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MODELLING OF STANDS RIGIDITY OF THE LONGITUDINAL-WEDGE MILL TO RISE ACCURACY OF THE STRIPS

Abstract. In the article, the mill of new construction is suggested. MSC. VisualNastran 4D software was used to calculate the stress-strain state of heavy duty details of the proposed mill. It is shown that the value of elastic deformation of the rolls elements and supporting frame is insignificant, which proves that rolls nodes of the working stands have high rigidity. It grants receiving required transverse and longitudinal gage interference and flatness of the rolled strips within the permissible tolerances. The conducted research also proves that reasonably high rigidity of the roll assembly of the working stand and equivalent stresses, aroused in the heavy-duty elements, are not exceed the maximum of the acceptable value of the stress limit for this material. At the same time, the rigidity of the stands construction of the multifunctional longitudinal-wedge mill satisfies the requirements of the standards.

Keywords: mill, modelling, rolling, strip, rigidity.

Introduction. Last decades tolerance characteristics of the strips cross-section are decreased in world production, it is connected with the general tendency of increasing requirements for sheet metal quality [1]. It is relevant as for the majority thin strips with the width of 0.8–1.5 mm, which is exploited in mechanical and civil engineering, and for the strips with the width of 1.8–3.0 mm, directed as the semi-finished products on the mill of cold rolling for producing automobile sheets.

It should be noticed, that development of the world economy, implementation of the newest innovation projects into the production require the usage of the materials with the complex of physical and technological properties, as a high strength, electro- and heat conductivity [2, 3]. Such properties belong to the strips made of brass, bronze, copper-nickel, aluminium alloys and precious metals with improved geometrical parameters. The cold-rolled strips and tapes of these alloys can be used for the production of electrical and instrument-making industry, as well as the goods of mass demand (heat exchangers, pipes, radiators, etc.). Therefore, jewellery, electrical and other industries in many countries needs to produce copper strips less than 1 mm thick, aluminium sheet with a thickness of 2–0.5 mm, strips of precious metals of less than 2 mm thick. In this regard, the development of theoretical foundations of production strips and tapes of these alloys with high quality geometric shape is a priority.

The geometric shape (flatness, longitudinal, transverse unevenness) of rolled strips is one of the most important indicators of the quality of sheet metal [4]. The formation of longitudinal unevenness at a fixed position of the adjusting screws associated with the change of rolling conditions along the length of the strip, thereby changing the pressure of the metal on the rolls, and hence the elastic deformation of the stand and rolls elements, which ultimately leads to a change the gap between the rolls and the strip thickness. In its turn, the formation of cross-sections unevenness's associated with the uneven conditions along the width of the deformation zone, the reason of which is an elastic deflection of the rolls, thermal bulge of the rolls, flattening and wear of the rolls drums, which are non-uniform along the strip width.

Currently producing bands and strands made of iron, non-ferrous and precious metals with high-quality geometric shape needs to be improved both by rolling equipment, and computer models, that adequately describe the process of getting the flatbedbands and strands.

In small enterprises, where ferrous metals including noble and precious metals are rolled, in most cases specialized low capacity sheet rolling mills are exploited [2, 3]. The conditions of sheet rolling are characterized by the presence of various constructive schemes of working stands, featured by the maximum design simplicity and which are effective in a large range of products. The most often duo or quarto stands are used, when rolling non-ferrous materials.

In [5, 6] it was found that during sheet rolling usually simultaneous change of the cross profile and flatness of band takes place. These parameters are interrelated. For example, as a result of the elastic bending of roller system, wear or heat convex of roll barrels the profile of the gap between the work rolls is changed, which creates a different compression of sheet metal sections across its width. Areas, drafted stronger tend to stretch out to a greater extent than less drafted parts, and draw them away, exerting in them the longitudinal tensile stresses. As a result of delaying effect of the less drafted areas in more drafted zones the longitudinal compressive stresses appear. Thus, areas of the sheet metal that receive less drawing down will be elastically stretched, whereas areas with more drawing down will be elastically compressed in the longitudinal direction. Described inequality of the longitudinal stresses will remain in the sheet metal in the form of longitudinal residual stresses, which are unevenly distributed over the strip width.

In the last 15–20 years, some aspects of modeling of elastic flattening and thermal regime of bands and rolls of hot rolling mills have been published [7]. However, comprehensive study, that allows to calculate the output geometric parameters of the rolled sheets depending on the technological parameters of the rolling process and control actions, are still missing. This is due to the complexity of the problem and the need to carry out industrial research on a large, high-performance metallurgical equipment, where there are very limited opportunities for scientific experiments.

