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ANALYSIS OF SPEEDS AND DYNAMIC MODE OF ROLLING ON REVERSING ROLLING STAND

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ABSTRACT
Determination of working load of rolling stands elements and parts are complicated proceeding. That complexity come from presence of large number of factors which impact to level and character of load, as well as their changeability during the rolling process. In essence, such changeability has stochastic character.
Analysis of changeability of rolling speeds, by that also dynamic mode, as very essential element for determination working loads of main drive on reversing rolling stand are presented in this paper. Possible forms of rolling speed changes which are the most common used and present in operations, their characteristics, as their impact on dynamic mode of rolling are defined. This analysis enables working load determination, analysis of stress state of elements of main drive of reversing rolling stand – blooming and further calculation of safety and reliability of basic parts.
Key words: rolling speed, dynamic mode, reversing rolling stand, working load

1. INTRODUCTION
Rolling is process of plastic processing of metal where by pass through between revolving rolls, casting block or semi-finished products is reduced in section and give desired shape, with improved of mechanical characteristic in same time. Rolling process is performed on one or more plant in which there are rolls and its name are rolling stands. Besides, in regarding to different kind of rolling process different rolling stands exist.
Determining of working load of rolling stands are very complex proceedings. That complexity is special presents at determining of load of reversing rolling stands. Their characteristics are that after ends of each pass is reversed – change direction of rolls revolution, and also during pass speed of rolls is changed.
In technological practice two often used shapes of rolls speed exist of change in rolling process, and such are: triangular and trapezoidal shapes of change. Both shapes are different influenced on dynamic condition of element. For concrete conditions of rolling, analysis of those states are very essential because of checks of stress states of elements, as also because of thermal check of driving electric-motor state. With optimizations of parameters and shapes of change, result of analysis can result in large reliability of rolling stands elements.

2. STRUCTURE AND CHARACTERISTIC OF MAIN LINE OF ROLLING STAND
Main line of rolling stand drive is system of mechanisms by which of transmission of motion and power are realized from driving electric motor to rolling rolls. By main rolling line is achieved forces and rolling moment, which are necessary for plastic deformation of metal that is located between rolls. Main drive line is different for different rolling stands. It may be said, that basic mechanisms or elements of every driving line are: electric motor, transmission driving gear, transmission stand and rolling rolls.

Characteristic of main line of reversing rolling stand is in that it is constructive designed that make possible change of direction of rolls revolution, and also regulation of speed of rolls during pass of material between rolls. Different rolling programs are present. Namely, in one period of time for time of one pass of material one direction of rolls revolution exists and usage one rolling groove, and in the next period – second pass exist opposite direction of rolls revolution and usage of second rolling groove. In essence, those grooves are different shapes. In some cases, on a roll can exist large number of equal grooves as well as usage one groove many times.

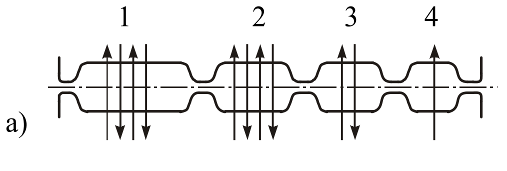

Figure 1. Plan of pass on reversing rolling stand

As shown, figure 1., through one groove can be achieved many passes. On one reversing rolling stand number of passes are between 9 and 15, and if is rolling of alloyed steel number of passes can be 25 to 27 [1]. Thus, cases of very different rolling programs are possible.

3. ANALYSIS OF SPEED MODE OF ROLLING

During rolling on reversing rolling stand, change of speed of rolls revolution can be performed on two basic ways: trapezoidal change (a) and triangular change (b). Figure 2. are shown these two kind of changes.

