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OBTAINING THE NECESSARY MECHANICAL PROPERTIES OF BLANKS OF PARTS MADE OF ALUMINUM ALLOY 7075 BY PHYSICAL MODELING

The article considers physical modeling for aluminum alloy 7075, widely used in mechanical engineering, in particular for elements of aircraft structures. This alloy differs from other rolled aluminum-based alloys not only by high values of strength properties, but also by the presence of a large number of intermetallic compounds of alloying elements. The workpiece for the parts is a round rolled product with regulated mechanical properties.

Thus, the purpose of this work was to determine the effect of the deformation pattern that occurs in metal during bar rolling on the mechanical properties of blanks of parts made of aluminum alloy 7075.

The present study draws attention to the importance of physical modeling in determining the characteristics of materials necessary for effective management of plastic processing processes. Analyzing the results of physical modeling, we identify the optimal parameters of material processing, such as microstructure, mechanical properties and chemical composition.

The results obtained allow a deeper understanding of the physical mechanisms underlying the production of blanks (rods) from aluminum rods of alloy 7075 by rolling, as well as optimizing it to achieve the required technical characteristics of products. Thus, as a result of physical modeling of the rolling process of bars made of aluminum alloy 7075, it was found that when the samples are deformed at a temperature of 250 ° C, the value of the plasticizing stress decreases by about 18%, and a more uniform distribution of microhardness over the transverse and longitudinal sections was obtained compared with deformation at a temperature of 200 °C.

The research is of practical importance for the metalworking industry, and can also be used for educational purposes to train specialists in the field of materials science and metalworking.

Keywords: workpiece parts, physical modeling, aluminum alloy 7075, metalworking, aluminum alloy microstructure, deformation of samples.

Introduction

Physical modeling methods used with great success both in fundamental research and in applied research aimed at transferring the results of laboratory research to a real industrial facility. Of particular importance are the methods of physical modeling used in plastic processing and materials science [1; 2].

Physical modeling allows, among other things, to very accurately determine the characteristics of materials, knowledge of which is necessary for the development of new or modernization of currently used production technologies. The use of physical modeling can be a determining condition for microstructure and mechanical influences, as well as conditions for plastic restoration. Another important goal of physical modeling of plastic recycling processes is to provide a description of the behavior of the material during these processes, allowing the development of modern technologies for rolling new materials. Physical modeling also makes it possible to determine the optimal conditions for plastic processing and select the chemical composition of the material based on the results of laboratory studies.

Materials and methods

Based on the results of physical modeling of the rolling process, it is possible to determine, for example, the values of the plasticizing voltage in each passage, making it possible to accurately calculate the energy and power parameters necessary for its implementation on an industrial scale. It is also possible to evaluate changes in the microstructure of the deformable material and its mechanical properties during the entire cycle of sequential deformation occurring during the rolling process [3]. The dimensions of the samples used in the simulation allow you to track the changes occurring in the microstructure of the simulated material. Thus, the physical modeling of real technological processes allows you to choose the optimal process parameters in order to obtain the desired microstructure of the plastically processed material [4].

The use of physical modeling methods in research preceding the process of introducing new technologies is associated with the use of modern simulators of plastic alteration processes, including taking into account thermal and plastic issues. With the help of simulation, it is possible to accurately record the reaction of the material to the applied heat release loads. This, in turn, allows us to determine the parameters of the technological process that ensure the production of products with a strictly defined microstructure and, consequently, the expected mechanical properties [5].

The growing range of research capabilities of simulators is also of great importance in the development of physical modeling methods.

Results and discussion

This section presents the results of physical modeling of obtaining blanks for further processing from alloy 7075 in a three-roll radial shear mill. These studies were carried out in a complex state of deformation using the STD 812 torsion plastometer equipped with the laboratory of Plastometric Research at the Institute of Plastic Processing and Safety Engineering of the Czestochowa Technical University.

Samples with the dimensions of the working part were used for testing: diameter d = 6 mm and length l = 10 mm. Temperature control was carried out using a type K thermocouple (NiCr-NiAl). The test material was heated at a rate of 1 °C/sec., then kept at this temperature for 10 seconds, after which the samples were deformed and then cooled at a rate of 0.5 ° C/sec. The general scheme of thermal and plastic processing in the physical modeling of the workpiece production process is shown in Fig. 1.

Due to the complex state of deformation, physical modeling studies were conducted using a complex state of deformation (simultaneous twisting with compression) [6].

