ROLLING OF SECONDARY CASTING ALUMINUM ALLOYS

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Increased output of semiprodcts made of aluminum and alloys based on it require a larger stock of secondary aluminum raw material. However, large fluctuations in chemical composition and insufficiently careful sorting of aluminum scrap at enterprises processing secondary metals have the effect that most secondary metals are low-quality casting alloys with high content of silicon, copper, magnesium, zinc, iron, and other elements. The poor mechanical properties and practically zero ductility of these alloys make them quite unsuitable as material of semiprodcts obtained by conventional methods of metal forming, and that creates great difficulties when materials based on them are to be used.

One of the promising trends of improving the properties of metals and of finding a fundamentally new technology of processing them is casting with high cooling rate of the melt. This greatly enhances the strength and ductility of many materials and improves their operational characteristics. A special place among the processes distinguished by high cooling rates in crystallization is held by the granulation of metals and alloys [1].

High crystallization speeds (10^3-10^4 deg/sec) of alloys in granules ensure a number of important changes in their structure and properties among which the most significant ones are the rapid refinement of the dendritic cells and intermetallic phases, reduction of liquation inhomogeneity, change of solubility of a number of alloying and impurity elements in the solid solution. As a result of such changes the granulation of aluminum alloys and their subsequent pressing or rolling yield formed semiprodcts of cast alloys or alloys with low ductility, and that opens up possibilities for the rational utilization of cheap secondary aluminum raw material. Specifically, rolling of granules does not ensure good technical and economic indices only, it also provides the possibility of obtaining unique materials with special properties.

The present work is a study of the influence of the main parameters in the rolling of granules of secondary casting aluminum alloys on the properties of the rolled stock. The investigations were carried out with the alloy AK5M2 (GOST 1583-73) containing a considerable number of different alloys with a wide range of concentrations. The rolling process was investigated on two-high rolling mills with roll diameter 170 and 300 mm. The rolling speed was changed within the limits 0.045 to 0.30 m/sec. The obtained strips were 40-120 mm wide and 0.7-2.5 mm thick. The pressure of the metal on the rolls was measured with the aid of load cells, the forward slip was determined by the method of cores.

It was established that the mechanical characteristics and quality of the obtained rolled stock of granules of secondary casting aluminum alloys are affected by many technological factors, mainly the heating temperature of the granules before rolling, deformation, rolling speed, temperature of the surface of the rolls. The best mechanical properties are found in rolled stock obtained from granules heated before rolling to 450-500°C (Fig. 1). In that case the strips do not have cracks along their edges and are distinguished by the good quality of the surface. When the temperature of the granules before rolling is further raised, the ductile characteristics of the material are impaired, obviously because the eutectic with low melting point melts [2]. It is therefore inadvisable to heat the granules of alloy AK5M2 before rolling to more than 510°C. On the other hand, heating to less than 450°C does not ensure the necessary level of mechanical properties of the rolled stock, and the ductility of the alloy does not suffice for attaining the indispensable deformation of the granules and their good welding together. Besides that, when the heating temperature of the granules exceeds 450°C, the contact stresses are considerably reduced and there is more complete liquation of the films adsorbed on the surface of the granules.

No less important is the influence of the degree of deformation of the granules in shape rolling on the properties of the rolled stock. To obtain rolled stock with good mechanical characteristics, the degree of deformation must be such that the oxide film on the granules is completely destroyed and air is most completely removed from the forming strip. When
reduction is increased, the granules are vigorously deformed, and their specific surface increases considerably. As a result the oxide film covering the surface of the granules is destroyed and on the surface there emerges metal free of oxides. High temperature and considerable pressure ensure firm welding together of the granules [3, 4].

Greater reduction in shape rolling of granules increases the maximal normal contact stress. To obtain a porefree strip suitable for further processing, contact stresses of more than 1000 MPa have to be induced. The running rolling pressure on rolls with 170 mm diameter is 150-160 kN per 10 mm width of the strip.

Equally important is the influence of the surface temperature of the rolls on the properties of the rolled stock. Higher temperature reduces the strength characteristics and considerably enhances the ductility of material in the deformed state. When the surface temperature of the rolls is raised from 20 to 300°C, relative elongation of the strips increases three or four times.

Higher surface temperature of the rolls entails higher temperature of the metal in the area of deformation, and in addition also higher temperature of the strip emerging from the rolls; this creates conditions necessary for processes of loss of strength to take place. The higher the surface temperature of the rolls is, the higher is the temperature of the emerging strip, and the more fully does the process of loss of strength proceed. Consequently, by changing the surface temperature of the rolls in the rolling of granules of aluminum alloys and leaving the other parameters constant, we can obtain rolled stock with specified thickness and with certain mechanical characteristics.

The influence of subsequent deformation on the properties of rolled stock of granules was studied after its annealing and cold rolling in several passes. At each stage of rolling the mechanical characteristics were measured. It was established that cold deformation improves considerably the structure and mechanical properties of the rolled stock. With increasing degree of cold deformation the tensile strength of the strip increases monotonically to 430-450 MPa (Fig. 2). After annealing it attains 270 MPa with 60-65% reduction, and after further reduction it remains almost unchanged. Relative elongation attains its maximum at 60-65% reduction, after further reduction it decreases in the case of strain-hardened strips and remains unchanged after annealing.

Cold deformation of strips made from granules leads to further destruction of the oxide films on the surface of the granules, and that is accompanied by an increase of the area of their metallic contact, welding of micropores and microcracks, improvement of the mechanical properties of the rolled stock. This process is concluded when overall reduction attains 60-65%, which corresponds to the stabilization of the characteristics of annealed rolled stock.

The level of the mechanical properties of rolled stock obtained from granules of alloy AK5M2 ensures an overall reduction of more than 55-70% in subsequent cold rolling. This makes it possible to obtain strips 0.4-0.5 mm thick from stock 1.1-1.3 mm thick without intermediate annealing.