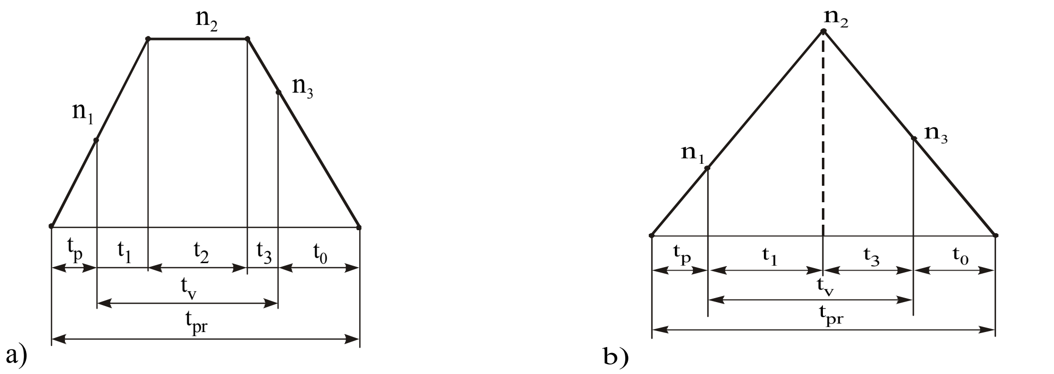

Figure 2. Shapes of change of rolls revolution speed

As shown, at trapezoidal change, time necessary for one pass t_{pr} are consist of time periods: acceleration time of rolling line without material t_p during that situation rolls speed is increase 0-n_1, time of acceleration of rolls with material t_l during that situation speed of revolution is increase from n_l to n_2, rolling time with permanent speed t_2 during that situation speed is constant n_2=const, time of rolls retard t_3 during that situation rolls speed is reduce from n_2 to n_3. When rolls come up speed of revolution n_3, material which is rolling left rolls and it's transported by roller table, and rolls are stopped in time t_0. After that cycle is repeated, with opposite direction of rolls rotation.
At triangular change do not exist period of constant speed of rolling, but it immediately began to reduce in the moment of attaining of speed n = n_2. That makes possible shorten of rolling time given piece but also increase of elements load. From point of view of getting of maximum capacity of blooming, suitable is attaining middle speed as bigger as possible. However, level of that speed is limited with conditions of sprue of material between rolls. Leaving the material, between rolls at bigger rolls speed, and it is also unwanted because that increase time of pause between two pieces. Additional limitations in speed are be found in impossibility of electric motor in question of size of commitment power for given speed. Because all of that it is necessary to spend proceedings of rational selection of speed and mode of rolling, but here it's not detailed spent and it is can find in accessible literature [2].

4. DYNAMIC MODE OF ROLLING

Setting the dynamic mode of rolling at rolling stand means establishing the all factors which influenced on working load of its elements, and it is consequence of mode of rolling. At rolling stands with regulated speed during the time of rolling– reversing rolling stands, besides static moment during the rolling process is necessary to take dynamic moment in calculation. The same is appearing as consequence of change of rolls revolutions speed, i.e. changes of speed rolling mode. Different speed mode has different influence on working load, so at calculation of rolling stands elements are necessary to perform suitable estimate for every mode.

4.1. Working load at trapezoidal change of speed

As shown on figure 2 a. at trapezoidal change of speed five different mode of work exist, i.e. every sub-interval of time t_p, t_1, t_2, t_3 and t_0 suitable belonging load. According to that, characteristic revolutions speeds are present as: n_1 – number of revolutions when piece entry between rolls, n_N – nominal speed, n_2 – number of revolutions at stable speed, n_M – maximal number of revolutions and n_3 – number of revolutions when material leaves rolls. For each number of revolutions (rolling speed) dynamic moment of rolling are defined to take into consideration length of interval between some changes. Changing of length of time interval and level of number of revolutions can influence on dynamic mode of rolling are obviously.

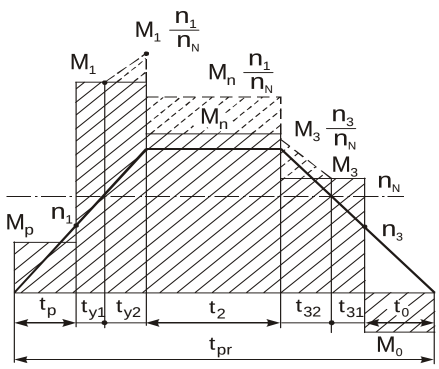

Figure 3. Flow of moment loading M=f(t) for trapezoidal shape of change

Graphical presentation of change of dynamic rolling moment at trapezoidal shapes of changes speed of roll revolving is shown on figure 3. In this case of rolling is: $n_1 < n_N$ a $n_3 > n_N$. That means that rolled piece entry between rolls when speed of roll is less then nominal speed, and coming out of rolls when speed is higher then nominal speed. However, if n_1 and n_3 has other level in this case we have other dynamic mode. Way of setting up the moment for individual intervals is given in [2].

