SUPERIOR VALORISATION OF THE METALLIC SCRAPS FOR OBTAINING BIMETALLIC STEEL-BRONZE PARTS

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Abstract: The possibility of bimetals producing by direct melting of the bronze machining chips into steel support is considered. The aim is the manufacturing of the bimetal that is formed by joint of a bronze layer on steel support. By this way the recycling of the metallic wastes as final products with value added is possible. In this paper the flow sheet for the bimetal manufacturing by this method was showed. Also the parameters that influenced the quality of bimetal were analysed. The quality of the bimetal was analysed in term of contact zone quality. The interface zone of two alloys was investigated by methods of metallographic and microscopic analyses.

Keywords: *bimetals, recycling, bronze chips, steel*

1. Introduction

In many industrial applications, the working surfaces of the parts are simultaneously exposed to a very different kind of stresses. In these types of working regime, the bimetallic materials can be used. These materials are obtained using the depositing process of one material, as layers with different thicknesses, on top of another material considered as a base. These metallic materials, also named bimetallic can satisfy some requests of the working conditions impossible to be obtained using one single metallic material. The covered steels with non-ferrous alloys layers are an example and the bimetallic pieces are obtained by the different methods production. The bimetals are obtained by metallic layers deposition on the surface of the support parts. The joining of the metallic layer on the solid support is determined by diffusion and thermal processes [1]. The metal deposition most is makes on one or both surfaces of the solid support. The thickness of covering layers is 8 – 20% of the support alloy. The first dates about the bimetals are early mentioned. In the published papers is show that 1858 is the year when the first patent (USA Patent) for the bimetal obtaining is mentioned. For the Germany the researches for the production of the cladded steel sheets begins in the seventh decade of the XIX century and a patent was realized. The first special industrial application for bimetals is dated from 1930. This is from USA and is referred at utilization of some steel sheets with nickel cladded for construction of the tank wagon for the chemical products transports. The production of the great quantity of the carbon steel sheets cladded with stainless steel starts around 1938 [2].

One method for obtaining of the bronze layer added on the steel support for the bimetal manufacturing is by welding process. For this is necessary the remelting of the bronze wastes and moulding in the form of bars. The gas-shielded arc welding process with wolfram electrode can be used for welding bronze on the parent steel [3, 4]. During the bimetal obtaining by this method a lot of problems are associated: the lost of metal is greater; the costs of labour and energy or materials are increased as well as the problems of environment protection are higher.

The present paper presents the researches for bimetal manufacturing from waste products. To create a bronze layer on the steel surface, bronze machining chips were used. In this case the chips waste of the bronze with aluminium complex alloyed with iron, nickel, manganese were used.

2. Experimentals and materials

In the experimental work, steel samples as supports were utilized, Figure 1.

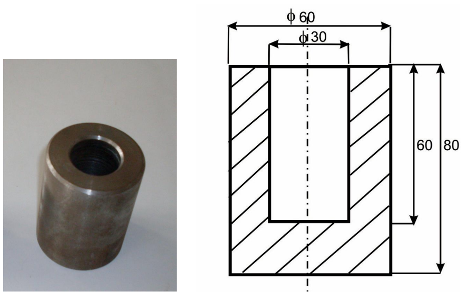


Figure 1: *Experimental steel sample used that steel support into experimental*

In accordance with the complex work of this bimetal that be used as bearing parts (ability to carry heavy loads under friction conditions without excessive wear and resistance to corrosion) we used selected bronze chips in accordance with certain chemical composition, Table 1 [5, 6].

Table 1: *Chemical composition of the bronze*

Elements, [wt%]	Al	Ni	Fe	Mn	Cu
Range expected	14-15	4-4.5	4-4.5	0.8-1.2	bal.
Chips	14.7	4.4	4.1	1.1	bal.

The fluxes with multiple actions were used: borax as neutral cover fluxes, glassy fluid cover flux, graphite as reducing flux containing carbonaceous materials and, copper-phosphorus metal mixed with bronze chips that self-fluxing on copper-base metals [7].

A resistance furnace was used for heating the samples, Figure 2.