Thus, improvement of power parameters, as well as the thermal regime of the rolling strip and cooling system of the roll of hot rolling mills is an urgent task not only for hot rolling plants, but also in general for rolling production [7-11]. An effective solution to this problem is possible on the basis of the improvement of the rolling equipment and the rolls systems, and development of automatic systems to control thickness, profile and flatness of the rolled strips, creating new ways of rolling and roll systems for their implementation.

In our opinion, the best method of control of the transverse gage interference and flatness is the creation of the mill with rational design, optimization of draft modes and reductions of hot rolling force. To this end, we have developed a new rolling mill construction [12], that allows to assign rational technological parameters of rolling.

The aim of the research: by using computer simulation to calculate the strength and elastic deformation of the heavy-duty multifunction mill elements and to determine the possibility of obtaining thin sheets of high quality.

Equipment, tools, materials and the method of the experiment. New multifunctional five-stands longitudinal-wedge mill (LWM) for rolling thin strips with accurate geometrical dimensions with simple construction was developed (figure 1).

Multifunctional LWM for rolling sheets of steel and alloy contains: motors, gearboxes, gear cage, universal spindles, couplings, stands with working and back-up rolls. At this, there are two and four back up rolls in the first three stands and in the last two stands respectively. Rotation of the working rolls, which are decreased in the rolling direction, is carried out through the bearing cages by the five gear-motors with angular velocity $\omega = \upsilon \cdot R$ (where υ - the rolling speed in each mill stand; R – the radius of the work rolls in each mill stand). The distance between the stands is increased by the amount of forward flow, and distance adjustment between the work rolls is made by the uniform worm push mechanisms located above and below of the mill frame assembly and bearing cages.

It should be noted that working rolls in each stand have a constant diameter, and the diameter of rolls in the sequentially arranged stands is reduced in the rolling direction. In output the thin strip is cut or reeled.

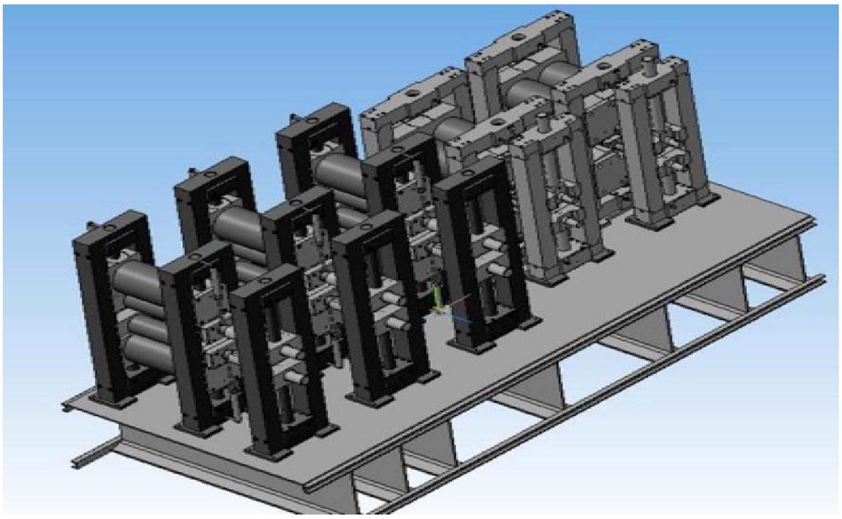


Figure 1 – Multifunctional longitudinal-wedge mill

In the work, a dynamic computer model for calculating deflection, vibration and stress-strain state (SSS) of working and back-up rolls in the elastic formulation was developed. The main technological nodes and parts, that make up the stands construction and perceiving rolling force, are non-driven back-up rolls, drive working rolls, frame, pillows of stands, etc.

Components of the stress tensor, von Mises equivalent stresses, as well as elastic deformation and vibration of rolls were calculated by using simulation modeling of stands elements and theoretical calculation based on the finite element method of the dimensional SSS [13].Strips rolling force of the multifunction LWM was calculated by using the methodology for calculating energy-power parameters of rolling. The methodology itself was developed by us [14].

Finite element analysis PATRAN NASTRAN software was used to implement the methodology for SSS and elastic deformation of stands parts calculation [15, 16]. PATRAN NASTRAN is computer modeling system, that allows to explore kinematics, dynamics of mechanisms with the possibility of calculating the stress-strain and thermal states as individual units, and mill as a whole.

