EFFECT OF HEATING CONDITIONS ON STRUCTURAL CHANGES IN INGOTS OF ALLOY AMg5

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The question of improving the properties of semifinished products made of alloys AMg5 and AMg6 used extensively in industry has been the subject of a considerable amount of work, but currently the problem of obtaining good processing characteristics for these alloys, which are difficult to work, is not completely resolved. With prolonged heating (even at low temperature) in the processes proposed for manufacturing semifinished products of alloys AMg5 and AMg6, there is decomposition of the solid solution of magnesium in aluminum, particularly in the area of welded joints. Precipitation of β'-phase in the form of continuous chains leads to a sharp reduction in corrosion resistance for structures [1]. Analysis of data [2-6] showed that the process adopted for obtaining cold-worked sheets of alloys with 4-7% Mg does not provide the optimum combination of corrosion resistance and mechanical properties. The properties of alloys AMg5 and AMg6 are affected mainly by those processing factors which cause distribution of β-phase in their structure [7]. For alloy AMg5 the recommended optimum temperature range for annealing is 310-335°C, as a result of which a uniform distribution of β-phase throughout grains and high corrosion resistance are obtained [8]. Consequently, with correct selection of casting and heat-treatment schedules it is possible to obtain good workability for alloys of the AMg type. There are no data in the literature for the effect of casting schedules on solid solution stability for these alloys.

The aim of the present work is to study the effect of casting and heat-treatment schedules on the structure and properties of alloy AMg5. Casting and heat-treatment schedules

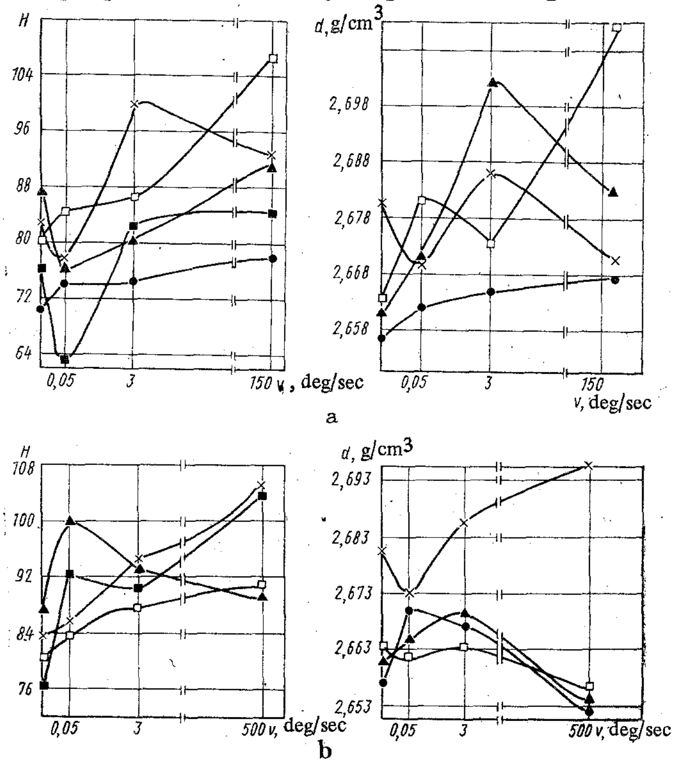

Fig. 1. Effect of cooling rate after annealing at 320°C with soaking for 3 (a) and 10 h (b) on alloy AMg5 microhardness and density: ×, ▲, ●, □, ■) ingots 1, 2, 3, 4, 5 respectively.

