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Washing Angle Polyterm by Clean Zinc and Zn-Mo-Al-Mg Melted Compressed Co-W Powder

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***Abstract* – The dependence of the wetting angle of pure Zn (99.9%) and Zn-Mo-Al-Mg (Serbian bronze) of compressed Co-W powder on the temperature in an atmosphere of pure He (grade A) was studied using the large "lying" drop. Wetting angle was measured in the CorelDraw x12 software environment. Found: 1) With an increase in temperature, the wetting angle decreases slightly. This is because the melt drop does not spread over the surface of the substrate but is impregnated into the substrate; 2) Zn additives reduce the wetting angle. A repeated study of the wetting angle of the samples showed that in the case of pure zinc, the results of the two experiments are in good agreement, and in the case of the "Serbian bronze" the results differ by 9 degrees, which is associated with the concentration and porosity of the substrate.**

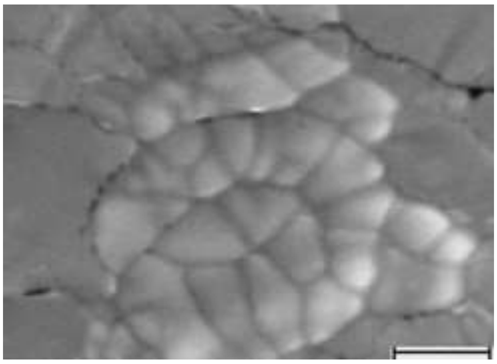
Keywords – wetting angle polytherms; pure Zn and Zn-Mo-Al-Mg melt; dropping method; compressed Co-W powder; solders.

I. INTRODUCTION

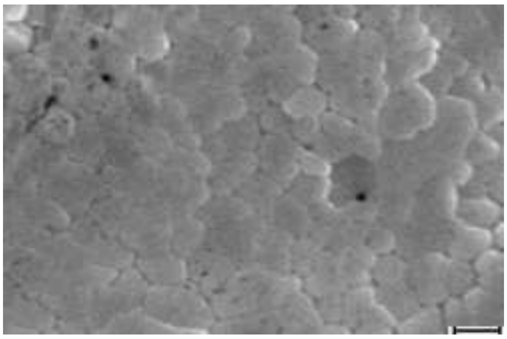
The addition of various elements to the zinc melt leads to a change in its properties. Thus, with the introduction of aluminum, the parameters of the galvanizing process are improved: the fluidity of the zinc melt increases, the alloys have good ductility. The zinc melt containing an additive of aluminum is much less oxidized, since a protective film of Al2O3 is formed on its surface, which, interacting with ZnO, protects the melt from oxidation. Molybdenum is added to Zn-Al alloys, which are highly susceptible to corrosion to metallic substances in order to improve the strength properties, as well as to improve the strength and increase the resistance to hydrogen embrittlement. Magnesium is introduced into the zinc melt (in small amounts up to 0.3%) in order to avoid intergranular corrosion in the presence of residual impurities of lead, tin and cadmium. However, at high concentrations, magnesium reduces fluidity and leads to cracking.

Comprehensive studies of the physical properties of zinc with the addition of aluminum and other elements are of undoubted interest from both scientific and practical points of view. Zinc-aluminum alloys have several advantages: they are relatively inexpensive; at small energy costs it is easily processed without environmental pollution; find wide practical application as a metal-anode of zinc-air electric batteries, new hybrid materials [1,2].

The work [3] presents the results of studying the phase alloy, the structure of grains and subgrains, as well as the microscopic strength of rapidly crystallized Zn-Al alloys, obtained by the method of one-sided cooling. In this work, alloys with Al additives from 0.25–12 at. % obtained by fusing components of not less than 99.99 in quartz capsules. The study of the surface morphology of rapidly crystallized Zn-Al alloys showed that the side closest to the mold consists of cells of a predominantly hexagonal type, which were also observed in a smaller version on the smooth side of the film. The sizes of these formations ranged from 0.5 to 3 microns. It should be noted that in the case of films of pure Zn, cellular structures were not found.



a)



b)

Fig. 1. Photomicrographs of the surfaces of the melt films Zn - 1 at. % Al. (a), (b) - sides B and A. Data [5]

It is interesting to note that there is a significant hardening of the material in Zn-Al alloys enriched with aluminum. Thus, in [4], an attempt was made to substantiate this phenomenon within the framework of a general theory using the example of Al-18.5 at. % Zn.