During design of working stands in PATRAN NASTRAN, to calculate SSS of the stands parts the following operations were made [15, 16]:

- creation of a 3D geometric model of every detail in the COMPASS software according to the working drawings and assembling of the nodes of the working stands;
- import of the model in PATRAN NASTRAN pre-processor with the adopted kinematic connections;
- selection of the materials for the details, their mechanical and physical properties (modulus of elasticity, mass density, Poisson's ratio, tensile strength, etc.);
- formation of the kinetically and statically boundary conditions;
- modeling of the calculated mechanical circuit that includes load distribution across the width of the rolling sheet;
- implementation of the delivery of the torsion torque to the rolls;
-input of the finite element mesh of new mill stands parts by using Mesh Seed option;
- definition of SSS of mill stands parts;
- modeling of the elastic connection between nodes of the stand that was simulated by CBUSH spring - damper element;
- assessment of thelevel of obtained elastic deformations and stresses in the volume of each part of the stands on the required stiffness and strength criteria and introduction of relevant amendments to the mill construction (solid model of the mill).

The method of the parameterization of the geometrical sizes of the construction was used in order to automatically correct the model of the mill. This method allows to make appropriate changes in the design of a new multi-function mill stands based on the calculations of strength.

Six and eight nodes of dimensional finite elements were exploited to simulate construction of the new mill. In addition, twelve types of the stiffness were considered to define the main characteristics of the stiffness of the mill stands.

It has to be noted that the steadier of the roll node of the stands was modelled in more detail. The computational model of each spherical roller bearing includes three types of components: an outer, an inner ring and two rows of rollers by18 in each.

During developing of the design scheme the condensed finite element mesh was used in the places of the supposed stress concentration.

Stress state of heavy duty components of the stands (back-up rolls and working rolls, frame, bearings, pads, bushings) was calculated by applying the rolling force and the effects of thermal stresses.

The kinematic connection between the heavily loaded elements was simulated by the rotating and sliding kinematic pairs for the common surfaces of interface. At the same time, the collision and friction in the rolls, pads, bearings, etc. weretaken into account.

In PATRAN NASTRAN heavy duty elements are supposed to be absolutely rigid and ensure the properties of thermal conductivity and heat transfer, i.e., thermal conductivity, specific heat and density are taken into consideration. For the material of stands parts the density and thermal properties were designated by default.

In the process of modeling the contact conditions are constantly updated to reflect the rotation of the rolls, and the deformation of the material, which allows to simulate the sliding between the back-up and working rolls, as well as between the work piece material. Contact between the working rolls and a thin sheet is modeled by Coulomb friction with the coefficien to f 0.5. In this case, the friction force between the rolls taken equal to 0.0868.

Temperature conditions during rolling in the multifunctional LWM consists of heat exchange between the rolls, the thin work piece and the environment, as well as a thermal effect due to metal deformation. The rolling process took place at a temperature of 300 °C. However, the initial temperature of the rolls taken was equal to 20 °C.

It should be noted that the rolls were assembled on the supporting necks of the bearing box by three degrees of freedom T_x, T_y, T_z. The material of the rolls has been accepted 9X1 steel with the following mechanical properties: modulus of elasticity – 2.1+11 *Pa*; Poisson's ratio - 0.283; shear modulus - 8.1839+10 Pa. The material of the frame stands is 40HS steel with the modulus elasticity $214\cdot10^3$ MPa and a tensile strength $\sigma_в$= 981 MPa. Punches factor of 40HS steel equals to 0.3. The material of the other parts of the mill is 45 steel with the following mechanical properties: modulus of elasticity – 2,034E+11 Pa; Poisson's ratio – 0.29; density – 7833.394 kg/m^3.

The strength and stiffness of working and backup rolls of the multifunctional mill were studied during hot rolling of the strips made of D16 alloy with the size of 0.7·400 mm. As the initial preform the-semi-finished rolled stock with the thickness h_0 = 3.5 mm was used.

For rolling the strip in the first, second, third, fourth and fifth stands the rational modes for rolling was used.

