UDC 004.942

THE RESEARCH LOADS ON THE SKIP OF MINE AND QUARRY ELECTROMAGNETIC LIFTING INSTALLATION

Aikeyeva A.A.[1], Zhautikov B.A.[2], Zhautikov F.B.[3], Mukhtarova P.A.[4]

[1]The Karaganda State University named after the academician E.A. Buketov,
[2]The Atyrau State University named after Kh. Dosmukhamedov,
[3]The Karaganda State Industrial University, 4The Asia Pacific University Innovation and Technology, Kuala Lumpur, Malaysia (aikeeva@mail.ru)

Article is devoted to research of loads on the skip of electromagnetic lifting installation which was carried out according to methods of calculation of thin-walled constructions. For determination the optimum parameters of the skip the analysis of influence of technology factors on the bearing ability was carried out. The construction is efficient from the point of view of durability if in all set service conditions it satisfies according to the accepted norms of durability. A number of calculations of action of various efforts to the skip are carried out. Critical tension was determined at the set skip wall thickness.

Keywords: electromagnetic lifting installation, skip, axial force, the destroying force, mine and quarry installation.

Introduction

In the formation of a competitive market economy the industry problem of reducing the cost of transportation of the rock mass, and hence the cost of minerals becomes crucial not only in Kazakhstan but also in the world. Enterprises of mining and processing of minerals for a long time need to modernize transportation of rock, in the implementation of the new hoist to transport high performance, speed, reliability, security at relatively low energy consumption.

The creation of energy-saving technologies of transportation of rock involves development of the mining industry, its rise to a new level to get capable for competition products, such as in Kazakhstan and in the world market [1,2]. Creation of electromagnetic installation will allow to solve the problem of high-performance and economically effective delivery of mineral from the deep horizons of fields [3].

Theoretical researches for analytical definition of the area of possible shift of loaded lifting vessel barycentre from the vertical axis of symmetry taking into account inequality filling of the load by calculation of the maximal size of shift of the barycentre of the skip were conducted [4]. Researches are conducted for determination of the maximal values of reaction of electromagnetic forces of electromagnets of the directing devices to the vertical wall of the moving ahead skip.

It is revealed that, setting the coefficient of container it is impossible to determine the size of wall thickness of a skip as with increase in mass of a skip shift of its center of mass decreases. Respectively the size of the loads operating of skip walls from electromagnets of the directing devices also decrease. We define wall thickness of a skip proceeding from an assessment of the yield values of the loadings operating on a skip during various periods of its work [4].

Statement of the problem

One of the main objectives of mechanics of lifting installations is determining the efforts in elements of skip construction of mine and quarry electromagnetic lifting installations in the concrete technological situation. As power loading of constructions of skips of mine and quarry electromagnetic lifting installations happens in the conditions of their interaction from the loaded and moved rock mass, the quantity of efforts are defined not only by manifestations of external pressure, but also parameters of lifting vessels constructions. That is rigidity on the bend, compression and torsion, conditions of contact with rock mass, existence and arrangement of pliability knots, their characteristic, etc.

Optimization of construction of skips of mine and quarry electromagnetic lifting installations is a real way of decrease in their metal consumption. Decrease in metal consumption conducts to considerable economy material inputs for production and installation, as well as operational costs of the electric power consumed by electromagnets, rotary hydrojacks, wearing of the directing devices.

The method of calculation

It is expedient to carry out analytical research of skip constructions of electromagnetic lifting installations and a number of calculations of action of various efforts to skip. To calculate the cylindrical covers under the influence of the axial force critical tension σ_{CR} and critical axial force T_{CR} are determined by the formulas [5,6,7]:

$$\sigma_{CR} = kE\delta / R, \qquad T_{CR} = 2\pi kE\delta^2 \quad , \tag{1}$$

where E – is modulus of elasticity, δ – is the wall thickness of the skip, R – radius skip, k - is coefficient of stability.

The coefficient of stability k for qualitatively made covers is defined (at R/δ = 100 … 1500) by means of the expression:

$$k = \frac{1}{\pi}\sqrt[8]{\left(\frac{100\delta}{R}\right)^3} \ . \tag{2}$$

Very short thin-walled cylinder, which length l≤1,22$\sqrt{R\delta}$ for the fulcrum end faces and l≤2,5$\sqrt{R\delta}$ for the jammed end faces, is calculated by the formula for a wide plate

$$\delta_{CR} = kE^2 / l^2 , \tag{3}$$

where k = 0,9 for the fulcrum and k = 3,6 for the jammed face edges [4].

The cover of the body of a skip of electromagnetic lifting installation is affected by the axial force T and the bending moment M. Calculation is applicable also in the case when the construction is affected by only axial force.

