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THE MATHEMATICAL MODEL AND GRAPHICAL ILLUSTRATION OF CORRECTED CONVEYING ABILITY FOR TRAPEZOIDAL BELTS

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ABSTRACT
Conveying ability of trapezoidal belts given through specific mathematical model or defined in a laboratory way for the corresponding profile and certain conditions is called nominal conveying ability P_{n1}. In real life, the trapezoidal belts are used to convey the power in the transmitter, which work under different conditions compared to those in laboratory. Therefore, the nominal conveying ability P_{n1} must be corrected for the actual case and this is called corrected conveying ability P_1. In this research paper, mathematical models and all impacts upon corrected conveying ability for two different profiles of trapezoidal belts are given and shown graphically.
Key words: trapezoidal belts, conveying ability.

1. THE MATHEMATICAL MODEL OF CORRECTED CONVEYING ABILITY

For a certain case in practice, the conveying ability of belt must be corrected in ratio with the nominal conveying ability P_{n1}. The nominal conveying ability P_{n1} can be read from the tables which are given by the maker of belts.

The correcting of nominal conveying ability Pn1 is done because of different factors in it, such as:

- *length of belt L,*
- *transmission ratio i, and*
- arc of contact α.

Final expression to determine the corrected conveying ability of trapezoidal belts, for the actual conditions is:

$$P_1 = K_\alpha \left(P_{n1} + \Delta P_L + \Delta P_i\right)$$

(1)

where:

K_α *– the factor of belt contact angle with the driver pulleyr (the small pulley),*

P_{n1} *(kW) – nominal conveying ability,*

ΔP_L *– addition of power because of length of belt impact,*

ΔP_i *– addition of power because oftransmission ratio impact.*

1.1. Belt length impact in conveying ability

Makers of trapezoidal belts make the corresponding profiles of belts with different length. Therefore, the length of belts is a stadard size. In practice, the length of belt depends on the geometric size of transmitter, which conveys the power.

Expression to calculate the addition of power, depending on the lenght of belt, is:

$$\Delta P_L = d_1 \cdot n_1 \cdot K_4 \cdot \log \frac{L}{L_o} \tag{2}$$

where:

d_1 (mm) – kinematic diameter of driver pulley (the small pulley),
n_1 (min^{-1}) – number of rotations of driver pulley,
K_4 – technological factor,
L (mm) – length of belt,
L_o (mm) – basic length of belt which differs for trapezoidal belts of different profiles.

From the second expression, ti can be seen that the addition of power ΔP_L might be positive, zero, or negative, depending on the ratio of lengths L/L_o.

The basic length of belt L_o depends on the profile of belt (tight or normal profile) and the technology used in making (made with winding or cutting).

1.2. Transmission ratio impact in conveying ability

Values of nominal conveying ability P_{n1}, which are shown in the corresponding tables, are for the angle of contact between the belt and the driver pulley $\alpha = 180^o$, respectively for the ratio of transmission $i = 1$.

In practice, usually are used transmitters with belts which have ratio of transmission $i > 1$ (reductors) or $i < 1$ (multiplexers). In such cases, the power which is being conveyed by the transmitter must be corrected for the value ΔP_i (kW).

The addition of power, which depends on the transmission ratio, is calculated through expression:

$$\Delta P_i = d_1 \cdot n_1 \cdot K_4 \cdot \log \frac{2}{1+10^x} \tag{3}$$

$$x = \frac{K_2}{d_1 \cdot K_4} \cdot \left(\frac{1}{i} - 1 \right) \tag{4}$$

where:

K_2 – technological factor,
$i = \frac{d_2}{d_1}$ *– theoretical ratio of transmission,*
d_2 (mm) – kinematic diameter of driven pulley (the large pulley).

1.3. Impact of contact angle of belt in the small pulley

In most cases, at transmitters with trapezoidal belts, angle of contact of belt with the driver pulley (the small pulley) $\alpha \neq 180^o$. The impact of contact angle in the power which the belt may convey from the driver pulley to the driven pulley is expressed through the factor K_α, which is calculated through expression:

$$K_\alpha = 1.25 \cdot \left(1 - 5^{\frac{-\alpha}{180^o}} \right) \tag{5}$$

2. GRAPHICAL INDICATION OF CORRECTED CONVEYING ABILITY

For engineers in general and constructors of transmitters with trapezoidal belts in particular, graphical indication of the above mentioned impacts in the conveying ability of belts is of a particular importance.

Expressions 1 through 5 are valid for all profiles of trapezoidal belts, however, some of the factors shown in these expressions differ for different profiles of trapezoidal belts.
Actually, the techological factors K_2, K_4 and the basic length of belt L_o as well, have different values for belts of different profiles.
Aiming to decrease the volume of work, graphical indication of factors which impact the conveying ability of trapezoidal belts, will be done for a tight profiles (*SPZ*), and for a normal profiles (*B*).

