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Performance analysis of the rolling equipment using computer modeling

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Abstract. The possibilities of modern computer technologies for the strength analysis of rolling equipment are shown. The example of calculation of a frameless stand 630 medium-section mill 450 at JSC “EVRAZ ZSMK” using the strength analysis module APMFEM Compass-3D is considered.

1. Introduction
Rolling equipment is widely used at metallurgical plants to produce finished products. The operating conditions of this equipment are associated with large static and dynamic loads, high temperature. Such operating conditions create high risks of incidents, significantly affect the quality of products. The cost of the main rolling equipment and the cost of its operation are very high and therefore all unforeseen stops and breakdowns significantly affect the cost and competitiveness of rolling products.

2. Methods of research
One of the possible ways to extend the service life of rolling equipment reducing the costs for its operation is a thorough calculation of strength with maximum consideration of all factors of influence. The issue of strength calculations of rolling equipment in the technical literature has been given great attention [1 - 3]. Available calculation techniques allow a preliminary assessment of the performance of rolling equipment to be performed, but their accuracy is not enough, calculations are cumbersome, many factors are left without attention. With the development of information technologies it became possible to solve the problems of equipment strength analysis at a new modern level, taking into account the influence of a great variety of factors.

The latest versions of Compass-3D, SolidWorks software contain modules for strength analysis of equipment and structures. Modules of strength analysis are based on the principles of three-dimensional finite element modeling and allow the distribution of stresses, safety factors for the yield strength and stability of a part, temperature at various points by volume to be found.

The use of the above mentioned software packages allows the designer to make correct and valid constructive decisions already at the initial stages of design using 3D models built. This, of course, improves the quality and saves time spent on designing.

The main task of finite element modeling in the software packages under consideration is the analysis of the strength of parts and assemblies, for which it is important to evaluate quickly the
reliability of elements with possible optimization of the design, using the associative relationship of geometric and computational models.

3. Results and discussion
Let us illustrate it with the example of the strength calculation of a frameless stand 630 medium-section mill 450 JSC “EVRAZ ZSMK” using APMFEM application of the strength analysis system Compass-3DV16. At the initial stage it is necessary to create a three-dimensional assembly of the upper roll chock and anchors and set the boundary conditions for fastening. Apply the calculated loads and generate a finite element grid with a given condensation coefficient on the surface and a dilution factor in the volume (figure 1). The resulting grid can be viewed both on the surface and in the depth of the body of the part by changing the position of the “visit depth” slider.

Figure 1. The generated finite element grid.

After carrying out preparatory operations, calculations are made. The information obtained in the calculations is displayed in the form of color maps, which shows the distribution of the studied value at any point in the volume of the structure under study. As an example, figure 2 shows the distribution of safe coefficients by the yield strength in the assembly body.

To evaluate the reliability of the results obtained, the safe coefficients were calculated by the yield strength using traditional methods [4] and compared with machine calculations. When carrying out verification calculations for real structures using APMFEM application, there was a problem with a limited library of steel grades. As the default one the application uses 10KP steel. This inconvenience can be eliminated by introducing a correction factor ($K_\sigma$).

$$K_\sigma = \frac{\sigma_{\text{base}}}{\sigma_{\text{calc}}}$$

where $\sigma_{\text{base}}$ – the yield strength of the material from which the corresponding part is made; $\sigma_{\text{calc}}$ – the yield point of the material used in the calculations.
Figure 2. Distribution of safe coefficients by yield stress in the body of the assembly.

Using the value of the correction factor, the true value of the safety coefficient by the yield strength ($K_t$) for any material can be determined using the formula:

$$K_t = K_o K_{calc} \times$$

where $K_{calc}$ – the calculated value of the safety coefficient by the yield strength when the material of the workpiece is used as default (steel 10KP).

Taking into account the correction coefficient, the minimum value of the margin factor for the yield strength in the computer simulation for the anchor was 46 for the roll chock 31. When calculating by the conventional method, the safety coefficient values for the yield strength were 48 and 34, respectively. A comparison of the obtained data shows that the results are close, divergence is not more than 10 %. However, the possibilities of computer modeling allow us to identify sections of the structure with a great safety coefficient by yield strength and reduce their metal consumption, and in areas with a low safety coefficient to focus on the planned inspections.

4. Conclusion

The results presented in the paper show the possibilities and advantages of modern computer technologies in assessing the performance of the main rolling equipment.

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