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COMPUTER-ASSISTED PROCESSING FOR ROLLING MILL FRAME RECONDITIONING

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Abstract

Roll stands frames are the most important parts of a mill. This frame supports the work rolls and other devices or mechanisms that ensure lamination precision and mill productivity. The reaction forces created by metal deformation during rolling must be withstand by the frame. Therefore, when designing and executing mill frames, special attention must be paid to their mechanical properties, such as: stiffness and resistance. The roll stand frame must possess high stiffness, strength depending on the forces that will occur during rolling, but in the same time, the design must be simple and with minimal production costs. The aim of this paper is to present a computer-assisted design of a roll stand frame from a rolling mill used for cold rolling processes.

Keywords: *roll stand, cold rolling, mill frames, computer-assisted, stiffness, resistance.*

Introduction

A roll stand is a complex system with many components which, by common action, performs the basic function in a rolling mill: the material deformation. Thus, steel mills include a large number of working elements, such as: constructive elements: roll stands frame, bearing holders, roll bearings, work rolls, back-up rolls, intermediate rolls etc.; mechanisms: rolls actuation, rolls positioning; oscillation devices, hydraulic cylinders etc.; auxiliary devices: roll changing equipment; devices for cooling and lubrication and different stands and devices used to driving the semi-finished product at the inlet and outlet of the mill [1-3].

The mill frames are the strongest elements, on this component are assembled all other mill components which directly or indirectly contribute to the metal deformation. They form a rigid housing that withstand to all the reaction forces created during metal deformation by cold rolling. This assembly also includes the pass line adjusting device, that is used to adjust the distance between the work rolls in order to obtain the desired semi-finished product reduction, this device can be mounted on the upper or lower side of the mill stand. Because during metal rolling, the most important parameter is the distance between the work rolls, i.e. semi-finished product reduction, the materials used for all the components that directly affect the metal deformation must possess low expansion coefficient. A high material expansion coefficient can lead to poor quality products. Usually, the frames are made of gray cast iron cast iron or large welded laminated profiles (metallic steels).

From a constructive point of view, a rolling mill includes closed frames and open frames, which are made up of two pillars, a lower crosspiece and a top crosspiece (detachable in case of open frames). The frames are obtained by casting, then the contact between framework elements and the surface which must be positioned on the ground are machined by splintering. Also, the frames are assembled together with molded crosspieces and bolts [6, 8-11].

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The concrete foundation and the base plates of the roll stand assembly must withstand to all the auxiliary components and electrical equipment, the frames are positioned on the foundation by means of steel or cast-iron base plates.

Rolls Stand Frame Designing

The Plastic Deformation Laboratory (2) from the Faculty of Materials Science and Engineering has a rolling mill with a missing part from the frame. The main purpose of this paper is to design the missing part in order to refurbishing the mill. The schematic representation of a rolling mill is presented in Fig. 1.

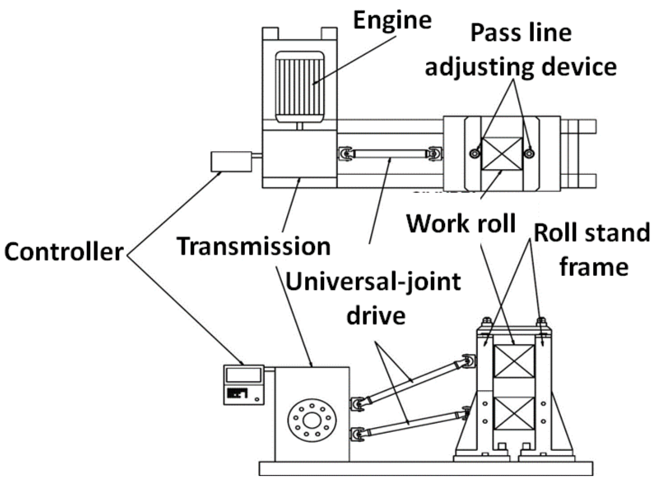
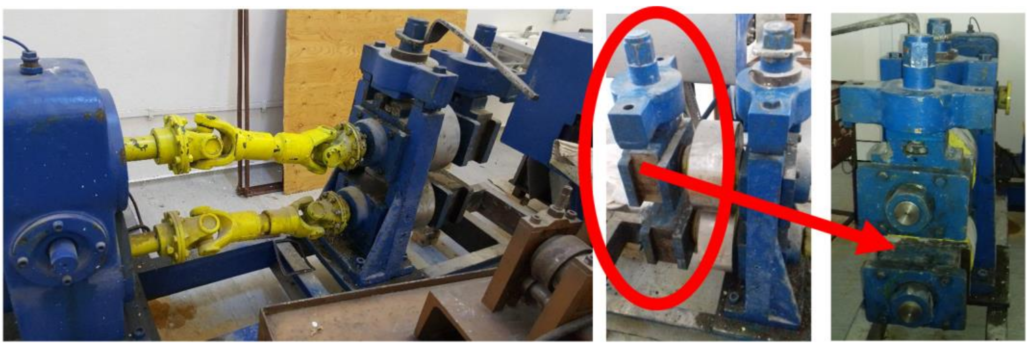


