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DEVELOPMENT OF AN ALTERNATIVE DRIVE CONCEPT FOR BELT CONVEYORS BY USING DRIVEN IDLERS

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ABSTRACT

The idea of distributing power along the conveyor belt system has been around for a long time. Intermediate drives are nowadays realized by linear belt-on-belt or tripper drives. Both systems have technical or financial disadvantages due to high investment costs or an increased stress for the conveyor based on additional transfer points. An alternative drive concept is the application of driven idlers to realize a huge decrease of the maximum belt tension. Therefore, new concepts are necessary to control the large number of driven idlers.

INTRODUCTION

Belt conveyor systems are the leading technology for the transportation of bulk materials over long distances. The capacity and length is mostly limited by the occurring belt tension, mainly caused by the bulk material or vertical route guidance. Due to the demand for longer conveying distances and higher mass flows, intermediate drives or high-strength steel cord belts with a strength of 10,000 N/mm can be used today [1]. High-strength steel cord belts are expensive and only shift the limiting factor for the conveyor design.
As a new technology of drive concepts the Institute of Transport- and

Automation Technology (ITA) of the Leibniz Universität Hannover in Germany is doing research in the field of driven idlers [2]. Former investigations were performed in the 1970s, but were not followed up due to a lack of controlling possibilities in those times [3]. Nowadays, control technologies have become a basic equipment and offer a wide range of possibilities. The research performed at ITA is focussing on the transferable forces under different conditions as well as the development of control techniques and algorithm for up to a couple hundred cross-linked driven idlers.
The advantage of driven idlers is not only to increase the distance of newly built conveyors, but also to increase the capacity of existing belt conveyor systems. BHP Billiton Limited (Australia) is looking for the most efficient way to increase the capacity of a bottleneck port conveyor. The installation time of additional driven idlers is expected to be way shorter than the installation time of a completely new main drive. Downtimes are reduced drastically and thus saving money. Therefore, BHP has installed a driven idler test device into the selected conveyor system to determine the maximum transferable forces and the required amount of additional drives under field conditions.

INTERMEDIATE DRIVES

Driven idlers are an alternative drive concept and have to be compared with conventional intermediate drives. In figure 1 the belt tension for three intermediate drive concepts can be seen, compared to the occurring belt tension at a conventional conveyor system with only one head drive. At a conventional belt conveyor (1) the belt tension increases over the conveying length due to the weight of the belt itself and mainly the bulk material. The maximum belt tension occurs at the head of the conveyor and provides the basis for the construction of the conveyor belt.

There are two concepts of intermediate drives that have proven well in the past decades and became state of the art. On the one hand additional drive belts (2), also known as TT Drive, were used. On the other hand additional drive pulleys (3), also known as Tripper Drive, were used and have prevailed theirselves as the leading technology of intermediate drives [4].

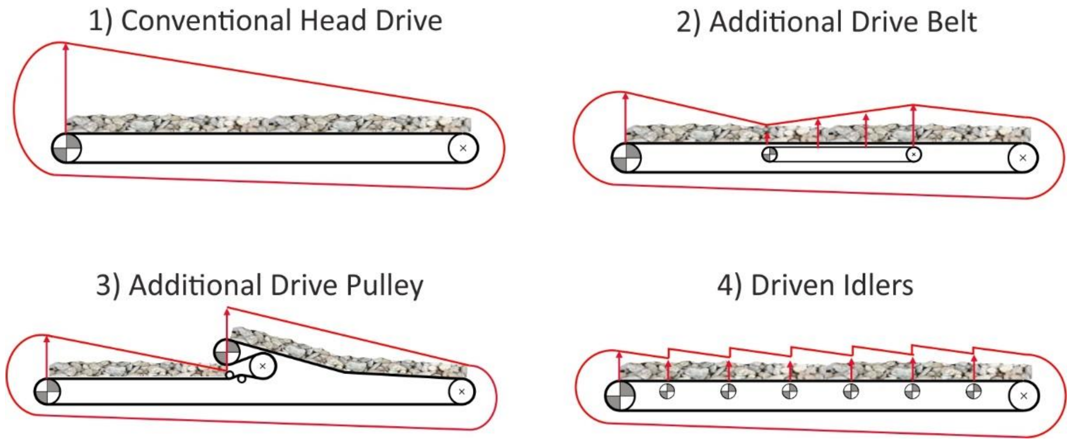

Figure 1: Belt Tension for different Drive Concepts

In comparison the idea of driven idlers (4) has two distinct advantages: At first the route guidance is not influenced and conventional idlers can be replaced easily. Secondly the belt tension can be reduced and equally distributed along the route. Furthermore driven idlers could especially be used in chosen sections of the conveyor, for example vertical curves, to secure the belt tension. The load sharing on the one hand is easier since you have many small drives that can be precisely adjusted, only have a small influence compared to a drive pulley and are evenly distributed, but on the other hand more complex because of the large number of drives along the conveyor that need to be matched and communicate with each other.