Results and discussion. The calculations of the new mill stands, made by using the finite element models, have shown that:

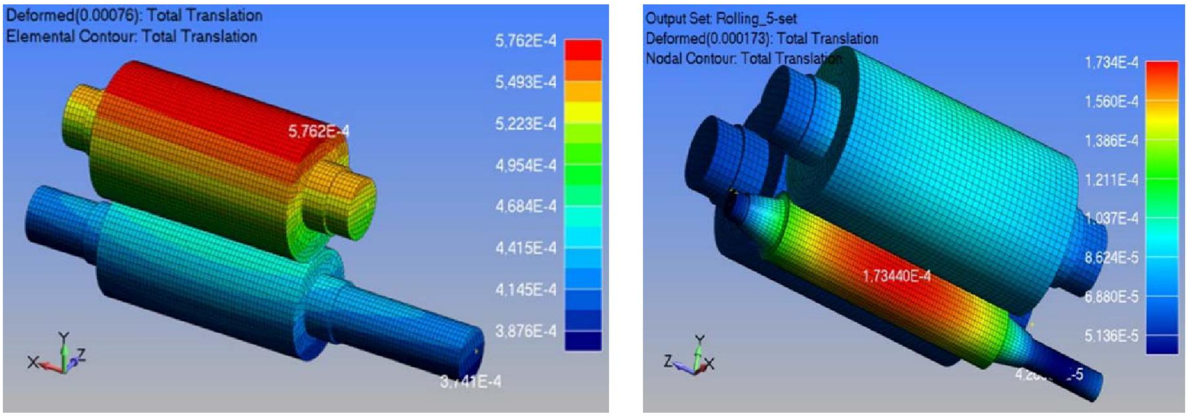
- maximum equivalent von Mises stresses of the first, second, third, fourth and fifth offered mill stands are equal to, respectively: in the bodies of the backup rolls - 12.9 MPa; 21.3 MPa; 6.95 MPa 20.59 MPa; 39.5 MPa, and in the neckoftheback-up rolls - 27.49 MPa; 62.83 MPa; 20.52 MPa; 0.2197 MPa; 0.3990 MPa;
- maximum equivalent von Mises stresses of the first, second, third, fourth and fifth offered mill stands are equal to, respectively: in the bodies of the of the working rolls – 22.14 MPa; 21.32 MPa; 13.02 MPa; 67.35 MPa; 52.89 MPa, in the neck of the working rolls – 36.90 MPa; 106.6 MPa; 39.05 MPa; 112.3 MPa; 88.16 MPa;
- under the influence of applied vertical forces (Y - direction) the rolls bend along the direction of forces action, i.e. maximum forces, arising in the Y-axis direction, lead to a maximum deflection in the same rolling direction;

- during rolling in the first, second, third, fourth and fifth stands of the multifunction LWM toward the Y-axis the following maximum values of displacement arise, accordingly: in the middle of the backup rolls body - 0.000106 mm; 0.0002792 mm; 0.00006738 mm; 0.00003579 mm; 0.00006721 mm, and in the neck of theback-up rolls - 0.00005351 mm; 0.0001275 mm; 0.00002573 mm; 0.00003161 mm; 0.00004161 mm;
- maximum values of the displacement in Y-direction of the first, second, third, fourth and fifth mill stands, respectively: in the body of the working rolls - 0.00009316 mm; 0.0002064 mm; 0.00005269 mm; 0.0002035 mm; 0.0001711 mm, and in the neck of the working rolls - 0.00006158 mm; 0.0001327 mm; 0.0000246 mm; 0.00009611 mm; 0.0001125 mm;
- little effort, arising in the direction of rolling axis, i.e., X-axis, give rise to small elastic movements of the rolls material in the same direction;
- during rolling in the first, second, third stands of the proposed mill, following maximum displacement values arise in the X-axis direction from the opposite drive of the stands: at the edges of the backup rolls body - 0.00002788 mm; 0.00006604 mm; 0.00001945 mm, respectively, while the same displacement values arise in the neck of the respective backup rolls;
- during rolling in the first, second, third stands in the direction of X-axis the maximum value of the displacement occur in the body and neck of the working rolls at the opposite side of the drive of the mill stands with the value of: 0.00002555 mm; 0.00006126 mm; 0.00002087 mm;
- during rolling in the fourth and fifth stands of anew mill in the direction of X-axis the maximum displacement occurs in the middle of the body of the backup and working rolls with a value equal to, respectively: 0.0001251 mm; 0.00005497 mm, and for the neck of these rolls - 0.00008638 mm; 0.00004047 mm;
- in the body of the backup rolls of the last two stands of the LWM in the X-axis direction following maximum values of the displacement arise, respectively: 0.00006695 mm; 0.00009568 mm and in the neck of the backup rolls - 0.00005204 mm; 0.00006797 mm;
- small forces, occurring in the perpendicular direction to the rolling axis, i.e. Z-axis, lead to the appearance of elastic displacements of the rolls material in the same direction;
- during rolling in the fourth and fifth stands of the proposed mill in Z-axis direction the maximum values of the displacement were equal to 0.000003809 mm; 0.000008941 mm respectively, occured from the side of opposite drive of the stands, at the edges of the backup rolls, while the same displacements arise in the necks of the respective backup rolls;
- during rolling in the fourth and fifth stands of the new mill in Z-axis direction the maximum value of the displacements in the working rolls also occurs at the opposite side of the drive of the mill stand. Their values for the body and neck of the working rolls for the fourth and fifth stands are equal to, respectively: 0.00003221 mm; 0.000026555 mm;
- during rolling in the first, second and third stands of the new mill in the Z-axis direction the maximum values of the displacement arise in the body of the backup rolls with the values of displacement for the body of the backup rolls are: 0.0004572 mm; 0.00127 mm; 0.0003196 mm, and for the neck of the working rolls – 0.0005040 mm; 0.001413 mm; 0.0003587 mm, respectively;
- in the first three stands along Z-axis direction following maximum values of the displacement occur: in the body of the working rolls – 0.0004106 mm; 0.001160 mm; 0.000363 mm, and in the neck of the working rolls – 0.0003736 mm; 0.001064 mm; 0.0002715 mm, respectively.

