Application of polymer composites in moving joints machines of the fat and oil industry

Oleksii Derkach, Dmytro Makarenko, Yevhen Muranov, Antonina Yashnova., Polina Derkach
Dnipro State Agrarian and Economic University, Dnipro, Ukraine
e-mail: flymakd@gmail.com, derkach_dsau@i.ua

Abstract: *The expediency of using parts made of polymer composites in moving joints of machines in the oil and fat industry is shown. The use of experimental moving joints provided an increase in the resource from 500 hours to 1080 hours minimum. Diagnostics of experimental moving joints revealed that some of them have signs of transfer of the composite material to the steel shaft. This is explained by the following factors: the presence of the transfer effect and operation at high temperatures of 140 °C. The operating modes of the equipment are maintained. Most of the experimental parts made of polymer-composite material are in a running-in state, as wear has not been recorded in them.*

KEYWORDS*: POLYMER-COMPOSITE MATERIALS, MOVABLE COUPLINGS, DURABILITY, OIL AND FAT INDUSTRY, SCREW CONVEYORS*

1. Introduction

Ensuring food safety is one of the primary tasks for any country. The branch of processing of agricultural products occupies the main place in solving the specified problem. For this purpose, at processing enterprises, use a variety of equipment and equipment that requires special conditions of use, which is related to work with food products. Therefore, first of all, nessesery pay attention to compliance with the safety requirements of the obtained products, and only then to their cost price. Conveyors of processing enterprises, depending on the characteristics of the transported material and the conditions of the technological process, can be divided into: inertial, suspended, scraper, plate, belt, screw, roller, etc. [1]. Each of them has its advantages and disadvantages, but in the oil and fat processing industry screw or screw conveyors have become the most common.

2. Statement of the problem

Screw conveyors have become widely used in the production and processing of oil and fat products. Their main advantage is the simplicity of construction and low cost [1]. Most scientific research is aimed at increasing the productivity of conveyors or the wear resistance of their working bodies [2-4]. Production processes in oil and fat industry shops involve the movement of technological materials over considerable distances. Therefore, structurally, the conveyors are made with a large number of bearing supports. Theese bearing require careful maintenance in the form of periodic maintenance, diagnostics or replacement. This leads to periodic stops of transportation lines for planned and preventive repairs. Such a system of operation of conveyors reduces the volume of products produced by enterprises for a certain period.

The main elements of moving joints that require systematic and frequent maintenance or replacement are bearing supports. In the production of sunflower oil, screw conveyors are used, which, according to the technological process, must transport sunflower pulp at temperatures of 90...95 ºC and higher; the rotation frequency of the conveyor shaft is 77 min^{-1}; the distance between bearing supports is 3 m; the productivity of conveyors is not less than 5 t/h. This additionally imposes certain restrictions on the use of materials for bearing assembly supports.

There are known solutions for the use of supports made of wood in the indicated moving joints. The advantage of such supports is their low cost, and the disadvantages include low durability. In order to slightly increase the service life of the supports, it is necessary to additionally heat-treat has been wooden bearings in lubricants. However, this does not ensure compliance with reliability requirements, and some of the wooden bearings fail even before the regular maintenance according to the regulations, which leads to an unplanned stoppage of production. One of the ways to solve this problem is the use of structural materials capable of operating in friction mode without lubrication at temperatures above 95 ºC. At the same time, products of wear or friction of such materials must be absent or be safe for use in the food industry. The positive experience of using polymer composite materials (PCM) in the construction of agricultural machines [5-7], industrial production equipment [8] and the food industry [9] is known.

3. Materials and equipment

The tribological properties of PCM during friction without lubrication were determined on a friction machine of disc type (Fig. 1) according to the method [10].

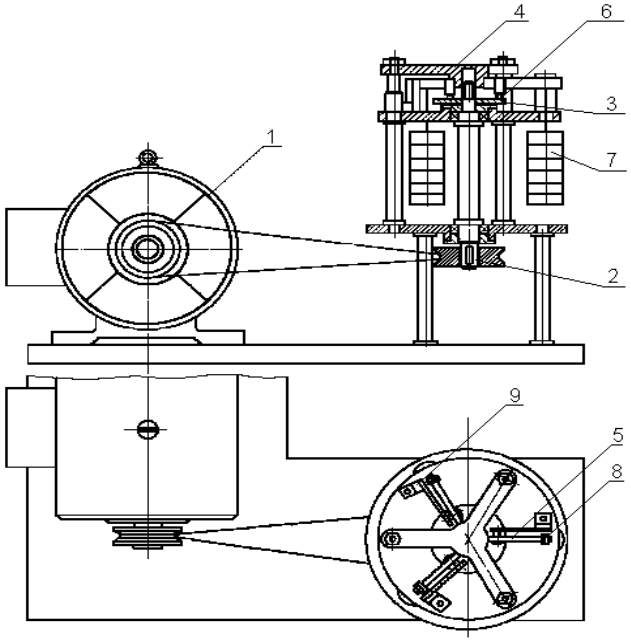

Figure 1 *– Friction disc machine.*
1 – electric motor; 2 – pulley; 3 – steel disk; 4 – cross; 5 – lever; 6 – carbon plastic

Modes of operation: sliding speed of the sample on the metal surface - 1.0 ... 2.5 m/s; pressure on the sample - 1.0 MPa; surface roughness of the metal disc – Ra = 0.63 μm; the friction path is 10,000 m. The test was carried out under two additional conditions: with removal of the transfer film from the surface of the metal disk and without removal of the transfer film. As can be seen from fig. 2, the temperature in the contact zone is lower than the friction condition in the presence of the transfer film. This is explained by the lower coefficient of friction on the film [5]. Thus, the operation of PCM parts based on polyamide reinforced with carbon fibers should not require additional care for the technical condition of the shafts.

