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THE POROSITY OF TiN BRONZE CASTINGS

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Preliminary Note – Prethodno priopćenje

The presented work presents the results of the research on the influence of the method of hydrogen removal from tin bronze on porosity and tensile strength. The dehydrogenation was carried out by three methods. In the first method, hydrogen was removed utilizing a vacuum furnace, in the second method, the melt was blown with compressed air, and in the third method, the melt was refined with the salt called Ecosal CU 440. Recirculating scrap was used to make samples. For comparative purposes, castings were also made of melted ingots of the alloy. The density of the castings was determined and the effect of the dehydrogenation method on porosity and the tensile strength was determined on this basis.

Keywords: TiN bronze castings, porosity, hydrogen in browns, tensile strength, refining.

INTRODUCTION

The presence of gases in castings is the greatest problem associated with the production of castings from non-ferrous alloys. Gases which pollute metal alloys can be divided into simple and complex. Simple gases include H_2, O_2, N_2, and Cl_2. Of these gases, hydrogen easily dissolves in metals, nitrogen is an inert gas to most metals, and oxygen has the greatest ability to form chemical compounds. The gas that contaminates the metal often comes from the mould, a metal, or is the result of improper pouring. The presence of gas in metal very often causes the formation of gas bubbles in the casting [1,2]. Gassing of the casting may also have other causes. One of them is keeping the melt for too long in the ladle or holding furnace. Another reason may be too low mould temperature, which affects the time of crystallization of the casting. The slower the solidification of the casting, the higher its porosity. The design of the gating system plays a very important role. If the gating system is poorly designed, it may increase the porosity of the casting. It mainly concerns castings of complicated shapes with different wall thicknesses [1, 3].

Impurities in copper and its alloys can be divided into gaseous and non-gaseous. When making castings of copper alloys, it is often referred to as the so-called hydrogen disease. The cause of hydrogen disease is the fact that hydrogen has a high ability to diffuse towards copper at elevated temperatures. Hydrogen, reacting with cuprous oxide, forms water vapour, which results in the formation of a large porosity of the casting. Hydrogen in the form of bubbles comes to the surface of the liquid metal even before it solidifies [4, 5]. Many years of research have so far failed to establish the relationship between the solubility of hydrogen in copper alloys and its porosity. Literature data show that for the porosity of a copper alloy casting to occur, a 40 % excess of oxygen is needed, so the formation of porosity in copper alloy castings is closely related to the activity of hydrogen and oxygen [6, 7]. Many foundries have a serious problem with hydrogen contamination of copper alloy castings. For making copper alloy castings, scrap is most often used, which is already contaminated, so the quality of the batch material differs from the quality of the finished, marked ingots. Unfortunately, the purchase of purified, high-quality alloys is too expensive, so the best and cheapest method is to develop an effective method for dehydrogenating copper alloys [3].

RESEARCH METHODS, RESEARCH MATERIAL

B10 bronze scrap was used to investigate the effect of the dehydrogenation method on the porosity and tensile strength of the copper alloy castings. The scrap pieces were melted in an induction furnace to 1 050 ^{o}C. The first batch of remelted scrap was poured directly into the die and heated to the temperature of 300 ^{o}C to check the degree of corrosion of the casting. Another batch of melted scrap metal was placed in a vacuum furnace along with a crucible. After turning on the vacuum pump, the surface of the liquid metal was boiling. After 15 seconds, the surface of the bath became still, which meant that the metal was degassed from the hydrogen. The calmed metal was poured into the heated mould. Another batch of molten scrap metal was blown with compressed air.

A glass tube is inserted into the molten metal. Compressed air was introduced into the metal bath for 300 s. To avoid contamination of the metal with oxygen, additionally, phosphor copper was added to the crucible in

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the amount of 0,05 % by weight of the liquid metal. The thus purified metal was poured into the heated mould. Another attempt to remove hydrogen was to introduce the Ecosal Cu440 salt into the alloy. The refiner was added to the melt at 5 %. After the refining treatment, the alloy was again poured into the previously heated die. For comparative purposes, a cast was also made of melted ingots of B10 alloy.

Castings were made in the form of bars with a diameter of 10 mm. After all the castings solidified, they were visually examined to determine their porosity on the surface.

To check the dehydrogenation effects of the samples, porosity tests were carried out on the castings. In order to determine the porosity of the cast samples, it was necessary to determine the density of each sample. The density test was performed with the use of a hydrostatic balance. It consisted in conducting measurements of the weight of samples in air and water and then calculating the porosity of the tested samples. After determining the porosity, the specimens were subjected to the tensile strength test. Metallographic specimens of the cast samples were also made to observe the degree of gasification of the samples inside the castings.

RESEARCH RESULTS

Figures 1 and 2 show examples of photos of the casts made.

The made castings differed significantly in the smoothness of the surface. The best surface of the casting was that of a sample cast from ingots of the B10 alloy. After dehydrogenation of scrap, the best surfaces were found for those refined with Ecosal Cu440 salt. The surfaces of the samples were smooth with no visible signs of gas bubbles. The worst surface was that of a sample cast from scrap. Surface defects arose as a result of the diffusion of hydrogen in the form of bubbles onto the surface of the liquid metal before it solidified. Hydrogen bubbles are trapped on the walls of the mould and in contact with oxygen, they form water vapour that causes surface porosity.