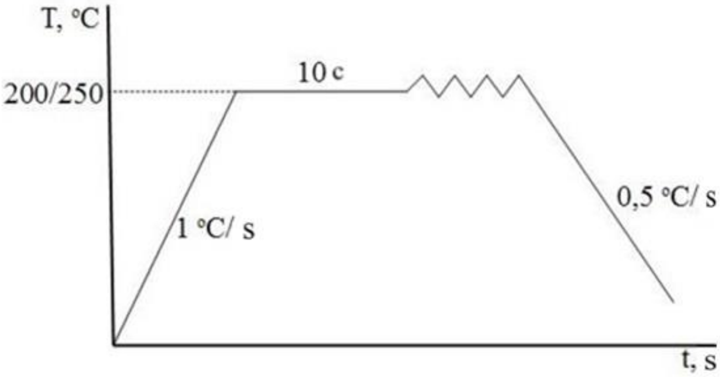

Figure 1 − The scheme of thermal plastic processing in the physical modeling of the process of obtaining blanks by rolling from aluminum alloy 7075

The deformation parameters were adopted based on the analysis of the results of numerical modeling of the process of obtaining blanks using the FORGE 2011 computer program while considering the research capabilities of the STD 812 torsion plastometer and were accordingly:

– compression deformation: ε = 0,29;

– torsional deformation ε = 3,12;

– the rate of deformation during compression $\acute{\varepsilon}$ = 0,80;

– the rate of deformation during torsion $\acute{\varepsilon}$ = 9,00;

Physical modeling studies were carried out at constant temperatures of deformed samples, which, in accordance with the conditions of numerical modeling, were 200 and 250 °C. changes in sample sizes during physical modeling of the workpiece production process are shown in Figure 2 [7].

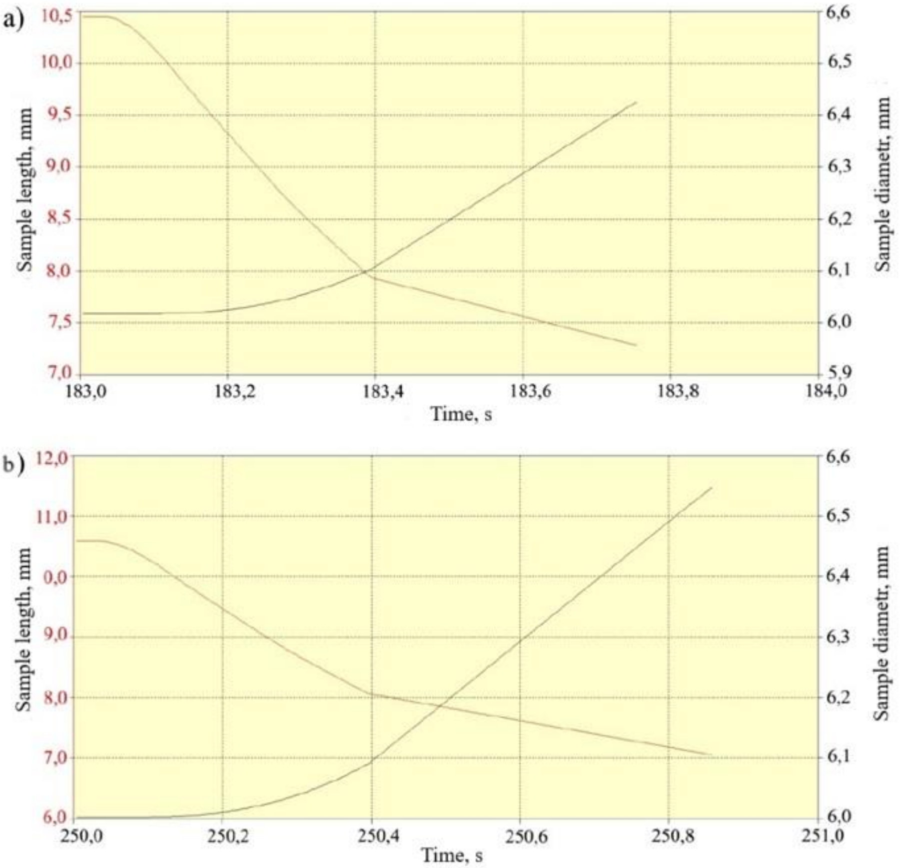

Figure 2 − Changes in sample sizes during physical modeling of the process of obtaining blanks by rolling from aluminum alloy 7075:
a) – Charge temperature 200 °C; b) – Charge temperature 250 °C

Figure 3 shows the change in the value of the plasticizing stress depending on the applied deformation for samples heated to temperatures of 200 °C and 250 °C.

