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WEAR OF A356/Al_2O_3 NANOCOMPOSITES AND OPTIMISATION OF MATERIAL AND OPERATING PARAMETERS

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The aim of this study was optimization of wear of nanocomposites with A356 alloy as a matrix. Different percentages of Al_2O_3 particles (0.2, 0.3 and 0.5 wt. %), with two average size (25 and 100 nm), were dispersed in the A356 matrix and fabricated by compocasting process. The tribological tests were conducted by the orthogonal L24 matrix. By application of the RSM method, a mathematical model was developed that best describes wear dependence on the observed factors and it was found that all considered factors have a significant impact on the wear of nanocomposite.

Keywords: *A356 alloy, nanocomposite, wear, ANOVA, RSM.*

1. INTRODUCTION

The nanocomposite is a material that has at least one reinforcement phase whose dimension is less than 100 nm. These are high-performance materials that have specific combinations of properties, so they are considered as materials for the 21st century. Today, nanocomposites offer opportunities for the development of new technologies in all sectors of industry [1]. Nanocomposites with the metal matrix are often referred to as metal matrix nanocomposites (MMnCs) [2].

Constant research to find materials of certain physical, mechanical, tribological and other properties has lead to the need for the application of optimization methods that shorten the time of development and testing. Design of experiment gives better results with less repetition of the experiments, reduces costs in the process of obtaining certain information, reduces the effect of random factors on research results and determines the legality of certain phenomena. As such, it is used in various spheres of society. The optimization methods used in scientific studies are: full factorial design, Taguchi method, Gray relation analysis (GRA), artificial neural network (ANN), genetic algorithm (GA), particle swarm optimization technique (PSO) and many others.

This study aims to investigate the wear of nanocomposites with a small percentage of Al_2O_3 nanoparticles by applying some optimization methods.

2. MATERIALS AND APPLIED METHODOLOGY

This paper focuses on the aluminium nanocomposites obtained by the compocasting process with mechanical alloying pre-processing, by varying the different reinforcement content of the Al_2O_3 nanoparticles. The experimental research was carried out based on an orthogonal L24 matrix using a tribometer with line contact geometry under lubricated conditions.

The applied method for processing experimental results is response surface methodology (RSM). This method is a set of statistical and mathematical methods used to establish a relationship between the dependent variable (response) with independent variables (factors) that have a certain impact on response. This is achieved by generating a mathematical model of a more accurate equation that describes the process. The goal of this method is to optimize the response that is influenced by the factors of the observed process. The advantages of applying this method in relation to classical experimental methods are reflected in the smaller number of experiments from which a large amount of information can be obtained, using a mathematical model that connects the response with the factors. Additionally, it is possible to observe the interactive effect of factors on the response. The estimation of the interactive effects of two different factors on the response in this method can be graphically represented on 2D or 3D diagrams. If three or more factors are examined, one must be set to the constant value, while changes in the values of the other two factors are shown in the contour diagram.

3. RESULTS AND CONCLUSIONS

Figure 1 shows the worn surfaces of two nanocomposites A356 + 0.5 wt. % Al_2O_3 tested for 1000 m, under normal load of 40 N and sliding speed of 0.25 m/s. The worn surface of both nanocomposites has narrow grooves in the wear track that are parallel to the sliding direction. Also, white regions in wear tracks are observed, which points that there was a transfer of material from the steel disk to the tested block (which is confirmed by EDS analysis). This indicates that the dominant wear mechanism was abrasion, with light adhesion as a secondary wear mechanism.

With the use of RSM, the mathematical model was developed. The significance and adequacy of the developed model, as well as the determination of the significance of the individual and combined influence of factors, are assessed by analysis of variance (ANOVA). Following the results of ANOVA analysis, at the reliability level of 95 %, it was found that all the observed factors have a significant impact on the wear of nanocomposites.

The optimal content of Al_2O_3 nanoparticles in the A356 matrix was 0.5 wt. %, considering the minimal wear amount.

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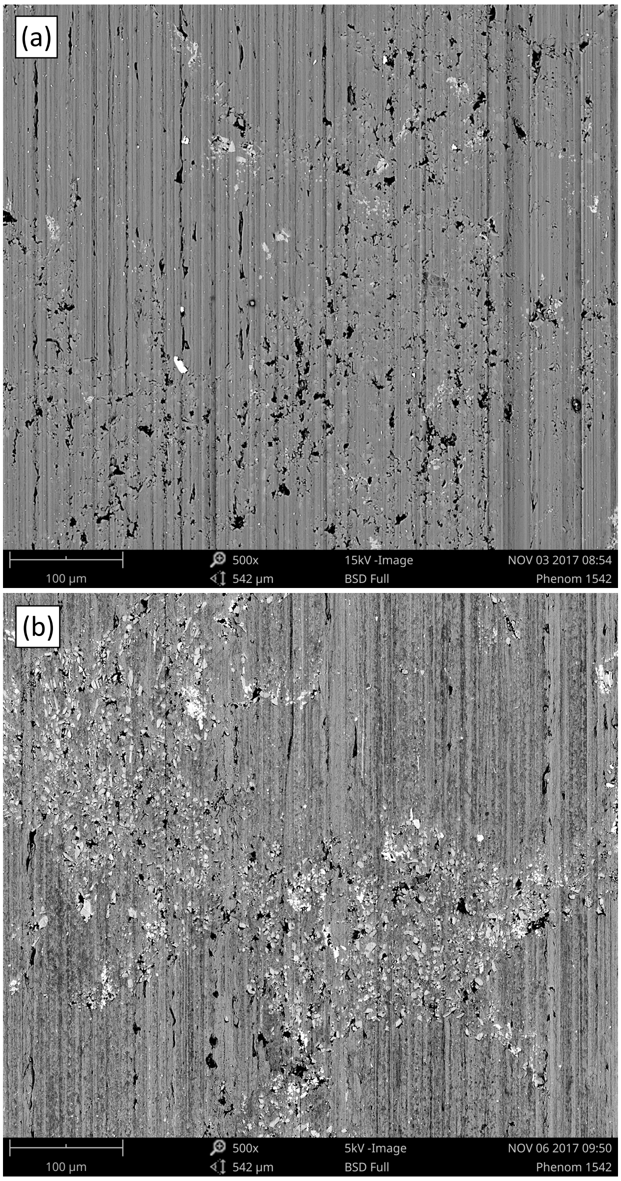

Figure 1. SEM micrograph of 0.5 wt. % Al_2O_3 nanocomposite with particles of: (a) 25 nm and (b) 100 nm

REFERENCES

[1] S. Veličković, S. Garić, B. Stojanović, A. Vencl: Tribological properties of aluminium matrix nanocomposites, Applied Engineering Letters, Vol. 1, No. 3, pp. 72-79, 2016.

[2] S. Veličković, B. Stojanović, M. Babić, A. Vencl, I. Bobić, G. Vadászné Bognár, F. Vučetić: Parametric optimization of the aluminium nanocomposites wear rate, Journal of the Brazilian Society of Mechanical Sciences and Engineering, Vol. 41, No. 1, Paper 19, 2019.