Figure 2: *Furnace used to melting the bronze chips into steel support*

The quality of bimetal is discussed in term of contact surface for both alloys (steel and bronze with nickel, iron and manganese). The structural aspects associated with heating process were presented. An Olympus microscope Metallographic was used. Optical microscopy included standard methods for preparing samples.

2. Results and discussions

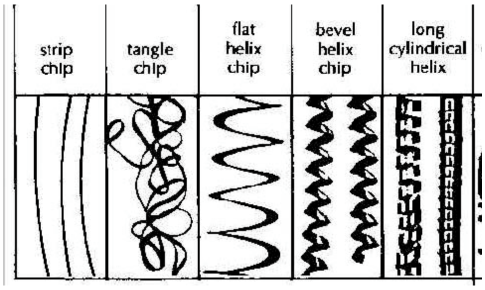
Although the method proposed for bimetal manufacturing is cheap and simple this involves any problems. The main are associated with the quality and the properties of the bronze and the bronze chips. Other are associated with processes that accompanying the copper alloys melting and joining with steel support.

The first condition for a quality process is referred on the properties of the recycled material. The success of any melting system depends on the physical characteristics and nature of the feedstock, therefore, the integration of durable, efficient pre-treatment is crucial in achieving full processing efficiency and hence, a high metal recovery. This is particularly important when recycling the machining chips, which have a high surface area per unit volume. Even small residues of water/oil soluble fluid will have a significant impact on metal recovery. Such contaminants interfere with the bronze and may lessen the joint strength or cause failure. For this reason the first step of the flow sheet is the pre-treatment.

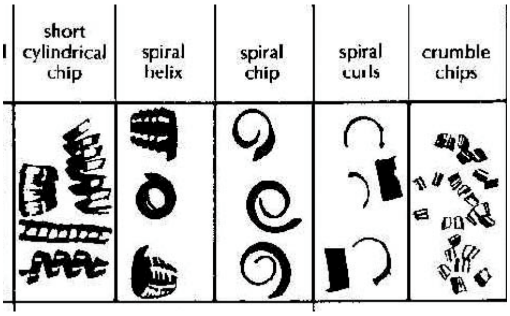
For good bronze melting into steel support are necessary small and uniform chips. The machining chips have diverse forms. The types of chips are categorised or subdivided into following categories, Figure 3.

To obtain the uniform chip size, these are crushed. The cleaning can be considered to be a two-stage process. In the first process of the stage the centrifuge separation to minimized water and coolants is applied. Also the magnetic separation to eliminate ferrous parts is sometimes necessary. Second process of this cleaning stage is based on thermal processes. The object is to remove the organic compounds from the surface of the chips by converting them into a gaseous state. This process requires a low temperature. Any water that is present within the chips will be vaporized. Then, at a higher temperature is removed the carbon-based deposit that remains on the surface of the chips.

The second condition for a quality process is referred on the physical and chemical processes that are developed in accordance with thermal conditions that are occurred at the melting of the copper alloys chips and at the heating steel support.



a.



b.

Figure 3: *Chip forming classification: a - not desirable; b – good* [8]

Copper is considered a half noble metal but with a high solubility for oxygen in the liquid state. Generally an oxygen and hydrogen pick-up can lead to very negative effects on mechanical and physical properties of copper and copper alloys. These gases have a high solubility in liquid copper alloys that decreases sharply during solidification. This can lead to bubble formation, i.e. porosity in the solid material. Oxygen can also form cuprous oxide (Cu_2O) above its solubility level that immediately reacts with the moisture of the air forming water vapors. Dissolved hydrogen and oxygen (or Cu_2O) will react with water under extreme pressure in the lattice and will form cracks and lead to embrittlement [9].

Borax as neutral cover fluxes are used to reduce metal loss by providing a flux cover. This melts at copper alloy melting temperatures to provide a fluid slag cover (borax melts at approximately 740^0C). The glassy fluid cover flux is used also. This flux agglomerates and absorbs nonmetallic impurities from the input material (oxides, machining lubricants, and so on). A reducing flux containing carbonaceous materials such as graphite is used. Its principal advantage lies in reducing oxygen absorption of the copper and reducing melt loss. Carbonaceous flux material should always be used with copper alloys to avoid gaseous reactions with sulfur or hydrogen from contained moisture. Use the copper-phosphorus metal mixed with bronze chips that are considered self-fluxing on copper-base metals is utilized. Some of these fluxes are mixed with bronze chips and some covered the input materials after their preliminary heating. Also the steel samples were heated before the filling with bronze chips and fluxes. The amount of flux used was established in accordance with their effect on the porosity and mechanical properties of bronze alloy. This is more that 5% of metal charge.