Figure 1 A casting made of melted ingots of B10 alloy

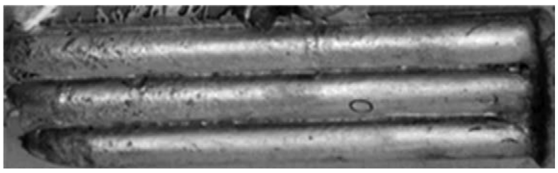

Figure 2 The casting is made of melted B10 alloy scrap, after blowing it with compressed air.

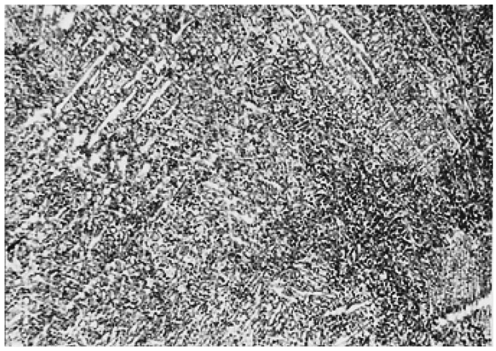

Figure 3 The microstructure of the casting made of remelted ingots of B10 alloy, magnification 100 x

Figure 4 The microstructure of the casting after blowing B10 scrap with compressed air, magnification of 100 x

Figures 3 and 4 show examples of the microstructure of the castings made.

No gas porosity was observed when observing the microstructure of the castings made. There were also no non-metal inclusions in any of the castings made. While the outer surface of the cast made of remelted scrap basically disqualified it due to large unevenness, the internal structure did not show significant porosity. The microstructure analysis showed only slight changes in the structure of the tested castings.

Figure 5 presents the results of the cast porosity tests.

The porosity tests confirm the conclusions drawn from the observation of the sample surface. When as-

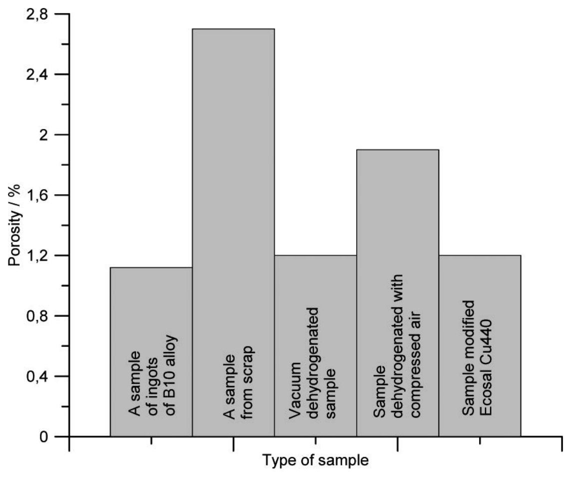

Figure 5 The results of porosity tests of the castings made.

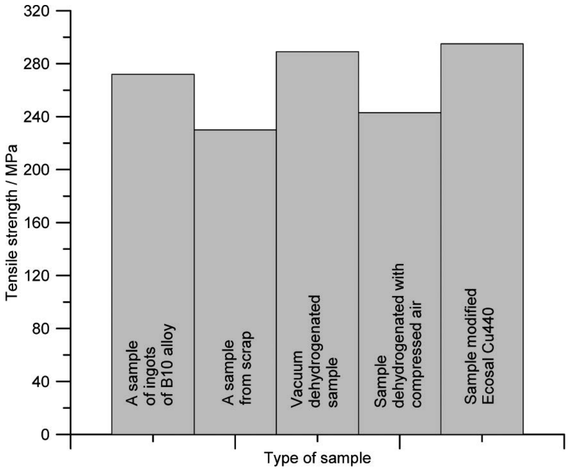

Figure 6 The results of the tensile strength tests of the castings made.

sessing the effectiveness of the casting dehydrogenation methods, it can be stated that the best method of degassing the liquid bath was the method of refining with Ecosal Cu 440 salt and the method of vacuum dehydrogenation. The average porosity of the castings amounted to only 1,2 % in both cases. The porosity of the cast made of remelted ingots of the B10 alloy was 1,12 %, so it was slightly lower than after dehydrogenation with salt and vacuum. Samples made of remelted scrap were characterized by a porosity of 2,7 %, and the porosity of samples blown with compressed air was 1,9 %.

Refining with Ecosal Cu440 salt gave very good dehydrogenation results, however, the addition of salt caused significant wear of the furnace crucibles in which the scrap was melted. Consideration should be given to using less salt for refining.

After the porosity was determined, all cast samples were subjected to a tensile strength test to determine the effect of the dehydrogenation treatment on this property. The results of the tests are shown in Figure 6.

The results of the tensile strength tests confirmed that the best results of purifying the alloy from hydrogen and other impurities are achieved by the application of a vacuum during scrap remelting or the use of refining salts. The tensile strength of the salt-refined samples was 295 MPa and was greater than the strength of the samples cast from remelted ingots.

SUMMARY

After carrying out the research, it should be concluded that by making castings of alloys prone to competition, such as alloy B10, one should avoid remelting the scrap. If possible, make castings only from marked ingots of the alloy. Since the purchase of ingots significantly increases the costs of making the castings, special care should be taken to clean scrap and use only recycled scrap. The best methods to get rid of gas porosity in the casting are vacuum dehydrogenation or refining the alloy with salt. The use of an appropriate method of hydrogen removal from the metal bath improves the mechanical properties of the B10 alloy.

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Note: The professional translator for the English language is Agnieszka Chmielewska,