1. Let's determine equivalent axial force

$$T_{EQ} = T + 2M / R \tag{4}$$

2. When M=0 β =1; T=0 β = 1,25

$$T_{CR} = fT_{EQ} / \beta , \tag{5}$$

here $\beta = \dfrac{2{,}5 + RT/M}{2 + RT/M}$.

3. Proceeding from value of excessive pressure of the skip of each diameter, necessary for work, we will define necessary value of the ultimate load according to Fig.1.

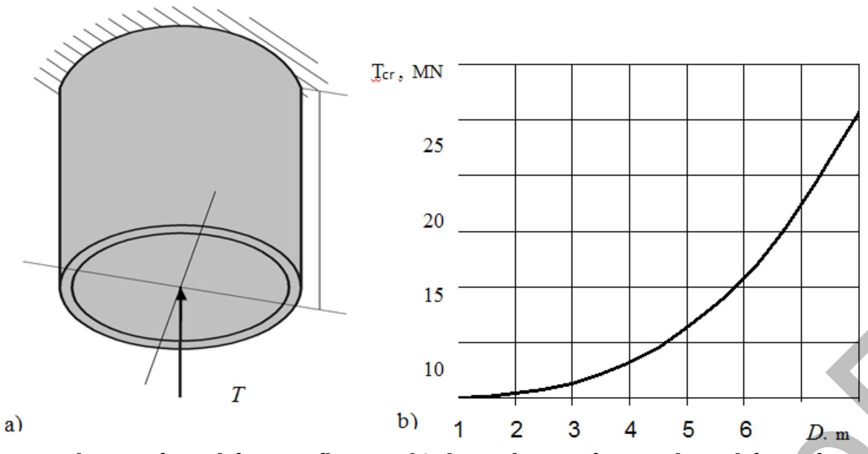
Determination of value of the critical destroying axial force will allow to prevent destruction (damage) of the case of a skip at its emphasis in extreme top situation in a trunk at the time of unloading.

4. Determine skip wall thickness:

$$\delta = 0{,}36\left(\frac{T_{KP}\sqrt[8]{R^3}}{cE}\right)^{0{,}42} , \tag{6}$$

Thickness of the skip is determined from the condition of the prevention of critical axial force to which the skip is subjected.

Dependence of diameter of a skip on minimum admissible thickness of skip wall is shown in Fig.2.



a) account scheme of axial force influence; b) dependence of critical axial force for various diameters of cylindrical skip;
Fig.1.Results of calculation of critical axial force

5. We will determine critical tension by finally accepted thickness of the skip wall

$$\sigma_{cr} = T_{cr} / 2\pi R\delta \tag{7}$$

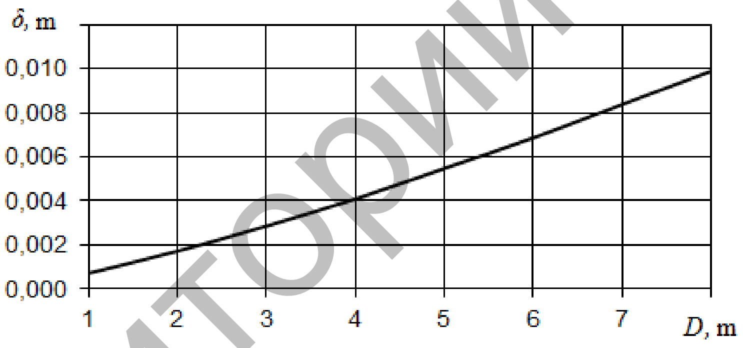


Fig.2. Minimum admissible thickness of a skip wall on the influence of critical axial force

Dependence of diameter of a skip on critical tension at influence of axial forces is shown in Fig.3.

Further we will carry out calculation of cross forces impact on a skip wall and action of local pressure upon cylindrical skips.

Cross forces on a skip wall appear at dynamic interaction of the vertical wall of a skip with the directing devices located at identical distance from each other on walls of a vertical mine trunk or the inclined quarry overpass.

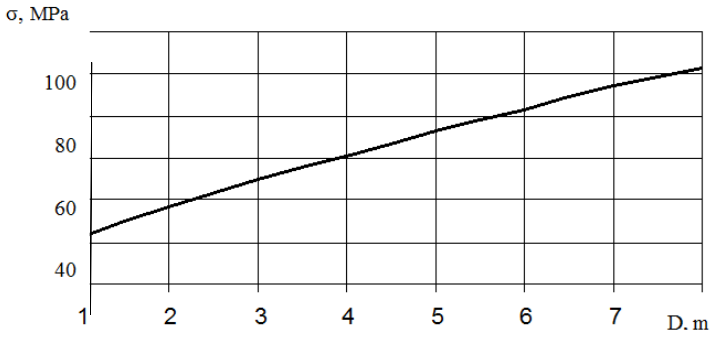


Fig.3. The value of critical tension from influence of axial forces

When loading the console cylindrical cover by the cross force of Q applied to absolutely rigid ring in the top part of a skip, the tension is defined by normal and tangent tension:

$$\delta_1 = \frac{Q_X}{\pi R^2 \delta}\cos\alpha\,;\ \delta_2 = 0\,;\ \tau = \frac{Q}{\pi R^{\delta}}\sin\alpha\ , \qquad (8)$$

here α – is the angle between the two radial sections skip.

