Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 50(3) (2018) 173-176
DOI: 10.22060/mej.2017.12899.5463

Investigation of the Wear Behavior of Graphite Steel (GSH48) in Ultrasonic Peening Process

A. Abbasi, S. Amini*, G. Shikhzade

Department of Mechanical Engineering, University of Kashan, Kashan, Iran

ABSTRACT: Rolling mill rolls are an essential component of the rolling stand and an important factor in the efficiency and quality of rolling products. The wear durability is very significant for optimizing operation and rolls life so wear test method and coefficient friction determination were utilized in order to determine the wear of rolling mill rolls made of graphite steel (GSH48). The amount of wear was determined on samples before and after conducting ultrasonic peening technology. In ultrasonic peening technology process, making work hardening and compression on surface layers of workpiece contribute to the improvement of some mechanical properties like surface roughness, hardness, and strength. After the simulation and manufacturing of ultrasonic vibratory tool and installing it on lathe machine, ultrasonic peening technology process was performed on the specimens prepared from rolling mill rolls. In the wear test, wear durability improved in the sample after ultrasonic peening technology process. In addition, the results suggested that the coefficient friction has been reduced around 50% after the process.
By preparing surface profile graph from the surface, it is perceived that the latitude and depth of wear have decreased after ultrasonic peening technology process. Scanning electron microscopy images were taken from the wear surface of the samples before and after ultrasonic peening technology process and wear mechanism was investigated that adhesive wear and surface fatigue wear mechanism before and abrasive wear mechanism after the process were observed. By performing ultrasonic peening technology process on the surface of the rolling mill rolls resistance to wear, strength, surface roughness, and their life have increased.

Review History:

Received: 13 May 2017
Revised: 3 July 2017
Accepted: 16 July 2017
Available Online: 24 July 2017

Keywords:

Ultrasonic peening technology
Wear
Graphite steel
Coefficient friction

1- Introduction

The rolling mill industry is one of the most current and thriving methods of producing metal production particularly steel. One of the main components and high usages in the rolling mill line is rolling mill rolls to which special attention should be paid. Since many pieces at the industry, including rolls are under wear, one of the most important tests of mechanical properties is the wear test which has a special importance. The wear is a process of surface destruction because of the mechanical contact of materials together.

Azoshima et al. in 2009, investigated the effect of rolling speed on coefficient friction in the hot rolling of the sheet and found that with the increase of rolling speed, the coefficient friction decreased [1]. Unal et al. in 2013 investigated the wear behavior of low carbon steel after shot peening process and showed that after the process, the wear resistance improved [2]. Abbasi et al. in 2014 accomplished the technology of cold forging on alloy steel 6XB2C in which surface smoothness enhanced from 0.6 to 0.132 [3]. In this paper, the effect of ultrasonic peening technology is investigated on the wear resistance of workpiece made of graphite steel GSH48 from the rolls of hot rolling and for this purpose, the design and manufacturing of the ultrasonic vibratory tool of Ultrasonic Peening Technology (UPT) equipment were performed.

2- Ultrasonic Peening Process

The material used in this paper is graphite steel GSH48 form rolling mill rolls with pearlitic structure and diffuse carbide. In order to conduct the UPT process on the lathe machine with the model TN50, rotation and feed rate were adjusted 45 RPM and 0.08 mm/rev, respectively. UPT equipment was located on the lathe machine instead of support and the workpiece was closed between the spindle and tip of the lathe machine. The ultrasonic generator device with model MPI and power 3 kW, frequency around 18 to 30 kHz and by controlling vibratory amplitude was utilized in order to generate electrical energy with high power and 20 kHz frequency. The transducer of ultrasonic vibratory tool consists of four piezoelectric which receives the frequency about 20 kHz from ultrasonic generator and converts to mechanical vibration. The mechanical strengthen by booster and horn and then exert consecutively impacts on the surface of the workpiece by the ball tool. By simulating the horn in ABAQUS software, the amount of longitudinal natural frequency gained 20466 Hz which should have the compatibility with 20 kHz natural frequency of the transducer. The modeling of UPT components in CATIA software is shown in Fig.1. The components of ultrasonic vibratory tool comprise transducer, booster, horn, and ball tool.

