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The Use of Intermediate Drive Units for Belt Conveyor Systems

Th. Weigel, Germany

Summary

In order to be able to increase conveying capacities and/or cope with inclinations in the conveyor route, where belt strength and available drive power may no longer be sufficient, intermediate drives are introduced which allow driving of the belt without using drive pulleys thus eliminating additional transfer points.

Details on the intermediate drive systems are given, and a new drive system (System Hörstermann) is introduced. This system was installed in an existing belt conveyor and operated with good results in a limestone mine. The test results are analyzed.

1. Introduction

One can hardly imagine any field of materials handling where belt conveyors have not been, over many years, particularly successful as a means for continuous conveying. Even where special requirements have to be met with respect to capacity or safety, and where it would seem that the present technical limits in design are reached, manufacturers and operators together have found new solutions.

As an example can be mentioned underground mining where today the governing belt strengths are often insufficient for the construction of inclined shaft conveyors. Similar problems arise in the field of long distance conveying. The length of individual conveyors is limited by the predetermined belt strength and the requirements for greater capacities.

One possibility of overcoming or removing such limits is the use of intermediate drive systems. In the following the special belt-type intermediate drive systems will be described.

2. Intermediate Drive Units

The requirement is to transmit driving forces to the conveyor belt without having to provide for additional transfer points.

Dr.-Ing. Th. Weigel, PHB Weserhütte AG, P.O. Box 260, D-6670 St. Ingbert 1, Federal Republic of Germany

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Furthermore it should be possible, in order to save costs, to use an existing, standardized, conveyor belt within an installation.

These points make it necessary to transmit the required force by friction. In order not to create any new transfer point the frictional forces must act on the conveyor belt directly, linearly and without any pulleys.

In this connection the question of the value of the friction coefficients and the normal force arises, i.e., what is the length which must be spanned by the intermediate drives, so that the belt conveyor can be operated.

A rule generally applicable to equipping the conveying route with intermediate drive units, i.e., for the ratio of length of belt conveyor to the overall length of the conveying system, cannot be given. Separate investigations must be made for each application. For horizontal or inclined belt conveyors, for example, varying lengths of intermediate drive units are required, according to the necessary lifting work.

Independent of the design of the intermediate drive unit the designer will try to keep the conveying line to be equipped with an intermediate drive unit as short as possible, as each intermediate unit means also additional construction components and therefore additional costs.

Fig. 1 shows the lengths of a straight belt conveyor that have to be equipped with intermediate drive units to enable their operation.

In the case of the intermediate drive unit, contrary to the ordinary operation with drive pulley, conveyor belt and driving belt are simply in contact with each other without any special binding arrangement. The force between the belts is achieved by frictional contact according to the Coulomb Friction Law: $F_R = \mu' F_N$, where F_R is the friction force transmitted by the intermediate drive onto the conveyor belt, μ' the friction coefficient and F_N the normal force acting between the conveyor belt and the driving belt.

For determining the curves in Fig. 1 it is assumed that the friction force F_R is greater or equal to the force of resistance F_W : $F_R \geq F_W$.

The force of resistance F_W includes in the case of horizontal belt conveyors all occurring main, secondary and special resistances; in the case of inclined belt conveyors the resistance forces from the downward slope drift also have to be added.

If L represents the length of the conveying line which is moved by an intermediate drive, L_Z the loading length of the

