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TECHNOLOGY OF PRODUCING FIBROUS STRUCTURE WIRE FROM CHIPS OF ALUMINUM–MAGNESIUM–SILICON ALLOYS

A technological scheme for processing the scrap of aluminum–magnesium–silicon alloy in the form of friable chips into rods and wire is introduced. This scheme is based on the powder metallurgy methods. The characteristic structure and the level of mechanical properties of the produced wire are denoted.

Keywords: friable chips, briquetting, combination of rolling and pressing, drawing, fibrous material, structure, mechanical properties.

A complex composite material is implied in cases when wire is not made of compacted metal material. This material has a metal coating consisting of a hard plastic body and a powder core, which is a friable mixture of heterogeneous particles [1]. During mechanical processing, the metal coating is in a complex interaction with the powder core; this causes complex movement of the powder particles and their elastic-plastic interaction under external load.

According to the suggested technology, making wire from friable fine chips (filing) of aluminum alloy АД31 and putting it into the metal coating is not accomplished. The process of making the final product can be divided into two parts:

– the technological scheme of producing an intermediate workpiece for drawing, which includes the preparation of chips for compacting, briquetting, briquette heating for extrusion, and hot extrusion for the rod of a specified diameter;

– the technological process of making wire consisting of multiple repeated operations of drawing the workpiece through dies and other auxiliary operations.

The method of chip processing in which the quantity of secondary raw material is quite high provides a higher yield ratio of metal chips in comparison with molting. Besides, energy consumption and harmful environmental impact are being reduced, which is a key issue for any type of industry.

It is well known that the suitability of metal chips for making press-items and wire depends on the compressibility during briquetting. The traditional scheme of pressing in rigid molds for making lengthened briquettes of cuboids form with height to width ratio 1 and length to width ratio 10 is not effective (such a ratio is determined by specific character of the equipment and the combination of rolling and pressing). Due to comparatively low briquettes density and cohesion of chips particles there is high probability of fillets rupture (breaking) during the pressing-out.

Briquetting of chips *2* is made in molds (fig. 1) consisting of upper *1* and lower *4* plugs, split matrix *3* and chase *5* with sloping contact surfaces. The experiment shows that briquetting pressures for providing integrated briquette density of 70–80 % must not be lower than 80–100 MPa.

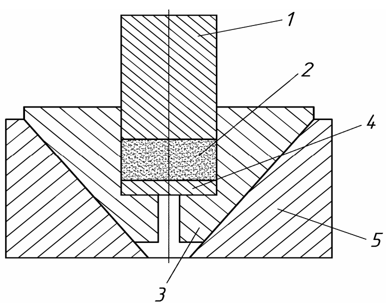


Fig. 1. The scheme of the briquette making mold for combined rolling and pressing

Fig. 2 shows the equipment for combined rolling and pressing to manufacture press-items. The stand consists of two steel frames *1* fastened by tie bolts *2* and mounted on the same base with the engine, gearbox, reducing unit (not shown in the figure). In the bronze tilting pads of sliding bearings *3* there are shafts *4*, on which fastened rollers *5* make the close roll-pass. Adjustments for the roller gap are made by special device of simultaneous and divided rotation of the push screws *6*.

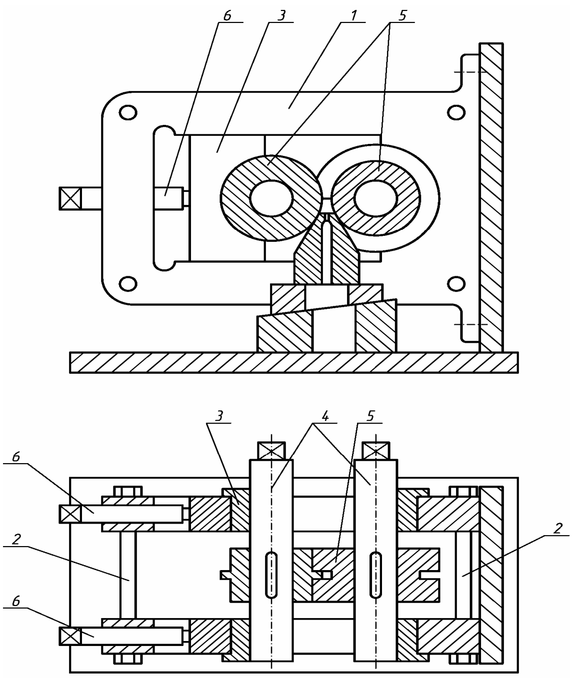


Fig. 2. Laboratory equipment for combined rolling and pressing of aluminum alloys on the basis of rolling mill DUO200

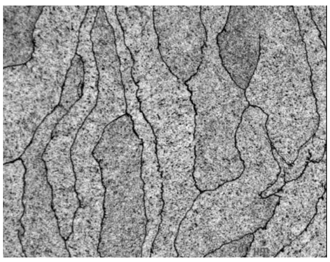
Before being placed into the rollers, the briquettes are heated to a temperature of 500 ± 20 ^{0}C in a furnace. At the same time the rollers are heated to the temperature of 80–100 ^{o}C. Briquettes inputting to the close roll-pass (fig. 3) is accomplished successively with the reduction of pauses up to their minimization.

