Conference Paper

Recycling Option of the Wrong Length Copper Wire

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Abstract

The purpose of the study is to study the possibility of utilizing copper waste from drawing. The experimental testing was carried out with reference to the compacting of segments of copper wire to produce products in the form of bars. The finite element method was used to evaluate the stress-strain state when the raw material compression scheme in the container was realized. It is shown that with the tested treatment modes a high level of strength properties is achieved, but an insufficient level of plastic characteristics.

Keywords: Recycling, copper wasters, stress, strain, program complex ABAQUS, finite element method, pressing, extrusion

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1. Introduction

In various industries, waste products are created, in the form of immoderate remnants of metal products. When winding the cores of generators, electric motors, transformers, a certain length of the current conductor is required, it is usually cut taking into account the positive tolerance, the use of a negative tolerance can lead to a shortage of material. As a result, after winding, there remains an immeasurable length of the conductor, which should go to remelting. Remelting of copper waste is accompanied by the appearance of technogenic formations in the form of gases and dusts [1]. Even modern methods of remelting, continuous casting and combined hot rolling of copper, such as CONTIROD [2], are accompanied by the appearance of man-made formations in the form of gases, particles of scale, chips from the work of the milling cutter. This forces again to conduct operations for cleaning metal and oxide waste from contamination, reducing oxides and returning to the process through re-melting. Additional sources of this type of waste are the front notch in the drawing process, which arises due to the need to thin the front end for threading, the presence of defective wire sections when using cold or hot butt welding of workpieces in drawing production [3].

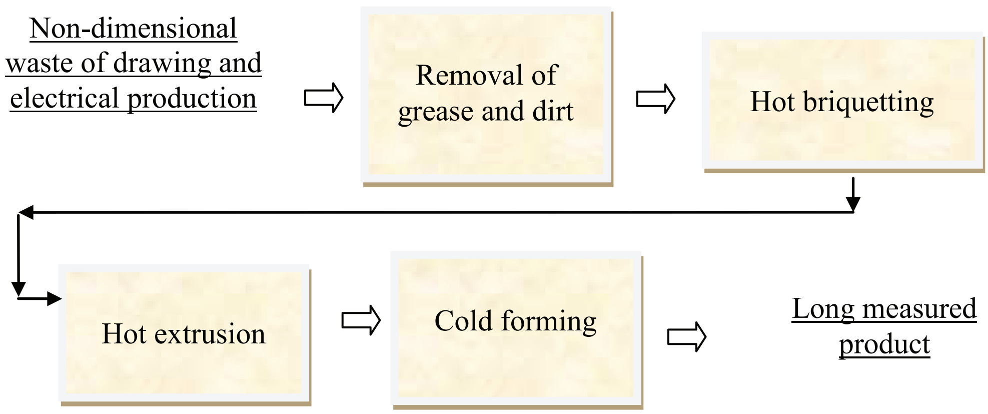
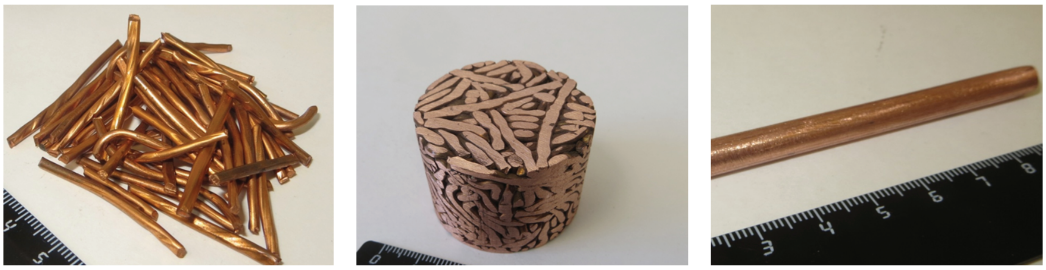


Figure 1: The proposed technological scheme.



a b c

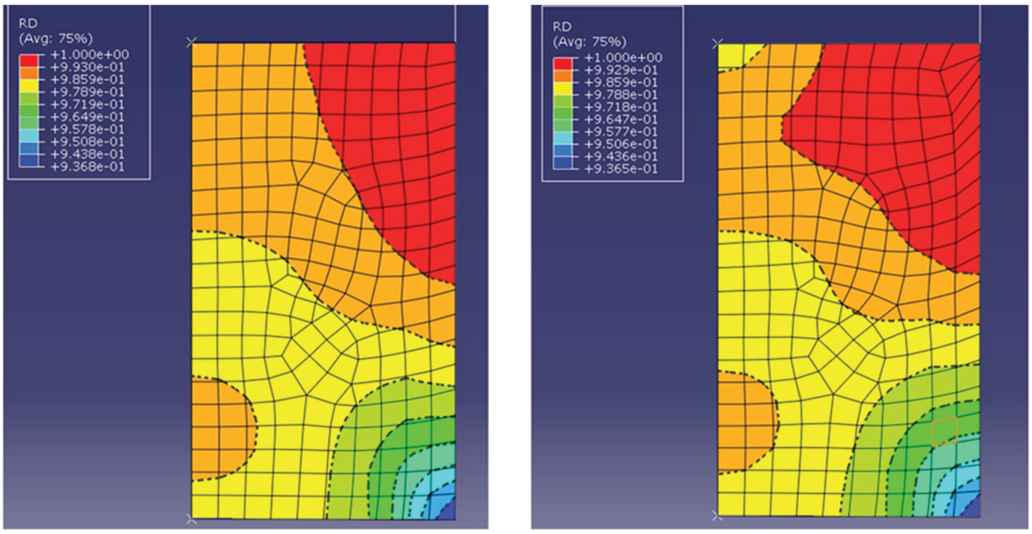
Figure 2: General view of the initial waste (a), briquette after hot compaction (b) and rod after hot extrusion (c).

