D. YERGALIYEV, A. TULEGULOV, A. ZHUMABAYEVA, A. BUKAYEVA,
M. SUIMENOVA, G. YESBOLAY, A. YUSSUPOV, A. ZHAUYT

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STUDY OF STRESS-STRAIN STATE OF THE ROLLER CONVEYOR

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Numerous studies have established that the damage to the lower surface of hot-rolled strips is mainly due to their friction against rollers of mill rollers. In this case, the probability of scoring, scrapes and other mechanical damage increases otherwise severe wear on the surface of the rollers, improper installation and jamming. This also applies fully to the pulling and forming rollers of the coilers. A prerequisite for preventing damage to the surface of hot-rolled strips is also the maintenance of a high level technical condition of the mill equipment, which includes inspections of wiring armature bars, roller conveyor rollers and other units for each transshipment, timely replacement and repair of individual parts and assemblies.

Keywords: hot-roller strips, stress-strain state, mill rollers, conveyor, pressure

INTRODUCTION

Currently the production of high-quality hot-rolled and cold-rolled sheets is one of the most important issues in the development of rolling production. Obtaining competitive hot-rolled and cold-rolled strips is possible if temperature-deformation modes of rolling are observed, energy-saving technological processes are used and equipment costs and repair costs are reduced [1]. In our opinion, a contribution solution of this problem can be made by improving the design of roller tables of the rolling mill and in particular, the diverting roller table. Our analysis of scientific and technical information shows that good results can be achieved with the use of discharge roller tables with a unique design [2]. In particular, the use of a discharge roller table, where high-pressure air is simultaneously used to cool the hot-rolled strips and reduce the load on its rollers, will improve the quality of the rolled strips [3]. Currently, continuous casting machines (CCMs) and continuous hot strip mills are mainly used to produce hot rolled thin strips of steels and alloys.

Their productivity is 3,5 - 6,0 million tons per year [4]. Slabs weighing up to 20 - 45 ton, thickness up to 300 mm and width equal to the width of the finished sheet are the starting material for rolling thin strips in continuous wide strip hot rolling mills. It should be noted that continuous wide-strip hot rolling mills consist of roughing and finishing groups of stands. Usually, the roughing train consists of free-standing stands and the finishing train consists of 6 - 7 four roll stands, which are combined into a continuous group. In the roughing group of stands, the distance between individual stands is greater than length of the roll. It is known that at continuous wide strip hot rolling mills coilers for coiling strips are installed behind the finishing train of stands. At the same time, intermediate roller tables are placed between roughing and finishing groups of stands, and after the finishing group, diverting roller tables are installed. Roller beds have a frame where rollers are placed in rows. Ox is used for transporting metal to a rolling mill, feeding it into rolls, receiving from rolls and moving between mill stands, as well as to auxiliary or finishing equipment. The main parameters of roller tables are the pitch, diameter and length of the roller barrel [5]. The roller conveyors have a group, individual or semi-individual drive (each roller or each two rollers has a separate motor), as well as rollers without drives (a gravity roller conveyor located with a slight inclination). Depending on the type of work performed and the material of transportation, rollers of the roller table can be cylindrical, stepped, ribbed, conical (for turning sheets) and two-conical (for pipes and rods). The rollers of the roller table can be one-piece and composite by design. It should be noted that the diverting roller tables are used for transportation, cooling with rational temperature conditions and coiling of strips. For cooling with rational temperature conditions, the continuous wide strip hot rolling mills roller tables are equipped with a water cooling device. The water pressure is 1 – 1,2 MPa.

MATERIALS AND METHODS

When rolling thin strips of metals and alloys in a given mill, through stands sequentially located in the rolling direction, in which the distance between the work rolls

A. Zhauyt, (a.zhauyt@aues.kz), Almaty University of Power Engineering and Telecommunictions, Almaty, Kazakhstan
D. Yergaliyev, A. Tulegulov, Academy of Civil Aviation, Almaty, Kazakhstan
A. Zhumabayeva, L. N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan
A. Bukayeva, M. Suimenova, G. Yesbolay, A. Yussupova, Yessenov University, Aktau, Kazakhstan

