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BIMETAL ROLLING TECHNOLOGY – ASYMMETRIC VERSUS SYMMETRIC PROCESS

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Abstract: As a result of the development of rolling technologies, laminating of bimetals is of particular interest due to many advantages of both technical and economic nature. By correlating the strength parameters of the lamination process with the asymmetrical lamination technology, bimetal products can be obtained with superior mechanical characteristics and quality. The products thus obtained can be used in the edge fields of the technique with long–term benefits in terms of reliability and cost. This paper highlights the complex nature of metal plating by lamination technology, which is considered asymmetrically technologically.

Keywords: bimetal rolling, asymmetric rolling process, coating of metallic materials, superior mechanical properties

1. INTRODUCTION

Plating means the non–demountable joining of two or more metallic materials in the form of layers by means of cohesive forces. The layered piece performs both cold and hot as a single object, summing or aggregating the properties of the component layers [1]. Plated products are distinguished from metallized ones by spraying through the thicker layer thickness. On plating the thickness of the film reaches the order of millimeters. Metallic layers do not exceed 2–3% of the total thickness of the object, while the coated ones reach up to 20%. The plating can be bilayered or multilayered metallic materials of different kinds. The choice of layers as thickness and nature is made according to the properties that are being pursued (mechanical, physical, chemical, etc.) to obtain them.

Several methods of plating metal materials are known:

- by casting – it is done by pouring the plated metal onto the prepared surface. The plate is heated to 1100 – 1300 K and adhesion is achieved by diffusion;
- by plastic deformation – it is achieved by pressing the plating surfaces. During compression, a plastic deformation of the component parts occurs and it is usually hot. The plastic deformation required for the plating is achieved by: rolling, extrusion, drawing;
- welding – applies to biggest bimetallic products. The plated metal is deposited by some welding method: manually, under a stream layer, in a slag bath, and the monolith product is processed by lamination (rolling process);
- placement by aggregation of powders;
- blasting.

At the base of all plating metal materials processes is the adhesion phenomenon. The main factors that influence the adhesion of plated materials are:

- the influence of metallic bonds – adherence – is due to the appearance of metallic connections between surfaces. If we approach two metal surfaces, there are always interacting forces of the Van Der Valls type (the distance is 102 A°). Interaction forces depend on the orientation of the crystallographic axes in the case of monocrystals. Can adhere atoms that have crystalline networks with the same parameters. Atoms with the direction of crystalline bonds that have not coincided will have an interaction between them without the formation of metal bonds;
- pressure – is the main means of bringing two surfaces into contact with the diffusion. The joint strength depends on the deformation. In addition to the total pressure, adhesion also depends on the applied pressure regime;
- temperature – the higher the temperature, the more diffusion and adhesion increase;
- structure of the contact area – steel sheets have a stronger adhesion as the decarburization is higher;
- chemical composition.

Table 1. Possible combinations of materials for plating metallic

No.	Materials	1	2	3	4	5	6	7	8	9	10
1	Steel		X							X	X
2	Brass	X									X
3	Aluminium	X				X	X				
4	Bronze										X
5	Gold	X	X	X			X				
6	Silver	X	X		X			X			
7	Stainless Steel	X									X
8	Lead	X	X		X		X				X
9	Tin		X	X	X	X	X				X
10	Copper	X		X			X				

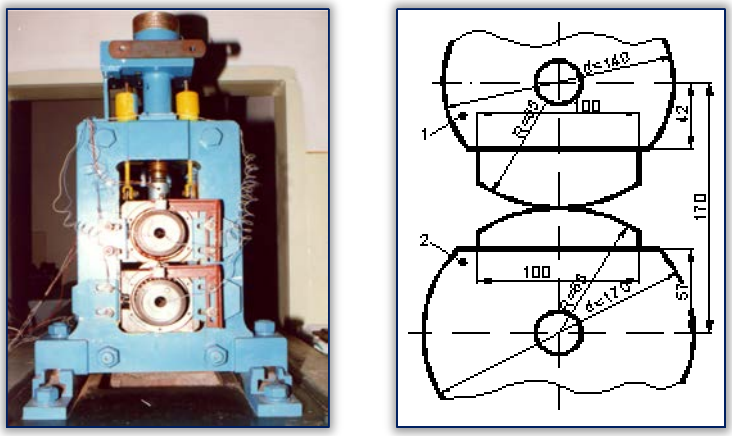
Through these technological processes we can obtain:
- single and bilateral plates and strips;
- multilayer metallic materials for tools;
- bimetallic strips for electrical contacts;
- bimetallic bars and bands for telecommunications;
- strips and strips for chemical installations;
- corrosion protection (on heat exchangers);

