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Depreciation of bearing blocks of rollers of roller conveyers of rolling mills

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Abstract. Essential increase in functional durability of a node of a roller of the roller conveyer of the rolling mill by the rational choice of parameters of the small-size shock-absorber (buffer adapter) is shown. At the same time dimensions of a node don't change, costs of reconstruction are small. The possibility of management of loadings in a bearing node without change of technology parameters of the process which is carried out by the rolling mill is confirmed.

1. Introduction

Metallurgical cars have high parameters on loadings, the sizes and speeds of executive bodies. Nodes of bearings, pillows of rolls, frames of roller conveyers and the bed of rolling mills, connecting spindles, toothed gearings and so on belong to similar parts. So, according to shop data, on a continuous broadband camp of 1700 of ArcelorMittal Temirtau plant only in fair group of cages about 50 bearings in a month collapse.

These are four-row cone bearers; the cost of each bearing is about $5000. In PJSC MMKIM. Ilyicha life cycle of such bearings (for example, the conic roller conveyer of a plate camp 3000 or the receiving roller conveyer of a continuous broadband camp 1700) makes only about two months. Places for installation of large-size shock-absorbers of compression or shift therefore it is necessary to use the small-size shock-absorbers installed under outer races of bearings are often not provided in modern designs of rollers of roller conveyers. The competent choice of parameters of such shock-absorbers would allow to increase significantly the functional durability of all node of a roller of the roller conveyer.

2. Simulation

There are no standard principles of design of shock-absorbers for metallurgical cars [1-3] today. In this direction many mistakes are made. There are only recommendations about creation of shock-absorbers checked by practice which allow to avoid rough miscalculations. It is possible to amortize and it is necessary only parasitic (harmful) loadings which aren't necessary for implementation of technology.

The main objective of depreciation is to reduce the maximum total load (that can be made only at the expense of parasitic loadings) [4-6]. A universal way of depreciation of loadings is increase in ability of the protected systems to accumulate elastic potential energy of deformation. The best is the option of increase in power consumption of system due to implementation of the shock-absorber in it [7]. At consecutive inclusion of a similar element in the elastic system of their power consumption are summed up, and possibilities of such system on depreciation of parasitic loadings significantly increase. Similar tasks successfully are solved on the basis of use of the molding constructional polyurethane having great values of specific power consumption [8, 9].

The purpose of the real work is essential increase in functional durability of a node of a roller of the roller conveyer of the rolling mill by the choice of rational parameters of the small-size shock-absorber installed under a bearing outer ring and also confirmation of a possibility of management of loadings in a bearing block without change of technology parameters of the process which is carried out by the rolling mill in general.

Result and analysis. The essence of protection of metallurgical cars against breakdowns by means of shock-absorbers, consists in the following. One of types of shock-absorbers (the buffer, a damper, the compensator, the adapter or a combination of several types) is established to the power line in which the level of parasitic loading is high. At the same time performance data of the car significantly changes (or one of its power lines). Respectively, parasitic loading decreases. It occurs at each loading [10-12].

In practice often it is necessary to solve a problem of improvement or modernization of the existing shock absorption system. It occurs when the existing shock-absorber has the insufficient power consumption connected with small specific power consumption of material of the elastic element (EE). In this case the main objective of the designer – within the existing dimensions of the slot to develop the safety lock shock-absorber (SLSA) of the maximum power consumption, keeping at the same time a proof load for the car.

We will illustrate the level of depreciation properties of devices which can influence irrespective of external impacts on the functional durability of parts of power lines by reduction of the arising loadings and tension. Below the change of functional durability of the car which isn't connected with change of technology process is considered. Specific subject of the analysis – rollers of the TLS 3000 conic roller conveyer of PJSC Mariupol Iron and Steel Works of Ilyich.

Originally the shock-absorber (figure 1) of a roller (adapter buffer) was installed on an external bearing ring. Emergence of the adapter is caused by dissecting of seats (plastic deformation of an aperture of a pillow). The reason – the high level of contact tension connected with excessive rigidity (and, so high sensitivity to geometrical deviations, first of all, to production accuracy) the contacting couple.

Installation of the adapter buffer improves distribution of contact tension. Their maximum values can be reduced by an order. After installation of adapters (polyurethane rings δ=20 mm thick) dissecting of pillows completely stopped. However life cycle of bearings practically remained invariable though the effect of reduction of loading (very insignificant) has to be shown. It is connected with change of performance data of the power line of a roller. In other words, the effect of depreciation in this power line is connected with reduction of its rigidity because of deformation of draft gear.