Fig. 1. Schematic representation of a rolling mill.

Taking into consideration how a rolling mill works and the symmetry between the roll stand pillars, the dimensions used to design the missing part were taken from the existing frame pillar.



a) b) c)

Fig. 2. a) Rolling mill overview; b) Roll stand without one pillar; c) Missing part positioning.

The missing part of the roll stand has been by means of CATIA V5 software [4, 5, 7].

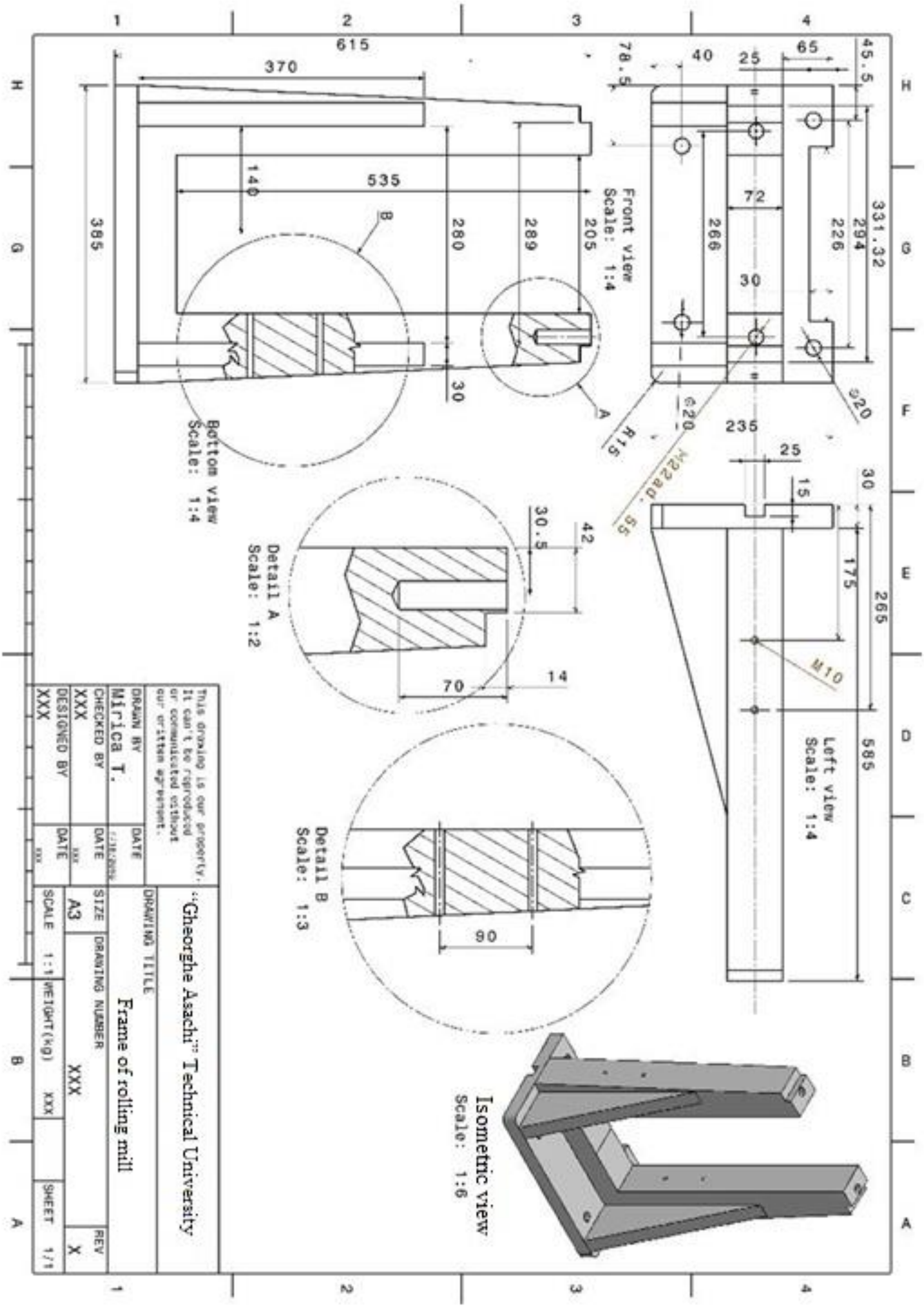


Fig. 3. Roll stand pillar 2D and 3D design.

The part has been designed taking into account the rolling mill dimensions and the purpose of the product, i.e. to support the equipment weight and to be fixed in the concrete foundation by means of two bolts. This component should be made of a massive structure (molded part), from a material with high density, machined and welded. The part weight is very important, because it places the rolling mill gravity center during working inside the base plates and has the role to absorb vibrations created during working in order to stop the equipment from falling apart, which can cause severe work accidents or scrap.

