УДК 620.18

INFLUENCE OF FRICTION MIXING TREATMENT ON MICROSTRUCTURE AND MECHANICAL CHARACTERISTICS OF L63 BRASS

A.V. Sudarikov, A.M. Cheremnov, A.V. Chumaevsky
Scientific Supervisor: Dr. E.A. Kolubaev
Institute of strength physics and materials science SB RAS, Russia, Tomsk, Academic, 2/4, 634055
E-mail: avsudarikov@ispms.ru

ВЛИЯНИЕ ФРИКЦИОННОЙ ПЕРЕМЕШИВАЮЩЕЙ ОБРАБОТКИ НА МИКРОСТРУКТУРУ И МЕХАНИЧЕСКИЕ ХАРАКТЕРИСТИКИ ЛАТУНИ МАРКИ Л63

А.В. Судариков, А.М. Черемнов, А.В. Чумаевский
Научный руководитель: д.т.н. Е.А. Колубаев
Институт физики прочности и материаловедения СО РАН,
Россия, г. Томск, просп. Академический, 2/4, 634055
E-mail: avsudarikov@ispms.ru

Аннотация. *В работе производилось исследование микроструктуры и механических свойств латуни марки Л63 после фрикционной перемешивающей обработки. Показано, что с увеличением количества проходов инструмента, размер зерна в зоне перемешивания уменьшаются за счет высоких пластических деформаций, что приводит к образованию мелкозернистой структуры. Микротвёрдость сплава Л63 в зоне перемешивания увеличивается на величину до 30% по сравнению с основным металлом. Предел прочности не существенно зависит от количества проходов инструментом вдоль линии обработки, в то время как предел текучести увеличивается на величину до 29%.*

Introduction. The production of metallic ultrafine and nanostructured materials has become widespread in the last two decades. Such a high interest in these materials is primarily due to the fact that they show improved physical and mechanical characteristics compared to materials with a coarse-grained structure [1]. One of the ways to obtain such materials is the friction mixing processing (FSP) method. This technology is similar to friction stir welding (FSW), but has significant differences. Friction stir welding involves joining different materials together, while FSP is aimed at changing the microstructure of a material to increase strength or form a composite material [2]. Thanks to the FSP technology, it is possible to obtain a homogeneous and uniform grain structure in the mixing zone [3]. Unlike traditional methods of materials hardening, the method of friction mixing processing allows obtaining the necessary mechanical characteristics in the processing zone by changing the process parameters (speed of rotation and movement of the tool). Due to the low heat input during processing, metal warpage does not occur, which ensures the preservation of the geometric dimensions of the part after processing, and there are also no undesirable structural and phase changes in heat -strengthened materials. FSP technology is currently widely used in the processing of titanium, aluminum, magnesium, copper, and other alloys [4]. After processing these alloys, an increase in the mechanical properties (strength, ductility, etc.) of the material is observed. Therefore, the friction mixing treatment results in an improvement in performance compared to the initial state of the material. At present, one of the least studied materials in terms of hardening by friction mixing processing are copper and copper alloys, the processing of which is associated with intense heat release and, in some cases, tool deformation. The purpose of this work is to reveal the structural features and mechanical characteristics of L63 brass after FSP.

Research methods. Friction mixing processing of L63 brass plates was carried out on a laboratory facility at the Institute of Strength Physics and Materials Science, Siberian Branch, Russian Academy of Sciences. The thickness of the used sheet metal was 3 mm, the processing depth was 2.5 mm. The selection of process parameters was carried out empirically. The surface treatment of the material was carried out in four successive passes with a steel tool with a screw pin. Optical microscopy of the obtained samples was carried out on an Altami MET 1C metallographic microscope and an Olympus confocal microscope. LEX 4100. Microhardness measurements were carried out on a microhardness tester Duramin 5.

Results. The results obtained show that with an increase in the number of tool passes, the metal mixing zone becomes more uniform and pronounced, acquiring a cup-like shape. Due to severe plastic deformations from pass to pass, the grain size decreases from the zone of thermomechanical influence to the center of the weld. In the mixing zone, the grains predominantly have a uniform equiaxed structure. There are no visible defects after processing.

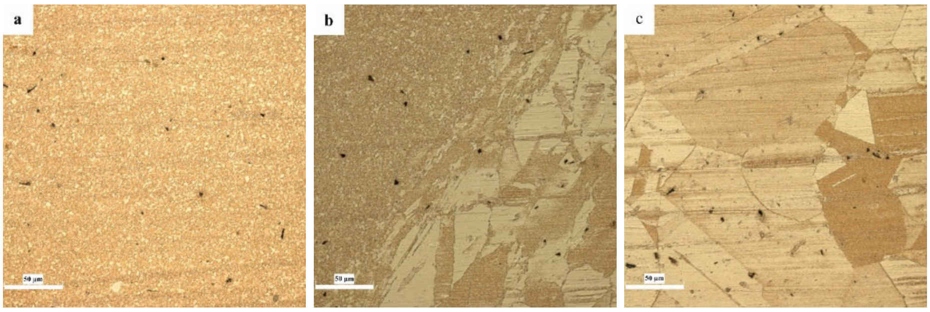

Fig. 1. Optical micrographs of the mixing zone (a), the thermomechanical influence zone (b) and the base metal (c) after the first pass of the tool along the processing line