It has to be noted that obtained calculations of the equivalent von Mises stresses not exceed the maximum values of the permitted limits of the strength of the roll material and the upper boundary of the contact fatigue stresses. It means that slight deviation from the process does not lead to the destruction and the appearance of defects on the surface of the rolls: cracks, pitting, spalling.

In general, the total value of the elastic deformation of the roll elements is small (figure 2), indicating a relatively high rigidity of the rolls unit of working stand. This guarantees a transverse polythickness and flatness of rolled strips within the required tolerance.

So, the greatest displacements for all working rolls of mill stands are along the rolling force application, in other words in the direction of rolling force action (along Y-axis). Displacements along the X and Z axes are virtually equal. For the backup rolls substantial is deformations along the Y and X axes, while for the working rolls and bearings is along Y and Z axes.



a b

Figure 2 – The picture of the total field of elastic deformation movements in the backup and working rolls of the first (a) and the fifth (b) stands of the multifunctional mill

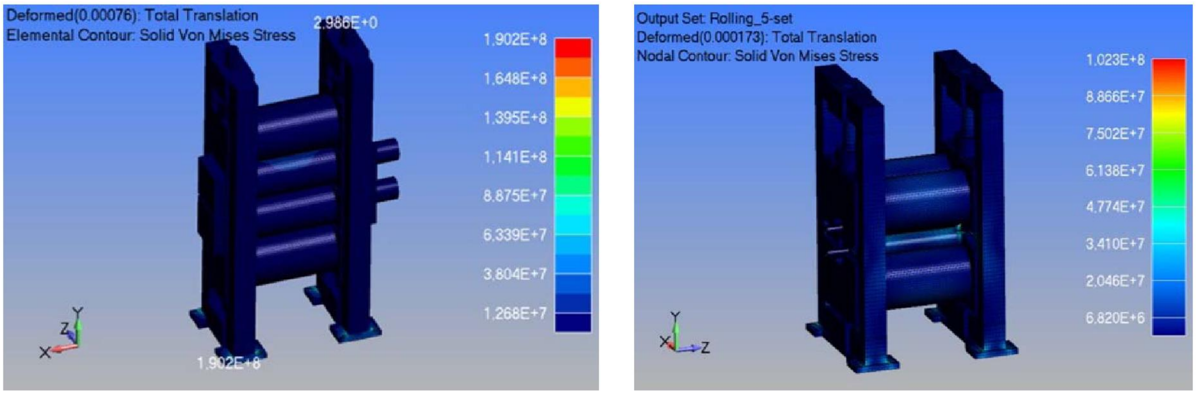
During rolling in the stands of new mill due to adecrease of the biting arc length during transmission from the first to the last stands, the length of the deformation area decreases. Such decrease of the deformation area length gives anadvantage for the proposed rolling process over the traditional rolling process. The advantage of the rolling on the new mill is significant (from 2 to 10 times) reduction of the metal pressure on the working rolls. From one side it allows significantly decrease elastic bend especially of the last stands rolls of the mill, and consequently to cut transverse gage interference and to improve the flatness of the rolled strips, on the other side to reduce the metal intensity of the rolling equipment during design and actuation of the rolling mills of new construction.