The equipment supports and fasteners have, as main purpose, the vibrations and mechanical shocks absorbing, which are created by the engine or by moving components during process. High vibration or mechanical shocks can lead to technological process interruptions and product price increases. The rolling frames positioning and fitting should be performed after prior measurements in order to maintain the parallelism constrains, between the support surface and the bearing housing, and the coaxial position with all other moving parts from the assembly.

During designing, another factor that must be taken into consideration is the fact that the bearing housing must withstand to high axial and transverse forces, resulted during metal deformation.

In Fig. 4 are presented the front, side, top and bottom views of the rolling mill missing pillar.

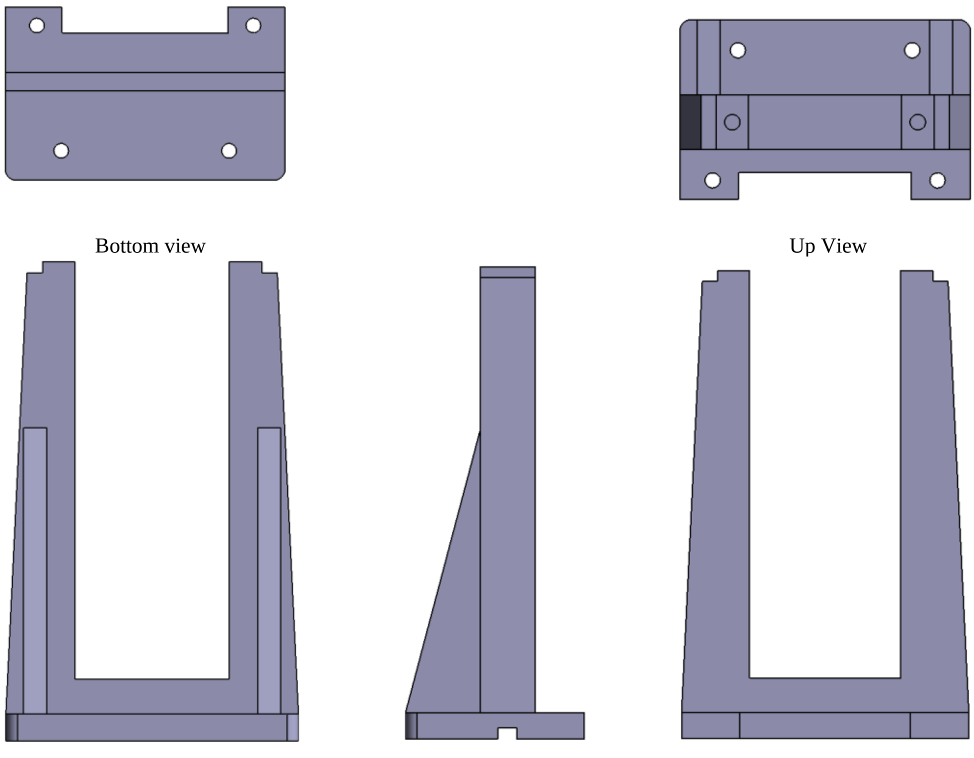


Fig. 4. Roll stand pillar 3D views: frontal, side, top and bottom.

