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ANALYSIS OF THE OPERATIONAL RISKS OF A BELT CONVEYOR USING THE METHOD OF DETERMINING THE OBJECT LIMITS

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Summary: Belt conveyors are machines used for transportation of packaged goods or bulk materials along horizontal and inclined paths. During operation of a belt conveyor, as in any human activity, unexpected and undesirable events may take place resulting in damage to human health or material loss. The analysis of these accidents contributes to understanding and proposal of measures suitable for reducing the risk as much as possible. The assessment of risks is not only a legal obligation but also a process of increasing safety at work.

Key words: belt conveyor, risks, limits of a machine.

INTRODUCTION

Increasing safety and protection of health at work is of social and economic importance. It is necessary to create favourable working conditions and develop working relationships that will result in optimization of the working process and have a positive economic effect. Favourable working conditions and good working relationships help reduce losses, increase productivity, and improve efficiency, effectiveness and quality of work. A properly functioning management system is crucial to providing constant prosperity and profitability of an enterprise. It is important to employ an effective management system to ensure safety and protection of occupational health. A holistic approach has to be applied to the management of safe belt conveyor transportation.

1. DETERMINATION OF THE LIMITSOF A BELT CONVEYOR

In determining the limits of an object and analyzing its technical risks, two basic categories of limits are important:

- general determination of limits of the analyzed object,
- further limitations of the object.

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1.1 General determination of limits

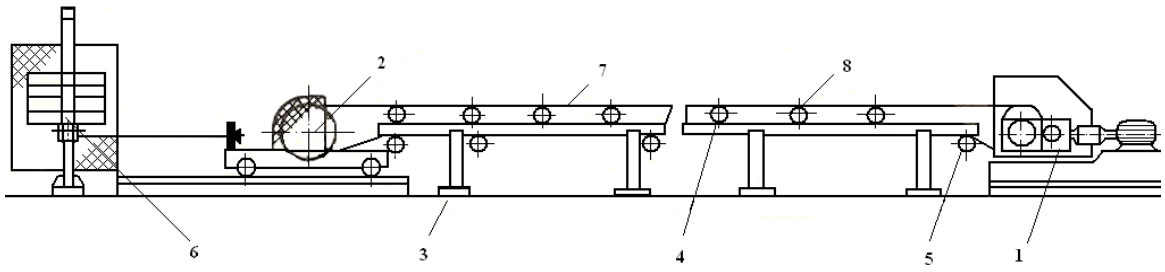
Determination of the limits of the analyzed object is preceded by the definition of the object‘s technical risk – in this case of a belt conveyor. A belt conveyor (BC) is part of the belt conveying technology and its most important component.

When dealing with the issues of the analysis, assessment and evaluation of risks related to belt conveyor, the following limits can be determined:

- limits of its use – the limitation includes assumed and reasonably inappropriate use of a belt conveyor during operation,
- spatial limits – (in terms of the range of movement, space, relationship operating
- machine, machine – source of energy)
- time limits - (in terms of the machine’s service life and intervals for servicing and maintenance)
- other limitations – e.g. environment – temperature, the weather, routine tasks, ..

For determination of these limits it is necessary to know basic components of a belt conveyor, i.e. to define the object of the analysis based on which it is possible to define its limits.

Fig.1 shows the principle scheme and basic components of the belt conveyor.



Source: Authors

Fig. 1 - Principle scheme and basic structural components of a belt conveyor

1 – driving pulley , 2 – reversing pulley , 3 – carrying steel structure , 4 – upper roller idlers , 5 – lower roller idlers , 6 – tensioning device, 7 – conveyor belt , 8 – belt running monitoring equipment

Fig.2 shows examples of installation of belt conveyors in the terrain as a component part of technological units.

Source: Authors

Fig. 2 - Practical application of belt conveyors

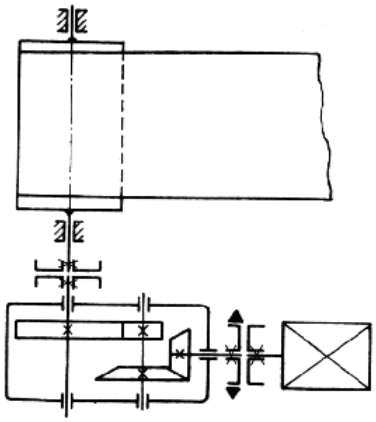
The most important structural and operational parts of a belt conveyor are the following:

a) The conveyor belt in terms of operation is the most important component of the conveyor. It is a continuous belt driven around the end drums that when rotating fulfills the function of both towing and carrying element and transmits all the resistant forces arising during its movement. Depending on the operational conditions, conveyor belts are manufactured with various covering layers. An appropriate choice of the covering layer ensures reliability and a long service life of the conveyor belt. (2). In case of wear and tear or if there is serious damage to a conveyor belt, such a belt presents danger in terms of safety as it can get torn up and cause injuries to people in its vicinity. If the conveyor belt is not centered with respect to the structure, it poses a danger to operators who are at risk of being buried under falling material when the conveyor belt gets deflected. The most commonly used internal structure of the conveyor belt is rubber-fabric (Fig.3, left) or steel cord (Fig. 3, right).

Source: The MATADOR Company

Fig. 3 - Internal structure of the conveyor belt

b) The driving station (driving unit and drum drive pulley) provides the movement of the belt conveyor which converts electrical energy into mechanical energy. Most belt conveyors used on the surface in the mining industry have two, three or four drive units and two drum drive pulleys. In terms of health and safety at work, the driving pulley itself which consists of rotating electrically powered components poses a danger of being pulled into the space between the drum driving pulley and the belt, or danger of the contact with the rotating components and the risk of being injured by electricity. The basic scheme of the driving station of the belt conveyor is shown in Fig.4.



Source: Authors

Fig. 4 - Driving station of the belt conveyor

c) Belt reversing pulley of the belt conveyor forms an end component of its track. For short conveyors (up to 100m) the function of the reversing pulley and belt tensioner pulley is usually joined. In other cases the reversing pulley is created by an anchored construction with roller bearing return drum in it. The return drum (Fig.5) changes the direction in which the conveyor belt moves (3). In terms of health and safety at work represents danger of being pulled into between the rotating drum and the belt.

Source: Author

Fig. 5 - Shell of the return drum of the belt conveyor

The tensioning of the conveyor belt is performed by the belt tensioner pulley. If the tension of the conveyor belt is not set correctly, it can slip and sag between belt roller brackets.

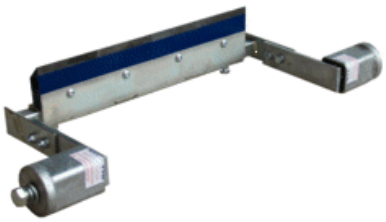
d) Carrying rollers are located in the conveyor idlers along the whole length of the belt conveyor. They support the conveyor belt and absorb the dynamic impact of materials falling on the belt conveyor at loading points or during transshipments. In terms of safety, the space between the moving conveyor belt and rollers poses a danger of injuries such as trapping, entangling, dragging, ripping off or bruising of one's arms.

Fig.6 shows three-roller idler, also called trough roller idler

Source: The Interroll Company

Fig. 6 - Trough roller idler

e) Supplementary and safety equipment used to ensure reliable running of belt conveyors is also potentially dangerous when in the operating mode, e.g. when being replaced. In practice, we can find cases of replacement of slatted guards during running of the belt conveyor. Fig.7 and 8 show guards of the belt conveyor.



Source: Author

Fig. 7 - Blade wiper stationary Fig. 8 - Blade wiper rotary

f) Carrying structure of the belt conveyor may represent danger when bumping into its sharp edges.

An attribute of a dangerous accident while operating a belt conveyor can be dragging a part of the body (mainly hand) into places where the conveyor belt (driving component) starts running on the belt conveyor drum. In practice, observations show that the above-mentioned dangerous accidents most often take place during cleaning of the drum or conveyor belt when it starts and a relative movement of the conveyor belt in relation to the driving drum occurs caused by the difference in the speed of the conveyor belt and the circumferential velocity of the driving drum.

1.2 Limits of the belt conveyor use

Determination of the limits related to the use of the belt conveyor includes foreseeable and reasonably inappropriate use. Accidents occur when safety regulations for the operation of belt conveyors are violated as well as the result of the breach of banned practices.

