Increasing the working efficiency of the forholler of the pilger rolling mill

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Abstract. The article examines the issues of increasing the reliability and efficiency of the feeding mechanism (forholler) of Pilger rolling mill. A new design of the trolley and the piston system of the brake chamber is proposed.

Introduction

Pilger mills of periodic rolling [1] are used for the production of hot-rolled seamless pipes of large diameter. The process of deformation is carried out on the mandrel in rolls with a variable radius of the caliber (Figure 1) rotating opposite to the direction of supply of the sleeve (workpiece).

![Figure 1. The scheme of hot pilger rolling](image)

During each revolution of the working rolls, the deformable sleeve makes a return movement to the length of the working cone (up to 1500 mm). The end of the reduction cycle is accompanied by an increase in the radius of the calibers, which ensure that the remaining angle of rotation of the rolls allows the workpiece to return to the deformation zone by sliding it in the direction of the outlet of the finished pipe by an additional one-time feed (30-60 mm). The procedure for the return and delivery of the workpiece, as well as its canting around its own axis at an angle of up to 90°, is performed by a feeding device, the so-called forholler. Forholler is the most responsible mechanism of the pilgrim mill, the reliability of which mainly determines the uninterrupted operation of the equipment and the quality of the pipes produced. The return movement of the billet together with a mandrel weight of up to 10 tons for a distance of up to 1500 mm in a short time interval not exceeding 0.5 s is accompanied by large dynamic loads. This explains the continuous attempts to further improve the design and search for optimal parameters of the law of motion of feeders [2]. The problematic issues of operation of the gun are:

Large dynamic loads during the half-cycle of the cyclic return of the workpiece to the rolling zone, the duration of which does not exceed half the half-cycle of the single-reduction cycle
the need for rapid acceleration and soft braking of the piston system at the end of the return movement of the workpiece, i.e. achieving a minimum, close to zero final speed and acceleration, excluding the removal of the liner from the mandrel in front of the compression bar and the cast of the workpiece relative to it;

- ensuring low-cycle strength at the final extraction of the mandrel from the liner and fatigue strength at high-frequency cyclic loading of the screw pusher, its movable traverse and the details of their connection.
- achievement of strict synchronization of the end of the workpiece movement with the moment of its gripping by working rolls, excluding both premature stopping and moving it during rolling;
- problems of sealing large-sized moving parts of the gun and their fatigue life are among the hard-to-solve problems.

At the present time, the most widely used are feeders with an air-hydraulic propulsor. When rolling in each single cycle of reduction, the workpiece moves opposite to the direction of exit of the finished pipe, ensuring a multiple increase in the air pressure in the chamber of the pneumatic cylinder 11 (Figure 2), designed to accelerate it during the return movement during the opening of the curved creepers of constantly rotating working rolls 1.

Figure 2. Scheme of movement of the pistons of the forholler during crimping of the workpiece

(1 – stand of pilger mill; 2 - rolled pipe; 3 – mandrel; 4 – body of forholler; 5 - guide chamber; 6 - guide piston; 7 – stock; 8 – hydrocamera; 9 - brake-axle; 10 - hydraulic piston; 11 - air chamber; 12 - air piston; 13 – feeder; 14 - clamping cylinder; 15 – traverse)

To guarantee the stopping of the return movement of the workpiece, before using the working part of the crochets, it is used brake devices of hydraulic type. They include a brake cylinder and a periodically inserted piston 10 with a constant or alternating diametral clearance with respect to the mirror of the brake sleeve (chamber), as well as a system of adjustable throttling outlets [3].

Figure 3. Scheme of the return movement of the forholler

During the period of the workpiece return to the deformation zone, its movement represents the sum of the movements of the trolley with the stop 5 by the amount of the single feed and the rod 7 together
with the mandrel 3 and the workpiece 2 by the total amount of rollback during rolling. Determination of the rational law of the return motion of the billet (Fig. 3) requires a reasonable choice of initial settings, including the initial pressure in the pneumatic cylinder and the parameters of the brake chamber chambers agreed with it, taking into account the change in the temperature regime of the working fluid and changing the rolling conditions of one billet, and the material of the original sleeve. The movement of the trolley by the supply amount is provided by a central screw mechanism, the nut of which is fixed in the worm drive wheel 13. A disadvantage of the known feeding mechanism is insufficient longitudinal stability and transverse deformation of the rod and screw, which worsens the work of the screw-nut pair, causing wear of the latter and reducing the service life of the feeder mechanism as a whole. In addition, in the process of operation of the forholler and previous measurements, its operation was found to be flawed, including the unstable braking of the moving parts before the cycle of reduction of the workpiece and breakdown in the fastening unit of the traverse-stop 5 of the feed mechanism. The connection of the feed screw with the traversing stop is shown in Figure 4 [5].