By means of an isometric view the three -dimensional of the pillar can be presented as can be seen in Fig. 5.

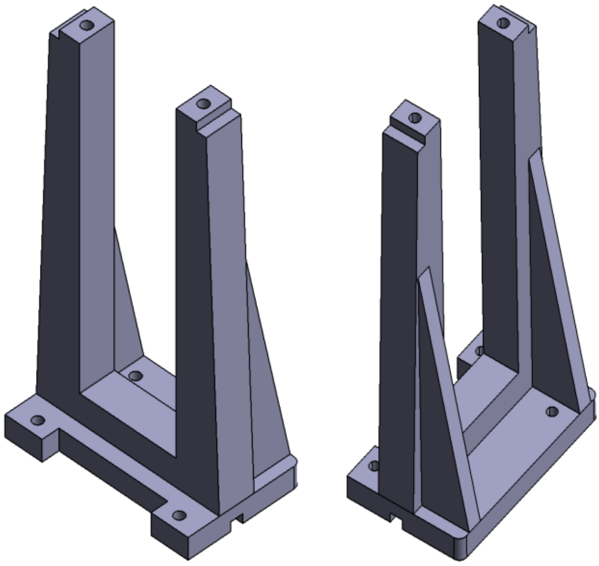


Fig. 5. Isometric view.

Stages of rolling stand designing by means of Catia V5R20 software

Base plate designing

The first step consists in the base plate, which supports the pillars, designing.

By using the PAD tool based on the sketch with the part external: 380 mm x 235 mm, it can be created a 35 mm thickness plate.

Base plate cutting

In order to cut the rectangular plate to a much closer shape to that of the final part, a rectangular sketch of 35 mm x 226 mm dimensions is created on the upper surface of the PAD prior created. Then the unwanted volume is removed using POCKET tool.

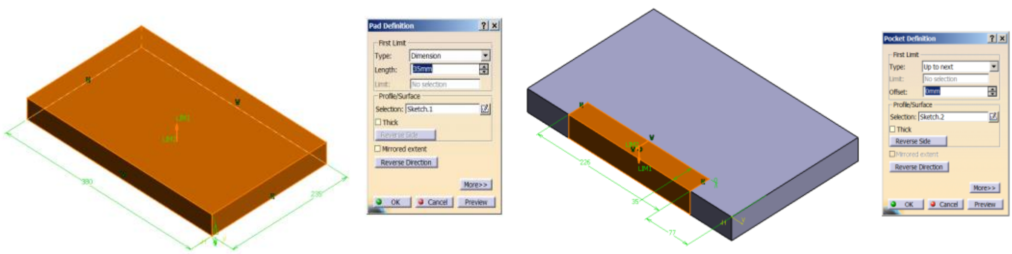


Fig. 6. Base plate designing.

Base plate edging

By means of the EDGE FILLET tool a transitional surface between two surfaces separated by a corner can be created. This rounded surface is created, in this case with a radius of 15 mm.

Base plate bottom surface

On the base plate bottom surface, a channel of 15 mm depth and 25 mm width is created from side to side. By POCKET tool means the material is removed with a 15 mm x 25 mm rectangular set to UP TO NEXT.

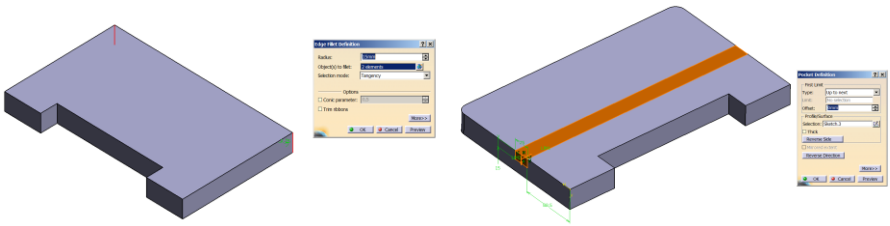


Fig. 7. Bottom of base plate designing.

