coupling

$$T_{HSmin} = s_f \cdot T_{HS}\ [Nm] =$$
$$= 3199{,}2\ [Nm] < T_{HSnom} =$$
$$= 9320\ [Nm]$$

3.2.4. Minimum coupling rating of low-speed coupling

$$T_{LSmin} = s_f \cdot T_{LS}\,[Nm] =$$
$$= 49087{,}8\,[Nm] < T_{LSnom} =$$
$$= 103000\,[Nm]$$

Where:

$s_f = 1.00\,[N]$ – service factor for belt conveyors for coupling calculation

$T_{HSnom} = 9320\,[Nm]$ – torque rating of high-speed coupling

$T_{LSnom} = 103000\,[Nm]$ – torque rating of low-speed coupling

4 DISCUSSION

The selected reducer 485-A2 meets in terms of power because the equivalent power of reducer is less than the reducer power rating, i.e. the reducer selected from the manufacturer's catalogue is the first size that exceeds the required power rating. Ratio of selected reducer corresponds approximately to the necessary ratio. Also, the selected reducer meets in terms of thermal rating because the application adjusted thermal rating is greater than the actual power transmitted by the reducer for conveyor belt drive. In case that reducer did not meet in terms of thermal rating, the alternative would be the selection of adequate method of auxiliary cooling and its calculation verification. Auxiliary cooling of reducer may be via shaft or electric fan, via cooling tubes in the reducer itself for oil cooling by water or via separate installation for oil cooling in which oil circulates by pump through air or water cooler placed near the reducer.

The selected couplings 1110T10 as high-speed coupling and 1180T10 as low-speed coupling meet in terms of load because the torque rating is greater than the minimum coupling rating in both cases. It should be noted that at coupling selection, the care was taken about the shaft diameter of connected equipment that corresponds to the bore diameter of coupling, which on the other hand has to be within the certain limits given in the manufacturer's catalogue data (see Table 1). Therefore, although i according to the load criterion, one size smaller coupling can be adopted for both high-speed and low-speed coupling, it was not possible due to the limitations in maximum dimension coupling size.

5 CONCLUSION

The results obtained by calculation have shown that the components of drive unit, i.e. the reducer and couplings are properly designed.

In this case, the verification was done by procedure given in the manufacturer's catalogue data of the Falk Company that, with minor differences, corresponds to the calculation of reducers and couplings of the other manufacturers. Selection the components of drive unit is an integral part of design not only belt conveyors, but for many other devices on the mechanical drive.

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