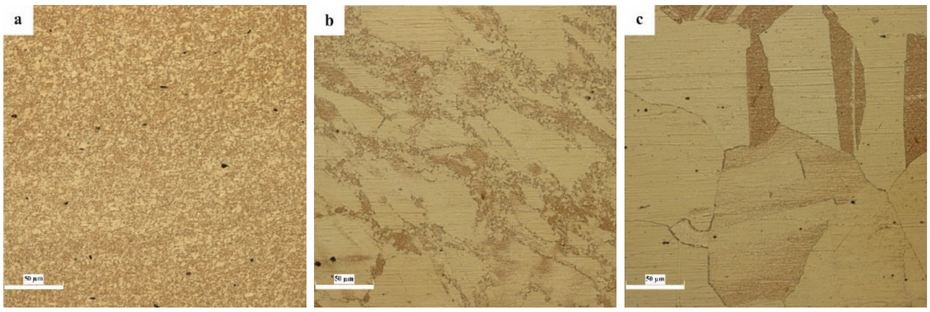

Fig. 2. Optical micrographs of the mixing zone (a), the thermomechanical influence zone (b) and the base metal (c) after the fourth pass of the tool along the processing line

On fig.1 and fig. 2 shows the microstructure of the mixing zone, TZM and base metal. The mixing zone, both after the first and after the fourth pass, is a fine-grained recrystallized structure. This is explained by the fact that it is she who experiences the highest rates of plastic deformation and high temperatures. In the zone of thermomechanical influence, a uniform metal flow in the direction of rotation of the tool is seen. The heat-affected zone and the base metal are not subjected to any mechanical stress, there is no plastic deformation there

, and the metal does not overheat. Thus, the modification of the original coarse-grained structure of the L63 alloy occurs as a result of the use of a thermal cycle in the machining process, caused by the dry friction of the tool.

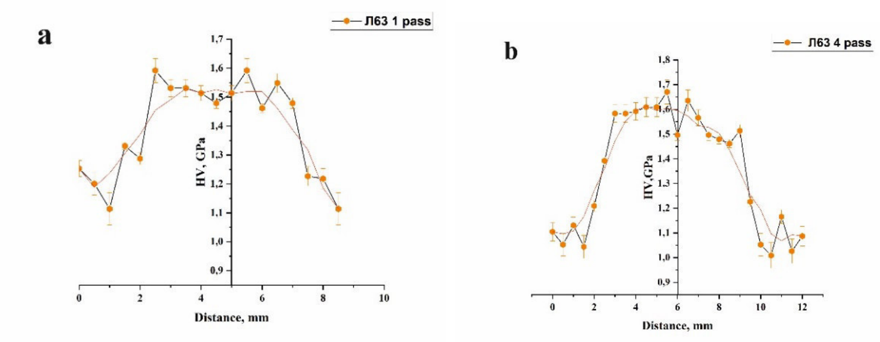

Fig. 3. Distribution of microhardness in the processing zone: a - after 1 pass; b - after 4 passes

The distribution of microhardness along the section of the section is shown in fig. 3. Based on the results obtained, it can be argued that both after the first and after the fourth pass, an increase in microhardness in the mixing zone is observed. The increase in microhardness after treatment is associated with the formation of small recrystallized grains, while the structure of the mixing zone becomes more uniform and fine-grained. The tensile strength of the material after one pass with the tool increases from 314 to 487 MPa, and after the fourth pass to 499 MPa. The yield strength in this case increases from 118 MPa to 318 MPa after the first pass and up to 409 MPa after the fourth pass. Thus, the samples are characterized by a greater increase in mechanical properties after one pass than after subsequent passes of the tool along the processing line.

Conclusion. The conducted studies show that the number of tool passes unequivocally affects the macrogeometry of the formation of the material processing zone. With an increase in the number of passes, the mixing zone becomes clearer and more pronounced. There are no micropores and microcracks in the material in the zone of influence of the tool, which indicates the optimally selected parameters of the processing process. In the mixing zone, the formation of a homogeneous fine-grained structure is observed. The maximum value of microhardness is noted in the middle of the mixing zone due to the formation of fine recrystallized grains. The tensile strength and yield strength of the material after processing increase, which indicates a high degree of applicability of the technique for hardening the surface layers of copper and copper alloys.

The work was performed according to the Government research assignment for ISPMS SB RAS, project FWRW-2021-0012.

REFERENCES

1. Shojaeefard M. H. Application of Taguchi optimization technique in determining aluminum to brass friction stir welding parameters // Materials & Design. – 2013. – V. 52. – P. 587-592.
2. Heidarzadeh A., Saeid T., Klemm V. Microstructure, texture, and mechanical properties of friction stir welded commercial brass alloy // Materials Characterization. – 2016. – V. 119. – P. 84-91.
3. Emamikhah A. Friction stir welding of CuZn40 brass alloy based on optimal response surface results: numerical and experimental analyses // Advanced Journal of Science and Engineering. – 2021. – V. 2. – P. 3-17.
4. Mironov S. Development of grain structure during friction-stir welding of Cu–30Zn brass // Philosophical Magazine. – 2014. V. 94. – P. 3137-3148.