Listed below are practices that are not allowed during operation of a belt conveyor:

- Start up the conveyor before warning other workers in order to alert them to the conveyor operation or in case of damaged and discarded safety equipment, removed covers or detected defects,
- Obstruct the area for the material inlet and outlet,
- Store any material in areas designated as crossovers or passageways for operators
- Load or unload materials at other points along the conveyor than at places designated for that purpose,
- Discard safety equipment and damage or illegally remove safety signs, boards and covers,
- Carry out any repairs if employees are not properly trained for this work or do not have necessary qualifications,
- Do the cleaning when a conveyor is powered and operating ,
- Perform lubrication with the conveyor running unless the location of the lubricated points allows it or perform any manual manipulations on rotating or moving parts of belt conveyors during their operation
- Step, climb over, walk across or crawl under running conveyors except designated and marked crossovers and passageways ,
- Clear up any fallen material in the area of driving, tensioning and reversing pulleys of the conveyor unless mechanization tools are used or operating instructions state otherwise due to serious reasons

In case of manual clearing of the material, operating instructions have to include a detailed specification of working conditions (training, type of tools utilized, supervision by another person, etc.).

Belt conveyors limits are given in STN ISO 5048 (6) and DIN 22131 – most often used in Germany.

1.3 Spatial limits of a belt conveyor

Determination of spatial limits of a belt conveyor means specifying the limits in terms of the range of movement and the relationship *operating – machine, machine – source of energy.* A belt conveyor can be installed outside and inside. It can be used in various operational conditions ranging from general to extreme operation mode. In many branches of industry, mainly fixed, portable and mobile belt conveyors find application. They are predominantly driven by electric power.

At this stage of the determination of belt conveyor limits it is also necessary to take the **human factor** into account, i.e. the level of qualifications, experience, education and abilities of belt conveyors‘users - employees: service, repair and maintenance personnel, technicians, instructors, apprentices and trainees. The accident rate statistics for belt conveyor transportation show that the human factor failure accounts for the highest percentage of accidents. The reason

for this was in application of dangerous procedures and lack of qualifications for performing the work properly and safely.

In manual instructions for operation most manufacturers generally advise that belt conveyors must be operated only by individuals older than 15 years old, mentally and physically capable who are provably trained for a particular workplace and authorized for operating the equipment.

Failures due to a human error are the result of factors such as discomfort, tiredness, physiological or physical stress, unprofessional approach to health and safety at work, breakdown of a running device, etc. Other potential causes of dangerous accidents may be due to the fault of an employer e.g. when works are not properly organized, protective equipment is not supplied, ergonomics principles are not applied to work activities (improper location of machines and equipment, blocking of pathways, bad visibility) etc.

1.4 Time limits of a belt conveyor

Time limit is characterized in terms of a belt conveyor's service life and intervals between maintenance periods. The service life of a belt conveyor is several tenths of years. The most important part of a belt conveyor is the conveyor belt whose life cycle mainly depends on the proper choice of the belt cover layer, type of the material transported, and last but not least, performance of maintenance works. The conveyor belt is mostly affected by pressure caused by the impact of materials fallen on the belt when according to the authors (2, 4) an inclined eccentric impact occurs that is characterized by a short-term duration (30-70 milliseconds) of a large impact force.

2. OTHER LIMITATIONS OF A BELT CONVEYOR

Other limitations of a belt conveyor include e.g. environment – temperature, weather, routine tasks, etc. Belt conveyors have a wide range of applications; they are used in mining and metallurgical industry, civil engineering, in the energetics industry, agriculture, etc. They are designed to suit precisely customers' specific requirements according to their space and operational conditions to be used outdoors as well as indoors. At present, belt conveyors are modified to withstand both general and extreme working conditions.

The analysis and assessment of risks based on the accidents that happened at work suggest that stationary belt conveyors with electrical power supply and regular monthly maintenance checks have to be considered. In the immediate vicinity of the belt conveyor, service and maintenance personnel with lower levels of qualifications, experience and abilities are to be considered. In case of a breakdown these are employees authorized to carry out repairs. Forbidden practices such as drum cleaning while the conveyor is powered and operating, removing of the cover, manual start-up, etc., improper location of machines or blocked passageways all account for accidents at work.

CONCLUSION

In the process of identification of dangers and threats related to belt conveyors, the following tasks associated with their operation were taken into account: launching, starting up, testing, running, stopping, emergency stops, launch again after a non-planned stop, starting up again in case of a breakdown, looking for breakdowns that cause problems (interference of personnel), cleaning, preventive maintenance and maintenance with a repair. Identification of dangers and threats related to belt conveyors was undertaken by a group consisting of the author of this doctoral dissertation paper, supervisor and a health and safety at work representative.

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