With an increase of the rolling speed on the mill of new design relatively small increase of dynamic loads in the main nodes of the stands and of the drive line occur. Mechanical vibrations of the stands nodes and line drive units can become a cause of small vibration magnitude. Studies have shown that in comparison with the last two stands relatively large vibration in magnitude appears in the first three stands of new mill. This is connected with the fact that two backup rolls are used in the first three stands, and four backup rolls are used in the last two stands.

Figure 3 and 4 show the calculation results as a distribution pattern of the equivalent stresses, elastic displacements, the stress tensor components in the power components of the multifunctional LWM stands.

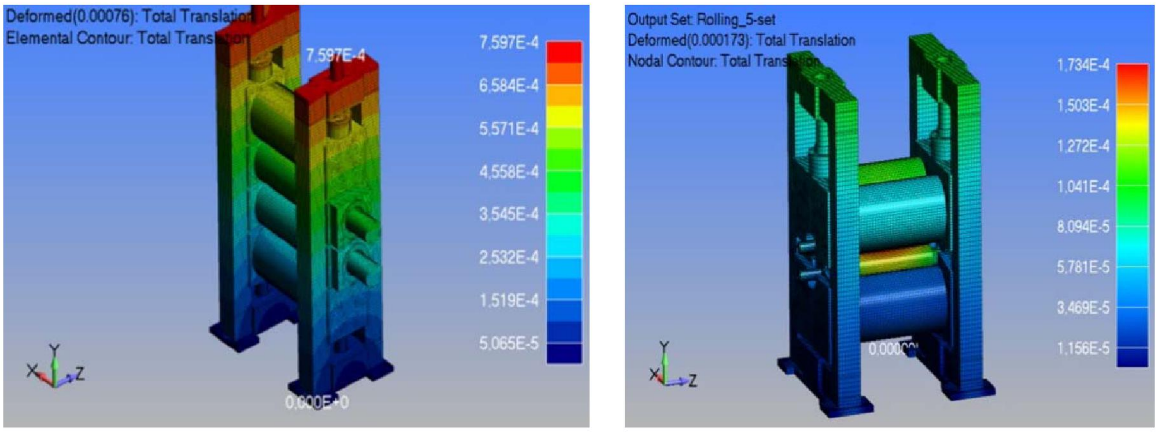
Carried on the finite element model calculations showed that:

- received maximum values of equivalent stress (the first stand - 63.39 MPa; the second stand - 114.4 MPa; the third stand - 52.74 MPa; fourth stand - 59.86 MPa; fifth stand - 47.74 MPa, Figure 3) are not exceeded the maximum permissible value of the tensile strength of 98.1 MPa for the material. In this case, the maximum values of the stresses are observed at the bottom of the frame crossmember;



a b

Figure 3 – Pictures of Mises equivalent stresses field distribution in the first (a) and the fifth (b) stands of multifunctional mill



a *b*

Figure 4 – Pictures of the total elastic deformations displacement field distribution
in the first (a) and the fifth (b) stands of the multifunctional mill

- during rolling in the first, second, third, fourth and fifth stands of the multifunctional LWM in the housing post in the vertical direction (Y-axis) the maximum by the value displacements occur. Their values for the first, second, third, fourth and fifth mill stands are equal, respectively: 0.0000925 mm; 0.0002661 mm; 0.00007282 mm; 0.00003479 mm; 0.00004188 mm;

- small forces, occurring along the axis of rolling direction, i.e. X-axis, give a rise to small elastic displacements of the frames material in the same direction. Wherein during rolling in the first, second, third stands of the proposed mill the maximum displacements by the value occur in entablature of the frame from the side of opposite drive of the stands. The values are equal to: 0.00005183 mm; 0.00001602 mm; 0.00005027 mm, respectively.

- during rolling in the fourth and fifth stands of new mill the elastic displacements in X-axis direction is uniformly distributed in the frame, as well as in the upper and lower cross pieces of the frame, wherein the maximum value of the displacement equals to: 0.00005015 mm (the fourth stand); 0.00008168 mm (the fifth stand);

- small forces, occurring in a perpendicular direction to the rolling axis, i.e. Z-axis, lead to the appearance of the elastic displacements of the frame material in the same direction. Wherein during rolling in the fourth and fifth stands of the proposed mill in the upper crosspiece of the frame from the opposite drive of the stands the maximum values of the displacements arise, that are equal to 0.00002995 mm; 0.00005795 mm, respectively.