Critical cross force:

$$Q_{CR} = \pi R \delta \tau_{CR}\,, \qquad (9)$$

where τ_{CR} calculated by formulas, which given in [5].

The destroying axial force when loading the cover pressure only in the circle direction:

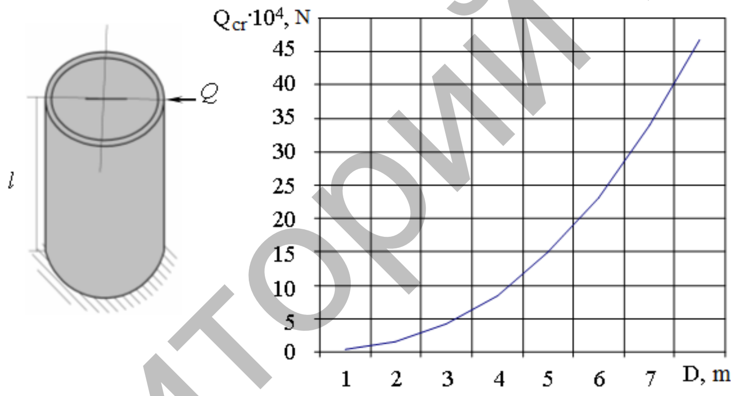
$$T_{CR} = 2\pi R \delta \sigma_{CR}\,, \qquad (10)$$

$$\sigma_{CR} = k_p \frac{E\delta}{R}$$

where $k_p=f(\bar{p}\,, R/\delta\,)$– coefficient from [5],

$\bar{p}=p/E\text{-}\ (R/\delta)^2$— the dimensionless parameter of pressure, in this case p — the value of normal pressure [5].

The received critical cross force is shown in Fig.4.



a) b)

a) account scheme of cross force influence; b) dependence of critical cross force for various diameters of a skip

Fig.4. Critical cross force

The destroying axial force when loading the cover by pressure is shown in Fig.5.

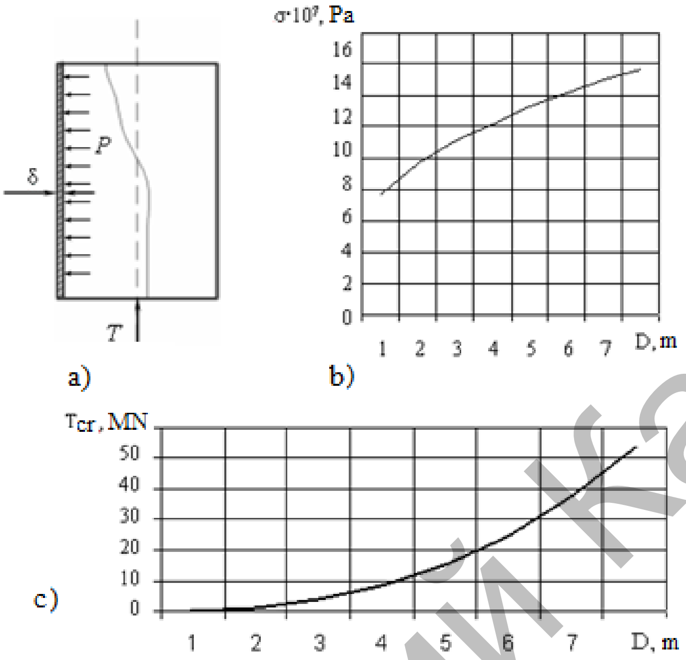
$$p_{cr} = 0{,}92\frac{E\delta^{5/2}}{a_1 R^{3/2}}\alpha \qquad (11)$$

Table 1 – Critical external pressure $p_{cr}\cdot 10^3$, Pa

R, m $P_{cr}\cdot 10^4$, Pa	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0
In the middle of a skip	3,38	11,2	22,2	36,1	53,5	71,4	93,4	115
Close to face end	6,57	20,6	39,8	63,2	93,6	125	164	202
Running loading in the middle of a skip	0,15	0,49	0,99	1,62	2,4	3,2	4,2	5,19

Apparently from Fig.6, dependence of the critical destroying force on the radius of a skip has almost linear character.

