Spiral Conveyor Commissioning

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Abstract. Spiral conveyor is theme, that is not fully described in the literature. Based on this fact this work is dealing with commissioning of spiral conveyor and describing the most common mistakes causing serious damages. Commissioning of spiral conveyor will be set by theoretical calculation, measurement during operating and from long term observation. All these assumptions lead to properly set of spiral conveyors and improve its lifespan.

Keywords: Spiral conveyor, Tension, Modular Belt, Production.

1 Method of belt running and forces inside of system

1.1 Principle of conveyor

Spiral conveyor with two drums is usually driven by 3 separate motors for ensure smooth running of the belt. In this type of conveyor, modular belt must be pushed instead of pulled this is achieved tension reducing in system [1] (see Fig. 1).

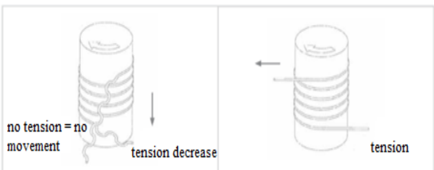

Fig. 1. Basic principle of movement.

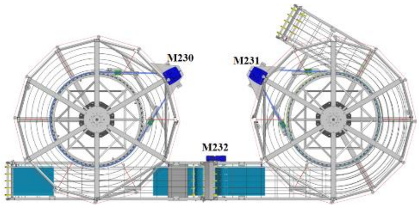

Fig. 2. Two-drums spiral conveyor with motors.

Speed of motor M230 (along direction of movement) has to ensure the highest peripheral speed. Motor M231 should be slower about 5-15% (depends on application and construction of spiral conveyor). Last motor M232 is direct drive of belt and operating with the slowest speed (see Fig. 2).
Final maximum force (Fu) or peripheral driving force is calculated by summarization elements of major resistance force (F_H) and minor resistance force (F_V).

$$F_H = f.L.g.(q_{RO} + q_{RU} + 2.m2.cos\delta) \quad (1)$$

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$$F_V = \mu.\frac{d_0}{D}.\mathrm{FT} \quad (2)$$

F_H – major resistance forces [N]
f – coefficient of friction [-]
L – length of conveyor [m]
g – gravitational acceleration [$m.s^{-2}$]
δ – angle of inclination of the belt conveyor [°]
m_2 – weight of 1 m conveyor belt [$kg.m^{-1}$]
q_{RO} – gravity force of rotating wheels with shaft on straight upper section of conveyor
q_{RU} – gravity force of rotating wheels with shaft on straight lower section of conveyor
F_T – size of tensioning force, which is determined by the supplier of the belt
d_0 – diameter of drum shaft for bearing [m]
D – diameter of driving drum [m]
μ – coefficient of bearing friction – 0,5 [-]

At initiation conveyor operation, the tensile forces of modular belt are different on different parts of conveyor [2]. The ratio of tensile forces in the conveyor belt is described by the Euler formula of fiber friction, where the given tensile forces are calculated according to the following formulas:

$$\frac{F1}{F2} \leq e^{\mu.\propto} \quad (3)$$

$$F_U = F_1 - F_2 \leq F_2 .(e^{\mu.\propto} - 1) \quad (4)$$

$$F_1 \geq F_U.(1 + \frac{1}{e^{\mu.\propto} - 1}), \quad (5)$$

$$F_2 \geq F_U.\frac{1}{e^{\mu.\propto} - 1} \quad (6)$$

F1 – pull force in the conveyor belt in the part of drive in on the drive drum [N]
F2 – pull force in the conveyor belt in the part of drive out on the drive drum [N]
μ – coefficient of friction between the conveyor belt and the drum [m.s-1]
α – contact angle of the conveyor belt on the drive drum [-]

For a correct calculation of given section of measurement must be taken correct contact angle and in the case of a calculation for the entire spiral or tower must be calculated the number of stairs, (see Fig. 3).
The Fig. 3 shows the theoretical setting of this type of over drive, which is set to one revolution of the belt (blue part), when the difference in the circumference distance on the outside of the drum (red curve) between one revolution of the belt and one revolution of the drum (grey part) is equal to the pitch of 4 floors of spiral conveyor.