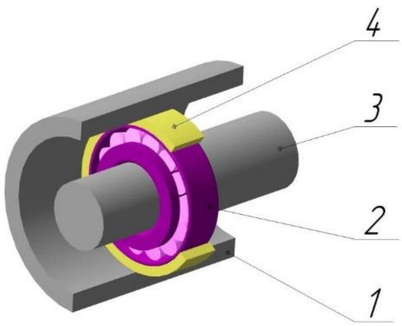

Figure 1. Scheme of installation of the ring shock-absorber (adapter buffer): 1 – pillow; 2 – bearing; 3 – shaft; 4 – shock-absorber

It is possible to estimate reduction of rigidity approximately, considering some data from operating experience. So, for example, it is known [2, 4] that dynamism coefficients for rollers of roller conveyers of rolling mills are very big due to the lack of depreciation and make $K_d \approx 40 \ldots 50$. We will accept for the considered case of $K_d \approx 40$. Then in the standard expression

$$K_d = 1 + \sqrt{1 + \frac{2h}{\delta_{st}}} \tag{1}$$

it is possible to discard both units, and $K_d^2 \approx 40^2 \approx 1600$. So, $2h/\delta_{st} \approx 1600$. This option corresponds to lack of depreciation. If depreciation is carried out by the buffer adapter, then δ_{st} has to increase up to δ'_{st} value:

$$\delta'_{st} = \delta_{st} + \delta_a \tag{2}$$

where δ_a – shock-absorber draft.
$\delta_{st}$and δ_a values can be found with an accuracy sufficient for quality standard. For definition of δ_{st} it is possible to consider that it is a roll depth of camber length of l and average diameter of d from action of the concentrated force of P_{st} (the peal weight share falling on one roller of the roller conveyer). Then

$$\delta_{st} = \frac{P_{st} \cdot l^3}{48EI_x} \tag{3}$$

where E =2·105 MPa – the normal module of elasticity for material of a roller (steel); I_x – axial moment of inertia of lateral section of a roller. It can be found approximately (if to replace a conic roller equivalent cylindrical) as $I_x = \pi d^4/64 \approx 0{,}05d^4$.

Static draft of the δ_a adapter can be found as reduction of height of the adapter h at action of force of P_{st} / 2 on it:

$$\delta_{a1} = \frac{P_{st} \cdot h}{2E_{k1} \cdot F_1} \tag{4}$$

where E_{k1} – the constructive module of elasticity for adapter material (with limited cross deformation). The rated scheme of the adapter buffer is shown in figure 2.

$$E_{\kappa 1} = E_c(1 + \chi\Phi_1^2) \tag{5}$$

$$\Phi = \frac{F}{F_b} = \frac{\pi d^2}{4\pi dh} = \frac{d}{4h} \tag{6}$$

where χ – coefficient of fixing of end faces of UE; Φ – UE form coefficient; The E_c – the module of elasticity of elastomer at compression; F_{b1}=64 sm^2 – the area of a free side surface of UE (shock-absorber end faces with sizes 16×2 of cm are conditionally free. Actually shock-absorber end faces in the accepted rated scheme free aren't, but allow overflowing of material from the lower half ring in upper); F_1 – the area of cross section of UE:

$$F_1 = a \cdot b = 16 \cdot 42 = 672 \text{ sm2} \tag{7}$$

$$a = 160 \text{ mm} = 16 \text{ sm} \tag{8}$$

$$b = D_{sr} = \frac{D_0 + D}{2} = \frac{440 + 400}{2} = 420\text{mm} = 42\text{sm} \tag{9}$$

In the reviewed example Adiprene L 167 ShA 95 polyurethane with the E_c =45 MPa was applied. In the absence of gluing and lubricant it is possible to accept χ=0.8. Then

$$\Phi_1 = \frac{672}{64} = 10.5 \tag{10}$$

$$E_{k1} = E_c(1 + \chi\Phi_1^2) = E_c(1 + 0.8 \cdot 10.5^2) = 89 \cdot E_c \tag{11}$$

$$E_{\kappa 1} = 45 \cdot 89 = 4000\text{MPa} \tag{12}$$

However the greatest possible module can't be more, than the volume module of elasticity K_y, i.e. $E_к \leq K_v$. The volume module of elasticity for polyurethane makes 3200 MPa [2, 4]. Therefore for the considered UE it is necessary to accept E_{k1}=3200 of MPa.

Assessment of ability of this shock-absorber to perform function of the buffer gear, i.e. to reduce parasitic loadings at power influences is given below. Assessment of the relation of δ_{st}/δ_{a1} is carried out as follows:

$$\frac{\delta_{st}}{\delta_{a1}} = \frac{P_{st} l^3 \cdot 2E_{k1} \cdot F_1}{48EI_x \cdot P_{st} \cdot h} = \frac{E_{k1} \cdot F_1 \cdot l^3}{24EI_x \cdot h} = 4.55 \quad (13)$$

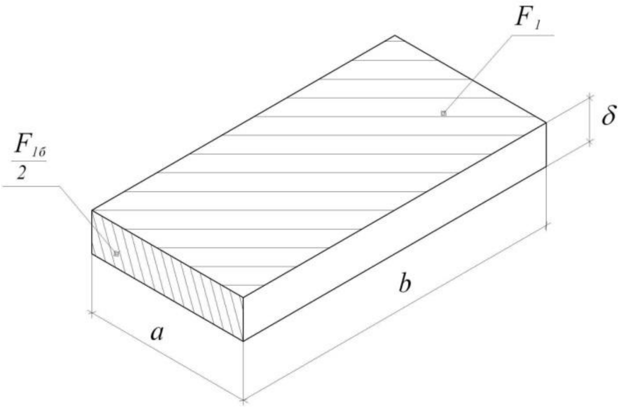

Figure 2. Rated scheme of the adapter buffer (option 1)