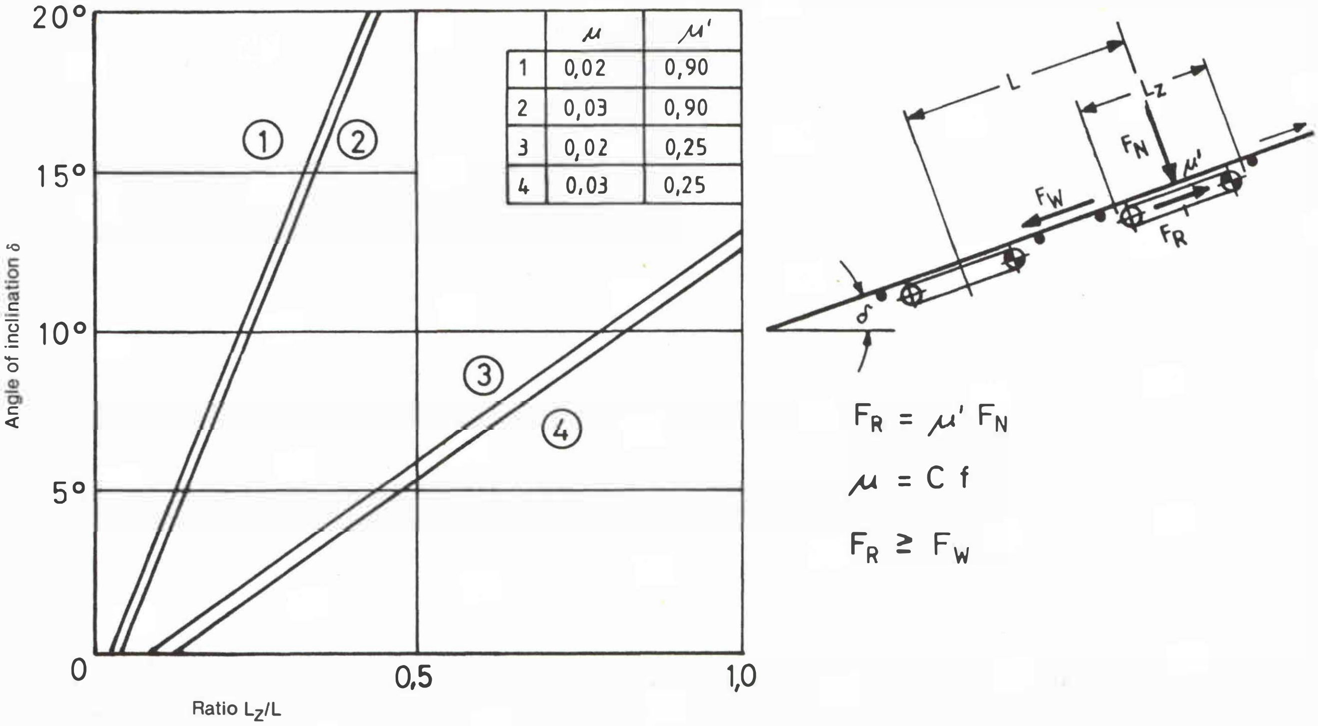


Fig. 1: Equipping of conveying line with intermediate drive units

intermediate drive and δ the angle of incline of the conveyor, then one can calculate, while neglecting the weight force resulting from the rotating idler components, the ratio L_Z/L. By $\mu = C \cdot f$ the coefficients and friction values for the capacity calculation for belt conveyors according to DIN 22101 are combined.

In Fig. 1 the ratio L_Z/L for an angle of inclination between 0° and 20° is plotted. The values used for μ, i.e., between 0.02 and 0.03, cover a large range of belt conveyors 0.25 and 0.9 were used as limits for the friction coefficients μ'. Similar values can be found in the literature.

As shown by the curves in Fig. 1 the length of the conveying route to be equipped with intermediate drive units depends considerably upon the friction coefficient μ' between the conveyor belt and the driving belt.

This is also the reason why the procedure of power transmission between the two belts should be studied in more detail.

3. A New Intermediate Drive System

In the patent literature various intermediate drive systems have been described. To date these have been mainly intermediate drive units following the carrying driving-belt procedure, wherein over a certain length L_Z a driving belt is carried along underneath the conveyor belt and through the troughing idler stations. A new system, however, is described below:

Whereas with the carrying/driving-belt drive units known to date the driving belt is in contact with the conveyor belt over the whole length of the intermediate drive, the new intermediate drive system (System Hörstermann) provides driving belt contacts with the conveyor belt always only over short distances and between these contact points it is separated from the conveyor by means of snub pulleys. Furthermore the driving belt is arranged, as shown in Fig. 2, only in the zone between center idlers of the troughing idler stations.

The advantage of this type of belt guidance becomes apparent when examining the movement of the belt points towards each other over the length of the intermediate drive unit. The force distribution in the conveyor belt and the driving belt is shown schematically in Fig. 3.

