Simulation of Wear Behavior of AISI 4130 Steel Against Al_2O_3 Ball

M.J. Rajabloo[1] M. Rafiei[2] H. Mostaan[3]

1- Introduction

Wear is the volume loss of contact materials in relative motion. The wear and corrosion are the initial stages of material degradation and in other stages lead to friction, noise, unwanted heat and dimensional changes. These degradation mechanisms lead to decrease in lifetime of components and catastrophic failure. Mathematical modeling and computer simulation with high calculation efficiency and user-friendly software packs assist to predict and control surface degradation mechanisms with low cost and time. Therefore, it is possible to simplify and simulate wear process. In the present study the simulation of the wear behavior of 4130 steel against Al_2O_3 ball is investigated.

2- Experimental

The stages of the research include Cad model design, simulation of wear process with different loads and validation of simulations with experimental results. Two important universal standards of DIN and ASTM, suggest the ball-on-disk wear test for evaluating the wear behavior of materials. Based on this wear experiment, the map of disk and ball was drawn and the simulation process was performed. The Hertzian software was used for calculating contact stress between the disk and ball. 4130 steel and Al_2O_3 ball were used as pair wear. For simulation of the wear process ABAQUS software was used.

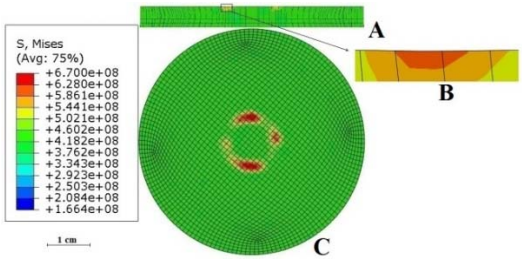

Fig. 1 Stress distribution areas in the disk under the normal load of 1 N

3- Results and Discussion

Wear simulation of 4130 steel under different normal loads. The stress contours in Fig. 1, Fig. 2 and Fig. 3 are up to 670 MPa for 4130 steel regarding the ultimate tensile stress of this steel. It means that the 4130 steel plastically deforms and the wear occurs after this stress. It can be easily seen that the plastic deformation and wear have occurred in all samples. Also, as can be seen with increasing the normal load during the wear test, the plastic deformation area was increased on the surface of 4130 steel.

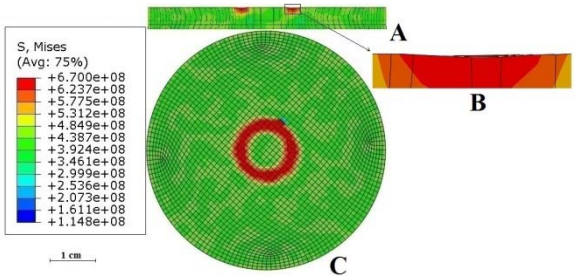

Fig. 2 Stress distribution areas in the disk under the normal load of 3 N

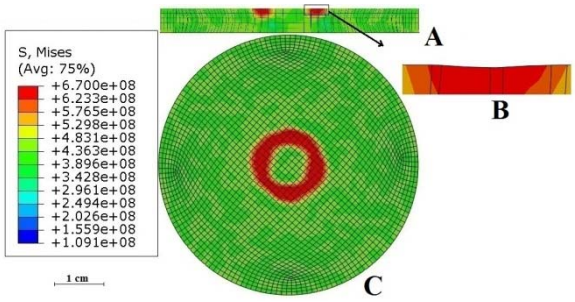

Fig. 3 Stress distribution areas in the disk under the normal load of 5 N

Wear behavior of 4130 steel according to experimental results. Fig. 4 shows the surface profiles of the wear track and the columnar diagrams of wear volume loss versus normal load for 4130 steel. As can be seen, with increasing the normal load from 1 to 5 N, the width and depth of the wear track increased, indicating the higher volume loss with increasing normal load (Fig. 4(d)). The increase in normal load resulted in higher contact stress and therefore, higher wear. Moreover, by increasing the frictional heat in the contact surface of Al_2O_3 ball and 4130 steel induced by increasing the normal load, the strength and hardness of 4130 steel were decreased. Therefore, the material was softer and more plowing could occur during the wear test. The presence of humps at the boundary of the wear track indicated plastic deformation and mass transfer. It has also been reported that with increasing the normal load, the contact stress and frictional heat are increased to over the elastic limit of one or both contact surfaces. Therefore, the plastic deformation of asperities increases the real contact surface. Other researchers have reported the same behavior.

[1] B.S Student Young Researchers and Elite Club, Najafabad Branch, Islamic Azad University, Najafabad, Iran.

[2] Corresponding Author: Assistant Professor, Advanced Materials Research Center, Department of Materials Engineering, Najafabad Branch, Islamic Azad University, Najafabad, Iran. Email: m.rafiei@pmt.iaun.ac.ir

[3] Assistant Professor, Department of Materials and Metallurgical Engineering, Faculty of Engineering, Arak University, Arak, Iran.

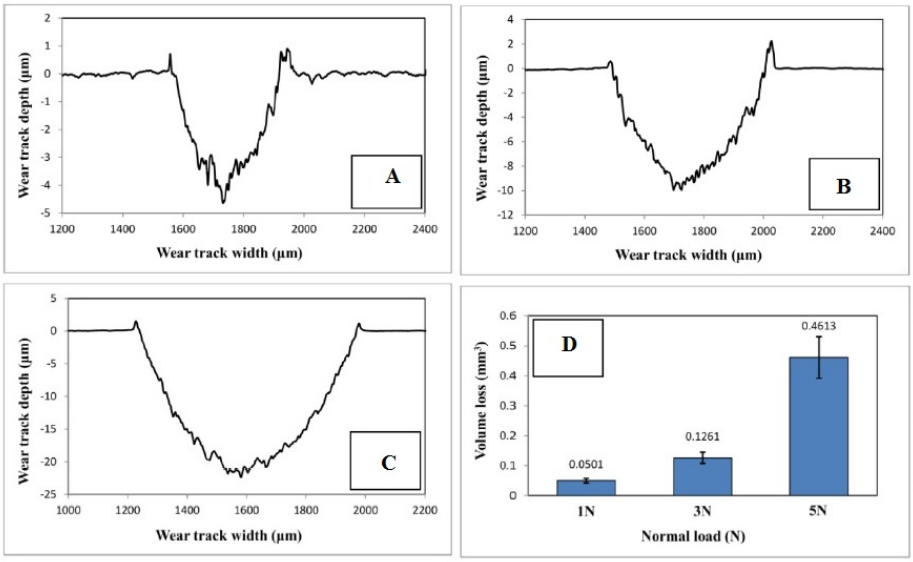

Fig. 4 Surface profiles of 4130 steel wear track under (a) 1, (b) 3 and (c) 5 N loads, and (d) columnar diagrams of wear volume loss versus normal load

4- Conclusions

1. With increasing the normal load, the contact stress between 4130 steel and Al_2O_3 ball increased.
2. In all wear samples the contact stress was higher than the ultimate tensile stress of 4130 steel. Therefore, the amount of plastic deformation and wear increase with increasing the normal load.
3. The experimental results verified the wear simulation of 4130 steel under different normal loads.