Return relation δa1/δst =0.222.
Relation of coefficients of dynamism

$$\frac{K_d}{K'_d} = \frac{\sqrt{\frac{2h}{\delta_{st}}}}{\sqrt{\frac{2h}{\delta'_{st}}}} = \sqrt{\frac{\delta'_{st}}{\delta_{st}}} = \sqrt{\frac{\delta_{st}(1+0,222)}{\delta_{st}}} = 1.1 \quad (14)$$

Thus, it is possible to consider that the installed adapter has also some effect of the buffer, i.e. reduces loadings of shock character approximately by 10%. However at installation of the adapter it was necessary to pass to the bearing of smaller diameter (400 mm instead of 440 mm). This bearing has dynamic loading capacity, for 25% smaller. If the effect of the buffer gear is K_d/K'_d>1.25, then the resource of the bearing will increase.

Use of polyurethane of smaller rigidity practically doesn't give effect because the adapter works in the conditions of comprehensive compression; means, E_k≈3200 of MPa will remain invariable for all polyurethane. But if to provide emptiness in an adapter body, then the F will change, so, and E_k. For example, the adapter can be executed from rings of the trapezoidal section (figure 3). Then form coefficient for an element from two rings

$$F_2 = 2 \cdot 0{,}4 \cdot a \cdot b = 0{,}8 \cdot 42 \cdot 16 = 538 см^2 \quad (15)$$

$$F_{b2} = 4\delta D_{sr} = 4 \cdot 2 \cdot 42 = 336 см^2 \quad (16)$$

$$\Phi_2 = \frac{538}{336} = 1.6 \quad (17)$$

$$E_{k2} = E_c(1 + \chi\Phi_2^2) = 45(1 + 0{,}8 \cdot 1{,}6^2) = 137 MPa \quad (18)$$

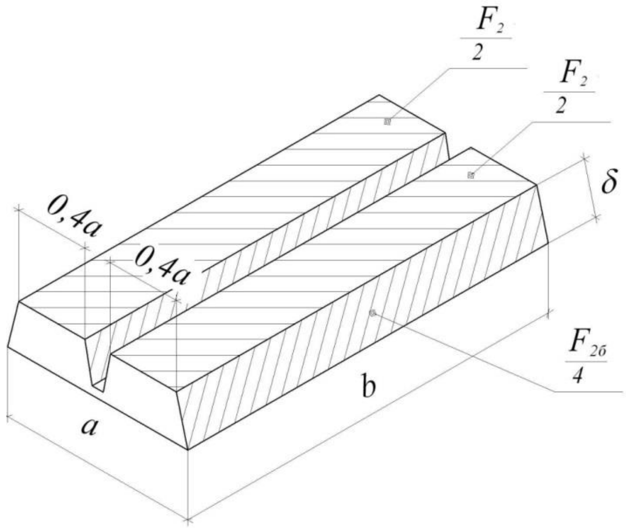

Figure 3. Rated scheme of the buffer adapter (option 2)

Relation δ_{st}/δ_{a2} =4.55·137/3200=0.195.
Return relation δ_{a2}/δ_{st} =1/0.195=5.13.
Change of coefficient of dynamism of K_d/K''_d =2.48, i.e. maximum loads decrease almost by 2.5 times. It much will increase a resource of bearings.
In this option the shock-absorber, except function of the adapter, performs also function of the buffer as significantly reduces values of the arising loadings. At the same time the functional durability of all parts of a roller increases; the coefficient of dynamism and, respectively, value of the maximum force decreases. The relation of functional durabilities in two options makes

$$\frac{n_{\phi 2}}{n_{\phi 1}} = \frac{P^* \cdot P_{max1}}{P_{max2} \cdot P^*} = \frac{P_{st} \cdot K'_d}{P_{st} \cdot K''_d} = \frac{K_d \cdot 2{,}48}{K_d \cdot 1{,}1} = 2.25 \quad (19)$$

i.e. the functional durability of all parts of a node of a roller increased by 2.25 times.

3. Conclusions

The reviewed example shows a possibility of essential increase in functional durability of a node of a roller of the roller conveyer due to the rational choice of parameters of the small-size shock-absorber. The calculation procedure and the choice of critical parameters of elastic elements of small-size buffers adapters is offered. Results of calculations were checked by implementation in a work practice of plate workshop 3000 (the conic roller conveyer, 20 support of rollers before and after a draft cage of KV-1, bearings No. 23248) and a continuous broadband camp of 1700 (the receiving roller conveyer, 4 support of rollers, bearings No. 2097148) of PJSC MMK of Ilyich. The resource of bearings after implementation of shock-absorbers was increased up to 22 months that is confirmed with acts of implementation.

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