Crystallization at high rates (~$10^6$ deg/sec) provides anomalously supersaturated solid solutions of refractory metals in aluminum [1-3]. This makes it possible to create a new group of special alloys.

However, these studies were carried out under laboratory conditions. In practice high cooling rates during crystallization may be obtained by atomizing an alloy in air in the form of 400 to 50 μm size powder [4] or centrifugal casting in the form of granules from 4 to 1 mm in diameter [5]. Under industrial conditions it is possible to obtain alloys crystallized at cooling rates of ~$10^5$-10$^4$ deg/sec [6]. So granules with a diameter of 4-5 mm are crystallized at a rate of $10^3$ deg/sec, and with a diameter of 1.0-1.5 mm at $10^4$ deg/sec. The higher the crystallization rate then the better are the properties of the alloy containing refractory elements. Improvement of equipment for casting granules has made it possible to obtain under industrial conditions 0.1 to 1.0 mm size granules and to increase the cooling rate during crystallization to $10^5$ deg/sec.

In this article using the example of the Al–Mn system consideration is given to the effect of increased cooling rate to $10^5$ deg/sec on the structure and properties of granules and pressed bar obtained under industrial conditions.

It has been shown [6] that during crystallization with a cooling rate of $10^4$ deg/sec a supersaturated solid solution of manganese in aluminum forms with 5.0% Mn. On increasing the manganese content of the alloy primary intermetallics (Fig. 1a) appear in the granule structure. An increase in cooling rate to $10^5$ deg/sec makes it possible to obtain in 300-600 μm granules an anomalously supersaturated solid solution of manganese in aluminum containing up to 6.7% Mn (Fig. 1b). There is a reduction in dendrite cell size in the alloy from 7-8 to 2-4 μm. In the structure of individual 200-100 mm diameter granules apart from solid solution there are primary intermetallics in the form of branched dendrites (Fig. 1c). Results of studying the change in lattice parameter and microhardness (Fig. 2a) for a solid solution of alloy Al–6.7% Mn in relation to granule diameter showed that in granules 300-500 μm in diameter much more supersaturated solid solution of manganese in aluminum forms than in 1000-μm-diameter granules. With a reduction in granule diameter from 500 to 300 μm the solid solution lattice parameter is unchanged. Two solid solutions form in 200-100 μm diameter granules; anomalously supersaturated and combined with manganese in which primary intermetallics are observed. Formation of primary intermetallics in these granules may be explained in the first place by the fact that drops of liquid metal begin to crystallize in the air before they reach the coolant in the equipment used. With cooling rate increased to $10^5$ deg/sec the boundary for maximum supersaturation of aluminum with manganese moves in the direction of greater manganese concentration. Figure 3 shows the change in lattice parameter and microhardness for granules of alloys in the system Al–Mn obtained with crystallization at different cooling rates. The appearance of primary intermetallics in the granule structure leads to a reduction in supersaturated α-solid solution of manganese and correspondingly to an increase in lattice parameter [6]. The maximum supersaturation of manganese solid solution in aluminum with 9% Mn was obtained by casting the alloy into a water-cooled copper mold, and this corresponded to the results in [2].

Some deviation in solid solution lattice parameter from the law of additions for manganese in the alloy is explained by appearance in the granule structure of eutectic inclusions located along boundaries of dendrite cells and grain boundaries.

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Results of studying the change in microstructure and properties of granules with the solid solution supersaturated to a maximum with manganese (6.7\% Mn) in relation to heating temperature showed that marked changes in structure occur after heating to 250\°C with soaking for 2 h. In the first place there is coalescence of eutectic inclusions along boundaries of grain and dendrite cells, and at higher heating temperatures there is breakdown within dendrite cells and their coalescence. It should be noted that an increase in $\alpha$-solid solution supersaturation with manganese leads to a reduction in its stability and to more complete breakdown at high temperature (see Fig. 2b). The strengthening effect during heating increases and shifts in the direction of lower temperature (Fig. 2b).

On the basis of data for the change in lattice parameter and microhardness of the granule solid solution it may be concluded that in order to obtain maximum strength properties for pressed semifinished products granule deformation should be carried out at the lowest possible temperature.