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RESEARCH OF THE THERMAL MODE OF THE DRUM MOTOR DRIVE OF THE BELT CONVEYOR

Introduction

Great opportunities for increasing labor productivity, reducing the cost of production, as well as creating favorable conditions for complex mechanization and full automation of transport processes at manufacturing enterprises open up the use of flow types of transport, mainly conveyor. Of the existing types of conveyors, belt conveyors of traditional design have become the most widely used. They are the main means of continuous transport in the main industries of Ukraine.

A characteristic trend of the modern development of belt conveyors in Ukraine and the world is a significant increase in their productivity, length and power. This is with an increase in cargo flows and the length of transportation. Thus, to ensure modern mine and quarry cargo flows, the domestic industry produces conveyors with a capacity of up to 5000-6000 m3/h. Conveyor lines with a length of 3 km or more are operated at the mining enterprises of Urayna, and conveyor lines with a length of more than 100 km are known in world practice, with the length of one conveyor being 8-10 km [1-4].

Drive systems are the basic systems of belt conveyors. The variety of routes of conveyors transporting goods has led to the appearance of a wide range of different types of drives and their configurations. Each of these types has its own design method and specific application limitations. For the Ukrainian industry, the drives with a spaced gearbox arrangement were the most widespread: electric motor, gearbox, drum. However, this layout has its drawbacks, the main ones of which include:

- Large dimensions;
- Low efficiency;
- High noise level;
- Metal capacity of the structure.

Along with this, various designs of motor-drums are becoming more widespread in the industry. These conveyor drive schemes are devoid of the specified disadvantages. A drum motor is an alternative type of belt conveyor drive, different from a gear circuit. The motor-drum is a section of pipe, closed at both ends with caps, inside which an electric motor and a gearbox are placed. The product itself is installed stationary on the bearing trunnions, while the drum rotates in the stationary trunnions when power is applied to it. The design feature of this drive provides a number of advantages:

- Long service life;
- Simple installation;
- High energy efficiency;
- High efficiency ratio;
- Low cost of ownership;
- Low noise level;
- Compactness;
- Increased protection against the influence of an aggressive environment;
- Low wear.

These advantages have led to the widespread use of motor-drums for conveyors in the food and trade industries. But it should be noted that the power of these drives is limited to hundreds of watts, which does not cause problems with regard to the cooling of the components. At the same time, the use of this arrangement for high-power drives under certain conditions can lead to overheating of elements, in particular, seals, insulation, bearings, and rapid exit from operational and serviceable states [5-6].

When solving the problem of ensuring the reliable operation of the drive of the motor-drum belt conveyor for cases of high power, it is necessary to consider the processes of heat generation and heat transfer

of the system: motor-drum-surrounding environment. Thus, in order to determine the thermal state of the object, it is necessary to analyze the whole complex of heat losses for individual components of the drive and, on the basis of the established data, create an equation of the thermal balance of the system: the motor-drum surrounds the environment. A detailed examination of the system will allow to minimize the heat consumption of the drive, which will allow to reduce the temperature of the drive as a whole.

The purpose and tasks of the research

The purpose of this scientific research is to develop a new method of determining the temperature regime of the motor-drum drive of a belt conveyor based on the analysis of the complex of heat losses for individual components of the drive and consideration of the equation of the thermal balance of the system: the motor-drum surrounds the environment.

To achieve the set goal, the following tasks were solved in the work:

Development of a structural diagram of sources of thermal radiation of individual components of the motor-drum drive of the belt conveyor, taking into account the peculiarities of the interaction of the component elements, which will allow establishing the mutual influence of various parts of the research object on its condition;

Create the equation of the thermal balance of the system: the motor-drum surrounds the environment;

Establish recommendations to minimize the heat effect on the drive elements, which will reduce the temperature of the drive as a whole.

Material and research results

When developing the structural diagram of sources of heat radiation of individual components of the motor-drum drive of the belt conveyor, we will consider a typical design that has found the greatest use in industrial enterprises of Ukraine. The prototype of the drive stations according to the motor-drum scheme was the design of the companies VP Transugillia and Interroll [1-4, 6]. The section of the motor-drum of this design is presented in Fig. 1. This line of motor-drums uses an asynchronous motor with a short-circuited rotor as an energy source. On the output shaft of the asynchronous drum there is a gear which is engaged with a gear wheel. A characteristic feature of this drive is the absence of a fan and air cooling. In this case, the space of the motor-maraban is filled with a working fluid that performs the functions of lubrication and cooling of the system components. To convert the torque, it is possible to use two versions of gearboxes: planetary and cylindrical two-stage, the version of which is shown in the diagram. A toothed wheel with an internal gear is used to transmit the torque to the drum. If necessary, the drum of this drive scheme can have ribs or be covered with rubber for better adhesion with rubber. It can be seen from the diagram that under certain conditions overheating of the drive elements is possible due to insufficient cooling.