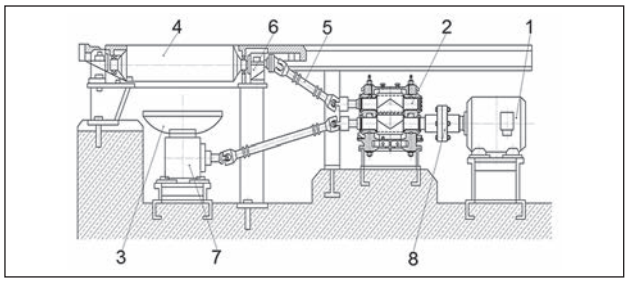


Figure 1 New design discharge roller conveyor:
1 – electric motor; 2 – gearbox; 3 – high pressure fan;
4 – hollow roller; 5 – spindle; 6 – bearing support,
7 – reducer; 8 – muff

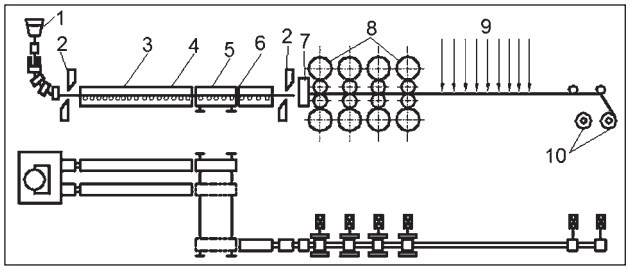


Figure 2 Two-strand installation: 1 – crystallizer;
2 – scissors; 3-4 – heating oven;
5 – transport and distribution vehicle; 6 - oven;
7 – master device; 8 – continuous mill with quarto stands; 9 – choking device; 10 – winders

from one stand to another increases by the amount of advance in this stand, the height decreases and required strip thickness is achieved. In order to improve the quality of sheet metal and reduce wear on the rollers of discharge roller table, we have developed a discharge roller table of a fundamentally new design. This discharge roller conveyor of a broadband rolling mill contains continuous rows of hollow roller sections and individual drives [6]. In this case, each roller of the discharge roller table is equipped with a gearbox, an individual fan, while the fan casing is made in the form of blades with an angle of attack of 35 - 40° and the blades - with a variable cross section and an angle of attack of 10 - 12°. In the calculation, the geometrical and finite element model of the calculated section, the fixing conditions, the application of forces to the transported sheet and the calculation of the stressed-deformed state rollers and the strength rollers of the guide roller are constructed. The calculation method is implemented using the Autodesk Inventor finite element analysis program. The system of computer modeling Autodesk Inventor allows you to explore the kinematics, the dynamics of mechanisms with the ability to calculate the stress-strain, both individual elements and the design as a whole. The assembling three dimensional geometric model of a retractable roller table was built in the CAD program of Inventor [7].

Transportation of hot-rolled strips is carried out as follows. Direct current (DC) or alternating current (AC) is supplied from the transformer to electric motors 1. Electric motors rotate the shafts of gearbox 2, and the shafts of the gearbox rotate the hollow rollers 5, as well

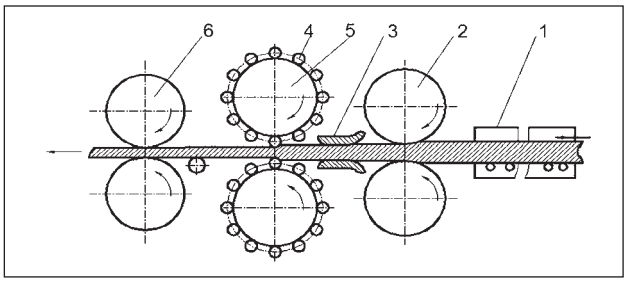


Figure 3 Scheme of installation with a planetary mill:
1 – pass-through oven; 2 – feed rolls; 3 – wiring;
4 – planetary working rolls; 5 – backup rolls (drums);
6 – ironing rolls

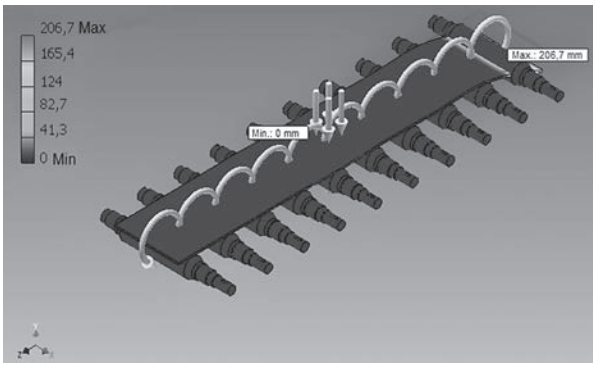
as the fan blades 3. The fan blades, while rotating, suck in air and direct the air with high pressure to the conveyed strip. All this leads to the rise of sheet metal in the vertical direction and a decrease in friction between the strip and the rollers, as well as the movement of the strip from the last stand of the mill to the coiler. In the discharge roller table, hot-rolled strips are cooled from rolling heating by removing heat by a cooling medium (air-water mixture) supplied to the surface of the hot strip.