The schedule in Fig.7 shows the intensity of increase of the critical destroying force at increase in diameter of a lifting vessel.



a) account scheme of action of axial compression and internal pressure;
b) maximum tension; c) critical force

Fig.5. Calculation of tension and critical force from the action of axial compression and internal pressure

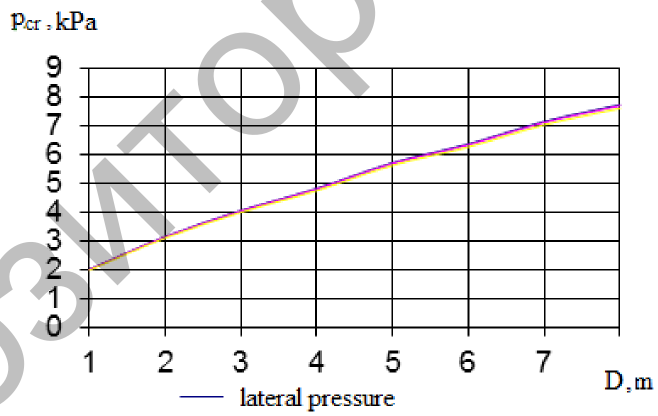


Fig.6. Critical external pressure

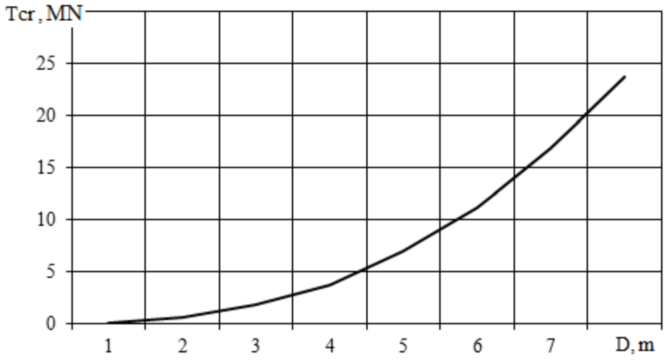


Fig.7. The value of the critical destroying force

Conclusion

The values of critical external pressure given in the table 1 allow to specify the necessary thickness of a skip wall depending on various factors – the side pressure, comprehensive pressure, as well as combination of loadings – the comprehensive pressure and axial compression. Critical external pressure in its value is less than excessive pressure on a skip. Schedules in figure 6 show dependence of critical side pressure, critical comprehensive pressure, dependence of critical comprehensive pressure and axial compression on the diameter of a skip. Functions have almost linear character. All critical pressure there is less than excessive pressure. The received concrete values of critical pressure can also be compared to the real mechanical condition of system for determination of its working capacity and reliability.

The analysis of the schedule shows that dependence of the critical destroying force on diameter of a skip nonlinear has character close to square dependence. The received concrete values of the critical destroying force can be compared to the real condition of the system "a lifting vessel – an electromagnet" for determination its working capacity and reliability.

This article is written on the basis of results of the researches which are carried out within grant financing of Ministry of Education and science of the RK by priority of "Technology of Minerals Development" on the subject "Justification and Development of Energy Saving Technology of Dredging Rocking Mass by Creation of Electromagnetic Lifting Installation" by priority "Power and Mechanical Engineering" on the subject "Development of the System of Automatic Control and Complex Protection of Energy Saving Electromagnetic Lifting Installation".

REFERENCES

1. Nikolaev Y.A., Zhautikov B.A. The need for the introduction of a new mode of transport in the mines and quarries of Kazakhstan. *Industry of Kazakhstan*, 2006, No.6, pp.19 - 22.
2. Aikeyeva A.A., Zhautikov B.A., Zhautikov F.B., Mukhtarova P.A. The introduction of energy-saving technology for transporting rock mass by creation electromagnetic hoisting installation. *Eurasian Physical Technical Journal*, 2013, **V.10**, No. 2(20), pp. 49 - 52.
3. Zhautikov B. A., Aikeyeva A.A., Zhautikov F.B., Mukhtarova P. A. Kazakhstan Innovative patent for the invention No. 27177. Electromagnetic lifting installation (options).
4. Aikeyeva A.A., Zhautikov B.A., Zhautikov F.B., Mukhtarova P.A. Research of the area of possible shift loaded skip barycentre of electromagnetic lifting installation. Eurasian Physical Technical Journal, 2014, **V.11**, No.2(22), pp. 62 – 69.
5. Lizin V.G., Pyatkin V.A. Design of thin-walled constructions. 1976, M.: Mechanical Engineering, p. 408.
6. Drozdova T.E. Theoretical bases of progressive technologies. 2011, M.: MSOU, p. 212.
7. Nikolaev Y.A., Zhautikov B.A. Methodical bases of calculation skips mine and quarry installations pneumatic lift installation. Coal, 2006, No. 11, pp. 32-33.

Article accepted for publication 11.05.2015