The belt tension in the conveyor belt is reduced in the contact points from T_{x1} to T_{x2}. This means that the conveyor belt is contracting. Accordingly, the tension in the driving belt increases, i.e., the driving belt is extending.

In case the ply moduli of the belts are known, as well as the tensions in the belt and the geometric dimensions, then the mutual movement of the belts can be calculated. In case one bases the Hörstermann System on the driving belt having only half the width of that with the carrying-and-driving intermediate drive type, then the movement of the belts in the contact faces decreases, with equal elastic characteristics of the belts, by a factor of 10.

This means that the power transmission is not affected by excessive slipping nor that the driving belt and the conveyor belt influence each other in their running behaviour; possibly showing, e.g., lateral misalignment. Furthermore limited slip means also less wear in the belts.

Now, how can this type of intermediate drive be put into practice?

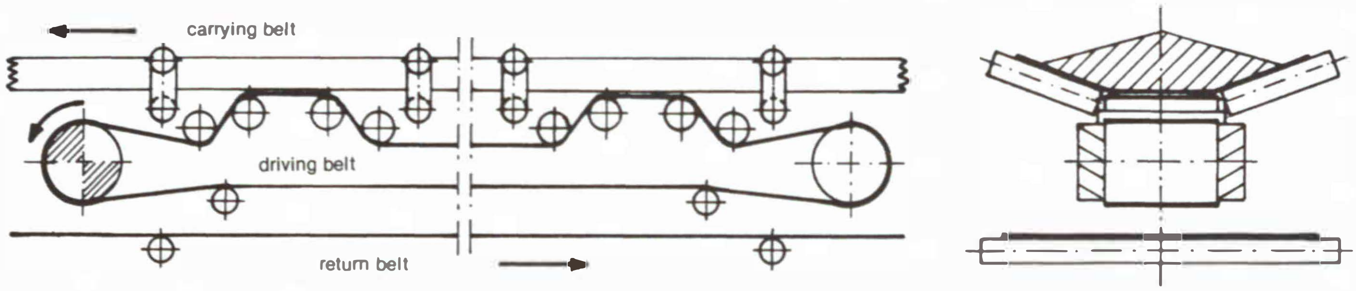


Fig. 2: Driving belt arrangement of intermediate drive unit

4. Application of the New Intermediate Drive System

Since March 1981 the intermediate drive unit shown in Fig. 4 has been in operation in a limestone quarry. The main technical specifications of the belt conveyors are as follows:

capacity	280 t/h
material handled	limestone, dolomite
grain size	0 to 700 mm
apparent density	1.4 t/m³
belt width	1,200 mm
belt type	St 2000
belt speed	1.05 m/sec
idler spacing in the zone of the intermediate drive unit	1,400 mm

The intermediate drive system has the following main specifications:

axial distance	11 m
width of the driving belt	400 mm
belt type	EP 800, vulcanized endless
installed power	25 kW
type of drive unit	DC-motor thyristor controlled
speed of the driving belt	0 to 1.5 m/sec., infinitely variable
type of take-up device	screw-type, cup spring gathers; locking of take-up pulley following adjustment

In the present case the intermediate drive system has been installed in an existing belt conveyor which is transporting the run-of-mine uncrushed limestone from the feeding point near the mining face to the crushing and screening station. Two complete belt tables of 6 m length each were replaced by an intermediate drive system. The troughing and the arrangement of the carrying belt have been maintained in the zone of the intermediate drive unit whereas the return belt was directed in its run downwards, by means of straight idlers, so that a clearance for installing the intermediate drive system could be created.

In Fig. 5 the arrangement of the snub pulleys for the driving belt is shown between two troughing idler stations. On the return belt only one idler can be seen since the belt is hidden by structural steelwork.

For determining the friction coefficient μ' prevailing during operation, the forces between the belts and the transmittable power, a detailed testing program was carried out.

