Management Systems
in
Production Engineering

2012, No 2 (6), pp 18-21

EFFICIENCY INCREASING OF BELT CONVEYOR'S DRIVE BY CERAMIC LAGGING OF DRIVING PULLEY

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Abstract:
In any point of the belt contact with the drum a relative speed compensation takes place that is carried out by a slippage even when the relevant contact spots are fairly clean and dry. This leads to heat generation that is being absorbed by both materials involved – by the belt as well as by the drum. Unlike the belt, the drum lagging would increase its temperature up to a certain limit that depends on number of factors. When the lagging surface temperature is reaching appx. 60°C some structural changes in the lagging material take place and further rise of temperature can create a risk of belt inflammation and destruction of the driving unit. This can be avoided by lagging the drum with new materials that eliminate any friction on the contact surfaces and that are heat resistant.

Key words: *conveyor belt, the drum, friction, heat*

INTRODUCTION

Pursuit to increase the performance of any technological process sooner or later reaches its bottle neck – the transport element. Further increase of the drive units output has been limited by its size, weight and cost and this brought to prime attention the facts what is really happening on the contact area of the driving drum and the belt. The wrap angle has been increased, the driving drums were doubled and also some attempts has been tried to increase the friction coefficient between the drum and the belt by using different materials. No other options are available but with higgher drive outputs some new problems tend to appear.

When using a poor quality lagging and a dirty drum surface the increased imminence of slippage takes place. While using this lagging it brings the need for unnecessary increase in belt tension, otherwise you may face the imminence of slippage with its impuls phenomenon. It is therefore necessary to always use a drum with a quality surface lagging. As an example, the temperature of conveyor belt on empty conveyor, belt speed 8 m/s, was measured as high as 38 to 48°C.

In the contact area of the drum lagging and the belt a special effect caused by tension and deformation in the rubber layers takes place. In theory the drum surface speed and the belt speed would be equal. In fact a mini belt slip generating heat takes place here while this heat is absorbed by both contact area materials, drum lagging and the belt. The amount of absorbed heat is in certain relation to materials used (steel, rubber, ceramics). Considering the length of the belt it can dissipate sufficient volume of heat in the surrounding environment and thus this would not affect the belt covers. Nevertheless the temperature of the surface area of the drum lagging increases to the point when the generated and dissipated heat are equal. Under normal operation the drum temperature would not exceed 60°C. During overloading more substantial belt slip takes place and as a result the drum lagging temperature as well as the drum body and the belt temperature shows a rapid increase that may lead to belt ignition and drive destruction.

TRACTION EFFICIENCY – INCREASING THE COEFFICIENT OF FRICTION

The transmittion efficiency of the belt conveyor drive can be increased by increasing the belt down-pressure to the drum, by increasing the wrap angle but also by increasing the friction coefficient. The development of drums regarding the contact surface went from the bare steel over to the rubber lagging and the V-shaped grooves. An other attempt, not a very successful one, utilised polyurethan lagging with V-shaped grooves. The development went further to using driving drum with bonded milled ceramics vulcanized into rubber with V-shaped grooves configuration (Fig. 1).