INVESTIGATION ON FORCE TRANSMISSION

The main problem of driven idlers is the limited force transmission because of a small contact area between belt and idler. Hereby, several factors have a greater influence compared to conventional belt conveyors.

To evaluate the use of driven idlers it is necessary to know the transferable power in optimal as well as bad conditions. Subsequently the design of the conveyor system and the operating conditions of the driven idler can be improved. Therefore, multiple test series are performed at ITA, which are supposed to provide a comprehensive basis for the design of driven idlers.

Exemplary test results are shown in figure 2 to compare the transferable motor power P_{el} for different vertical loads F_V in relation to the occurring slippage between belt and driven idler. The driven idler has a diameter of 240 mm and a blank steel coating. The belt velocity is set to 4 m/s. Three different width-related vertical loads F_V of 2.5, 5 and 15 kN/m are compared and it can be seen that the transferable electrical motor power increases for higher vertical loads

F_V. For example an ore conveyor with a vertical load of 15 kN/m can be driven with a motor power of around 7.2 kW at a slippage of 1 %. A conveyor for lighter material with a vertical load of 2.5 kN/m can only be driven with a motor power of 2.7 kW at the same value of slippage. These results apply to dry ambient conditions at 20 °C. Further investigations have shown that the transferable force can be slightly improved at higher ambient temperatures of 40 °C or decreased at lower ambient temperatures of 0 °C. Temperatures below 0 °C will decrease the force transmission even more due to the existence of ice at the belt running side or idler coating and thus reducing the friction factor. The belt sag is not considered in the measurements shown and is supposed to greatly improve the force transmission. Furthermore, first investigations have shown an improvement of the force transmission for smaller idler diameters.

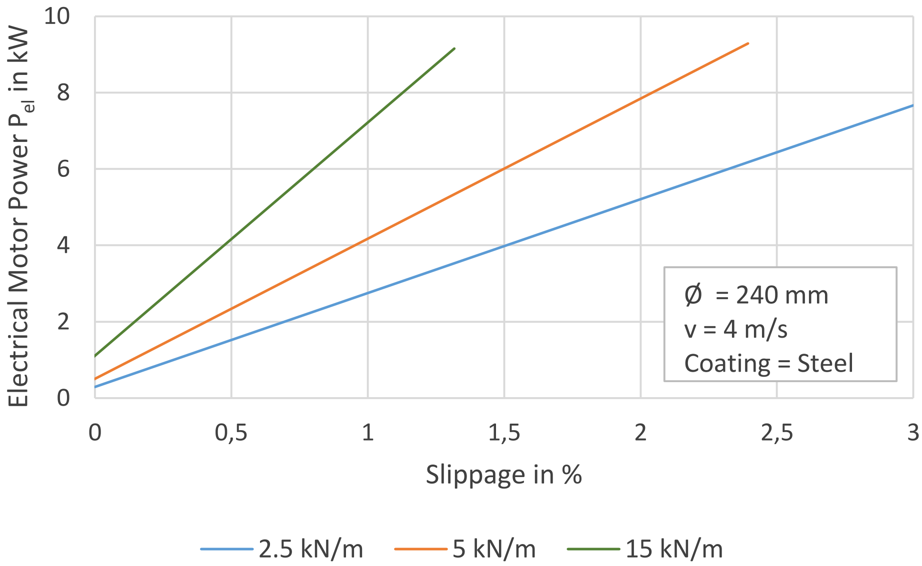

Figure 2: Transferable forces compared for different vertical loads F_V

A critical point of operation might result from the influence of moisture for example caused by dew or rain. The friction factor is reduced and due to the small contact area, slippage between the driven idler and conveyor belt is greatly supported. Therefore test series are performed to determine the loss of transferable power caused by moisture. The results for a bright steel surface have shown that the transferable power is reduced by approximately 30 % during a constant moistening of the belt running side. This loss is acceptable, but has to be considered when designing a driven idler as intermediate drive.
An improvement of the power transmission in wet ambient conditions might be found in customized idler coatings. Special patterns on the idler result in a better drain of the water. Figure 3 shows three exemplary coatings as they are

also used on conventional drive pulleys. The rubber coating for example can be made with horizontal stripes or diamond pattern. Furthermore, ceramic inserts can be used to increase the friction factor or the coating lifetime.

