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Investigation of the effect of the burnishing applied to the Al2024 alloy on the surface roughness

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ABSTRACT

Surface roughness is a very important factor in determining the quality of the product to be obtained, as it affects the production cost and performance of mechanical parts. Surface quality is primarily considered as a design parameter to determine functional properties such as corrosion resistance and fatigue strength of the part. Therefore, this study aims to improve the surface roughness of Al 2024 material, which is generally used in aerospace and defense industries. Ball burnishing unit is designed to reduce the surface roughness after the machining of the manufacturing parts and to save both time and cost. The effects of force, feed rate and number of passes on the surface roughness were investigated as finishing process parameters. As a result of the experiment, it was observed that the roughness value decreased with the increase of the force and the number of passes, and the roughness value increased with the increase of the feed rate.

Introduction

Aluminum and its alloys are metals that are widely used in industry due to their lightweight, strength and easy forming capabilities [1]. Due to the low densities of aluminum alloys (2.81 g/cm^3), the use of aluminum alloys in both the automotive and aviation sectors continues to increase day by day [2].

Surface roughness is a parameter that affects the mechanical properties, performance and production cost of machined parts [3]. After traditional machining methods such as turning and milling, characteristic irregularities (valleys and peaks) occur on the surface of the part [4]. Minimizing these irregularities is a critical problem for the manufacturer. Ball burnishing process is based on the principle of removing surface roughness by creating plastic deformation with the pressure applied to the workpiece surface using an apparatus [5]. This method is a fast, no-expertise, inexpensive mechanical surface improvement process. The parameters that affect the surface quality while the ball burnishing process is applied to the workpiece are as follows: burnishing force, the properties of the machine used, the material properties of the workpiece and ball, ball types and the environment are made in many studies [6].

The aim of this experimental study is to obtain the most suitable surface roughness values in Al-2024 different burnishing forces, feed rate and number of passes of the aluminum alloy, which has an important place in the industry.

Material and Method

2.1. Experimental design

Al2024 aluminum alloy was supplied from Seykoç Aluminum factory (Turkey) as workpiece in the experiments. In the experiments, Ø50 x 300 mm sized Al 2024 filled cylindrical workpiece was used. The chemical content of the Al 2024 alloy is presented in Table 1. Before starting the experiments, the roughness value of the

workpiece surface was measured as Ra=0.915 µm and Rz=5.049. The burnishing process was performed on a universal lathe with the custom designed ball burnishing equipment. The test apparatus and burnishing equipment used in the study are shown in Figures 1. In addition, the Taguchi method was used in the experimental design. Table 2 shows the factors used in the experiments and their levels.

Table 1. Chemical composition of the workpiece used in the experiments.

Material	Fe	Si	Cu	Mn	Mg	Zn	Ti+Zi	Al
Al2024	0.5	0.5	4.35	0.6	1.5	0.25	0.15	Balance

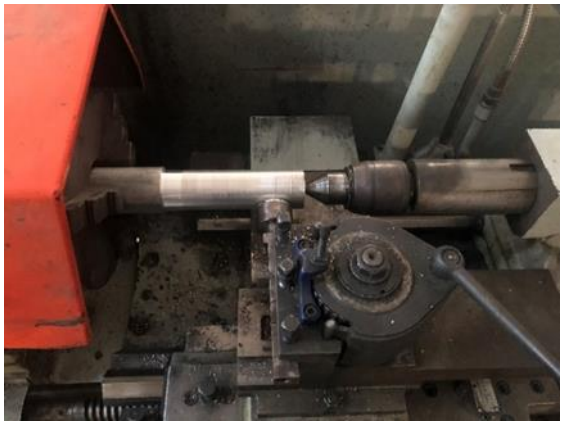

Figure 1. Experimental setup

Table 2. Process parameters and their limits

Code	Factors	Levels	
		1	2
A	Force (N)	100	200
B	Feed rate (mm/min)	0.625	1.25
C	Passes	1	2

2.2. Measurements

The surface roughness is used as a measure in determining the surface properties of the workpiece materials [7]. The surface roughness value is generally calculated by taking into account the arithmetic means values of the absolute values (Ra). The surface roughness data of the specimens are taken from three different parts of the Al 2024 workpiece material. Surface roughness tests were carried out using a surface profilometer.

Results and Discussion

The surface roughness values obtained after different burnishing parameters of the Al 2024 aluminum alloy and the S/N ratios calculated from these results are given in Table 3. In Figure 2, the effects of factors on surface roughness values are presented.

While interpreting the graphs regarding the factors affecting the surface quality of the Al 2024 alloy, the surface roughness value decreases while the force value increases from 100N to 200. The reason for this can be explained as the increase in pressure on the surface of the workpiece and the prevention of cavitation in the surface layer by compression. Likewise, an increase in the number of passes improves the surface quality. On the other hand, it is seen that increasing the feed rate decreases the surface quality and the experiments should be done at low feed rates to improve the surface quality.

Conclusion

In this study, ball burnishing process was applied in different parameters to increase the surface quality of the Al 2024 workpiece. The results obtained are below.

- The surface roughness value increases with the increase of the force and the number of passes and decreases with the increase of the feed rate.
- The lowest surface roughness value was obtained in the parameter combination where the force was 200N, the feed rate was 0.625mm/min, and the number of passes was 2.

Table 3. Parameters and results after burnishing process

Experiments	Parameters			Results		
	Force	Feed rate	Passes	Ra (µm)	Rz (µm)	S/N Ra (µm)
1	100	0.625	1	0,435	2.111	7.230
2	100	0.625	2	0,407	1.745	7.808
3	100	1.25	1	0,802	3.744	1.916
4	100	1.25	2	0,772	3.512	2.247
5	200	0.625	1	0,447	2.702	6.993
6	200	0.625	2	0,326	2.904	9.735
7	200	1.25	1	0,668	3.002	3.504
8	200	1.25	2	0,550	3.142	5.192

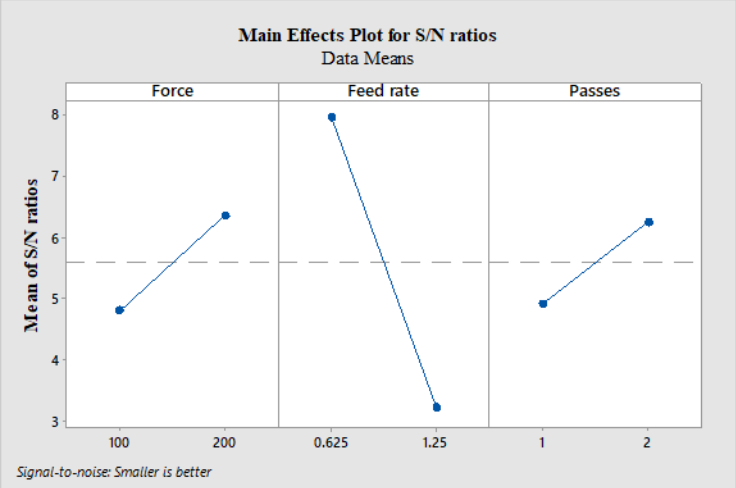

Figure 2. Main effects graph for S/N ratios of surface roughness

Author contributions:

Suleyman Cinar CAGAN: Experimental plan, experiments, conceptualization, methodology, data curation, Investigation, writing-reviewing and editing
Berat Baris BULDUM: Investigation, writing-reviewing and editing

Conflicts of interest:

The authors declare no conflicts of interest.

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