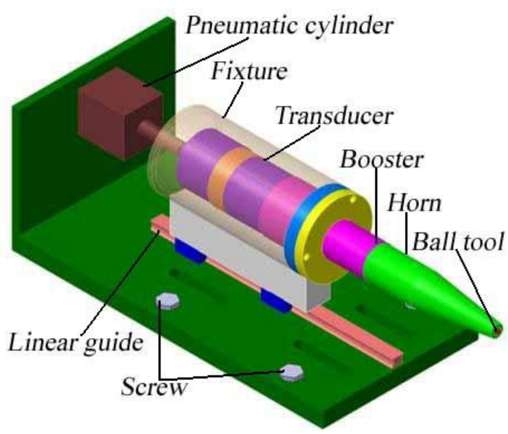

Fig. 1. Modeling of UPT equipment Components in CATIA

Corresponding author, E-mail: amini.s@kashanu.ac.ir

Fig.2 indicates the components of the UPT equipment which is assembled on the lathe support.

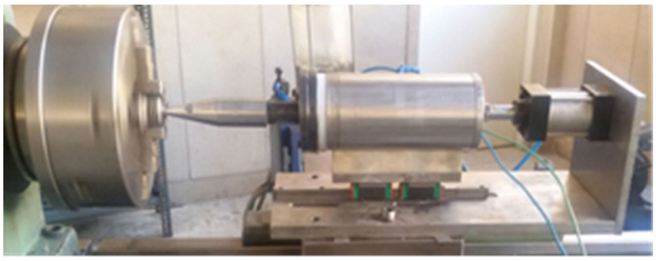

Fig. 2. Assembling of the UPT equipment on the lathe

In this paper, UPT follows Eq.(1) in which P_t is the total force exerted on the surface of the workpiece, P_{st} is the static force and P_{dy} is a dynamic force. The dynamic force follows from *f* shows a generator frequency at time *t* and *P* which is the amplitude of the dynamic force. Altering frequency by ultrasonic generator contributes to different dynamic forces on the head of the ball tool. The static force is provided by the pneumatic cylinder and exerted to the fixture [4].

$$P_t = P_{st} + P_{dy} = P_{st} + p\ sin 2\pi ft \quad (1)$$

According to Hall-Petch relation, yield stress and hardness of common polycrystalline material depend on its grain size that is brought in Eqs.(2) and (3). From the relation, it is perceived that with the decrease of grain size, yield stress and hardness increase [5, 6].

$$H_y = H_0 + kd^{-1/2} \quad (2)$$

$$\sigma_y = \sigma_0 + kd^{-1/2} \quad (3)$$

3- Wear

3- 1- Wear experiment

UPT process was conducted on the frontal of the cylindrical specimen with the diagonal and length of 20 mm made of graphite steel. The thickness of the standard specimen is 5 mm for the wear device and a pin made of ball bearing steel 52100 was utilized for the tool of wear device. The adjustment was accomplished in accordance with Table 1 in the wear device with the pin method on the disc.

The diagram of the weigh decreases in the sliding distance with 0.07 m/s speed and 4 kg weight is indicated in Fig.3. In the figure, the amount of weight decrease is reduced a lot after UPT process and as a result, the wear on the sample after the process is very little because the surface becomes hard and polished.

Table 1. The arrangement of parameters for the wear

frequency (Hz)	Speed (m/s)	Rotation (rpm)	Force (g)
40	0.07	100	1,3,6,9,12

3- 2- Coefficient friction

Coefficient frictions are 0.5 and 0.25 before and after UPT process, respectively. The results suggest the decrease of the coefficient friction around 50 percent after the process. In UPT process, by moving the ball tool on the surface of the workpiece, the surface overhangs or tops are involved in plastic deformation and began to move towards empty space and fill cavities, leading to the enhancement of the surface roughness and then resulting in the decrease of the coefficient friction.

