CHARACTERISTICS AND DESIGNING OF THE BELT CONVEYOR ELEMENTS

Dragan ŽIVANIĆ¹ - Igor DŽINČIĆ² - Radomir ĐOKIĆ¹ - Atila ZELIĆ²
¹ University of Novi sad, Faculty of Technical Sciences, Novi Sad, Serbia
² University of Belgrade, Faculty of Forestry, Belgrade, Serbia

Received (14.10.2016); Revised (25.11.2016); Accepted (28.11.2016)

Abstract: The belt conveyor system is the most convenient and economical means of transporting materials in bulk and unit loads. A belt conveyor must be designed, constructed and maintained so that the belt consistently runs on its mechanical system of idlers and pulleys. Specifying the right belt for the application requires a good knowledge of the environmental conditions. The engineering of practically all belt conveyor installations involves a comprehensive knowledge of the proper application of conveyor drive equipment, including speed reduction mechanisms, electric motors and controls, and safety devices. Utilising the characteristics of flexibility, strength and economy of purpose the belt conveyor is the practical solution to conveying bulk and other materials. In this paper we will represent basic elements of the belt conveyors (belt, idlers, pulleys, drive, ...) their main characteristics, design and applications.

Key words: belt conveyor, design, idler, drive

1. INTRODUCTION

A belt conveyor can be used for handling a variety of bulk materials and unit loads, over a wide range of capacities. It provides an economical and practical means for transporting materials over long distances and over terrains requiring a wide range of paths of travel. A belt conveyor is a conveyor in which the product rides directly on the belt.

Belt conveyors have a high mechanical efficiency. Its carrying capacity depends on the belt width, angle of trough, and belt speed. Carrying capacity is high because relatively high speeds are possible. A smooth belt conveyor may travel up slopes up to 25° and there is always the possibility to recover energy on downhill sections.

Design of belt conveyors has improved over the years and now belt conveyors are an inevitable part of material flows in the modern industry.

Controls of the basic parameters (speed, capacity, ...) and elements condition (position of the belt, temperature in roller and pulley bearings, ...) are necessary for increase work reliability of the belt conveyors. In this goal, there is a requirement to apply certain safety and control devices with proper monitoring. [1]

There are more types of belt conveyors that are used in modern material handling systems. The most commonly are in use flat belt conveyor, telescoping belt conveyor, magnetic belt conveyor and trough belt conveyor, which will be dedicated the most attention in this paper.

A flat belt conveyor is normally used for light and medium weight loads between operations or machines. It is especially useful when an incline or decline is included in the conveyor path. Because of the friction between the belt and the load, the belt conveyor provides considerable control over the orientation and placement of the unit load; however friction also prevents smooth accumulation, merging, and sorting on the belt.

The belt is generally either idler or slider bed supported. If small and irregularly shaped items are being handled, then the slider bed would be used; otherwise, the roller support is usually more economical.

A telescoping belt conveyor is a flat belt conveyor that operates on telescopic slider beds. They are popular at receiving and shipping docks where the conveyor is extended into inbound/outbound trailers for unloading/loading. The troughed belt conveyor is often used to transport bulk materials. For most materials and most conveyors, the forming of the belt into a trough provides the benefit of a generous increase in the belts carrying capacity. When loaded, the belt conforms to the shape of the troughed rollers.

Magnetic belt conveyors provide a good solution for transporting ferrous parts, horizontally, on inclines or vertically. They are also ideal solution for separating ferrous from non-ferrous material or parts.

The utilisation of adequate accessories to clean the belt at the feed and discharge points yields corresponding
improvements to increase the life of the installation with minor maintenance.

In relation to the other conveyor, the belt conveyor has the following advantages:

- less energy consumption,
- reduction in numbers of personnel,
- quiet and safe work,
- long periods between maintenance,
- less damage to conveyed material,
- reduced business costs, ...

Projects have therefore been realized where belt conveyor system lengths may be up to 100 km long with single sections of conveyor of 15 km.

2. THE BASIC ELEMENTS OF BELT CONVEYORS

There are many possible variations in the design of a troughed belt conveyor depending on the purpose and duty for which the conveyor is being designed. Similarly the choice of individual components, features and accessories found on a belt conveyor should be selected on the basis of the functions which have to be performed by the conveyor. The basic elements of belt conveyors, according to fig. 2, are:

- the belt (1) which forms the moving and supporting surface on which the conveyed material rides,
- the idlers (2) which form the supports for the troughed carrying strand of the belt and the flat return strand,
- the pulleys (3) which support and direct the belt,
- the belt tension system (4) which control belt tensions,
- the drive (5) which imparts power through one or more pulleys to move the belt and its load,
- the loading and discharge devices (6) and
- the structure (7) which supports and maintains alignment of idlers, pulleys and drive.

Assuming proper selection of these elements, an engineer must then devise the proper integration of the belt conveyor within a system. In practice, according to the variety of uses, it is possible to have many other diverse combinations of elements and other accessories. [3]

2.1. The belt

In a belt conveyor, the belt represents the important component, the most perishable and costly item. The belt should have the following characteristics: high strength, long service life, small specific elongation, low self weight, high flexibility, low hygroscopic, ...

In general, a belt consists of three elements, according to fig. 3.: top cover, carcass (steel cord) and bottom cover.