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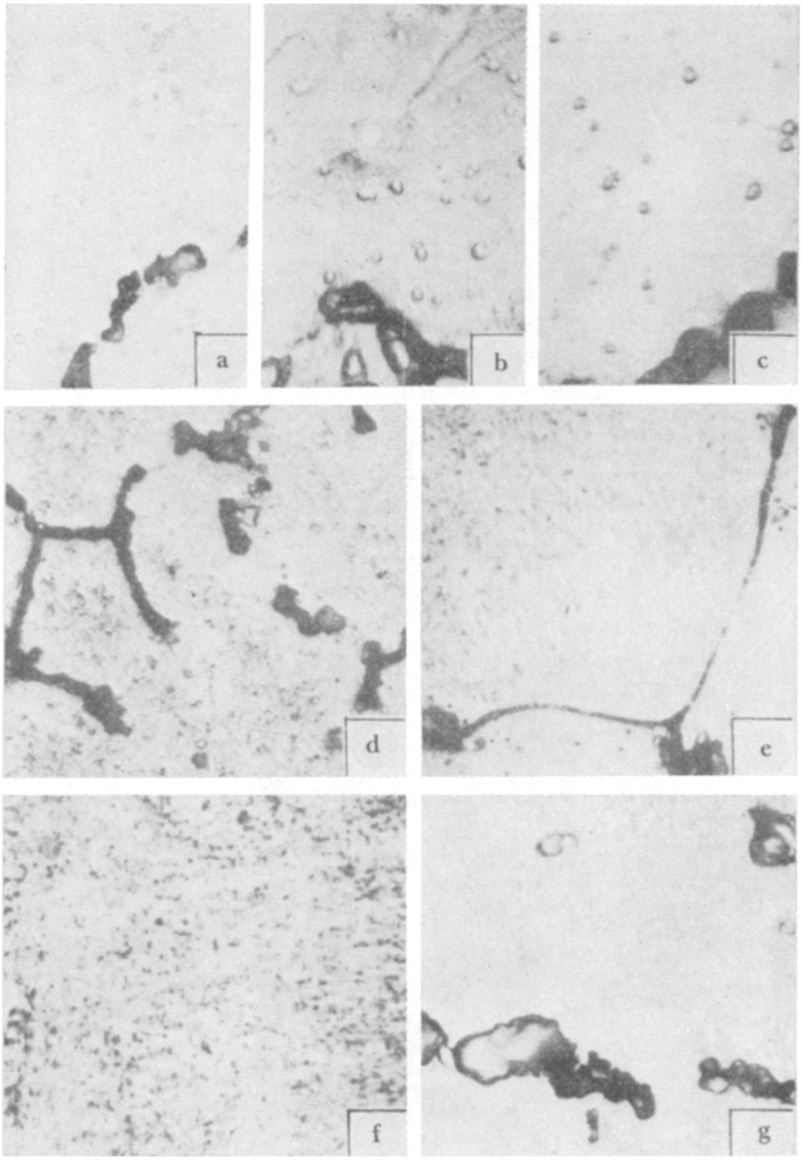

Fig. 2. Microstructure of alloy AMg5 in the cast homogenized (490°C for 6 h) condition (a-c) and after annealing at 320°C for 3 h and cooling at a rate of 0.05 (d, e) and 150 deg/sec (f, g). (×1800): a, e) ingot 1; b, d) ingot 2; c, g) ingot 4; f) ingot 3.

for ingots of alloy AMg5 prepared under industrial conditions are given in Table 1. Heat-treated specimens of alloy AMg5 were tested for resistance to intercrystalline cracking according to GOST 9.021-74. Density was determined in specimens 20 × 30 × 30 mm in size by hydrostatic weighing on analytical scales. Microhardness was measured in PMT-3 equipment with a load of 0.2 N. Alloy microstructure was studied by means of an optical microscope at magnifications up to ×2700.

The properties and structure of AMg5 alloy in the annealed condition are affected both by temperature and by casting rate (Fig. 1). The complex nature of the dependence of microstructure and density for alloy AMg5 on casting and heat treatment schedules is mainly connected with structural transformations in solid solution based on aluminum (Figs. 2 and 3). In the original condition all of the ingots of alloy AMg5 have a homogeneous structure of solid solution with a different degree of alloying element supersaturation, which depends on the schedule for preparing ingots; precipitates of insoluble β-phase are also observed (see Fig. 2a-c).

TABLE 1

Ingot	Casting temperature, deg C	Casting rate, mm/min
1, 5	705	130
2	720	130
3	720	160
4	730	180

Notes: 1. Chemical composition of melt I (ingots 1-4): 5.7%, Mg; 0.6% Mn; 0.4% Fe; 0.3% Si; 0.06% Ti; balance aluminum. Melt II (ingot 5) differs from melt I in magnesium and manganese content: 5.3 and 0.5% respectively.
2. After annealing, specimens of each ingot were cooled at rates of 0.05, 3, 150, and 500 deg/sec; annealing duration 3 and 10 h.