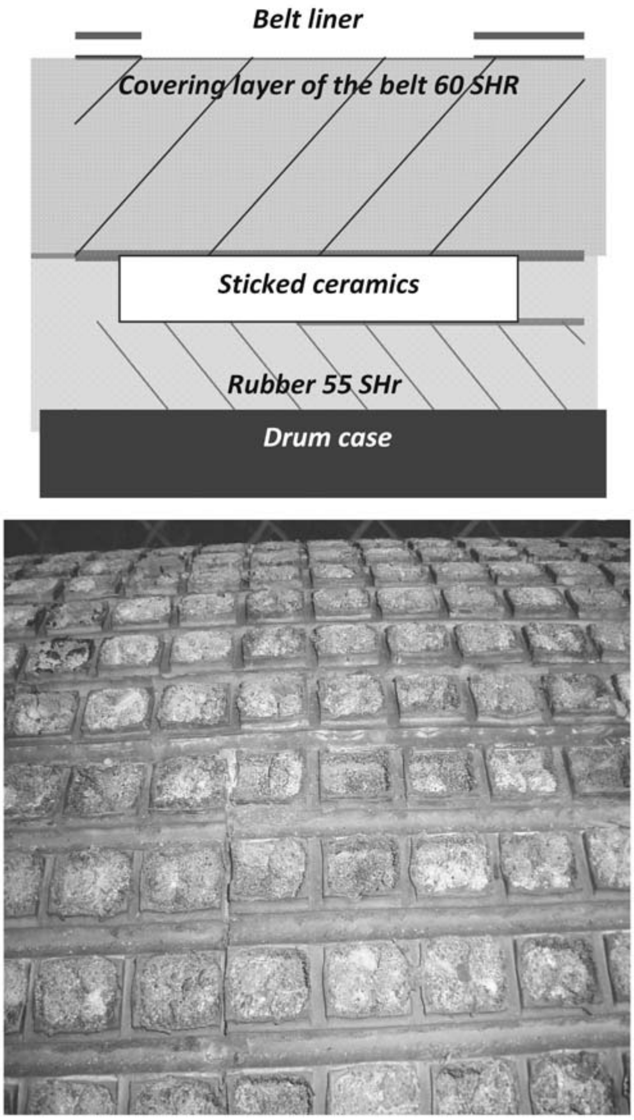

Fig. 1. Heat transmission on the drive drums

The above options mentioned have had their advantages and also drawbacks:

- A drum with rubber lagging featured a higher coefficient of friction but the thermal characteristics of this combination worsened at the same time. The heat generated at the contact area is conducted into the two elements involved, ie. into the belt and also the lagging. The rubber lagging tends to cummulate the heat in the drum and as a result the drum temperature is increasing and may exceed the critical temperature resulting in a local separation of the lagging from the drum surface, in some cases it may result in a spontaneous ignition of the belt followed by a fire on the drive unit.
- Drums with ceramic lagging (bonded milled ceramics vulcanised into rubber) also feature a higher coefficient of friction and at the same time partially bring the drum temperature to lower levels. Nevertheless during conveyor operation a gradual destruction of the bond material appears (due to temperature and ageing) and the ceramic lagging can crumble away. This is when the ceramic lagging is losing its point and the traction conditions return back to rubber to rubber level with all the already mentioned drawbacks.
- When starting up the drive it is necessary to bring the peripheral force on the drum that can overpower the conveyor resistance and accelerate the inertia mass of the system. The spreading tension wave results in a sudden decrease of the pretension force a thus decreasing the traction efficiency of the drums to handle the required peripheral force. The tensioning device can absorb the exceeding belt length resulting from belt elongation up to the belt speed 0,5 m/s only. It is therefore necessary to pretension the belt enough before the start up and create the necessary reserve in force and elongation of the belt. The tensioning action should start at the same time as the belt starts moving when it is possible to reduce the effect of belt tension decline beyond the driving drums effectively.
- After the tension wave goes through the whole length of the belt followed by an encrease of the belt tension it is no more necessary to increase the pretension level.
- The tensioning function can be disabled after the belt speed exceeds 1 m/s and the belt tension is higher than the belt start up bottom limit.
- During the steady running condition of the conveyor the motor of the trailing drum consumes only 50% of the current of the leading drum motor. This is caused by the fact that while the drum diameters are equal the trailing drum features much higher slip resistence as compared with the leading drum. This is where the slip resistance levels have to be adjusted.

The above options therefore feature some hazard factors:

- Micromovements on the contact area between the drum and the belt (creeping).
- The effect of temperature onto the drum surface.
- The limiting value of the transmitted pulling force – disproportion in motor's currents.

DRUMS WITH CERAMIC LAMELLAS/PLATES FLEX-LAG – SINTERED CARBIDE WITH CYLINDRICAL STUDS, VULCANIZED INTO RUBBER

It is currently considered that the most effective solution for driving drums lagging is use of rubber straps with vulcanized ceramic FLEX-LAG lamellas/plates that feature a 1 mm high studs. These studs sink into the belt covers and thus prevent from mutual movement between the belt and drive drum. This eliminates the so called belt creeping and the resulting heat build-up, furthermore, the ceramics being an excellent heat insulator minimize the heat transfer effect on the drum structure.

The rubber straps with vulcanized ceramic lamells are shown on (Picture – Fig. 2). The individual lamells are 2x2 cm in size and have 13 studs 3 mm in diameter. The overall thickness of the lamells is 5 mm and the studs are 1 mm high. The straps with ceramics can be either bonded or welded. A drum with this type of lagging is shown on the picture.