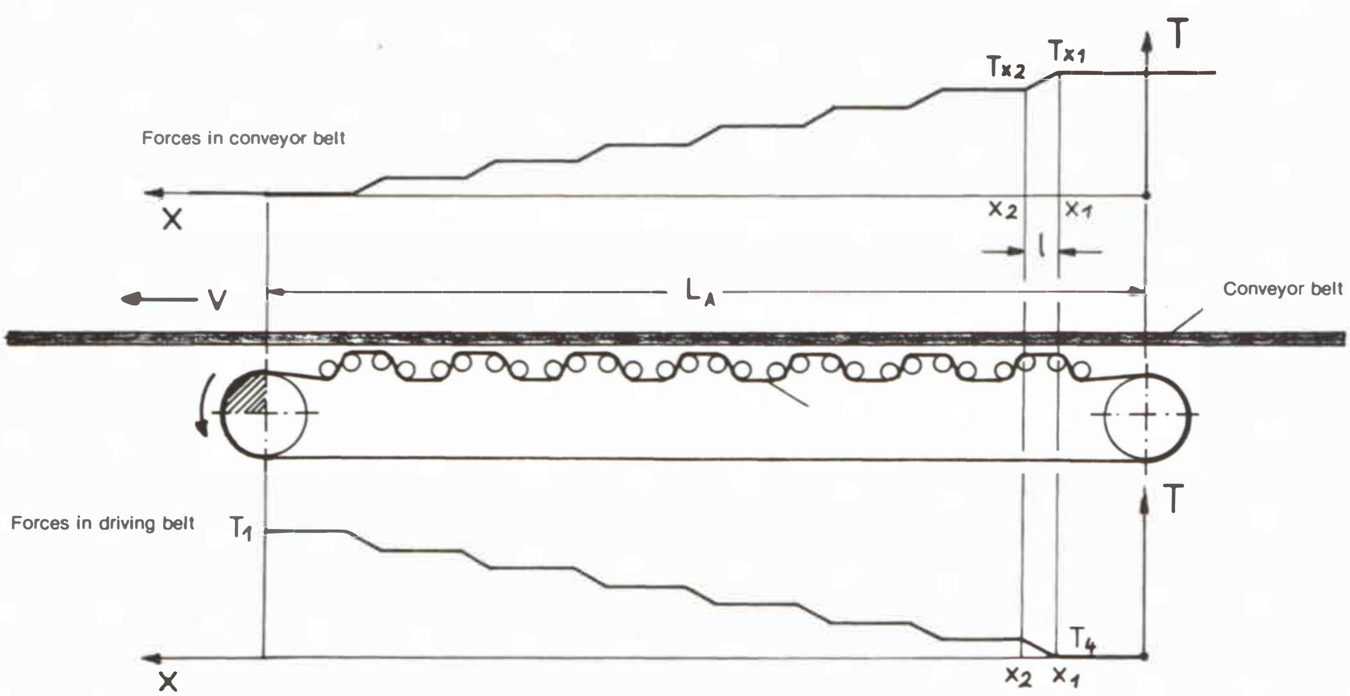


Fig. 3: Distribution of belt forces in the region of the intermediate drive system