- during rolling in the first, second and third stands of thenew mill the largest maximum displacement in Z-axis direction occurs in the lower crosspiece of the frame. In this case, the maximum values of displacement for the lower cross member of the frame are equal to 0.000005111 mm; 0.000001516 mm; 0.000004097 mm;

- total displacement distribution pattern in three directions corresponds with the deformed shape of the construction shown in figure 4. The maximum displacement observed in the upper cross frame of the mill stands (0.0007597 mm - first stand; 0.002182 mm - second stand; 0.0005997 mm - the third stand; 0.0001074 mm - fourth stand; 0.0001041 mm - fifth stand);

- as a whole, distribution of safety margin for the housing post satisfies the condition of strength at the safety factor adopted as 10. The weakest point of the frame is the upper cross member.

It should be noted that the use of only two backup rolls has a certain influence on the elastic deformation of the bearing. However, the use of four backup rolls in the last two stands of the mill reduces both the magnitude (changing from 0.0008 to 0.0009 mm) and the area of the elastic deformation of roller bearings. An outer bearing rings have the maximum deformation, at this with the decreasing diameter of the rolls and increasing the number of backup rolls the area with the most elastic deformation of the bearing is shifted into the inner side of the roll neck. This is due to the change of load application schemes in the roll node of the multifunctional LWM.

Roll carriage, inside which the necks of the roll are placed, can elastically deform in the vertical and horizontal planes, as well as rotate relative rolling axis. The elastic displacement in the direction of load action for the roll carriage, located from the side of roll drive, is 1.2 times greater than for roll carriage, arranged at an opposite side to the roll.

Thus, the strength of heavy duty components of the stands complies with the technical requirements applicable to the mills. With this, new multifunctional LWM has enough high rigidity of the stands construction. Based on the research results it can be noted that rolling strips on the proposed mill will not lead to the production of finished steel with longitudinal and transverse gage.

According to the conducted research in the work, the measures for the multifunctional LWM stands modernization were developed. It is shown that it is required to install hydraulic pressure device for controlling the roll gap of the work rolls in the fourth and fifth stands of the proposed mill. To ensure uniform distribution of the load and increase the life of the bearing it is offered to strengthen the rolls by the freely floating rolls carriage. It is suggested to replace the double row spherical roller bearings on a tapered roller bearing by larger capacity in the fourth and fifth stands of the mill. The proposed design solutions will reduce the strain level of the stands.

Conclusion.

1. Based on the simulation results it is proved that the stresses, arising in the details of the construction of multifunctional LWMstands during the rolling process, does not exceed the maximum allowable stress.

2. By the calculation it is established that the reduction of the diameter of the rolls in the direction of rolling has a significant impact on the reduction of the elastic deformation of the heavy-duty elements of the multifunctional LWMstands, with the use of four backup rolls in the last two stands of the mill, that reduces both the magnitude and the elastic deformation area of the bearing of the mill rolls node.

3. It is shown that the value of the elastic deformation of the rolls and frame elements is small, and it proves that the nodes of the rolls of the working stands have enough high rigidity. It assurances producing of the rolled strips with the transverse and across interference gage and flatness within the required tolerances;

4. It is proved that the strength characteristics of the new mill stands satisfy the strength condition of the mills. At this rigidity of the stands of multifunctional LWM construction meets the requirements of the standards.

REFERENCES

[1] Antipeen V.G. (2002). JSC “Chermetinformation”. “Ferrous metallurgy” bulletin 8: 3–9. (In Russian).

[2] Mashekov S.A., Absadykov B.N. (2012). Kazakh-British technical university. Monography: 300.

[3] Kulik A.N., YurkovK.Yu., Faichak A.A., Shevchenko V.V. (2008).Perspective construction of the precision mills. [ZahistmetalurgIynihmashin vid polomok] 10: 3-7. (In Russian).http://www.nbuv.gov.ua/portal/ natural/Zmmvp/2008_10/3.pdf.

[4] Maximov E.A. (2006).National metallurgy. Equipment. 9: 45 – 51. (In Russian).

[5] Maximov E.A. (2005). National metallurgy. Equipment. 1: 22-27. (In Russian).

[6] Braunshtein O.E. (2001). Journal of Mining and Metallurgical Academy of Natural Sciences section. Department of the metallurgy: collection of the science materials. 10: 94-99.(In Russian).

[7] Mazur V.L., Nogovytsin A.V. (2010). Dnepropetrovsk: RVA “Dnepro-Val”. 500 p.(In Russian).

[8] Tret’yakov E.M. (1981). Production of economical types of rolling and metal coating. Moscow: Metallurgy: 4-8. (In Russian).

[9] Maximov E.A. (2006). National Metallurgy. Equipment. 11: 60-65. (In Russian).