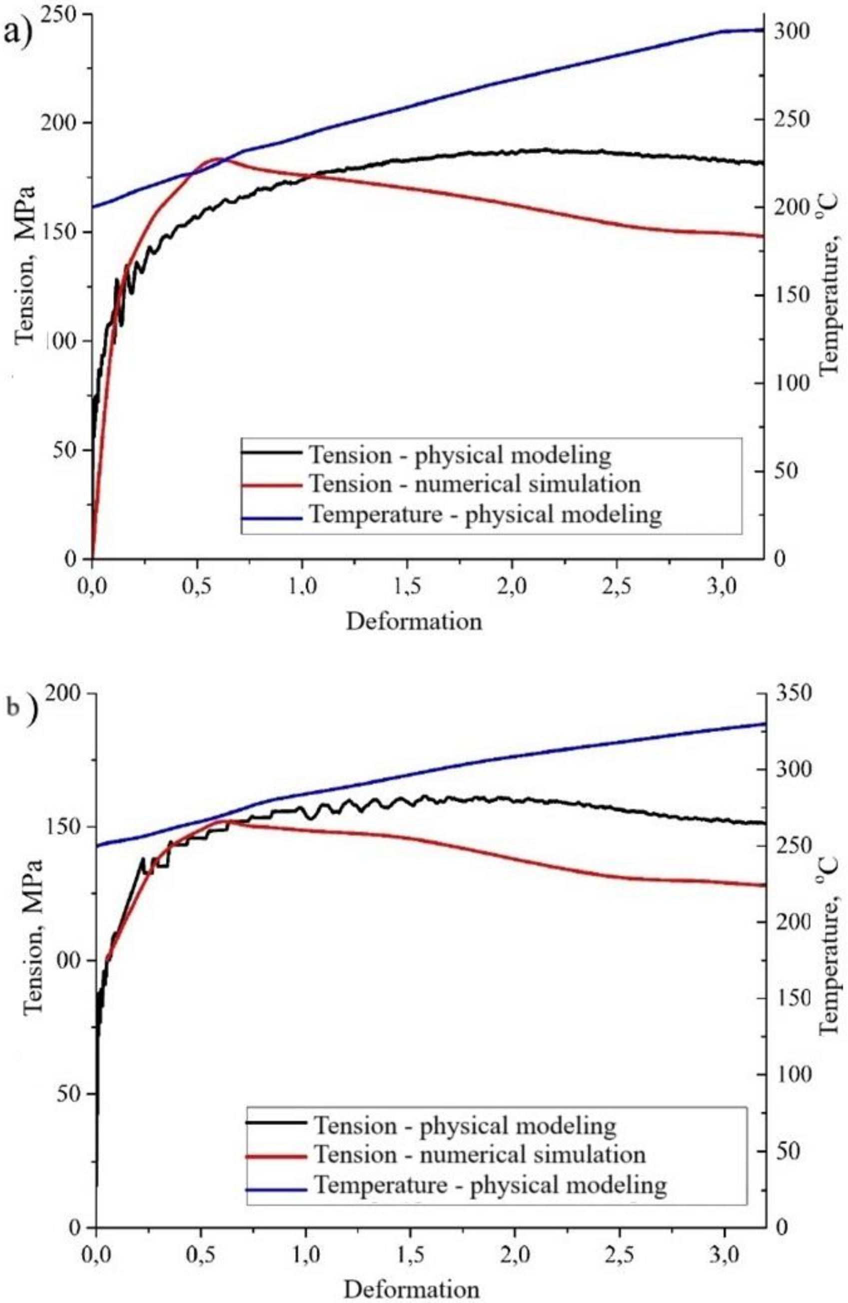

Figure 3 − The course of voltage changes of aluminum alloy 7075 in the physical simulation of the rolling process at temperatures of 200 (a) and 250 °C (b)

Based on the analysis of the test results presented in Figure 3, it can be concluded that the values of the plasticizing stress of the alloy under study, obtained as a result of physical modeling, are close to the values obtained as a result of numerical modeling. The greatest correspondence of the values of the plasticizing stress occurs at the initial stage of the deformation process [8]. At high strain values, the differences between the values of plasticizing stress obtained as a result of physical and numerical modeling increase. The values of the plasticizing stress of the material under study obtained by physical modeling are greater than the values obtained by numerical modeling. This may be due to the influence of the temperature of the alloy under study on the value of the plasticizing stress [9]. During the numerical simulation of the rolling process of workpieces in a three-roll radial shear mill, the temperature of the studied rods increased with an increase in the applied plastic deformation. On the contrary, the process of physical modeling of the analyzed rolling process was carried out at a constant temperature of the deformable sample.