Frame designing

The side profile of a pillar with the dimensions specified on the 2D drawing (Fig. 3) will be created as a sketch. These dimensions can be also viewed in Fig. 8. By means of PAD tool a 72 mm thickness profile is created. After creating the 3D profile of a pillar, it can be copied by means of MIRROR tool on the other side of the base plate. Mirroring will be done by a plan created in the base plate middle which is parallel to the 15 mm x 25 mm profile created in Fig. 7.

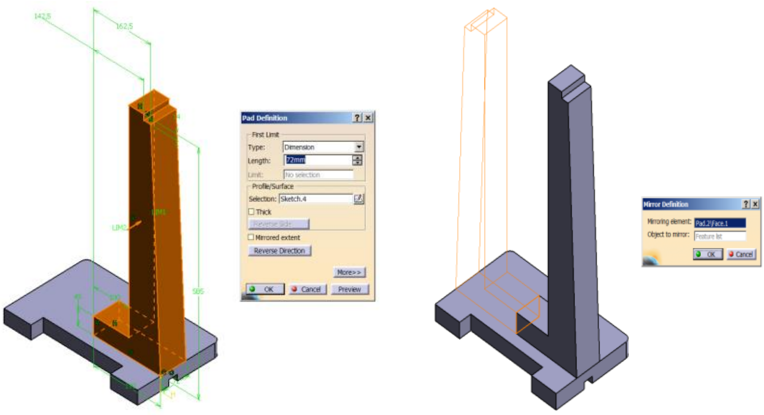


Fig. 8. Pillar designing.

The supporting rib

After creating the 3D profile of both pillars, the support rib will be created by means of STFFENER tool, as can be seen in Fig. 9. The rib created can be copied by means of MIRROR tool.

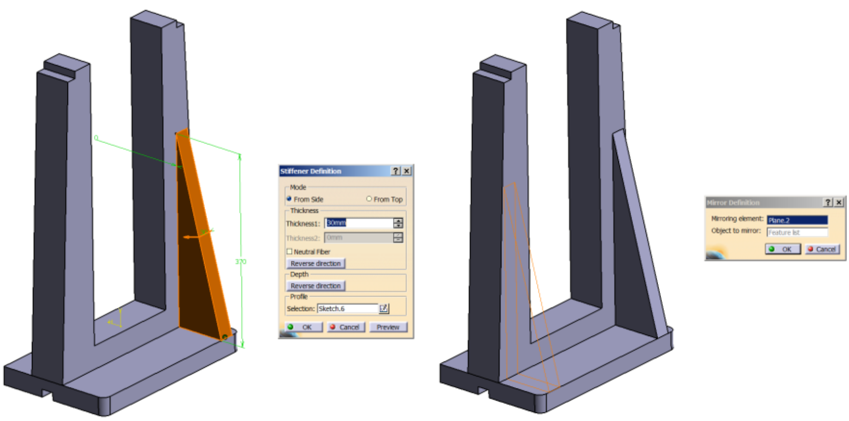


Fig. 9. Pillar supporting rib.

Base plate drilling

Because the base plate must be positioned on the concrete foundation, multiple 20 mm holes must be realized. The first hole is created by means of HOLE tool and have been multiplied by means of MIRROR tool, as can be seen in Fig. 10.