[10] Maximov E.A. Improved quality and improved flatness of the strips made of stainless steel with self-regulation process of asymmetric rolling // Metal Technology. 2010. No. 9. pp. 19-24. (In Russian).

[11] Lunev V.E., Shubin I.G., Rumyancev M.E., et. al. (2003). Production of steel. 6: 28-29. (In Russian).

[12] Mashekov S.A., Nugman E.Z., Mashekova A.S., et. al. (2009). Patent of the Republic of Kazakhstan No.20969.Bulletin No. 3. (In Russian).

[13] Ivanov K.M., Shevchenko V.S., Jurgenson E.E. (2000). Saint-Petersburg Institute of Mechanical Engineering, 217 p. (In Russian).

[14] Mashekov S.A., Orlova E.P., Absadykov B.N., et al. (2015). Reports of the National Academy of Sciences of the Republic of Kazakhstan. 5: 41-49. (In Russian).

[15] Kopanev D. (2010). MSC.Software Corporation, 169 p.(In Russian).

[16] Rybnikov E.K., Volodin S.V., Sobolev R.Y. (2003). MSC.Software Corporation, pp. 130, 174. (In Russian).

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МЕТАЛДАР МЕН ҚОРЫТПАЛАРДАН ЖАСАЛҒАН ЖҰҚА ЖОЛАҚТАРДЫҢ ДӘЛДІГІН ЖОҒАРЛАТУ МАҚСАТЫМЕН БОЙЛЫҚ-СЫНАЛЫ ОРНАҚТЫҢ ҚАТАҢДЫҒЫН МОДЕЛЬДЕУ

Аннотация. Мақалада құрылымы жаңа орнақ ұсынылған. Металдарды қысыммен өңдеу процестерін есептеу үшін қолданылатын шеткі элемент әдістемесі бағдарламасы MSC.visualNastran 4D пайдаланып, ұсынылып отырған орнақтың қатты жүктелген элементерінің кернеулі-деформациялы күйі есептелді. Орнақтың пішінбілігі мен тұғыры элементерінде пайда болатын серпімді деформация мөлшері көп емес екені жұмыста көрсетілді. Бұл жұмысшы қапас пішінбілігі торабының қатаңдығы жеткілікті жоғары екендігін дәлелдейді. Осының бәрі, талап етілетін ауытқу шегінде бойлық және көлденең бағыттағы алақалыңдық пен планшетілікті илемделетін жолақталуға мүмкіндік береді. Жаңа орнақ қапастарының беріктіктік сипаттамасы орнақтарға қойылатын беріктік шартын қанағаттандыратындығы жүргізілген зерттеулермен дәлелденді. Осы орнақтың ауыр жүктеме түсетін элементерінде пайда болатын эквивалентті кернеулер, осы элементтер жасалған материалдардың беріктік шегінің рұқсат етіліетін максимальды мәнінен аспайтындығы анықталды. Осы кезде көпқызметті бойлық-сыналы орнақ қапастарының қатаңдығы МЕСТ-дің талабына сәйкес келеді.

Түйін сөздер:орнақ, модельдеу,жаймалау, жолақ, қатаңдық.

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МОДЕЛИРОВАНИЕ ЖЕСТКОСТИ КЛЕТЕЙ ПРОДОЛЬНО-КЛИНОВОГО СТАНА С ЦЕЛЬЮ ПОВЫШЕНИЯ ТОЧНОСТИ ТОНКИХ ПОЛОС ИЗ МЕТАЛЛОВ И СПЛАВОВ

Аннотация. В статье предложен стан новой конструкции. С использованием программного продукта конечно-элементного (КЭ) анализа, специализированного для расчета процессов обработки металлов давлением MSC.visualNastran 4D, рассчитано напряженно-деформированное состояние тяжело нагруженных элементов предлагаемого стана. Показано, что величина упругой деформации элементов валков и станин невелика, что свидетельствует о достаточно высокой жесткости узла валков рабочих клетей. Это гарантирует получение поперечной и продольной разнотолщинности и планшетности прокатываемых полос в пределах требуемых допускаемых отклонений. Проведенным исследованием также доказано, что прочностные характеристики клетей нового стана удовлетворяют условию прочности станов и возникающие в тяжело нагруженных элементах эквивалентные напряжения не превышают максимально допустимое для данного материала значение предела прочности. При этом жесткость конструкции клетей многофункционального продольно-клинового стана соответствует требованиям ГОСТов.

Ключевые слова: стан, моделирование, прокатка, полоса, жесткость.

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