Two rows of planetary rolls with a more perfect planetary mill are proposed in the work. In such a mill, the intermediate rolls rotate against the rolling direction, while the work rolls rotate in the rolling direction. This rotation of the rolls facilitates work of the feed rolls and stabilizes the process.

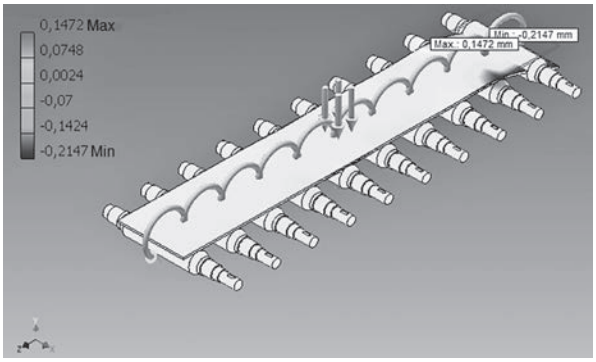
The assembling three-dimensional geometric model of a retractable roller table was built in the CAD program of Inventor. For the possibility of automatic correction geometry of the escaping roller table the method of parameterization of the geometric dimensions of the structure was used. This method allows, based on the strength calculation results, to make appropriate changes to the design of the take-off roller table. Thus, in the course of the preliminary analysis work of the outrigger roller table, the most loaded power element of the outgoing roller table was taken into account, like a roller. From the lower part of the outgoing roller conveyor to the transported strip, air with high pressure directed from the fan acts [8]. This allows you to reduce the amount of vertical forces that occur on the rollers when the strip moves along the outgoing roller table. As a material for the commercials, the Autodesk Inventor steel of the grade-35c was selected from the Autodesk Inventor steel database of mechanical properties: the Young's modulus of 200 GPa, the strength of 420 MPa, and the Poison coefficient of 0,3.

RESULTS AND DISCUSSION

The results of the study distribution of stress-strain state during the transportation of a strip 12 mm thick on a discharge roller table with lower air pressure and without air pressure are presented in Figures 4 - 7 respectively.

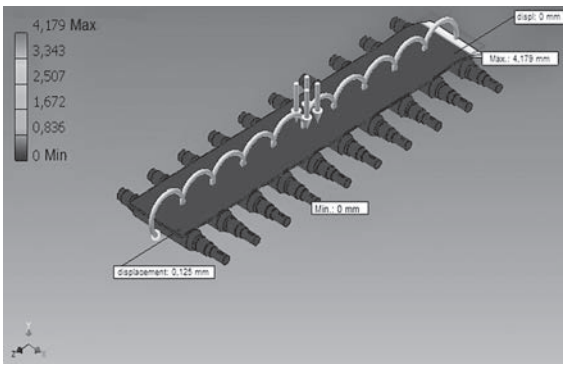


a)

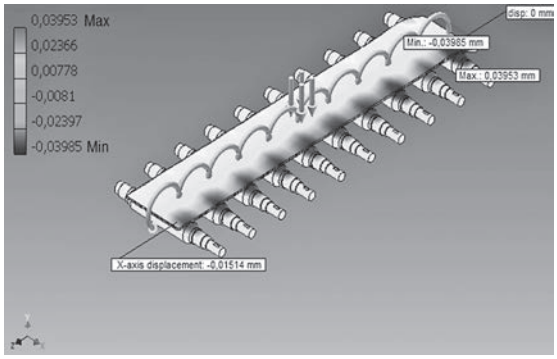


b)

Figure 4 The pattern of the distribution of the total displacement (a) and the displacement along the X (b) axis in the rollers during the transportation of the strips in the roller table without lower air pressure



a)



b)

Figure 6 The pattern of the distribution of the total displacement (a) and the displacement along the X (b) axis in the rollers during the transportation of the strips in the roller conveyor with the lower air pressure