M The addition of various elements to the Zn-Al alloy changes the morphology, structure, spatial location and size of the precipitates (embryos). For example, the introduction of Mg into the melt improves the wear resistance of Al-Zn alloys and the corrosion resistance of the Al-Zn alloy coating during hot dip galvanizing.

At present, alloys of iron group metals, co-precipitated with tungsten, Co-W [7], which are promising for industrial use as thermo-wear-resistant magnetic-hard materials [8, 9] with high microhardness, are of great interest. Such alloys can be an alternative to chromium coatings [10–13].

The effect of cobolt additives on the strength characteristics and mechanical properties of tungsten carbide-based ceramics in [14]. It is noted that these dependencies have opposite trends.

Zn-4% Al alloy and systems based on it [15] are traditional cast alloys, since they have high fusibility, easy finishing, good mechanical properties, and are not susceptible to intergranular corrosion. The microstructure of such alloys usually consists of areas occupied by a solid solution of Zn-Al, surrounded by a eutectic structure. It should be noted that the eutectic alloy Zn-5% Al in practice is most often not used due to its extreme fragility.

II. Results

All experiments were conducted on a vacuum unit (Fig. 2.) described in detail in [5]. Figure 2 shows a diagram of the subcolumn device of the experimental setup.

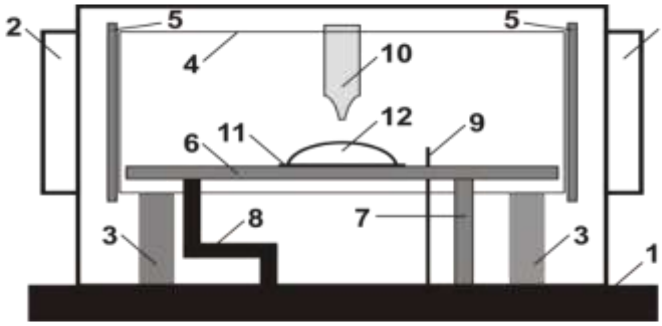


Fig. 2. Diagram of subcollege device. 1. The basis of the installation; 2. Windows to observe the experiment; 3. Electrodes; 4. Oven; 5. Shutters; 6. Adjustable "table"; 7. Fixed leg "table"; 8. Movable leg "table"; 9. Thermocouple

Before the start of the experiment, the vacuum chamber was pumped out to a residual vapor phase pressure of 102 Pa, then He was launched into the chamber. A drop of the melt under study was fed to the substrate through a curved quartz capillary, after which the profile of the drop was photographed. At this temperature, the drop was kept for 1 minute, and the time interval was 2 minutes. Profile pictures of the drop were taken using a digital camera. Measurement of the wetting angle was made in the environment CorelDraw x12.

Samples for the study were obtained from a zinc alloy produced at the "Electrozinc" plant (Vladikavkaz, Russia). The main additives to zinc (98.13 wt.%): Molybdenum (0.597 wt.%), Aluminum (0.560 wt.%) And magnesium (0.249 wt.%).

TABLE I. The composition of the "Serbian bronze"

Element	weight. %	determination error
Zn	98.13	0.06
Mo	0.597	0.030
Al	0.560	0.030
Mg	0.249	0.027
Sn	0.0859	0.0088
Si	0.0679	0.0088
Fe	0.0660	0.0033
Ar	0.0569	0.0060
Bi	0.045	0.017
Ca	0.0367	0.0025
K	0.0184	0.0028
Ti	0.0183	0.0017
S	0.0167	0.0021
Gd	0.0152	0.0054
P	0.0117	0.0033
Cr	0.0110	0.0024
Cu	0.0108	0.0047
Mn	0.0045	0.0022

Table 1 shows the quantitative composition of the Serbian Bronze, from which it is clear that Mo (0.597 wt.%), Al (0.56 wt.%), Mg (0.246 wt.%) Are the main additives to Zn.