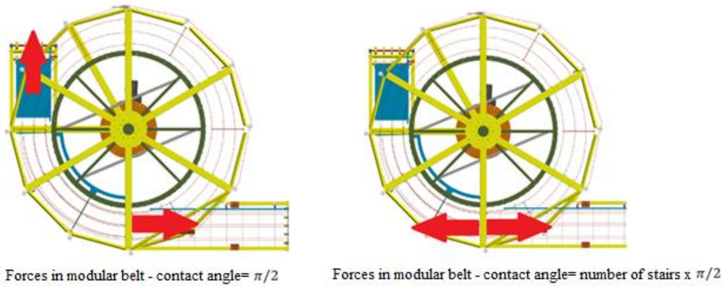

Fig. 3. Forces in belt at the different contact angle.

After these sets the spiral conveyor is ready for first test with products. All further corrections of setting it should be done during full load of spiral conveyor after few days of production when new belt will be settled down. [3]

2 Checking of load of spiral conveyor within production

Final phase of measuring and checking of system within full load of product is showing how spiral conveyor was set. Final result must be verified after long term of producing.

2.1 Load of the motors due to the fullness of the spiral conveyor by products

The using sensors on the spiral conveyor, it is possible to examine the fullness of the entire system with products (blue area of the graph in Fig. 4). The values are then compared with the current consumption of individual motors (orange, gray and yellow lines in the graph in Fig. 4).

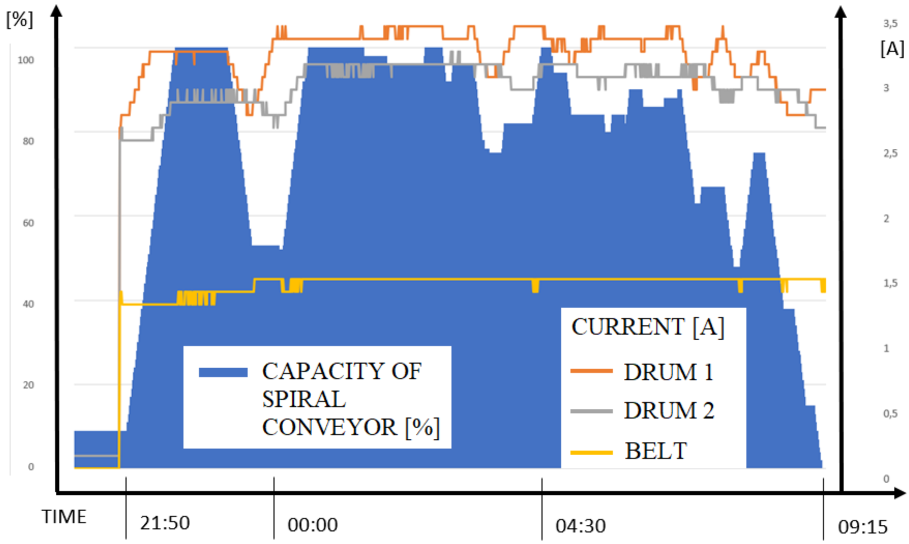

Fig. 4. Load of the motors due to the fullness of the spiral conveyor by products.

As the graph shows, when the capacity of the products increases, the flow rates of individual engines increase as well. The current consumption of the first engine (orange line) shows a faster growth and a faster decrease compared to the second engine (gray line) based on the design of the spiral conveyor. The current values for the third motor are almost unchanged after the full ramp-up of production.

Fig. 5. shows the magnitude of the tension force depending on the fullness of the spiral conveyor. The repeating pattern of the graph shows the placement of the measuring device on the spiral conveyor where the highest tension force always appears on the first curve of the second drum.

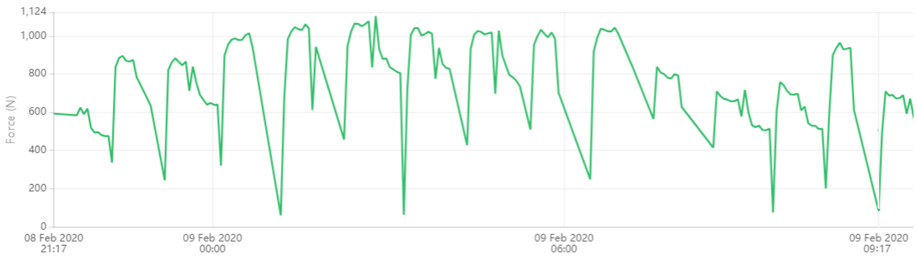

Fig. 5. Progress of the load on the modular conveyor belt.

In this way, reference values can be determined as for the current consumption of individual motors so the measured values of the tensile force on the modular belt. During regular service to verify the correctness of the entire system settings, all measured values are compared with a new measurement. This helps to detect the incorrect setting of the spiral conveyor, further hidden or newly incipient defects.

