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MATHEMATICAL MODELING OF AN ELECTROMECHANICAL SYSTEM OF DRUM SHEARS

Rolling production technology is developing towards the widespread use of continuous rolling mills (sheet, section, billet mills). The shears used for cutting metal are a very important machine in these flow lines [1].

Drum-type shears with inclined upper knife are installed between roughing and finishing groups of stands of hot rolling mill "1700" of sheet rolling shop No.1 of JSC "Qarmet" and are designed for cutting of front and rear ends of the underlay.

On the basis of available technical documentation the scheme of the mechanical part of the equipment of drum flying shears installed at the hot rolling mill "1700" of sheet rolling shop No.1 of JSC "Qarmet" was developed.

The asymmetry of this design due to the different diameters of the flying scissor drums is of particular note. One of the important features of the electromechanical system of drum flying shears is the presence of elastic links. The drum drive is a two-mass electromechanical system, where the kinematic gear plays the role of an elastic link. Such systems are classified as systems with elasticities of the first kind [2]. The shears are driven by two DC electric motors type P19-75-7K 1750 kW 190 rpm through a spur gearbox.

To analyze the dynamic modes of the electric drive of drum shears, a mathematical model of the drive motor with a closed angular speed control system, supplemented by a six-mass model of the mechanical part of the drum shears, has been developed. To derive the equations of the mathematical model of the multi-mass mechanical part of the drum shears it is proposed to use the Lagrange equations of the 2nd kind, which allows to use a general approach to solve the equations of similar models.

To improve the accuracy of the mathematical model, a theoretical analysis of forces and moments of cutting resistance for drum flying shears was performed. The equation for calculating the cutting force and moment of resistance of the electric drive of drum fly scissors was obtained.

This equation allows, knowing the geometric dimensions of the workpiece, the operating value of shear stress (taking into account the temperature state of the material) and the shear angle, to estimate the required cutting force to be developed by the flying shears for the correct execution of the cut. For steel in the fully formed austenitic region (which is characteristic of temperatures around 1250 °C), typical values of the critical shear stress may be in the range of 15-30 MPa.

In a number of design problems, a value of about 20 MPa is often taken for approximate estimation. This value is indicative and can be adjusted depending on the specific conditions of the hot rolling process and steel composition. In practice, additional empirical coefficients or adjustments may be introduced to account for factors such as non-ideal cutting conditions, the influence of process dynamics, the accuracy of the shear gap, etc.

MATLAB/Simulink program with Simscape Electrical library was used to analyze the obtained mathematical model of drum shears.

The developed mathematical model of drum shears allowed to estimate additional dynamic forces arising in the mechanical part due to asymmetry of the mechanical part design. Comparison of modeling results with available experimental results confirms the adequacy of the developed mathematical model.

References

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