![Figure 4. Trolley and feed screw feeder of forholler’s the initial design](image)

A complex of full-scale measurements, including pressures in the pneumatic and brake chambers, strain gauging measurements on the rod of the forholler and the feed screw was carried out. It is established that the feed nut forms an unstressed connection with the supply screw, loaded during the rolling period by cyclic loads varying according to a law close to a symmetrical one with a duration of 1.5 s. The source of maximum values of cyclic loads is the peak pressure in the brake chamber of the forholler, which determines the maximum value of the longitudinal force transmitted through the carriage of the forholler and the traverse-stop on the screw and nut of the feeder. Recorded in the process of full-scale measurements, the maximum of these forces reaches 600 kN per cycle [6-8]. In the process of extracting the mandrel from the rolled tube, the load on the transmission of the screw-nut of the feed mechanism is determined by the forces developed by the additional hydraulic cylinders and by the feed screw drive with the fixed carriage of the forholler. The period of recurrence of these loads is 250-300 times higher than the duration of the rolling cycle. Under these conditions it is permissible to consider the loading regime as static. The measured values of the maximum forces during the extraction of the mandrel were 1000 ... 1100 kN, of which 80% are the forces developed by additional hydraulic cylinders.
In order to improve the reliability of the feeding mechanism, a new design of the trolley and the piston system of the brake chamber is proposed. According to the proposed variant shown in Figure 5, the travel stop of the bogie is made in the form of two parallel screws connected to a rigid restraint frame located in the guides of the base under the carriage, the screws being rotatably disposed from the nuts mounted in the drive gears cooperating with the central driving gear of their driving device.

Figure 5. Feed restriction mechanism

The feeding mechanism of the pilger mill operates as follows (Figure 5). Before the start of the rolling of the next workpiece, the rigid bounding frame 5 is set to its initial position by moving it by the return movement of the screws 4 to the stop 10 of the carriage. To carry out the feed of the workpiece, the electric motor 9 is moved to the operating position, communicating the translational motion at a predetermined feed rate to the screws 4 through the drive gear 6, the driven gears 7 and the nuts 8 fixed therein. In this case, the rigid limiting frame 5 connected to the screws 4 moves in the guides of the base 1 under the carriage 2, limiting the movement of the stop 10. In this case, the rods of the hydraulic cylinders 3 fixed to the carriage 2 are made, by the fluid pressure, by the constant contact of the abutment 10 with the frame 5. After the end of the rolling of the next workpiece, the carriage 2 is retracted to the rear starting position by the rods of the hydraulic cylinders 3, and the frame 5 is returned by the screws 4 due to the reverse with the increased speed of the engine 9 to the touch with the stop 10 of the frame 5. The movement of the rigid frame 5 in the guides of the frame 1 eliminates the loss of its stability and transverse vibrations, providing an increase in the efficiency of the feeder.

For the design justification of the structural dimensions of the details of the proposed mechanism, let us consider the loads acting on the system during the operation of the feeder. The carriage 2 (Figure 1) moves under the action of the force \( \Delta F \) of the hydraulic cylinders 3, which results from a difference in the forces of the piston and rod cavities. When the carriage moves, a friction force \( F_{TP} \), directed against the movement, occurs. During rolling and during the acceleration of the moving masses, the force from the pneumatic chamber \( F_{BOYD} \) acts on the carriage, which in turn is transferred to the rods of the hydraulic cylinders, causing additional deformation of the compression. During the period of active hydro-braking, a force \( F_{TOPM} \) arises, causing a deformation of the extension of the rod of hydraulic cylinders. Frame 5 has the algebraic sum of the \( F_{FRAME} \) of all external forces.

During the rolling and acceleration period, the equilibrium equation takes the following form:

\[
\Delta F - F_{TP} + F_{BOYD} - F_{FRAME} = 0
\]  

(1)

During the period of active braking the equation of equilibrium takes the form:

\[
\Delta F - F_{TP} - F_{TOPM} - F_{FRAME} = 0
\]

(2)

Here, \( F_{BOYD} \) and \( F_{TOPM} \) are determined from the solution of equations (1) and (2).
Carrying out the limiter of the trolley in the form of parallel screws connected to the rigid bounding frame makes it possible to increase the rigidity of the screws in the transverse direction, which increases the reliability of the screw-nut pair and, as a result, the reliability of the entire feeding mechanism. The design of the elongated U-shaped frame allows manipulation to remove the mandrel and is independent of the drive unit for returning the cart of the forholler to its initial position when the next workpiece is rebooted.

Figure 6 is a diagram of the forces acting on the frame of the feed limitation mechanism for the entire rolling cycle. As can be seen from the diagram, the maximum load on the frame, equal to the sum of the forces from the feed cylinders and braking forces, occurs in the active braking phase of the moving parts of the forholler when the workpiece is returned to the stand.

![Figure 6. The forces perceived by the traverse of the feed restriction mechanism](image)

The complex of design changes in the feeding device is designed to improve the reliability of the Pilger Rolling Mill as a whole, in order to avoid spontaneous fluctuations in the values of single feeds and, thus, to increase the geometric accuracy of the dimensions of the rolled pipes.

**Conclusion**

So, the main directions of increasing the efficiency of the newly proposed design of the forholler of the pilgrim rolling mill are [9]:
- Increase the load capacity of the mechanisms of moving the frame structure due to the bifurcated two-screw reinforced line of the drive device;
- Increase the maneuverability of the mandrel-mandrel extraction devices in the final rolling stage by releasing the inner space for the carriage withdrawal, removing the load from the beam of the frame structure and completely transferring the mandrel extraction force to an additional hydraulic drive;
- Increase of stability of movement and stability of values of cyclic single feeds of a preparation in a working cage.

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