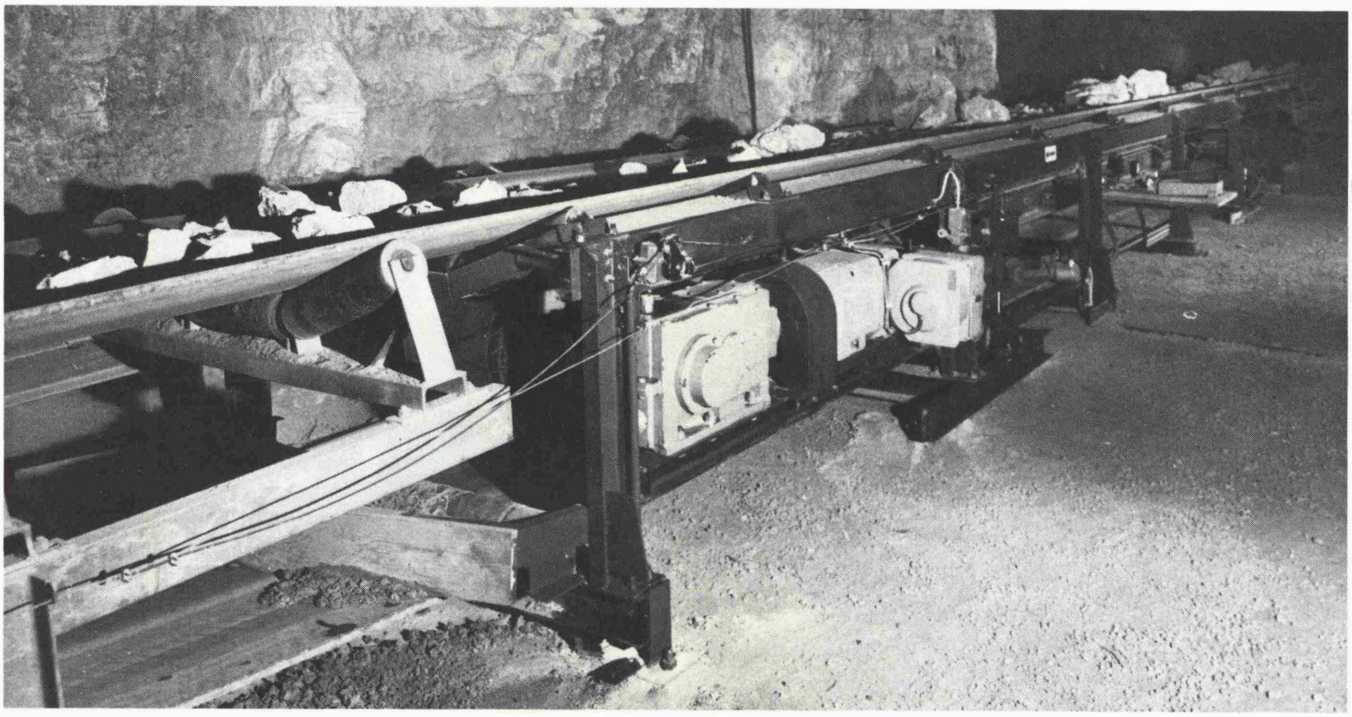


Fig. 4: Intermediate drive system installed in a limestone mine

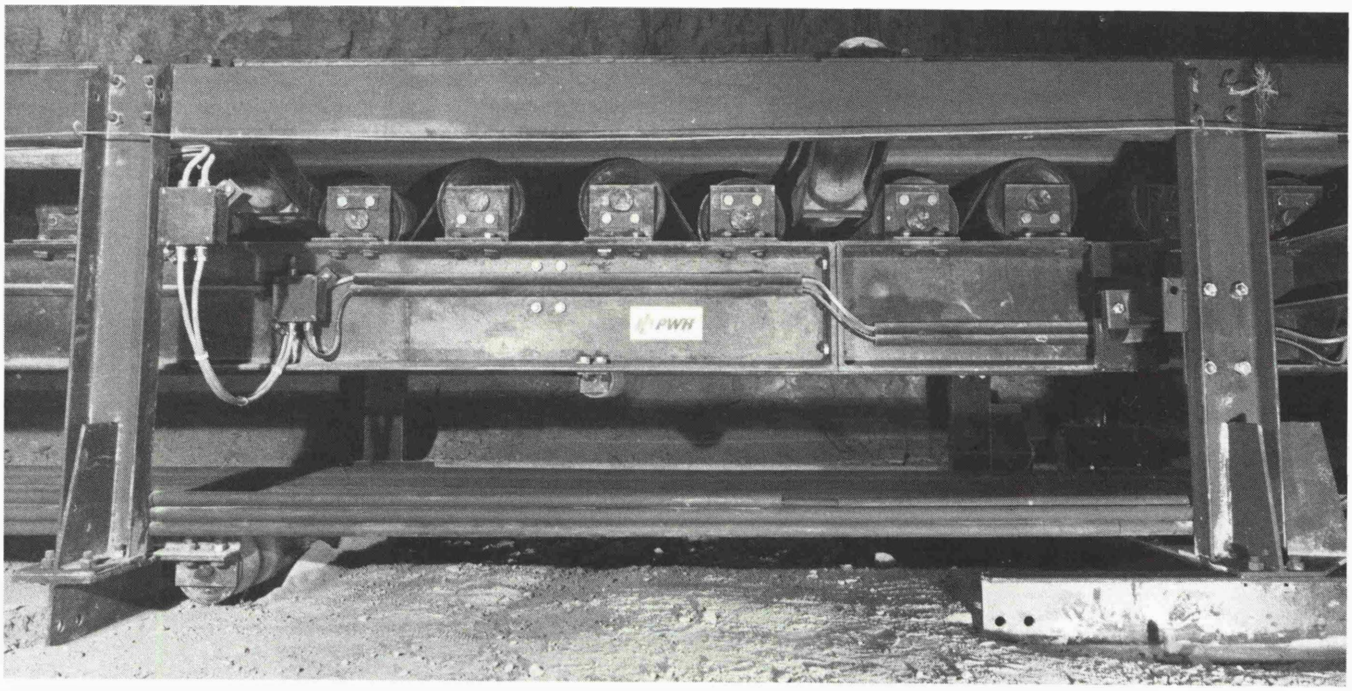


Fig. 5: Arrangement of the driving belt

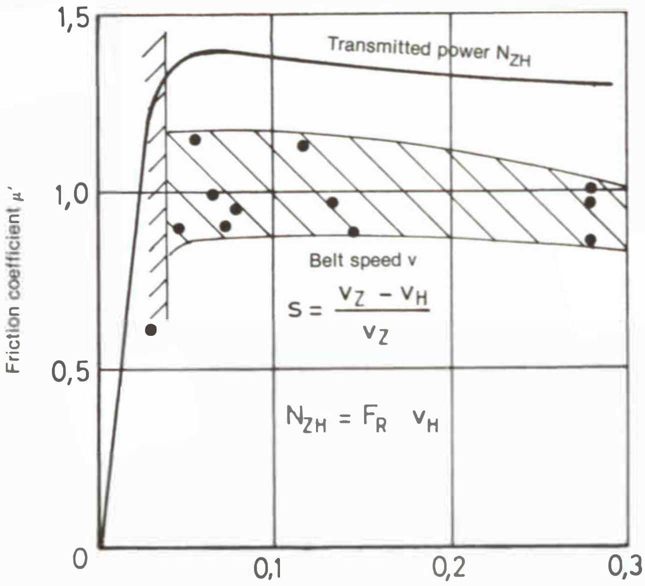
The following data were monitored and later evaluated:

- Power consumption of the intermediate drive unit,
- power consumption of the main drive unit,
- normal forces between the conveyor belt and the driving belt,
- speeds of conveyor belt and driving belt.

While taking into consideration the efficiency data of motor and gearbox the friction coefficient μ' is calculated from the slip between the belts and the power consumption of the intermediate drive unit. The no-load run-losses of the intermediate drive system are deducted when determining the values, by forming the difference between the no-load motor output and the output under full load during operation.

The measured friction coefficients μ' are plotted in Fig. 6 against the slip s. The friction coefficients are in the region between $\mu' = 0.85$ and 1.14. With increasing slip the friction coefficients decrease slightly and in the case of very small slip small friction coefficients are found. These data represent the actual friction coefficients and not the possible maximum coefficients. Fig. 6 contains the friction coefficients over a very large region of slip up to $s = 0.3$. The operating point of the intermediate drive is with a slip of $s = 0.03$ to 0.04 as marked by the vertical separating line.

The schematic curve plotted in Fig. 6 depicting the power transmitted by the intermediate drive onto the conveyor belt shows the same tendency as the friction coefficients. From slip $s = 0$ to a maximum value at $s = 0.06$ a rapid increase of



the transmitted power occurs. With further increasing slip values the transmitted power begins to decrease again.

Besides the measured data, useful experience was gained by observing the operation of the intermediate drive unit over a longer period of time. This experience can be used for the construction of future drive arrangements. The positive results obtained during the operation prove that this type of drive unit is a good solution for the problems referred to at the beginning of the article. The intermediate drive systems allow for an even more flexible adaptation of belt conveyors to their intended purposes.

Fig. 6: Friction coefficients between conveyor belt and driving belt