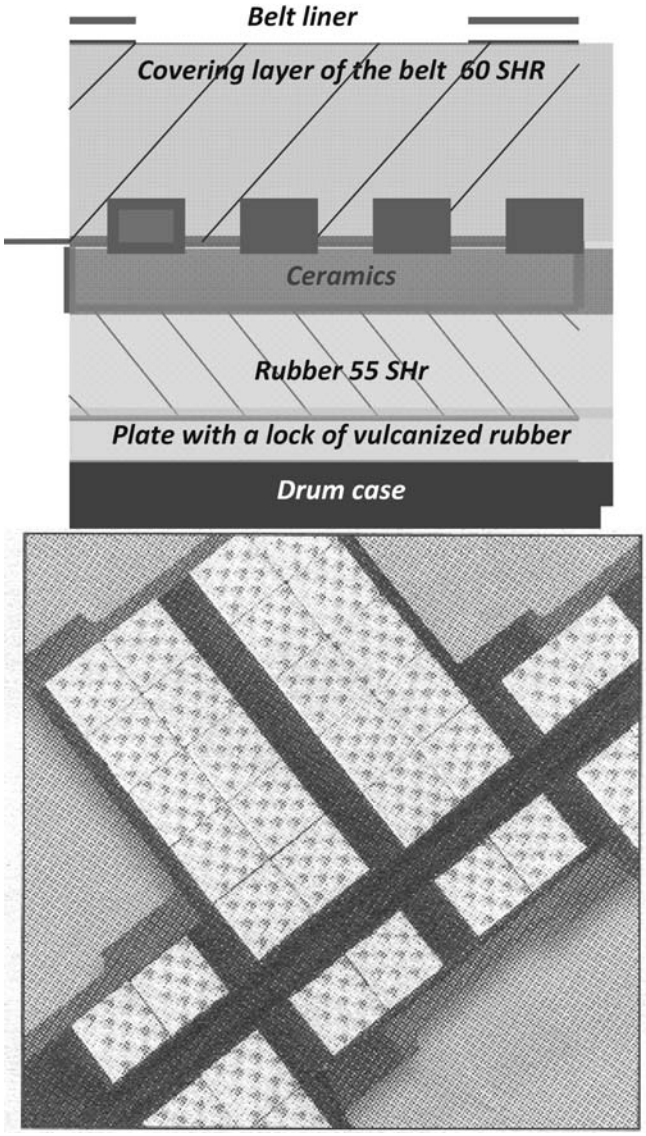

Fig. 2. Heat transmittion (non-transmittion) on drum with the ceramic lagging

Using the FLEX-LAG ceramic lagging features number of advantages:

– Improvement in pulling force transmittion, increased friction coefficient even in wet conditions in comparisson to the classical type of lagging (converges to 1);
– Takes up belt dynamic forces during the belt conveyor operation;
– Elimination of the belt slippage;
– Improves the removal of water and dirt between the drum and belt, prevents drum surface from dirt mounting;
– Much improved drum life – minimize drum body wear;
– Minimize the belt bottom cover wear;
– The straps with ceramics can be easily welded;
– Any damage on the drum lagging can be easily repaired.

It can be concluded that the drums with the FLEX-LAG lagging can be used even in the most difficult operational conditions. Similarly as the grooves on the rubber lagged drums also the configuration of the ceramic lamells on the drum surface itself helps considerably to clear off the potentially sticky material and prevents its mounting up on the contact area. The muddy deposits can also be cleared out by a water jet. Here it is possible to state that on the contrary to general opinion – the drier the better – the more water the better. The drum with a FLEX-LAG arrangement is then no more the weakest link of the belt conveyor system. Furthermore you do not need to fit the earlier required sensing system, eg. temperature monitoring probe etc.

All the above mentioned observations can be more or less seen on all belt conveyors but there is one that radically minimize entire hazard factors. And that is the belt conveyors drives design. It was unambiguously proven in practice that the conveyors with two or multi drum drives in close vicinity to each other are considerable contribution to faster damage and destruction of not the drum lagging only but also the belts. This is due to existence of only a short elastic element of belt that is to compensate most of the dynamic surges in the belt betwen the two cascading drives. The effect of the above on the life of lagging and trouble free operation of the drive unit has been proven by design of drives for surface conveyors (12 to 15 m) and the deep mine application drive (1 to 1,3 m) where you can observe different conditions on motors during the start-up and also conveyor running, straining of the belt covers and drum lagging. When using the FLEX-LAG ceramic lagging it is much easier to control this effect.

Considering the theory of the pulling force transmission from the driving drum onto the conveyor belt that has been based on affinity educed for laminar friction as per Euler, the relation between the leading edge force and the trailing edge force, a known friction coefficient on the drum surface and the wrap angle, this can be then defined as a quotient of the two forces:

$$\frac{F_1}{F_2} = e^{f\alpha} \tag{1}$$

where:

F_1 – leading edge force [N]
F_2 – trailing edge force [N]

When using the ceramic lagging FLEX-LAG the classical friction coefficient is losing its bearing as the transmission conditions are rather approaching the transmission utilizing the spur belt. It has been experienced that the life of this ceramics is at least 12 years, it is still running and shows no signs of damage.

ACKNOWLEDGEMENTS

The article is based on partial solving the grant MPO FR-TI 1/537 „Comprehensive diagnostic system for belt conveyors".

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