In the physical simulation of the process of obtaining blanks at a temperature of 200 ° C (Fig.3 a), the maximum plasticizing stress was 180 MPa. In turn, for samples deformed at a temperature of 250 °C (Fig.3b), the maximum value of the plasticizing stress was about 160 MPa. From the analysis of the data shown in Figure 2 (a), it can be seen that an increase in the temperature of the deformable aluminum alloy 7075 from 200 to 250 ° C leads to a decrease in the values of plasticizing stress by about 18% in both physical and numerical modeling. Samples were taken from the material after physical modeling to study the distribution of microhardness (Fig. 4) in the transverse and longitudinal sections. A Future-Tech microhardness meter was used to measure microhardness. These studies were carried out by the Vickers method at a load of 2.94 N with an iteration time of 5 seconds [10].

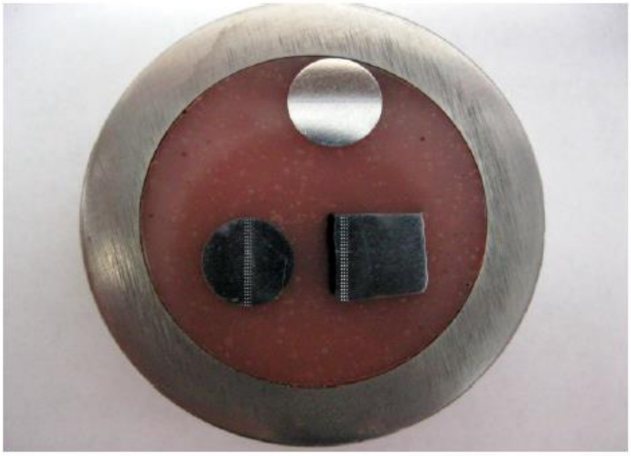

Figure 4 − Samples of aluminum alloy 7075 for microhardness test

The distribution of microhardness of samples from the alloy under study after physical modeling at temperatures of 200 and 250 °C in the transverse and longitudinal sections is shown in Figure 5.

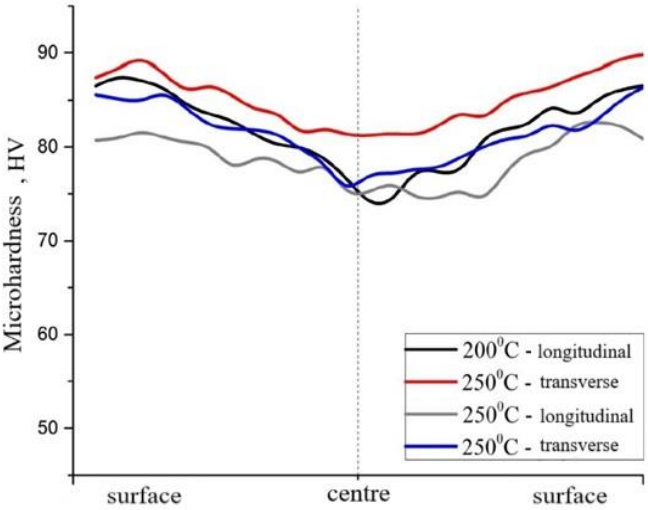

Figure 5 − Microhardness distribution of 7075 aluminum alloy samples deformed at temperatures of 200 °C and 250 °C

Conclusion

Based on the analysis of the microhardness distribution of aluminum alloy 7075 samples, it can be concluded that the highest microhardness was characterized by areas lying near the surface of the workpieces (rolled products), and the lowest was in the center of the workpieces. This distribution of microhardness was due, characteristic of the twisting process, to the distribution of deformation across the cross-section of the deformable material. The greatest deformation occurs in the near-surface areas, and the smallest in the axis of the deformable material. For samples deformed at a temperature of 200 °C, the maximum microhardness values were 87 HV in the cross section of the currant and 89 HV in the longitudinal section. The lowest values of the microhardness of the alloy under study were 71 HV in cross section and 81 HV in longitudinal section. A similar nature of the microhardness distribution of aluminum alloy 7075 was also observed for samples deformed at 250 °C. In this case, the maximum values of microhardness were 82 HV in the cross section of the currant and 86 HV in the longitudinal section. The lowest values of the microhardness of the alloy under study in this case were 74 HV in cross section and 75 HV in longitudinal section.

Analyzing the results of physical modeling of the process of obtaining blanks from aluminum alloy 7075, it was found that when the samples are deformed at a temperature of 250 ° C, the value of the plasticizing stress decreases by about 18%, and a more uniform distribution of microhardness over the transverse and longitudinal sections was obtained compared with deformation at a temperature of 200 ° C.