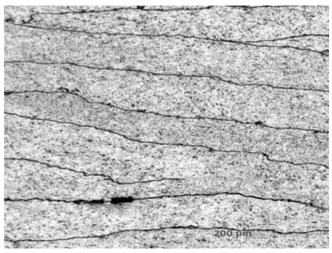
A 7–8 mm gap between the rollers makes the density of the chips compact to 85–90 %. Therefore, the compacted material now comes to the area of pressing-out and this makes the deformation chips settling crosswise the pass easier.

The diameter of the holes for making press-items is 7 and 9 mm and that corresponds to the drawing coefficients 8 and 5.

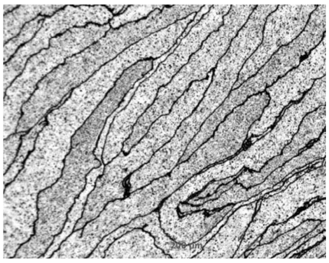
Fig. 3. The moment of inputting billet on the rollers

Diameter of a 9 mm rod

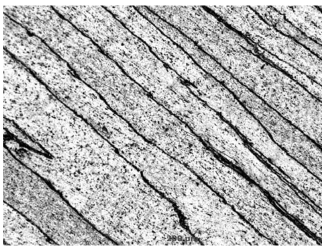




Diameter of a 7 mm rod



a



b

Fig. 4. Typical microstructure of the rods (×160) in longitudinal (*a*) and crosscut (*b*) direction

