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To cite this article: S N Vikharev 2020 *J. Phys.: Conf. Ser.* **1515** 042005

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Reliability of plate of knife refiners

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Abstract. The subject of the researches is reliability of plate of knife refiners. Mathematical model of reliability connecting technical resource of plate with the major factors influencing reliability is offered. Influence of regime, operational, efficiency and protective factors is considered. Recommendations about increase in reliability of plate are developed. Offered technique of reliability research can be used in other machines, for example, in centrifugal pumps.

1. Introduction

Now refining of fibrous semi-finished products is made in knife refiners. The most unreliable element of these machines is the plate [1-3]. The set of publications is devoted to analysis and increase in reliability of plate [4-6]. Knife of plate are exposed to intensive wear. Main type of wear of knife - abrasive and emergency [7].

Article purpose is to investigate reliability of the plate of knife refiners and to develop recommendations about increase in technical resource of the plate.

2. Reliability model

It is not possible to create analytical model of reliability of plate now almost. Perhaps only creation of model which qualitatively describes influence of various factors on reliability of plate. Technical resource – one of key indicators of reliability of plate. This indicator depends on many factors.

On basis of the conducted researches [1,3-7] it is possible to write down that the technical resource T depends on factors of refining, design of refiner and its technical condition

$$T = k_i(K_i, P_i, E_i, A_i)$$

where k_i - nonlinear coefficient connecting i - factor with technical resource, K_i, P_i, E_i, A_i - respectively constructive, regime, operational and protective i - factors.

Researches of reliability of plate at enterprises of branch are conducted. The technical resource of plate has wide spacing from 100 to 16000 hours and depends on above-mentioned factors.

3. Research of factors of reliability of plate

3.1 Regime and operational factors



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Carry to regime factors characteristics of the ground material, its concentration and extent of cleaning of foreign inclusions. Many authors note that at increase in concentration reliability of plate increases [3,4]. It is called by increase in a knife gap at increase in concentration and an exception of boundary friction of plate at operation of refiner. Foreign inclusions in the fibrous weight (sand, metal) call emergency wear of plate and reliability of plate decreases. Many researchers speak about need of careful cleaning of fibrous weight before refining [4,8,9].

It is possible to carry plate material, speed of sliding of rotor on stator to operational factors and a knife gap. Plate material in many respects defines its reliability. Plate happens metal and nonmetallic. Now active search of material of plate for the purpose of increase in its reliability is conducted [8,9]. The diamond-bearing plate is offered [9,10]. With increase in speed of sliding of rotor on stator and reduction of a knife gap the intensity of wear of plate increases and its reliability decreases [11].

3.2 Efficiency factors

In zone of grind of standard knife refiners there is sliding friction. The sliding friction coefficient in zone of grind depends on properties of fibrous layer, speed of sliding and gap between rotor and stator [12,13]. There were attempts to replace sliding friction in grind zone with swing friction, i.e. to use the grinding spheres [14]. Coefficient of friction of swing much less coefficient of sliding friction and wear at such friction of the grinding plate is less. Therefore, reliability of plate with use of friction of swing is higher. However, because of complexity of design this plate was not widely adopted in the industry.

As rule, plate of refiner is not under repair, and is replaced entirely. Difference in the mass of new and worn-out plate does not exceed 10%. The worn-out plate comes back to manufacturer on melting that increases transportation costs. Now there were maintainable designs of plate with type-setting knife [15]. In these designs only worn-out knives are replaced, and the case of plate (matrix) is not replaced. Such design allows to repair plate by forces of the enterprise operating knife refiners. Designs of type-setting plate of refiners protected by patents [16,17] are developed. One of perspective developments is the type-setting segment plate which is allowing to type any drawings of knife and having the increased rigidity of fastening of its elements [18].

At operation between rotor and stator of refiner there is liquid or boundary friction [13]. Liquid friction – knife of plate is completely divided by fibrous layer; the metal contact is absent. Intensity of wear of knife at the same time is minimum. Reliability of plate at liquid friction high. At boundary friction knife are not completely divided by fibrous layer and there is metal contact between knife. Intensity of wear of knife at the same time high and reliability of plate low. It is necessary to exclude boundary friction between rotor and stator at operation of refiner. However, possibility of boundary friction is put even at design of these machines. At operation there are distortions and beats of plate. Distortion of stator arises because of wrong installation of plate and (or) insufficient rigidity of design of refiner [19]. Beats of the rotor are called by distortion when landing disk to refiner shaft, insufficient rigidity of design of rotor, gaps in elements of design of rotor knot, including radial gaps in bearings and dynamic forces arising at operation of refiner. Method of vibration diagnostics of distortion of stator is offered by author in publication [19].

Rotor knot of refiner – high-precision knot which has to provide situation of stability of rotor disk or cone at grind. Many researchers speak about need of stable knife gap at refining [3,20]. In rotor knots stability of provision of rotor disk depends on accuracy of production of bearings and details of rotor knot interfaced to bearings, on quality of installation, on adjustment of bearings (size of radial gap) temperatures of support connected with instability and respectively changes of size of gap. Now in knife refiners' bearings with gap are used. Research of dynamics of rotor of refiner is conducted by author in work [14]. It is offered to use bearings with tightness. In this work method of calculation of force of tightness is given in support of rotor knot of refiner for providing its situation of stability. As showed researches, main component of amplitude of beating of rotor are gaps in rotor design elements. Not accounting of other components leads to error which is not exceeding 20%. Beats of rotor were determined by the developed technique [14] at nominal radial gaps in bearings of rotor knots. Settlement

amplitude of beating of rotor of refiners are in limits of 0.40 - 1.68 mm. Operational knife gap is in the same limits and there can be even less than 0.40 mm. Therefore, in design of the most rotor knot the possibility of metal contact of rotor and stator at refining is put, and, therefore, low reliability of the grinding plate is put.