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ФИЗИКАЛЫҚ МОДЕЛЬДЕУ АРҚЫЛЫ АЛЮМИНИЙ 7075 ҚОРЫТПАСЫ ДАЙЫНДАМАЛАРЫНАН БӨЛШЕКТЕРДІҢ ҚАЖЕТТІ МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІН АЛУ

Мақалада машина жасауда кеңінен қолданылатын 7075 алюминий қорытпасының физикалық модельдеуі, атап айтқанда авиациялық конструкциялар элементтері үшін қарастырылған. Бұл қорытпа алюминий негізіндегі басқа қорытпаларынан беріктік қасиеттерінің жоғары мәндерімен ғана емес, сонымен қатар легирлеуші элементтердің көптеген металларалық қосылыстарының болуымен де ерекшеленеді. Бөлшектерге арналған дайындама реттелетін механикалық қасиеттері бар дөңгелек прокат болып табылады.

Осылайша, бұл жұмыстың мақсаты 7075 алюминий қорытпасынан жасалған бөлшектер дайындамаларының механикалық қасиеттеріне шыбықтарды илемдеу кезінде металда пайда болатын деформация схемасының әсерін анықтау болды.

Бұл зерттеу пластикалық қайта өңдеу процестерін тиімді басқару үшін қажетті материалдардың сипаттамаларын анықтауда физикалық модельдеудің маңыздылығына назар аударады. Физикалық модельдеу нәтижелерін талдай отырып, біз микроқұрылым, механикалық қасиеттер және химиялық құрам сияқты материалдарды өңдеудің оңтайлы параметрлерін анықтаймыз.

Алынған нәтижелер 7075 алюминий қорытпасының өзектерінен дайындамаларды илемдеу арқылы алудың негізінде жатқан физикалық механизмдерді тереңірек түсінуге, сондай-ақ бұйымдардың қажетті техникалық сипаттамаларына қол жеткізу үшін оны оңтайландыруға мүмкіндік береді. Сонымен, 7075 алюминий қорытпасынан жасалған шыбықтарды илемдеу процесін физикалық модельдеу нәтижесінде 250 °C температурада үлгілердің деформациясы кезінде пластификация кернеуінің мәні шамамен 18%-ға төмендейтіні анықталды және 200 °C температурадағы деформациямен салыстырғанда көлденең және бойлық қимада микроқаттылықтың біркелкі таралуы алынды.

Кілтті сөздер: бөлшектерді дайындау, физикалық модельдеу, 7075 алюминий қорытпасы, металл өңдеу, алюминий қорытпасының микроқұрылымы, үлгілердің деформациясы.

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ПОЛУЧЕНИЕ НЕОБХОДИМЫХ МЕХАНИЧЕСКИХ СВОЙСТВ ЗАГОТОВОК ДЕТАЛЕЙ ИЗ АЛЮМИНИЕВОГО СПЛАВА 7075 ПУТЕМ ФИЗИЧЕСКОГО МОДЕЛИРОВАНИЯ

В статье рассмотрено физическое моделирование для алюминиевого сплава 7075, широко используемого в машиностроении, в частности для элементов авиационных конструкций. Этот сплав отличается от других прокатных сплавов на основе алюминия не только высокими значениями прочностных свойств, но и наличием большого количества интерметаллических соединений легирующих элементов. Заготовкой для деталей является круглый прокат, с регламентируемыми механическими свойствами.

Таким образом, целью настоящей работы было определение влияния схемы деформации, возникающей в металле при прокатке прутков на механические свойства заготовок деталей из алюминиевого сплава 7075.

Настоящее исследование обращает внимание на значимость физического моделирования в определении характеристик материалов, необходимых для эффективного управления процессами пластической переработки. Анализируя результаты физического моделирования, мы выявляем оптимальные параметры обработки материалов, такие как микроструктура, механические свойства и химический состав.

Полученные результаты позволяют более глубоко понять физические механизмы, лежащие в основе получения заготовок (пруток) из алюминиевых стержней сплава 7075 прокаткой, а также оптимизировать его для достижения требуемых технических характеристик изделий. Так в результате физического моделирования процесса прокатки прутков из алюминиевого сплава 7075, было обнаружено, что при деформации образцов при температуре 250 °С значение пластифицирующего напряжения снижается примерно на 18 %, и было получено более равномерное распределение микротвердости по поперечному и продольному сечению по сравнению с деформацией при температуре 200 °С.

Ключевые слова: заготовки деталей, физическое моделирование, алюминиевый сплав 7075, металлообработка, микроструктура алюминиевого сплава, деформация образцов.

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