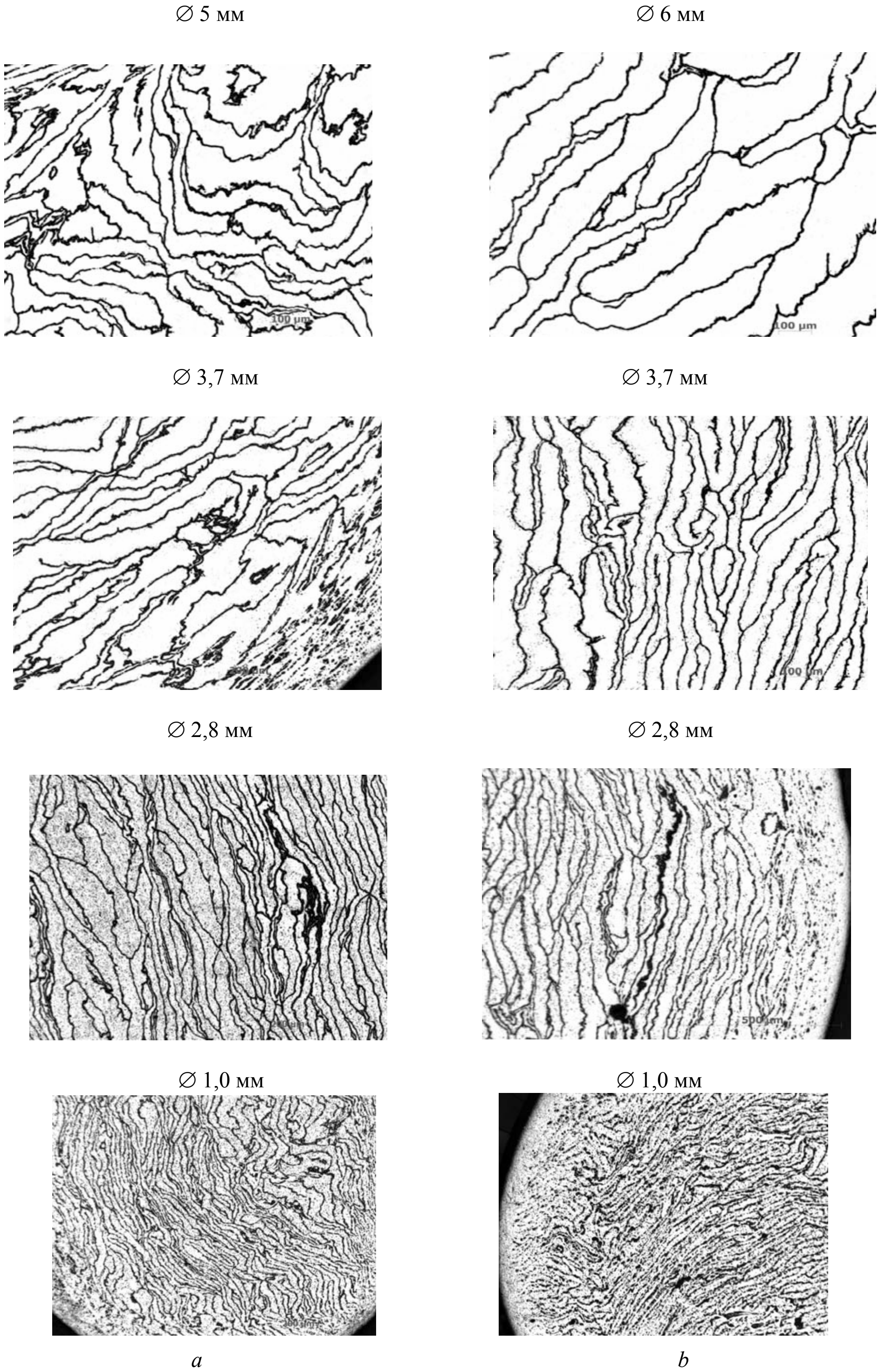


Fig. 5. The cross-sectional microstructure of the wire made in different compression modes from rods with diameters of 7 (*a*) and 9 (*b*) mm

Samples were taken from the middle part of the rods to determine their characteristic structure and mechanical properties. These samples were tested afterwards according to the existing standards.

Fig. 4 shows the results of metallographic research, which shows that the level of deformation during laboratory testing is inefficient for setting the chips particles. The microstructure has clear boundaries between particles in the form of oxide film and uncommon continuity. There is no difference between the sample structure of rods with diameter 7 and 9 mm. Consequently, we may speak about a typical stable structure in chip particles of different thickness, lengthened to the direction of extruding and separated by steady oxide film. There is no setting between chip particles. In other words, the physical contact generally takes place on the chips irregularities with spreading (not breaking) of oxide film over the contact area.

The next technological stage was the cold drawing of the pressed rods and making wire with a final diameter of 1 mm which was carried out on the catenary drawbench applying stress of 50 KH and without intermediate annealing of average compression ε_{cp} = 15–20 %.

The experiment did not have a task of optimizing the compression mode.

Sampling for metallographic testing and mechanical properties assessment was carried out on the intermediate diameters. The deformation degree by that moment was given by:

$$\varepsilon_{\Sigma} = \frac{d_0^2 - d^2}{d_0^2} 100\,\% .$$

Fig. 5 shows the microstructure of wire made in different compression modes from rods of 7 and 9 mm in diameter. The trend in structure changes along with the increase of relative compression is the same in both cases, i.e. the decrease of wire diameter results in the reduction of the structure and its granulated property in the surface layers of the wire. This is caused by an irregularity of deformation in the wire section when the layers contacting the dies are subjected to greater deformation. Fig. 5 shows the dispersion of oxide film in surface layers of the wire which must affect the properties of product. Surface discontinuity in structure is unlikely to affect it considerably, as it has random a character and is not connected to the suggested technological scheme.

The estimate of mechanical properties for the produced wire was carried out by tensile testing with determination of tensile strength σ_B, specific elongation δ and reduction of area ψ. Fig. 6 shows the testing results. The points indicate the averages for the five tested samples.

In result of our research we now have the technology of manufacturing aluminum wire from anisotropic composite material with the properties determined by the orientation of fiber in one direction. In this case it concerns "specified" technological anisotropy which occurs in definite schemes of plastic deformation. The fiber pieces (prolate chips) have different length depending on their thickness. This is why there is a different number of fiber pieces in the rod samples per cross sectional area in both longitudinal and crosscut direction. In addition, the higher the mode of deformation in drawing (the less the wire diameter), the longer are the boundaries between chips in their cross section.

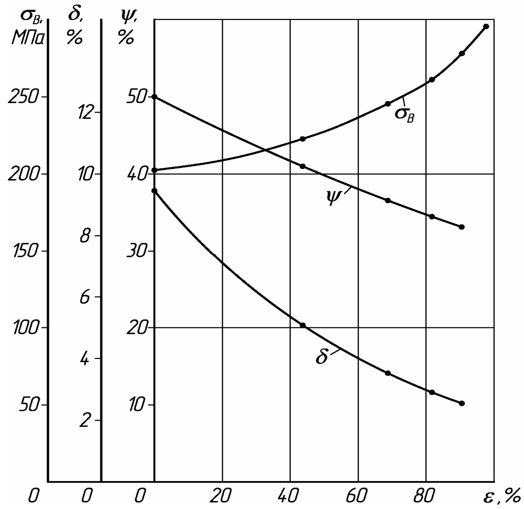


Fig. 6. Changing of mechanical properties of semi-finished items made of alloy АД31 chips after hot pressing (ε = 0 %) and cold drawing

Though it is difficult to indicate the application field of wire from friable fine chips of aluminum alloy АД31, we can suppose that due to its low production costs and mechanical characteristics, it can be used in fuse welding. According to the All-Union State Standard 7871 the tensile strength of such type of wire should not be less than 100 MPa. In addition it can be used for such mass consumption goods as binding wire. Mechanical characteristics for such goods are not specified, however the tensile strength in solid (not annealed) state should not be less than 140–160 MPa, and elongation not less than 2–3 %.

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