Algorithm for automatic setting of the gap mill DUO-300

Algorytm automatycznej nastawy szczeliny walcowniczej walcarki DUO-300

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The article describes the set gap mill DUO-300 forms part of the rolling of the Faculty of Production Engineering and Materials Technology of Czestochowa University of Technology. Control of technological line based on controllers PLC. For communication between the individual elements used data bus CANBus. The paper describes in detail the algorithm set the upper roller mill. Automatic control according to the algorithm presented primarily allowed to shorten the time and increase the precision of the set of rollers which was impossible to obtain the original, manually controlled system.
KEYWORDS: controller PLC, data bus CANBus, rolling mill DUO-300

The main component of semi-industrial, laboratory rolling mill successively developed since 2011 at the Faculty of Production Engineering and Materials Technology of the Czestochowa University of Technology, is the DUO-300 reversing mill [1] with nominal parameters:

- diameter of rollers 300 mm,
- rolling force 500 kN,
- rolling moment 20 kNm,
- rolling speed 0.45 m/s.

This rolling mill was equipped with a manually operated electromechanical rolling mill adjustment system with hydraulic balancing of the upper roll. This was a source of many inconveniences, mainly such as low precision and long-lasting, troublesome set-up procedure, which practically prevented the reverse rolling in many courses. There was also a lack of an interface enabling setting the system to be integrated into the structure of the overhead control system of the entire CANBus-based rolling mill.This has led to the modernization [2], which consisted in developing the positioning system with position transducers directly measuring the position of the adjusting screws and the force sensors and creating anautomatic control system based on programmable controllers. As a result - due to the increase of parameters of the roll setting system (i.e. reduction of the set time and its accuracy), it became possible to widen the scope of the experimental rolling of new materials [3, 4, 5].

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Structure of the setting system

The structural details of the rolling gap setting system are shown in fig. 1a, while its electromechanical and hydraulic diagram – in fig. 1b

a)

b)

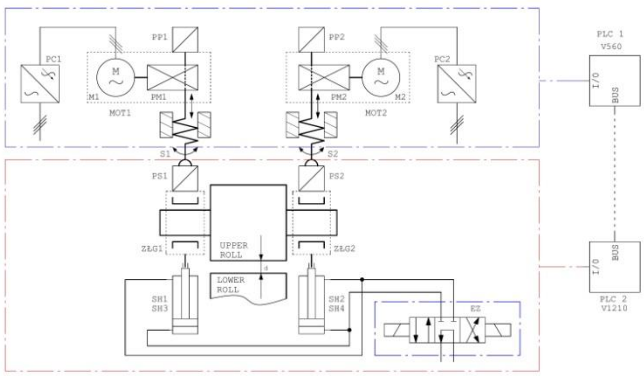

Fig. 1. View *(a)* and electromechanical diagram *(b)* of the mill roll mill set-up system DUO-300

The upper cylinder, mounted in ZLG1/ZLG2 bearings, is hydraulically balanced with SH1/SH3 and SH2/SH4 actuator pairs, controlled jointly by the EZ distributor. The upper points of the upper roll pressure are determined by position of the compression ends of the setting screws S1/S2. There are PS1/PS2 rolling force sensors between bolts and bearing housings. Adjustment screws are driven by MOT1/MOT2 gear motors, in which the spindles of PM1/PM2 gear units are slidably mounted on their spindles and the torque is transmitted through wedges. Screws during movement, rotate or twist from the threaded sleeves embedded in the plate bonding the top of the cage from the top. The insertion of the pressure screw studs defining the roll gap height *d* is measured with a 100 mm potentiometric position transmitter PP1/PP2. A detailed description of the construction solutions used is found in [2]. There are two PLCs responsible for the set-up. They are part of the master structure of the rolling mill control and measurement system and at the same time they perform a number of other tasks. The first of them, Vision V560, which is installed in the control cabinet of all the drives connected to the rolling mill and controls their operation, works with positioning screws and controls motors M1/M2 gearmotors through frequency converters PC1/PC2. This controller is also an interface for the hydraulic power supply contactor and EZ splitter, whose coils are powered by AC 230 V. The second one, Vision V1210 controller, located on the operator panel whose main task is to set and acquire and display the parameters of the rolling process, works with force sensors and develops control signals for hydraulic lifting and lowering of the upper cylinder. In order to achieve the automatic setting of the rolling gap height, the two controllers process a co-developed special two-track algorithm, which is implemented in ladder language. Data exchange between paths of the algorithm is done using the *CANbus* communication bus, which connects all controllers of the control system.