2. Proposed Scheme

More effective from the standpoint of energy saving and the emergence of additional technogenic entities in relation to remelting, the processing option for such wastes is the application of pressure treatment methods without transferring the metal to a melt state. As calculations show, the greatest energy costs fall on the redistribution of heating of the metal and its transfer to the liquid state. Here there is the greatest number of technogenic formations. The general technological scheme of waste treatment without remelting is shown in Figure 1.

The proposed scheme roughly corresponds to the trajectory of the operations used in the processing of such technogenic formation as chips [4]. To assess the possibility of implementing the processes shown in Figure 2, a number of experimental and calculated studies were performed. As a result, it was possible to evaluate the necessary processing parameters and the quality of products obtained by the method proposed.

The appearance of the object for processing is shown in Figure 2a, the state of the briquette after hot briquetting is shown in Figure 2b, the hot-pressed product is shown in Figure 2c.



a b

Figure 3: Distribution of the relative density parameter (RD), with friction coefficients of 0.2 (a) and 0.4 (b).

3. Simulation Process

The process of compacting the briquette is described by the finite element method. During the simulation ABAQUS (ABAQUS, Inc. and DS, © Dassault Systèmes, 2007) were used for the following statement of the problem. The deformable material is porous copper. The hardening curve corresponds to the copper grade ETP with an appropriate approximation of the experimental data. The finite element type used is quad-dominated, their number is 213, the problem is axisymmetric.

The model of the medium (porous metal plasticity model) is available in the interface of the software module and is described by the condition of Gurson's yield condition, which was used by a rather large number of researchers. The yield condition is constructed on the deformation scheme of a spherical pore in an ideal plastic material and is operable at a small value of porosity. The initial ratio of the height of the deformation region h_0 to the radius *R* is 2, the relative displacement of the punch is $\Delta h/h_0 = 0.1$.

Figure 3 shows the obtained field of distribution of relative density, calculated at two values of the coefficient of friction on contact surfaces (the right half of the deformation region is shown).

According to the obtained decision, we judged the possible degree of heterogeneity of the properties of the briquette created at this stage of processing. As can be seen from the figure, the regions of reduced density are localized at the end of the workpiece, which is opposite to the end of the active punch and is shifted toward the surface. Usually, to minimize the harmful effects of friction, a lubricant is used to deform various materials. However, in this case, the use of conventional lubricants is extremely limited due to the danger of contamination of the porous material.

4. Achieved Properties

In the course of the measurements, it was found that after the hot pressing, it is possible to achieve a temporary resistance of the resulting product of about 230 MPa, while further cold drawing by drawing it can be increased to a range of 280 ... 415 MPa. The left border of the range corresponds to a relative reduction of 16%, and the right border to 87%. It was also found that the use of drawing allows to increase the reduction of area to 58% with the accumulation of the relative reduction parameter up to 44%. However, with subsequent accumulation (an increase in the number of drawing passes), the reduction of area begins to decrease quite intensively.

It was shown that with the tested treatment regimes a high level of strength properties is achieved, but an insufficient level of plastic characteristics. Metallographic studies have shown that there are pores in the structure of the product to be obtained, for the healing of which additional processing techniques are needed, for example, intensification of deformation by applying additional shearing stresses in the hot briquetting or extrusion stages, the positive effect of which is shown in the publications [5, 6] or by using a combined rolling-extrusion process. The problem of further cold working, such as drawing, remains the difficulty of closing the discontinuities of the metal in the form of pores, especially in the central part of the workpiece. To intensify the compaction, processes of drawing with a greater compression level than at the present time could be proposed, which is achieved by an extension of the deformation center and the use of drawing machines operating without anti-tension.

Previously performed work in the field of utilization of chips from aluminum and its alloys [7, 8] showed that the processes of compacting lead to the production of quality products. It can be hoped that the same effect can be obtained when implementing copper waste treatment schemes.

5. Summary

The study showed the possibility of obtaining products in the form of rods made from copper drawing waste. The method allows abandoning the remelting of metal, which should result in saving energy costs.

6. Acknowledgments

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