Figure 3: *Preparation of the samples before introduction in the heating furnace*

The heating temperature ensures only the melting of the bronze chips and also for the bronze bounding on the surface of the steel. The heating temperature is very important for obtaining a good adhesion of the bronze layer on steel surface. This was established in accordance with the thermal process that is developed in the samples. The thermal regime should ensure the melting of the bronze, the superheating of this melt for developing the diffusion zone at interface with steel support. Certainly, this was correlated with the Cu-Al binary diagram and with the influence of other elements (iron, nickel and manganese) that are present in the aluminium bronze composition. After heating the samples were maintained at optimum temperature and then were slowly cooled together with the furnace.

The experiments were carried at different work temperatures between 1200 and 1300^0C. The experimental shows that heating of the samples at 1200^0C cannot ensure a complete melting of the bronze chips, Figure 4.

The choice of 1300^0C as optimum temperature is confirmed by the experimental samples, Figure 5.

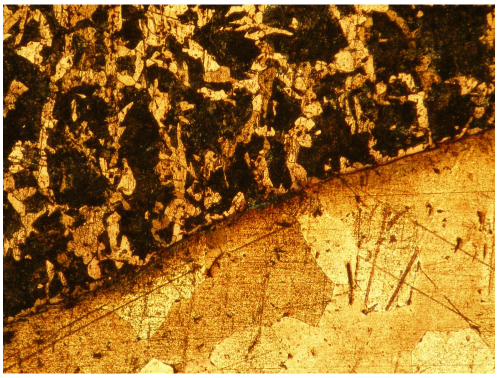
Figure 4: *Bronze chips incomplete melted that were heated at 1200^0C*

Figure 5: *Good adherence of bronze on the steel surface for the bimetal sample obtained at 1300^{0}C, slowly cooled with furnace (surface after exposure to metallographic attack)*

At surface of the support steel, the aluminium bronze with nickel, manganese and iron was adhered to obtain the bimetal. The appearance of the joint zone shows that the process was conducted with optimum parameters. The surface layer had no defects such as oxide films, or porosity, Figure 6 and 7.

The bonding takes place during heating and melting processes. In this way, with participation of diffusion processes good bimetals can be manufactured.

Figure 6**:** *Aspect of bimetal at interface (100X without exposure to metallographic attack)*



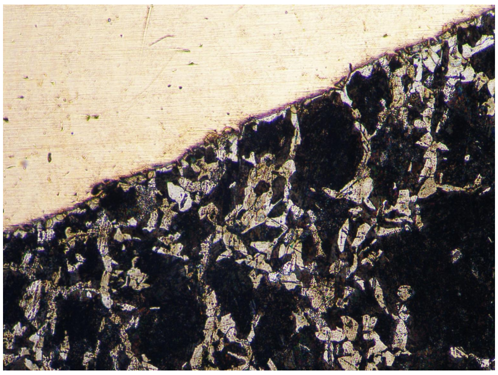


Figure 7: *Microstructure of bronze and steel support after of exposure to metallographic attack (100X)*

4. Conclusions

Usually, the recycling of the chips presents many difficulties [10, 11]. Firstly, the metal chips can be classified in the category of hazardous waste because have residues of water/oil soluble fluid with significant impact on metal recovery. The generation of pollutants are considerable. In the method proposed some of these negative problems are suppressed. By other hand the metal losses at remelting are higher. The direct melting of the bronze chips into steel supports for the bimetal manufacturing is possible. It is a cheap and simple solution to transform the machinery wastes as final products that can satisfy the requirements in industrial applications. The important factors that influenced the manufacturing process are the dimension of the chips and the cleaning. Also, the heating and the melting parameters in accordance with the physical and chemical properties of materials most correlate. Especially, all of these have particularity in respect to the materials utilised, the manufacturing processes and the bimetal applications.

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