Graph 3 shows the polytherm of the wetting angle of pure zinc compressed Co-W powder. The graph shows that the wetting angle varies slightly, i.e. Zinc does not wet this substrate. This is because there is an oxide film on the surface of zinc, since zinc is well susceptible to oxidation.

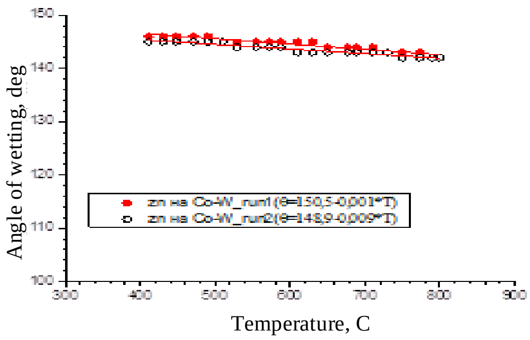


Fig. 3. Polytherms of the wetting angle of the substrate of extruded Co-W powder with a melt of pure Zn.

The wetting angle is influenced by the fact that the substrate is a pressed powder. And we assume that a drop of the sample under study does not spread over the surface but is impregnated into the depth of the substrate. This is confirmed by the fact that traces of impregnation are found in the transverse section of the sample. For the studied samples, we repeated the result 2 times. In the case of pure zinc, the result of both experiments coincides well with each other, the difference between which is 2 degrees.

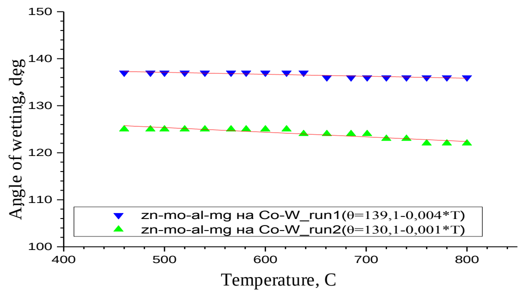


Fig. 4. Polyterms of wetting angle of the substrate of extruded Co-W powder with Zn-Mo-Al-Mg melt

In Figure 4 in the case of Serbian bronze, there is a slightly varying wetting angle, but the results of the two experiments differ sharply from each other. This may depend mainly on the substrate. Substrates may have different concentrations. Also important is the porosity of the surface.

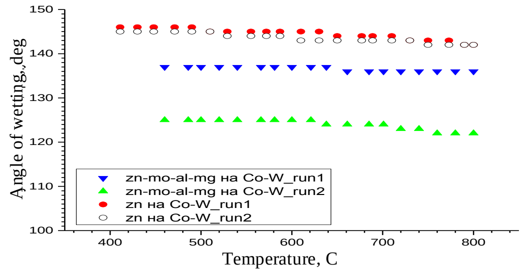


Fig. 5. Polytherms of wetting angle of the substrate of extruded Co-W powder with pure Zn and Zn-Mo-Al-Mg melt

Figure 5 shows the final schedule. It is shown that additives to zinc reduce the wetting angle.

TABLE II. EQUATIONS FOR Θ BY THE LEAST SQUARES METHOD

№	Melt	Equation
1	Zn (обмер 1)	Θ=150,5-0,001*T
2	Zn (обмер 2)	Θ=148,9-0,009*T
3	Zn-Mo-Al-Mg (обмер 1)	Θ=139,1-0,004*T
4	Zn-Mo-Al-Mg (обмер 2)	Θ=130,1-0,001*T

III. Conclusion

Using a droplet method in a helium atmosphere using the CorelDraw x12 software package, we obtained polyterms of the wetting angle of a substrate made of compressed Co-W with pure zinc and industrial zinc alloy with small admixtures of molybdenum, aluminum and magnesium in the temperature range from the melting point to ~ 8000C. Equations for the wetting angle by the least squares method are obtained.

It was found that this substrate is not wetted in any of the studied cases.

Based on the analysis of literature data in the zinc-aluminum and zinc-aluminum-metal system, the need for more intensive study of the wetting angle, which are widely used due to the unique combination of properties, has been established.

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