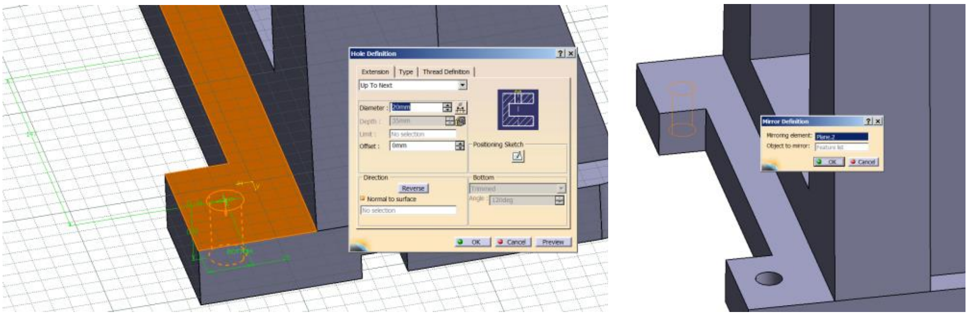


Fig. 10. Base holes 1 and 2 creation.

By means of the same HOLE tool, on the other side of the base plate a hole must be created with the diameter of 20 mm, as can be seen in Fig. 11. In order to multiply this hole, the MIRROR tool is used, the middle plane created has also been used as reference plane.

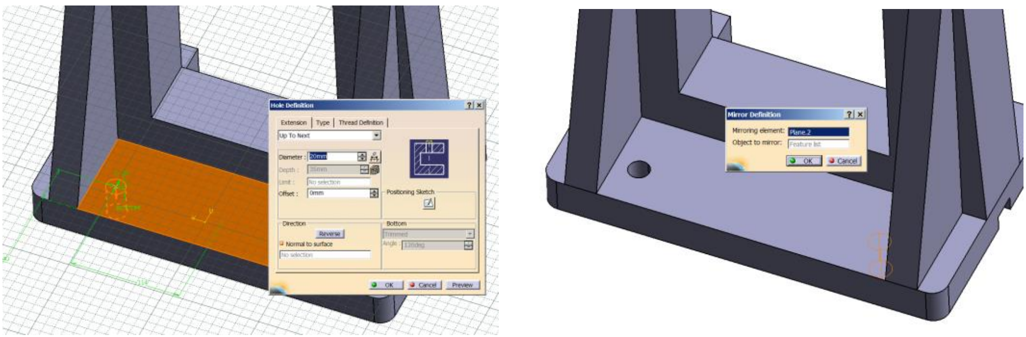


Fig. 11. Base holes 3 and 4 creation.

Pillars threaded holes creation

These holes can be created by means of the THREAD function which is available in the HOLE tool. A M22x1.5 of 50 mm length thread is created in a 70 mm deep hole (Fig. 12).

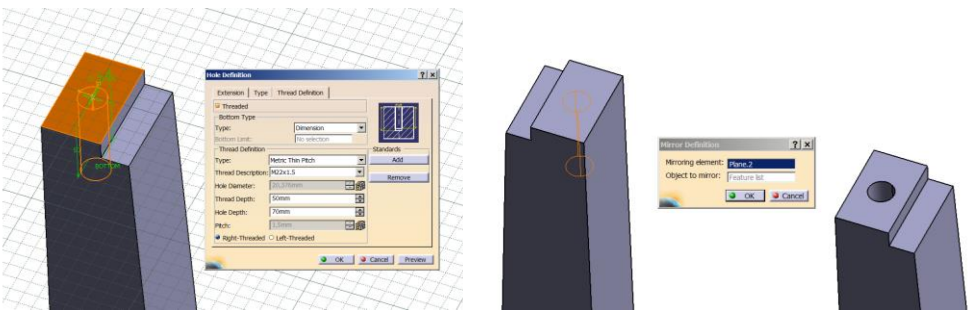


Fig. 12. Pillars holes creation.

Threaded hole multiplication can be realized by means of MIRROR tool, using the middle-created plan as reference.

Resistance and Forces Calculation

Cold rolling forces calculation is very important because, the material selection and specific dimensions must be done according to the values obtained [12]. Taking in to consideration the rolling forces (F) and the bending moment (M) specific to a brass plate of 100 mm width and 20 mm thickness. The resistance and forces can be calculated using the equations 1 to 9:

$$F = S \cdot p_m; \qquad S = \frac{b_0 + b_1}{2} \cdot l_c; \qquad l_c = \sqrt{r \cdot \Delta h} \tag{1}$$