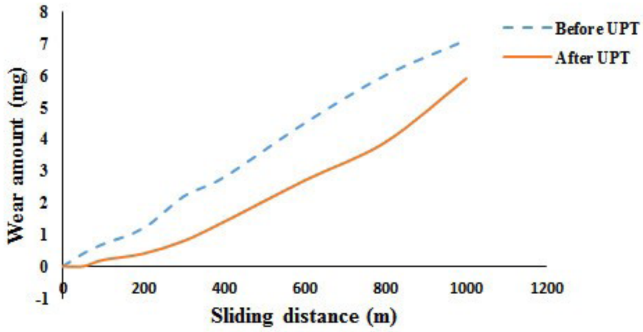

Fig. 3. Wear diagram before and after UPT

3- 3- The xperiment of the profile of wear surface

The profile of wear surface was measured by means of the measurement device of surface roughness with model Mituoyo-SJ-210 that had -28 µm depth and 3.5 mm width before UPT process and -16 µm depth and 2.2 mm width after the process and the wear depth is less. In addition, the area under the diagram of the surface profile was gained in Arean software being -0.0541 mm^2 and -0.017 mm^2 before and after UPT process respectively that the reason after the process is less wear in the sample.

3- 4- Mechanism of wear surface

By preparing Scanning Electron Microscopy (SEM) image from wear surface, the mechanism of wear was investigated. Transference and penetration of atoms into the interface levels of the involved surfaces contribute to adhesive connection and create outstanding areas on the surface. Moreover, the effect of surface fatigue has been represented on the surface in other parts and it can, therefore, be said that the mechanism of wear forms the kind of adhesive and surface fatigue. The effect of abrasive and surface fatigue of the electron microscope images from wear surface after UPT process that wears mechanism is of the abrasive type.

4- Conclusions

By conducting the experiments of wear, the profile of wear surface and electron microscope, the following results were obtained:

- The coefficient friction in the specimen are 0.5 and 0.25 before and after UPT process, respectively. The results suggest the decrease coefficient friction about 50 percent after the process.
- By preparing the surface graph from the wear surface, the amounts of areas under the diagram are -0.0541 mm^2 and -0.0170 mm^2, respectively that the reason is the more little wear of the sample after UPT process.
- The microstructure of the surface was performed by the experiment of SEM, resulting in wear mechanism process is from the adhesive type and surface fatigue before UPT process and from the abrasive type the process that shows the increase of strength, hardness and compressive residual stress.

References

[1] A.Azushima, Y.Nakata, T.Toriumi, prediction of effect of rolling speed on coefficient of friction in hot sheet rolling of steel using sliding trobi-simulator, *Journal of Materials Processing Technology*, (2009) 6.

[2] O. Unal, R. Varol, A. Erdogan, M. S. Gok,Wear behaviour of low carbon steel after severe shot peening, *Materials Research Innovations*,17(7) (2013) 519– 523.

[3] A. Abbasi, S. Amini, A. Emamikhah, Design and implementation of the ultrasonic cold forging technology process for improving surface mechanical properties of 6XB2C cold-worked alloy steel tool, *Journal of Engineering Manufacture* 230(2) (2014) 267-278.

[4] C.M.Suh, G.H.Song, M.S.Suh, Y.S.Pyoun, Fatigue and mechanical characteristics of nano-structured tool by ultrasonic cold forging technology, *Materials Science and Engineering A*, 443 (2007) 101-106.

[5] N.Hansen. Hall–Petch relation and boundary strengthening, *Scripta Materialia*, 51 (2004) 801–806.

[6] A. Amanov, O. Penkov, Y. S. Pyun, D. E. Kim ,Effects of ultrasonic nanocrystalline surface modification on the tribological properties of AZ91D magnesium alloy, *Tribology International*, 54(2012) 106–113.

Please cite this article using:

A. Abbasi, S. Amini, G. Shikhzade, Investigation of the Wear Behavior of Graphite Steel (GSH48) in Ultrasonic Peening Process, *Amirkabir J. Mech. Eng.*, 50(3) (2018) 529-540.

DOI: 10.22060/mej.2017.12899.5463