To prevent the resonant modes of refiner, its elements, to reduce amplitude of fluctuations of rotor and it is offered to reduce dynamic tension in material of knife of plate author in publications [21-23]. In these publications' techniques of dynamic calculation of refiner, rotor and knife of plate are offered.

3.3 Protective factors

These factors include controlling and operating systems which increase reliability of the plate [24]. Management of work is made by additive, change frequencies rotation of rotor, regulation of an expense of semi-finished product [1-3,24]. At hit of inclusions in zone of refining or metal contact of rotor and stator amplitude of high-frequency vibration of stator sharply increases [19,24].

Scheme of device realizing way of protection of plate from emergency wear of plate and regulation of process of refining is submitted in figure 1, a, and algorithm of protection of plate and management of functioning of refiner is presented in figure 1, b.

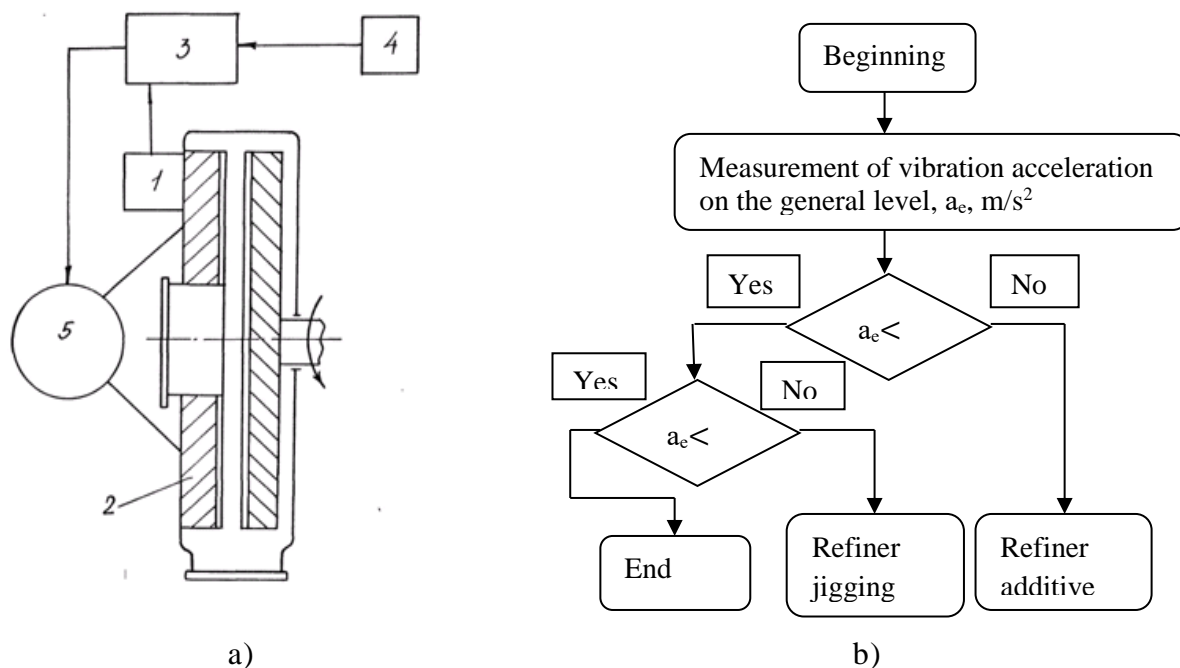


Figure 1. Scheme of the device for protection of the plate from emergency wear and regulation of process of refining (a) and an algorithm of protection of plate and management of functioning of the refiner (b).

The scheme turns on the vibration inverter 1 which is fixed on the stator 2 by means of wave guide. The vibration inverter 1 is connected to the regulating block 3 which, connects to the control point adjustment 4 and the mechanism of additive 5 [20]. By means of vibration inverter 1 vibration of stator 2 will be transformed to proportional electric signal by it which arrives on an entrance of the adjusting block 3 where there is comparison of amplitude of the received signal with signal from control point adjustment 4. By means of the control point adjustment set the required operating mode of the machine. In case of signal amplitude deviation from vibration inverter 1 from the set control point adjustment signal, block 3 sends signal to additive 5 mechanism which brings it into accord with set way of change of additive of refiner.

4. Conclusions

Influence of regime, operational, efficiency and protective factors on reliability of plate is investigated. Mathematical model of reliability is developed.

For increase in reliability of the plate it is recommended:

- to increase concentration of weight and to reduce the speed of sliding of rotor on stator;
- to carefully select material of plate and to clean weight from foreign inclusions;
- to use swing friction in refining zone;
- to use maintainable plate;
- not to allow plate distortions at its installation;
- to eliminate gaps in design of rotor knot and to use bearings with tightness;
- not to allow resonant modes of refiner and its elements, including plate knife;
- to use protection devices for prevention of emergency wear of plate.

The offered technique of research of reliability can be used in other machines, for example, in centrifugal pumps.

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