Where:
S – contact surface, mm^2;
p_m – mean value of deformation area pressure; p_m = 250 MPa [13];
b_0, b_1 – cold rolled product width before and after deformation b_0 = 100 mm; b_1 = 104 mm.
r – work roll radius, r = 150 mm;
l_c – angle of bite;
Δh – linear reduction of cold rolled product height, h_0 = 20 mm; h_1 = 18 mm; Δh = 2 mm.

$$S = \frac{b_0 + b_1}{2} \cdot l_c = 102 \cdot \sqrt{300} = 1766.69 \ \text{mm}^2 \tag{2}$$

$$F = S \cdot p_m = 1766.69 \cdot 250 = 441672.95 \ \text{N} \tag{3}$$

The frame crosspiece must withstand to a maximum load that depends on the rolled product mechanical properties and multiple safety and dynamic coefficients which values are according to the literature [13], depending to the rolling mill type.

$$\sigma_c \le \sigma_a, \quad \sigma_a = \frac{R_{max}}{c \cdot s_p} \tag{4}$$

Where:
σ_a – frame admissible tensile strength;
σ_c – brass deformation tensile strength;
R_{max} – tensile strength, MPa; R_{max} for S235 (DIN EN 10025), R_{max} = 360…440 MPa; by choosing the minimum value in the range, R_{max} = 360 MPa;
c – dynamic coefficient of fatique, c = 1.2 ÷ 2.5; by choosing the minimum value in the range, c = 1.2;
s_p – safety coefficient for fatique strength; s_p = 2 ÷ 5; results s_p = 2.

$$\sigma_a = \frac{360}{1.2 \cdot 2} = 150 \ \text{MPa} \tag{5}$$

According to equation (3), equation (6) becomes:

$$\sigma_c = \frac{F}{2S} \le \sigma_a \Rightarrow F_{max} = 2S \cdot \sigma_a = 647774.55 \ \text{N} \tag{6}$$

Where:

F_{max} – frame admissible (maximum) rolling force.

The created frame must withstand to tough working related to the stresses which occur during material deformation, i.e. when rolled product is compressed, which are:

- vertical rolling forces;

- bending moment developed by the normal force to the rolling zone and its vertical component that is passing through the center of the roll.

Working time at rolling process:

$$M = F \cdot b_d = 441672.95 \cdot 0.002 = 883.34 \ N \cdot m \tag{7}$$

Where:

b_d – rolling bending moment distance, b_d = 2 mm;

The rolling bending moment is calculated with the equation:

$$\sigma_a = \frac{M_{max}}{W} \Rightarrow M_i = 150 \cdot 10410.83 = 1561624.50 \ N \cdot mm = 1561.62 \ N \cdot m \tag{8}$$

$$W = \frac{b \cdot h^2}{6} = 10410.83 \ mm^3 \tag{9}$$

Where:

M_{max} – frame admissible (maximum) bending moment;

W – resistance module;

b – stand frame length; b = 65 mm (see Fig. 3);

h – stand frame width; h = 31 mm (see Fig. 3).

According to our calculation, in case of cold rolling of brass sheets products, the deformation force developed during process is F = 441672.50 N, this value is much lower than the maximum stress that can be supported by the designed frame, which withstands at F_{max} = 647774.55 N.

During rolling, a maximum bending moment which corresponds to the rolling force and roll length, M = 883.34 N·m, is produced, which is lower than the moment, of about M_i = 1561.62 N·m, at which the designed frame can withstand without any damage.

Conclusion

In order to design and create the driving, active and supporting elements used at rolling mills assembly, there are multiple factor that must be taken into account, such as: the rolling mill type, rolling product type and shape.

The rolling stand is assembled of supporting, stabilizing and fixing components of a rolling mill. In order to be fastened, multiple bolts are used to fix the frame to the concrete foundation. The supporting elements of the stand are made of massive molded products that are machined and eventually welded in the lower area (base of the frame), after which adjustments are made in order to observe the deviations from the mounting (coaxial, parallelism etc.). High density materials must be used because the frame places the rolling mill gravity center during working inside the base plates which ensure the equipment stability.

The main dimensions (height, width) of the rolling mill stand are chosen depending on the moving parts of the rolling stand (the rollers), in order to keep the equipment stable and steady.

The material from which the mill rolls are made must possess high resilience and good vibrations absorption properties.

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