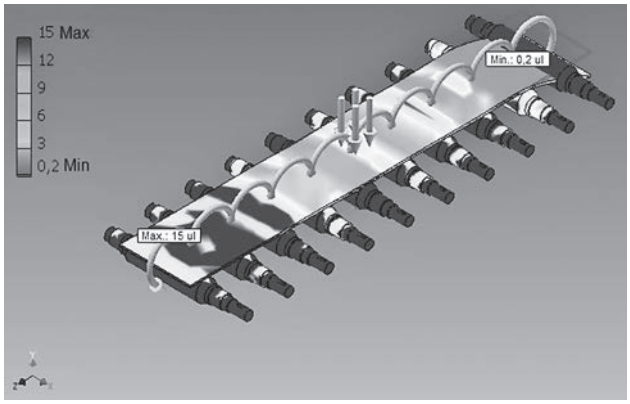


Figure 5 The distribution pattern of the safety factor in rollers during the transportation of strips in a roller table without lower air pressure

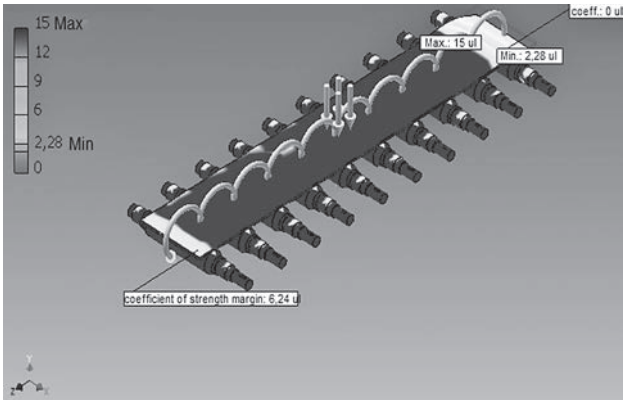


Figure 7 The distribution pattern of the safety factor in rollers during the transportation of strips in a roller conveyor with lower air pressure

Calculations carried out on finite-element models showed that:

- The maximum equivalent voltage in the roll barrel is 27,5 Pa, and for the neck of the rollers 24,4 Pa of the proposed roller conveyor. And the maximum equivalent voltage occurs in the roll barrel. The resulting maximum values of equivalent stresses (27,5 Pa) do not exceed the maximum allowable value for the material of rollers 420 MPa;
- Under the influence of applied vertical forces, the rollers elastically bend in the direction of the force, and the neck of the rollers elastically deforms in the same direction, the maximum value of the equivalent deformation being for the roll of rollers 8,217E-011, and for the neck of the rollers -7,061E-011 of the proposed outgoing roller conveyor;
- The largest values of total displacements are concentrated in the non-drive side of the rollers of the outgoing roller conveyor. The maximum value of the movement is 1,49159E-006 mm;
- As a whole, the value elastic deformation of the elements of the rollers is small, which indicates a decrease in the effort of the proposed outgoing roller table produced on the rollers [1]. This guarantees the possibility of reducing wear and breakage, as well as the failure rollers of the proposed roller conveyor.

CONCLUSIONS

1 The distribution safety factor pressing mechanisms of the first three stands of the new mill satisfies the strength condition (the calculated margin of safety does not exceed the accepted safety factor of safety);

2 The projected cushions, gear wheels of the first three stands of the multifunctional mill have sufficient safety factor;

3 The results of calculations using the analytical method and using the program COMPAS 3D, Autodesk Inventor are quite consistent. The discrepancy between the values of the determined values does not exceed 5 - 7 %.

4 A new design of a continuous roller conveyor for continuous mills was proposed and constructed;

5 It is shown that the maximum values of effective stress and strain do not exceed the maximum permissible value for the material of rollers;

6 It is proved that the maximum stress and strain concentrations are observed in the barrels and neck of the rollers and the maximum value of displacement are observed in the non-drive side of the rollers of the outgoing roller conveyor;

7 It is proved that when the belts are transported on a new retractable roller table due to a significant reduction in the metal pressure on the rollers, the value of its elastic deformation decreases. This guarantees the possibility of reducing wear and breakage, as well as the failure rollers of the proposed roller conveyor.

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Note: The responsible for England language is Aigerim Nauryzbayeva, Almaty, Kazakhstan