2.1. Graphical indication of belt length impact in conveying ability

Using expression 2 through MathCad software, for two values of diameter d_1 (63mm and 112mm), four different values of number of rotations n_1 (720, 960, 1440 and 2880 min^{-1}) of the small pulley, and for the interval of the length of belts from 400 mm through 5000 mm, the addition of power ΔP_L has been shown graphically for *SPZ* and *B* profiles.
SPZ – is a belt of tight profile made with winding (Envelope Construction).
B – is a belt of normal profile made with winding.

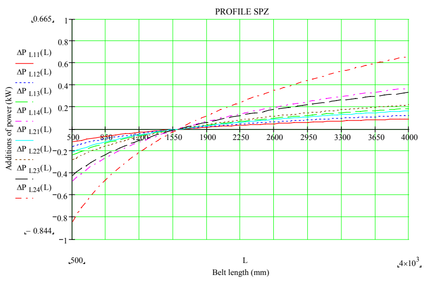

Figure 1. Addition of power ΔP_L (kW) for SPZ profile for n_1 =720;960;1440; 2880 min^{-1} and d_1 = 90; 170 mm.

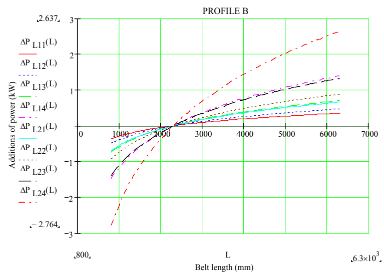

Figure 2. Addition of power ΔP_L (kW) for B profile for n_1 =720;960;1440; 2880 min^{-1} and d_1 = 63; 112 mm.

2.2. Graphical indication of transmission ratio impact

Using expressions 3 and 4, through MathCad software, for two diameters (minimal and maximal) four different values of number of rotations (720, 960, 1440 and 2880 min^{-1}) of the small pulley and for the interval of transmission ratio 1 through 5 has been graphically shown the addition of power ΔPi for *SPZ* and *B* profiles.

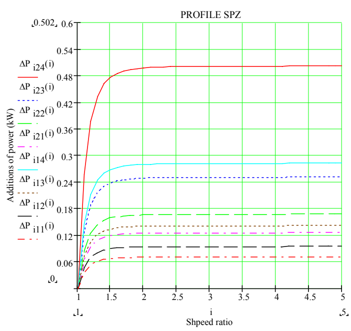

Figure 3. Addition of power ΔPi (kW) for SPZ profile for n_1 =720;960;1440; 2880 min^{-1} and d_1 = 63; 112 mm

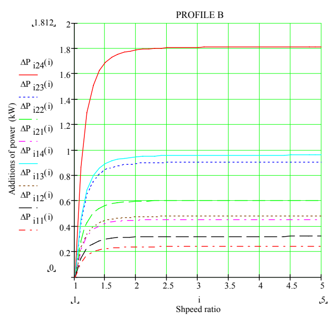

Figure 4. Addition of power ΔPi (kW) for B profile for n_1 =720;960;1440; 2880 min^{-1} and d_1 = 90;170 mm

2.3. Graphical indication of contact angle impact

Using expression 5, through MathCad software, for the value of of contact angle of 60 ^{o} through 240 ^{o}, the factor K_{α} has been graphically shown for the *SPZ* and *B* profiles.

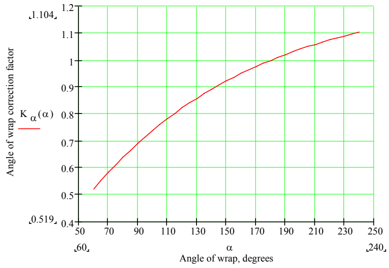

Figure 5. The facctor of embracement angle of belt with driving gear.

3. CONCLUSION

Based on mathematical expressions given in this paperwork, and based on diagrams which resulted from the given expressions, we can conclude that:

- the nominal conveying ability of trapezoidal belts depends on technological factors of belts constructive factors of the transmitter,
- at anytime when constructive coniditions allow, the length (L) of the belt is better to be higher than the basic length (L_o) because the addition of power will be positive (figures 1 through 2)
- for the d_1 diameter, and for the n_1 the same number of rotations of the small pulley, the addition of power ΔP_L goes through a light increase by increasing the length of belt (L),
- for the same length (L) of belt, by increasing the diameter (d_1) of the small pulley, and by increasing the number of rotations n_1, the addition of power ΔP_L is highly increased,
- the increase of transmission ratio in interval i = 1...2, affects a lot the conveying ability
- for the transmission ratio i>2, he addition of power ΔPi get constant value,
- by increasing the diameter d_1, and by increasing the number of rotations $n_{1,}$ the addition of power ΔPi increases a lot,
- by increasing the angle of contact between the belt and the driver pulley, the conveying ability increases as well,
- the analyzed impacts of conveying ability of trapezoidal belts have little differences for belts made with winding and cutting.

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