The carcass is the reinforcing element and takes up the tensile forces necessary in starting and moving the loaded belt, absorbs the impact energy of material during loading. The carcass may be of either textile reinforcement or steel cords. In case of textile reinforcement the carcass is normally built up of a number of plies of textile fabric. These plies may be made from rough woven cotton fabric or from synthetic fabrics (capron, nylon, ...). The plies are connected by vulcanization with natural or synthetic rubber. The strength of fabric and the number of plies in the carcass of the belt may be varied together to suit the strength requirement. However if the belt is too tough, troughing of the belt and bending it round the pulleys will be very difficult. Therefore the belt with lesser number of plies with stronger fabric is generally preferred because it is more flexible. Steel cord belting is used when good trough ability, small specific elongation and higher operating tensile forces are required. Belt with synthetic fabrics is generally selected for underground mining applications where fire hazard exists. [5]

The primary purpose of the covers is to protect the belt carcass against damage. The properties needed for the cover of belt include resistance to cutting, gauging, tearing, abrasion, aging, moisture absorptions and in some cases resistance to oil, chemical and heat. Different qualities of cover material are designated by different grades. The cover grade is determined by the characteristics of the material to be handled. [5]

The two ends of a belt are joined directly on the conveyor either by vulcanizing or hinged metal belt fasteners of different designs. Vulcanization is the most reliable method of splicing.

2.2. The idler

The idler is used to effectively support belt and material and secure operation of conveyor. The type and dimensions of idlers used in belt conveyors depends mainly on the width of the belt itself, the pitch of the troughing sets, and above all, the maximum load on the idlers most under pressure. The correct sizing of the idler is fundamental to the guarantee of the plant efficiency and economy in use. There are two basic type of belt conveyor idlers:
carrying idlers include troughing idler, transition idler, impact idler, self aligning idler and
return idler include flat idler, V type return idler, sleeve idler and spiral idler.

The carrying idlers are in general positioned in brackets welded to a cross member or frame. The angle of the side roller varies from $20^\circ$ to $45^\circ$.

Impact troughing idler have roller covered by a resilient material. They are used at loading points where impact resulting from lump size and weight of the material, so belt and rollers can be prevented from damage.

Misaligned conveyor belts are potentially the cause for many problems associated with the conveying of bulk materials. This includes material spillage and reduced life to conveyor belting and conveyor structure. When the position of belt is changed from its center line on the same plane, the self aligning idlers can correct this condition, fig 4.

The return idler set may be designed incorporating one single width idler or two idlers operating in a “V” formation at angles of $10^\circ$. [4]
The idlers should be designed, chosen and manufactured to optimise belts working life.

2.3. The pulleys

In the belt conveyors, according to function, can appear following types of pulleys: drive, return, bend and take up, and according to the position head and tail.

The drive pulley is turned (driven) by a motor. The shell face of the conventional drive pulley or the motorised drum may be left as normal finish or clad in rubber of a thickness calculated knowing the power to be transmitted. The cladding may be grooved as herringbone design, or horizontal grooves to the direction of travel, or diamond grooves; all designed to increase the coefficient of friction and to facilitate the release of water from the drum surface.

The drive pulley diameter is dimensioned according to the class and type of belt and to the designed pressures on its surface. In the return pulleys shell face does not necessarily need to be clad except in certain cases, and the diameter is normally less than that designed for the drive pulley.

2.4. Belt tension system

The minimum necessary tension at the slack side of the return pulley, besides guaranteeing the belt adhesion to the driving pulley so as to transmit the movement, must also guarantee a deflection not exceeding 2% of the length of pitch between consecutive troughing idler sets. [4]
The force necessary to maintain the belt contact to the drive pulley is provided by a tension unit which may be a screw type unit, a counterweight or a motorised winch unit. This will be used to maintain an adequate tension in all working conditions.

The screw type tension unit is positioned at the tail end and is normally applied to conveyors where the length of the belt conveyor are not more than 40 m.

The counterweight, fig. 5, provides a constant tensional force to the belt independent of the conditions. Its weight designed according to the minimum limits necessary to guarantee the belt pull and to avoid unnecessary belt stretch.

The belt tension of a conveyor belt system is of a varying value along the system flight and is governed by the following influencing factors:

- length and local track of the system,
- number and arrangement of the pulleys as driven/braked,
- characteristics of the driving and braking equipments,
- type and location of the belt tension device,
- operating and loading state of the system.

The minimum movement of a tension unit must not be less than 2% of the belt conveyor length if conveyor using textile woven belts, or 0.5% if conveyor using steel corded belts. [6]

2.5. Drive

Belt conveyor drive equipment normally consists of a motor, speed reduction equipment, and drive shaft, together with the necessary machinery to transmit power
from one unit to the next, or, alternatively by motorised pulley.
The force required to drive a belt conveyor must be transmitted from the drive pulley to the belt by means of friction between their two surfaces.
The drive pulley is larger in the center than the ends. This helps keep the belt in the center. The drive pulley is completely covered with vulcanized rubber. This keeps the pulley from slipping under the belt. The conveyor drive must be put together to take up as little space as possible.
The motorised pulley, fig. 6., is used today more and more as the drive for belt conveyors thanks to its characteristics and compactness. It occupies a minimal space, is easy to install, all working parts are inside the pulley and therefore it needs very limited and occasional maintenance.

The loading devices is designed to allow easy loading and sliding of the material in a way to absorb the shocks of the load and avoids blockage and damage to the belt.

 Bulk materials should flow through a loading devices evenly and consistently.

3. CONCLUSION

Successful operation of belt conveyors requires their ability to stand up to the environment that they are used in.

A properly designed and maintained belt system has long service life and low operating cost. The initial cost is high for short distance belts and relatively low for long distance belts compared to other types of conveyors. For these reasons, belt conveyors are widely used for handling a variety of bulk materials and unit loads in many installations.

Selecting a belt conveyor requires careful calculation and consideration in order to achieve optimum conveying capacity and longest possible operational lifespan of the belt and the minimum amount of production time lost due to avoidable repair and maintenance to the conveyor system itself.

REFERENCES