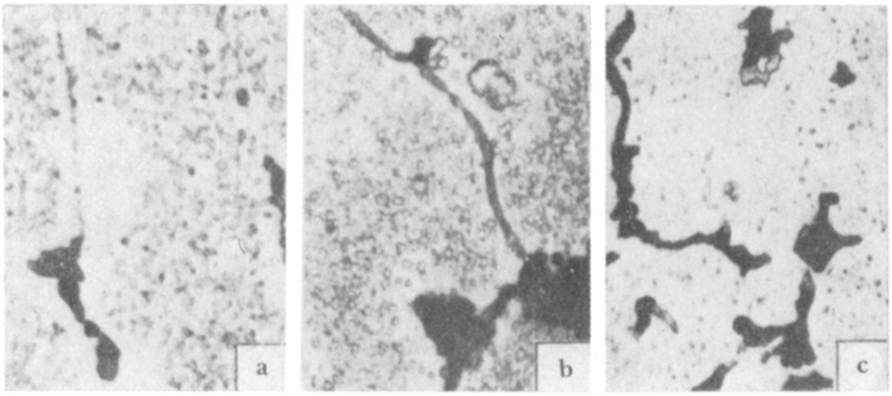

Fig. 3. Microstructure of alloy AMg5 after annealing at 320°C for 10 h and cooling at a rate of 500 deg/sec. (×1800): a, b, c) ingots 5, 1, 2 respectively.

The effect of magnesium and manganese content in alloy AMg5 is revealed in the redistribution of alloying elements in solid solution and insoluble phases; during annealing of ingot 5 specimens, decomposition proceeds continuously and it is localized, i.e., regions are observed impoverished in alloying elements, which points to a marked tendency for melt II to corrosion failure in contrast to melt I (ingots 1 and 2) (Fig. 3).

As a result of an increase in casting temperature up to 720-730°C the degree of solid solution supersaturation with alloying elements increases, and during heat treatment there is more intense decomposition, i.e., generally continuous (see Fig. 2d, e).

With cooling of ingots at a rate of 500 deg/sec after annealing at 320°C, in specimens of ingot 2 dispersed particles of excess phases were distributed less densely than in specimens of ingot 1 (Fig. 3b, c). With an increase in casting rate to 180 mm/min the corrosion resistance of alloy AMg5 is reduced, and this is explained by the presence of zones impoverished in alloying elements (see Fig. 2g). The resistance of alloy AMg5 to corrosion also decreases with an increase in its cooling rate after soaking at 320°C for 3 and 10 h, which may be explained by a reduction in the uniformity of distribution and degree of dispersion of precipitating particles.

CONCLUSIONS

1. Schedules for preparing ingots of alloy AMg5 affect the distribution of alloying elements in α-solid solution based on aluminum and insoluble phases; with an increase in melt temperature the content of magnesium in solid solution probably becomes greater than in excess phases; after casting at increased rates the basic amount of magnesium remains in excess phases.

2. During annealing of alloy AMg5 castings there is decomposition of solid solution whose character is affected by the original cast structure; a more supersaturated solid solution decomposes more intensely. An increase in annealing duration from 3 to 10 h provides more uniform distribution of alloying elements in the alloy.

3. The nature of solid solution decomposition during annealing has a marked effect on the corrosion resistance of alloy AMg5 ingots; a reduction in the degree of the dispersion of precipitating particles and the uniformity of their distribution leads to a reduction in resistance of this alloy to corrosion.

4. The corrosion resistance of alloy AMg5 is also reduced with an increase in cooling rate after annealing at 320°C.

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EFFECT OF SECOND-STAGE SCHEDULES OF TWO-STAGE AGING ON THE STRUCTURE AND PROPERTIES OF ALLOY V96Ts1

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The main goal in this work is a comprehensive study of the change in strength properties and corrosion resistance of alloy V96Ts1 during heat treatment and also establishing the relationship between these properties and alloy phase composition by electron microscope studies of the fine structure.

As the results of recent works [1-3] have shown, in order to improve the corrosion resistance of high-strength aluminum alloys in the system Al–Zn–Cu–Mg, it is desirable to use them after the so-called softening aging schedules, which also promote an increase in fracture toughness and a reduction in crack development rate. Similar results might be expected with the use of isothermal hardening, since the structure of aluminum alloys in this case, as in the stage of coalescence aging, is characterized by the presence of stable phases and also a reduction in residual stresses compared with their values after normal hardening and single-stage aging.

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