2. THE EXPERIMENTAL PLANT AND TESTING METHOD

The research for this theme purpose have been made on a 170 mm reversing two–high rolling mill, created and installed in the no conventional technologies and plastic deformation laboratory of the Faculty of Engineering Hunedoara [2,3,4].

An experimental installation formed of: special construction rollers, bearings, punctiform captors for lamination pressure, lamination forces captors and lateral pressure captors it was created for research in condition of technological similitude symmetrical and asymmetrical process.

In figure 1 it is presented in overview the mentioned installation, with the way force captors are assembled in order to determine the lateral efforts in the longitudinal asymmetrical lamination but also to show the author's contribution regarding method of experimentation.



a. b.

Figure 1. Experimental installation: a – front view of the installation; b – the asymmetrical rolling process

The bearing holders of the inferior roller were modified for recording the lateral efforts so that the respective captors could be installed incorporated perpendicularity on the bearing's axis.

On the surface of captors were stuck tensometric stamps bound in deck, stamps that modify their dimension under the action of the effort to be measured. These dimensional modifications of tensiometer stamps are generating variations of their electric resistance, that are proportional to the deformation efforts and the measuring of the forces is limited to the measuring of these resistance variations. The symmetric and asymmetric rolling process was carried out by equipping the work rolls with segments adjusted with various radii, which have led to the following ratios between the diameters of the upper (D_s) and lower (D_i) rolls:

$$\frac{D_s}{D_i}=\frac{170}{170};\frac{160}{180};\frac{150}{190};\frac{140}{200}[mm]$$

3. REDUCTION AND VELOCITY OF DEFORMATION OF METAL MATERIALS THROUGH LAMINATION PROCESS

When passing through the deformation zone, the metallic material deforms in thickness from h_0 to h_1, so that the maximum relative reduction in the material exit plane between the cylinders will be [5]:

$$\varepsilon=\frac{h_0-h_1}{h_0}\cdot 100 \quad (1)$$

The partial reduction at any coordinate point φ is determined by the expression (2):

$$\varepsilon_\varphi=\frac{h_0-h_\varphi}{h_0}=\frac{h_0-h_1-D(1-\cos\varphi)}{h_0}=\varepsilon-\frac{2R}{h_0}(1-\cos\varphi) \quad (2)$$

In order to determine the mean value of the flow limit, it is necessary to know the average degree of deformation along the length of the contact spring, which can be determined with the relation 3:

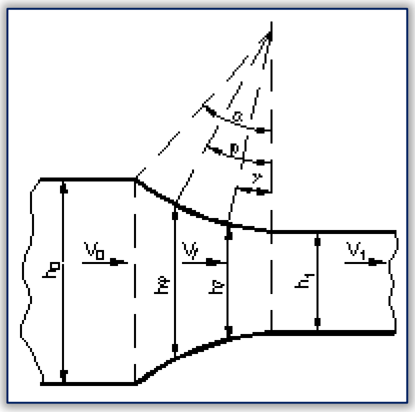


Figure 2. Reduction zone from rolling process

$$\frac{\varepsilon_m}{\varepsilon} = 1 - \frac{2}{\frac{\Delta h}{R}}\left(\frac{1}{2} + \frac{\Delta h}{4R} - \frac{1}{2\sqrt{1-\frac{\Delta h}{4R}}}\right) \tag{3}$$

Currently, to determine the influence of the deformation velocity on the flow limit value, it is usually considered the mean velocity along the contact spring. This is determined by the expression:

$$\int_0^{\alpha} u_{\varphi} d\varphi = \int_0^{\alpha} \frac{2h_1}{2h_{\varphi}^2} \lambda \cdot v \cdot tg\varphi d\varphi \tag{4}$$

where from:

$$u_m = \frac{1}{\alpha}\int_0^{\alpha} 2h_1 \cdot v \cdot \lambda \frac{tg\varphi d\varphi}{\left[D(1-\cos\varphi)+h_1\right]^2} \tag{5}$$