For the production of sliding bearings of screw conveyor supports, PCM of our own production based on polyamide 6.6 reinforced with carbon fiber was chosen. This material is workable at PV factor up to 2 MPa·m/s in friction mode without lubrication and at temperatures in the friction zone up to 120 ºC. The material was obtained on an experimental extruder equipped with two dispensers (Fig. 3).

The extruder is made with two dispensers - for polymer material and carbon fibers; with the help of a worm with a diameter of 45 mm, the dosed mass is mixed and transported through four heating zones. Then, through the die, the composite is pressed into a bath with water, in which cooling is carried out, and then the

already cooled strands are crushed into granules on a granulator. Residues of moisture from the obtained PCM were removed by drying in a thermal cabinet at a temperature of 120ºC for at least 3 hours. The dried granules were processed into finished parts by the method of pressure casting in a press mold on a hydraulic casting machine (Fig. 4).

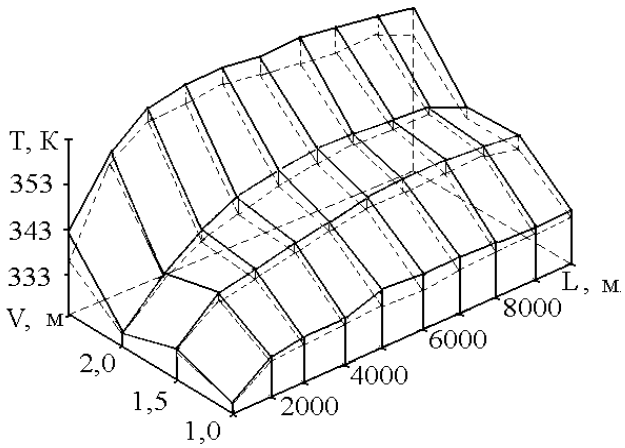

Figure 2 *– The influence of sliding speed and friction path on the temperature of PCM in the contact zone along the film (- - -) and without film (□)*

Figure 3 *– Experimental extruder*

Figure 4 *– PL-32 injection molding machine*

The technology of processing granules into products was carried out under the following conditions: the pressure of injecting the material into the mold was 11 MPa, the temperature of the melt was 255...260 ºC, the temperature of the mold was 75...80 ºC, the duration of exposure under pressure after filling the mold was no less than 30 seconds.

4. Results of production tests

Experimental sliding bearings had the form of semi-annular elements obtained by cutting a part (blank) of an annular shape (Fig. 5). The specified elements are installed as sliding bearings in the supports of the screw conveyor, which was used to transport the pulp of sunflower seeds for subsequent removal of oil from it.

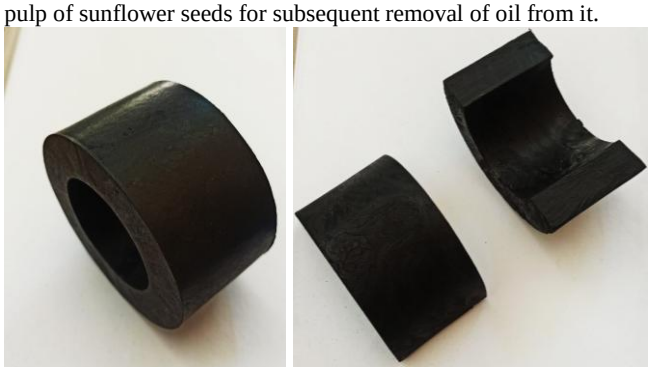

Figure 5 *– Experimental elements of the bearing supports of the screw conveyor: a – part (workpiece) of a cylindrical shape made of PCM; b – experimental sliding half-bearings*

Experimental elements of bearing support of the screw conveyor worked for 1080 hours without maintenance or failures. After their defecting, a partial transfer of PCM to the conveyor shaft of those supports located in the pulp supply area after heating was recorded. This may indicate a violation of the technological process of heating the transportation product (pulp) according to the temperature criterion. It was established that the temperature in the contact zone of the bearings was up to 135...140 ºC. After dismantling the supports with experimental sliding bearings, our was found that it had wear of up to 0.1 mm, which indicates that they were in a running-in condition. The resource of such minimum elements is increased by 2.5...3 times, compared to elements made of wood. The technological mode is maintained. The proposed technical solution is protected by a Ukrainian utility model patent [11].

It was established that additional heat treatment of PCM parts, in a lubricant environment, does not significantly affect the amount of wear and strength characteristics, compared to untreated parts. Therefore, the specified technological operation was not carried out for other batches of parts made of PCM.

5. Conclusions

The workability of PCM, based on polyamide 6.6 reinforced with carbon fiber, as a structural material for the elements of the bearing supports of the screw conveyor of the oil and fat industry has been proven.

The developed materials have significant corrosion resistance and do not damage steel welded parts, even under friction conditions without lubrication. The use of experimental parts makes it possible to realize the construction of bearing supports that do not require maintenance during the entire period of their operation.

The production of such bearings does not require significant expenditure of resources, and their use allows to increase the service life of bearing units by 2.5...3 times compared to the use of standard elements made of steel or wood.

6. References

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