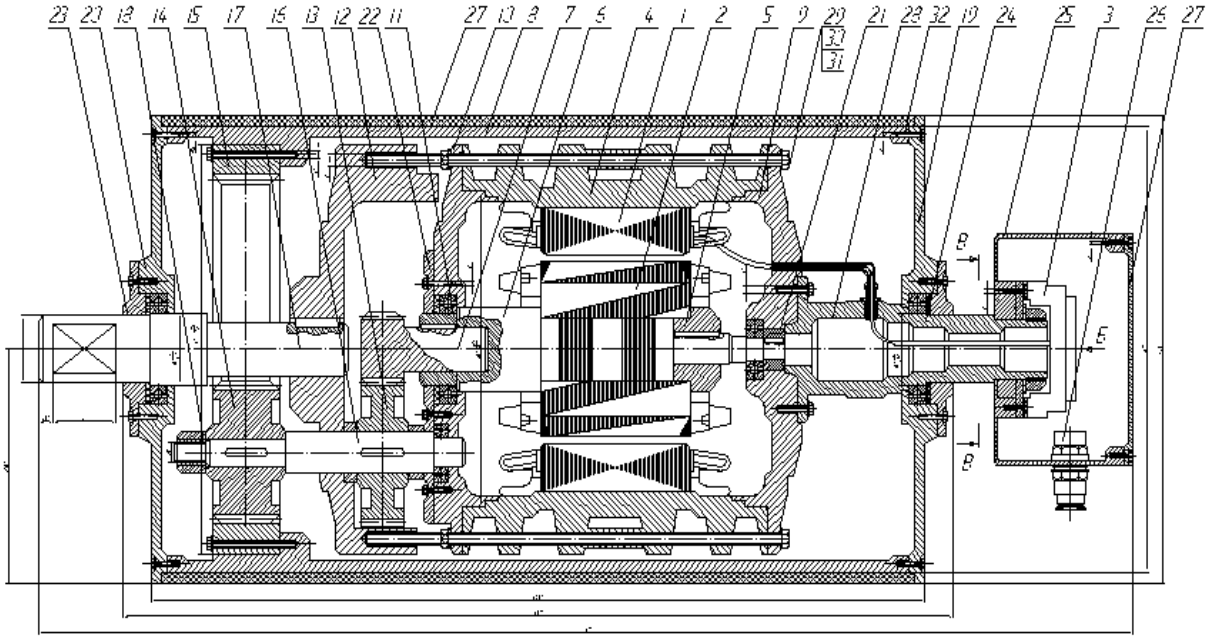

Fig. 1 – Section of the motor-drum drive of the belt conveyor

The analysis of the obtained data indicates a significant limitation of the required power of the drive, which allows the use of this type of drive for short-length conveyors. Also, in the case of using lined drums, the heat transfer coefficient of the system will decrease significantly, which will reduce the heat transfer and the maximum power value. It is possible to increase the power of the drive according to this scheme by means of forced cooling of the working fluid.

Conclusions

1. Based on the analysis of the design of the motor-drum drive, the quantitative characteristics of the sources of thermal radiation of individual components of the drive were established, taking into account the peculiarities of the interaction of the component elements, which made it possible to establish the mutual effects of various parts of the research object on its condition;

2. On the basis of the equation of the heat balance of the motor-drum system surrounding the environment, the limit values of the drive power are set with the known geometric parameters of the system. The analysis of the obtained data indicates a significant limitation of the required power of the drive, which allows the use of this type of drive for short-length conveyors. Thus, for a diameter of 1 m and a width of 1 m, the power is 30758 W, which is not enough to ensure the movement of a converter with a length of more than 300 m.

References

1. Шахмейстер Л. Г., Дмитриев В. Г. Теория и расчет ленточных конвейеров //М.: Машиностроение. – 1987. – Т. 336. – С. 6.4.
2. Визначення впливу зміни проектного положення профілю стрічкового конвеєра на навантаження роликоопор / А. В. Данілін, С. В. Зайченко, С. П. Шевчук, Н. І. Жукова, І. М. Пасічнюк // Геоінженерія : науково-технічний журнал. – 2020. – Вип. 3. – С. 20–25.
3. Шевчук С. П., Зайченко С. В., Вапничная В. В. Обоснование массогабаритных параметров роликов ленточных конвейеров по критерию надежности //Перспективы развития восточного Донбасса. – 2016. – с. 221-228.
4. Волошин Г.М. Обґрунтування параметрів конструкції елементів конвеєрних роликів за критерієм енергоєфективності //Гірничі, будівельні, дорожні та меліоративні машини. – 2016. – №. 88. – с. 40-46.
5. Зайченко С. В., Вовк О. О., Шевчук Н. А. Обґрунтування параметрів конструкції елементів конвеєрних роликів за критеріями довговічності //Вісник національного технічного університету України київський політехнічний інститут. серія: Гірництво. – 2016. – №. 31. – с. 65-73.
6. Hamacher S. The Drum Motor. – Springer Berlin Heidelberg, 2020.