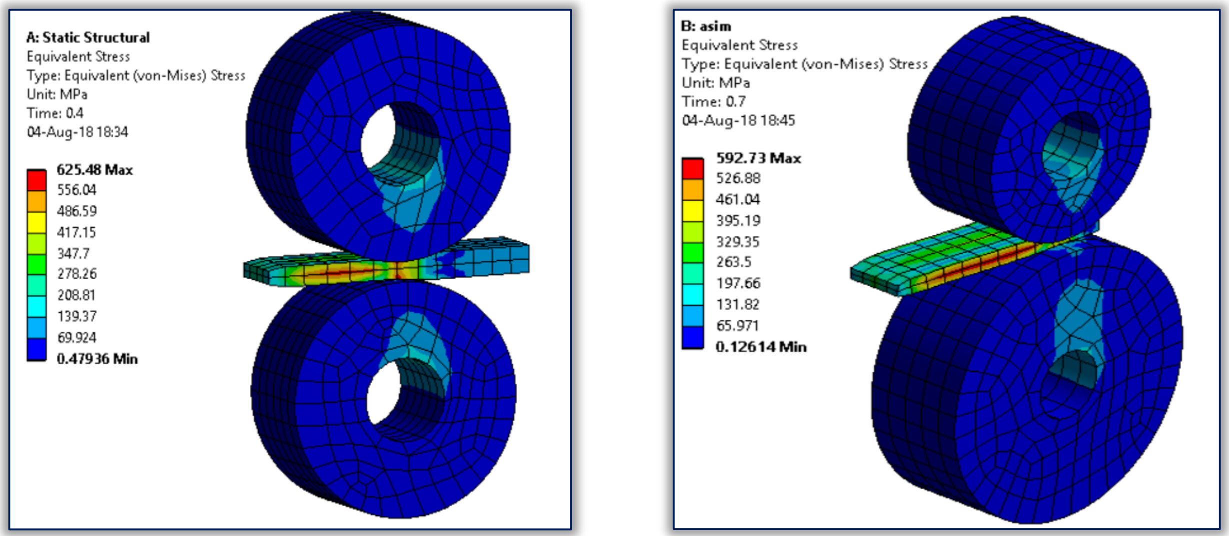
after integration and transformation, the relationship is obtained:

$$u_m = \frac{2h_1.v.\lambda\left[(h_1+D)\frac{\Delta h}{h_0 h_1} + \ln\frac{h_0}{h_1 \cos\alpha}\right]}{(h_1+D)^2.\cos\alpha} s^{-1} \tag{6}$$

in which: λ – represents the coefficient of elongation; D – cylinder diameter; α – angle of grip in radians.

The relatively flat rolling of strips, in the general case, the geometric distortion is composed of two parts (Figure 3):

- the metal sliding portion on the cylinders, where the contact friction is subject to Coulomb's law; here are actually two portions, in the immediate vicinity of the geometric deformation zone, i.e., the inlet and outlet of the metallic material between the cylinders;
- the grip portion where the material slip on the surface of the cylinders is missing, i.e. the metal surface layer moves at a tangential velocity equal to the peripheral speed of the cylinders, or the particles of metallic material as if they stick to the surface of the cylinders [6].



a. b.

Figure 3. Equivalent stress (von– Misses); a – symmetric process; b – asymmetric process

4. CONCLUDING REMARKS

It has also been clarified by the present study the qualitative passage laws from the symmetrical to the asymmetric process, depending on the change in the lamination conditions, confirming the idea that the symmetric process is only a particular case of the asymmetric process that is widespread in the industry's rolling practice. The joint strength depends on the deformation. In addition to the total pressure, adhesion also depends on the applied pressure regime.

The plating of metallic materials through lamination can be optimized by adopting asymmetrical longitudinal lamination. Knowing the strength and technology parameters of lamination plating leads to the achievement of superior quality products and superior mechanical properties.

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