Control algorithm

Structure of the developed algorithm is shown in fig. 2.

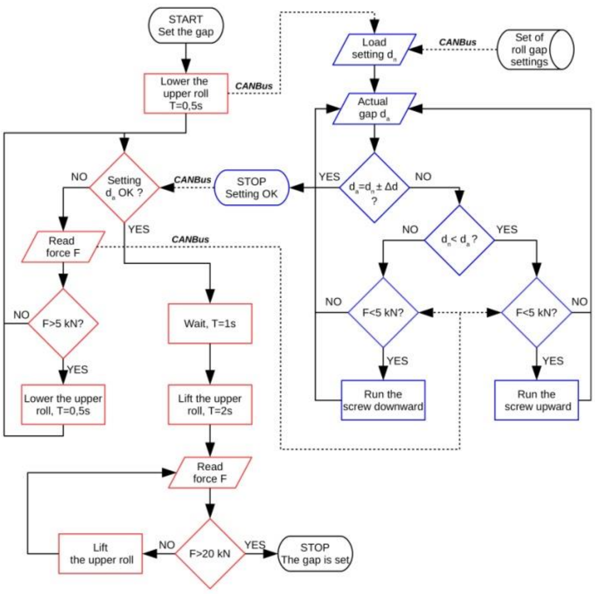

Fig. 2. Roller setting algorithm

The functional path of the hydraulic control system is marked in red, and in blue – the electro-mechanical setting of the pressure screws position, which implements the three-point controller. Algorithm set-up is performed in the "escape-chase" mode, which prevents mechanical locking of the propeller motors of the adjusting screws due to high axial forces [2]. In contrast to the manual control, the position of pressure screws is fixed first and then the upper cylinder is lifted and pressed against them. During the setting - in the event of a change in the height of the gap from larger to smaller - the upper roll moves horizontally, each time the force sensor rods come into contact with the ends of the downward pressure screws. The start of the setting is initiated by the operator by means of pressing the button on the control panel. This causes the adjusting screws to release to the force transducers via pulse (T = 0.5 s) leaving the upper cylinder assembly. At the same time, a new gap adjustment value d_n is loaded and sent to the pressure control system. This is then compared to the current value of d_a, as measured by the screw position sensors. If the difference of these two values is greater than the set dead band Δd, then depending on the sign of this difference, the adjusting screws are moved up or down towards the preset position. This movement is conditioned by the value of the force read from the force sensors. At the moment of exceeding the specified force limit F (5 kN), when the front of the bolt is approaching the force sensor, the geared motor stops and triggers another step operation of lowering the upper cylinder.

Setting run

Fig. 3 shows an example of the process of setting a rolling gap.

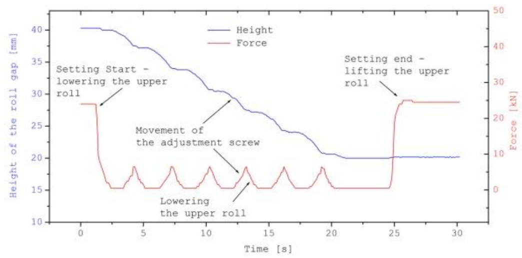

Fig. 3. Setting process

For better visualization, its height has been varied over a wide range - from 40 mm to 20 mm. As can be seen from the course of changes in the force and the height of the gap, the 3-second cycle of the pressure sequence and the upper cylinder is characteristic for the automatic setting.

During this time, the average setting speed is approximately 1 mm/s. This speed assures a collision-free operation of the entire system and a change of the roll gap for the typical settings used for stocks of 20 ÷ 40 mm during the reverse of the main drives of the mill.

Conclusions

The two-track algorithm for automatic control of the rolling gap setting system is an original solution that fits into existing engineering solutions in the field of mechanics as well as the accepted concept of operation of the master control system. At the same time, the use of CANBus to transfer data between paths of the algorithm simplified the structure and reduced the number of necessary wiring. From a functional point of view, besides simplifying the operation of the mill, the automatic control - according to the presented algorithm - has enabled, in particular, to reduce the time and increase the precision of the roll setting, which is impossible to obtain in the original, manually controlled system.

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