3 Incorrect setting and consequences

If not focused on the correct commissioning and settings of the spiral conveyor, will caused excessive wear of the belt, or an increase in its tension, which has a negative impact on the life time of the mechanical components.

3.1 Speed of first drum is much faster than speed of second drum

If speed of first drum will be faster than second drum the modular belt will be released at the top of fist tower of conveyor, which will cause not enough friction between belt and drum, not enough rolling away from drum and belt will started lifting up on the inside of radius as is showed in Fig. 6.

Spiral conveyor doesn't have any safety elements for guarding of this issue. What is commonly used are metal profile which are held belt on the inside radius and prevents its lifting.

Fig. 6. Lifting the belt on inside radii as a result of higher tension on top of first tower.

3.2 Speed of first drum is lower than speed of second drum

In case of higher speed of the second drum in compare with the first drum, tension going increasing on outside radius of belt (see Fig. 7).
This has the effect of lifting up the modular belt at the outside diameter.

Fig.7. Lifting the belt on outside radii as a result of incorrect speed of drums.

For this type of fault spiral conveyor has active control which stopped the whole system in case that modular belt going to lift.

3.3 Over drive is too large

At a high over drive, the belt begins to move jerkily mostly on the first drum, this causing the shaking of whole tower and unwanted cyclic stress.
The belt tension in lower part of drums looks very small, but on the top of decreasing part of spiral conveyor this tension is going higher and if add cyclic stress with increasing tension of belt so that all these facts are helping reduce life time of belt faster.

3.4 Over drive is too short

If over drive is not enough, that means angular speed of modular belt is almost equal as angular speed of drum. It caused increasing tension of outside diameter of modular belt.

In case of correctness manufacturing of modular belt this matter could not have impact to life time in short time period (see Fig. 8).

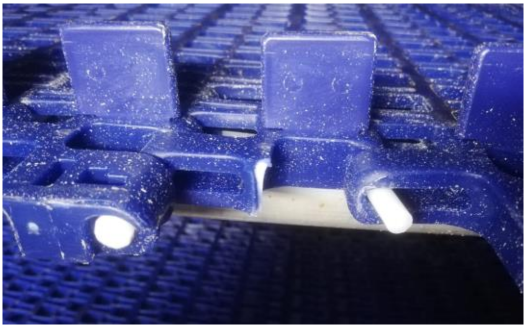

Fig. 8. Broken outside part of modular belt.

Weakness points are stand out after long time period with other causes of breaking parts of belt – cycling stress. Cycling stress together with higher tension and manufacturing defects leads to destroying of modular belt after couple months or years depends on load in system based on type of production.

4 Conclusion

This work was focused on spiral conveyor commissioning based on theoretical calculations, test measurements. The most important aspect of spiral conveyor setting is the correct adjustment of the motors so that the belt is not pre-tensioned unnecessarily and its lifespan is not shortened [4]. Another important setting is over drive, which must be set correctly, in other case arise cyclical stress on the system [5]. All settings have been verified by measurements and compare with [6]. The results of the measurements must be compared during further inspections.

References

1. J. Kold[1] and C. Silverman[2]: Conveyors Used in the Food Industry – Chapter 27. [1]JK-Innovation, Struer, Denmark [2]Volta Belting Technology Ltd., Karmiel, Israel.
2. M. Kusnerova[1], M. Repka[2,] M. Harnicarova[3], J. Valicek[4], R. Danel[5] and Z. Palkova[6]: A Study of the Connection Between Bending Stress and Belt Friction Using a Servomotor Controlled by a Computer. IEEE: PP(99):1-1, DOI: 10.1109
3. Habasit Homepage, https://www.habasit.com/en/Support-and-Services/Belt-Engineering
4. Z. Xingnan[1] and R. Glovnea[2]: Conveyors Used in the Food Industry – Chapter 27. [1]JK-Innovation, Struer, Denmark [2]: Grease film thickness measurement in rolling bearing contacts. DOI: 10.1177.
5. Film Thickness of Mechanically Worked Lubricating Grease at Very Low Speeds, https://tribos.wordpress.com/2016/06/23/film-thickness-of-mechanically-worked-lubricating-grease-at-very-low-speeds/>
6. V. Quaglini[1] and P. Dubin[2]: Friction of Polymers Sliding on Smooth Surfaces. DOI: 10.1155