By V. A. Tjuganovu if dynamic moment is added to static moment we obtained total moment which loading of rolling stand elements [3].

$$M_m = (M_V + M_{tr}) / \eta \pm M_{din} \qquad ...(1)$$

Where: M_V – moment of rolling, M_{tr} – frictional moment, M_{din} – dynamic moment, η - efficiency factor.

Analysis of dynamic mode of rolling enables determining of total moment, and also checking of driving motor in heating. For checking the main drive elements for each interval is necessary to establish maximal moment and it is compared them with nominal moment, i.e. perform check on short-term overloading. After that method it is moving to check of driving motor on heating.

Criterion for revision of motor on heating is defined as:

$$M_{KV\Sigma} \leq 0{,}9\ M_n \qquad ... (2)$$

Where: $M_{KV\Sigma}$ – square moment for all period t_p , M_n – nominal moment.

It is possible to determine $M_{KV\Sigma}$ for each time period, at trapezoidal mode of rolling, is possible to determine $M_{KV\Sigma}$, so in that way is possible to check of motor of reversing rolling stand. As shown on figure 2.a. square moment for trapezoidal moment of change is possible to define as:

$$M_{KV\Sigma} = \sqrt{\left(M_p^2 \cdot t_p + M_1^2 \cdot t_{y1} + M_1^2 \cdot t_{y2} + M_n^2 \theta_1^2 \cdot t_3 + M_3^2 \xi_3^2 t_{32} + M_3^2 t_{31} + M_0^2 \cdot t_0\right)/t_{pr}} \qquad ...(3)$$

Where are: M_i – belonging moment (figure 3), t_i – belonging time (figure 3).

If motor by its characteristic doesn't meet, then is necessary to change dynamic mode of rolling [3].

4.2. Working load at triangular change of speed

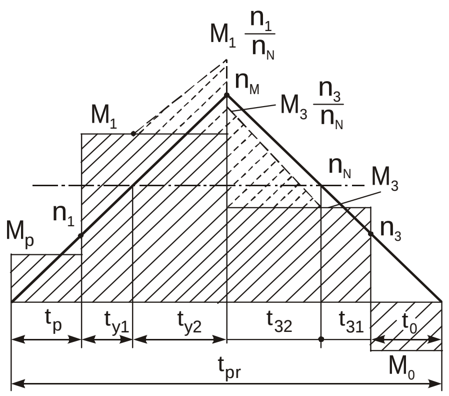

Figure 4. Flow of moment loading M=f(t) for triangular shape of change

In contrast to trapezoidal shapes of speed change at triangular shape of change no exist time period with constant rolling speed.

Because of that, dynamic mode of rolling is different in regard to trapezoidal. Figure 4. shown flow of load changes for triangle shape of rolling speed change.

At this dynamic mode of rolling there are characteristic periods of time t_1, t_{y1}, t_{y2}, t_{32}, t_{31}, t_0, as also belonging speeds n_1, n_N, n_3 i n_M. Performed similar method as at trapezoidal shape of rolling speed change, it is possible to define belonging dynamic moment and square moment of motor.

$$M_{KV\Sigma} = \sqrt{M_p^2 \cdot tp + M_1^2 ty_1 + M_1^2 \xi^2 ty_2 + M_3^2 t_{31} + M_0^2 t_0 / t_{pr}} \qquad ...(4)$$

$M_{KV\Sigma}$ is determined when then for this shape can be performed check of motor on heating according to expression (2). Setting up the maximal moment for each interval and comparing with nominal moment as it is noted for trapezoidal shape of change go before this activity.

5. CONCLUSIONS

From above performed analysis for reversing rolling stand we can come to the following conclusions:

- At reversing rolling stands there are possible following shapes of speed change: triangular and trapezoidal or their combination.
- On the basic of adopted shape of change is possible to set up dynamic mode of rolling. Extraction of dynamic moment for each interval of time during pass is gone before its.
- Maximal moment during each interval (M_{st} + M_{din}) is necessary to compare with maximal moment of motor $M_{m\,max}$
- After that it is possible to define square moment for all intervals $M_{KV\Sigma}$, and to check motor on heating.
- If elements of main line or electric motor of rolling stand don't meet all noted conditions, with changing shapes of change of speed for different passes is possible to attain suitable conditions for defined elements of main drive of rolling stand [4].

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