Figure 3: Different coatings for drive pulleys, referring to [5]

CONTROL CONCEPT

As mentioned above, it is possible to use driven idlers as an additional drive for conveyor systems. Despite the different environmental parameters in comparison with a head drive such as a much smaller contact arc or a significantly greater dependence of the transferable force on slippage, it is generally possible to control a single driven idler. However, in order to utilize the possible advantages offered by the reduction of the belt tension (see figure 1), more than one single driven idler is required. To control each single driven idler in an optimal and efficient way, different information need to be collected as well as to be analysed. This information relates to the actual belt speed, the local load on the top of a driven idler, the rotational speed of the driven idler, and the target speed of the conveyor belt. Most of the information is partially drive-dependent or position-dependent and must be determined accordingly for each individual driven idler.

In addition to the possibility to increase the mass flow of existing conveyor systems by using a small amount of driven idlers, the main goal of the current research is to realize conveyor systems with significantly enlarged conveying distances based on the drive concept of driven idlers. In order to achieve this goal, a control concept is necessary, which is capable of collecting all information and determining the respective speeds and torques for each driven idler in real time. As the number of driven idlers increases, the complexity of the control task increases as well. A classic, central control concept quickly reaches its limits. In order to solve this problem, it is useful to distribute the control task to a large number of small control systems, which are capable of processing the control task in real time. As shown in [6], a very complex control task can be solved very well by small, distributed control units (DCUs) which are capable of exchanging information among themselves. Each of these distributed control units controls one single driven idler and is capable of exchanging information with other DCUs. All of the DCUs together are both able to take over the control of their respective driven idlers and able to collect the necessary information and forward them to their neighbours. The information collected at a particular location in the conveyor system is relevant primarily to the DCUs, which have a spatial proximity to the location of the information acquisition. For this reason, it is important that the individual DCUs of driven idlers, which are close to each other, are grouped on the control level in neighbouring areas. This idea of grouping individual DCUs is shown more detailed in figure 4.

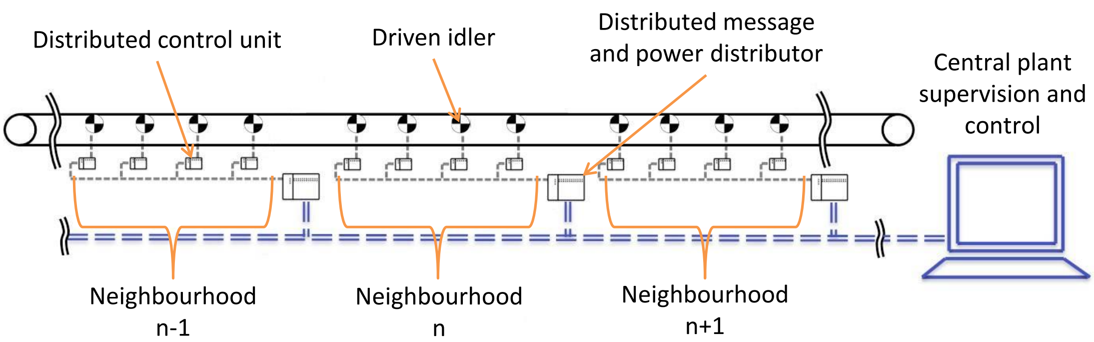

Figure 4: Grouping of DCUs to control conveyor systems

Thus, the information exchange between these DCUs can be spatially limited and the data traffic on the communication channel can be reduced compared to a communication model in which all DCUs communicate with each other. By reducing the control complexity and the clearly regulated communication between the individual DCUs, it is possible to control a conveyor system in close proximity to any number of driven idlers in real time.

CONCLUSIONS

The use of driven idlers provides a wide range of possibilities. Besides the conventional intermediate drives further applications are possible. Driven idlers can for example be used to balance local belt tensions in small curve radii or vertical route guidance. Another advantage is the easy upgrade possibility of existing conveyor systems, where the flow rate of an existing conveyor has to be increased after several years of operation. Instead of a

completely new main drive, driven idlers can be installed with a reduced downtime. The flow rate is increased while keeping the belt tension constant.
Laboratory tests are performed at ITA to provide a comprehensive basis for the design of a belt conveyor with driven idlers. Hereby, main factors for the force transmission between driven idler and belt are investigated. For example the influence of the vertical load is shown to be a main factor for the amount of transferable drive power.
Besides the mechanical design, a main aspect of research at ITA is the development of an intelligent control concept. Here, several hundred driven idlers shall communicate with each other and adjusting their drive power autonomously. A similar concept is also developed at ITA and already working successfully for small-scale multidirectional transport modules used at warehouse logistics.

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