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Temperature and Surface Roughness in Magnetic Abrasive Finishing Process for CuZn28 Brass Alloy

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Abstract: The effect of Magnetic Abrasive Finishing (MAF) method on the Temperature rise (Tr) and the surface Roughness (Ra) has been investigated in this research by determining the optimum temperature through the optimum surface roughness to improve the quality of surface layer for CuZn28 brass alloy plates. Sixteen runs were done in order to determine the optimum temperature in the contact area (between the abrasive powder and surface of workpiece) and the change in the surface Roughness (ARa) according to Taguchi Orthogonal Array (OA). Four technological parameters (cutting speed, finishing time, working gap and the current in the inductor) with four levels for each parameter have been used, the matrix known as a L16 (4') OA. The Signal to Noise (S/N) ratio and Analysis of Variance (ANOVA) techniques were performed for analys ing results of Tr and ARa using the statistical software (MINITAB1), to establish the best optimum condition and identify the significant parameters affecting on the temperature rise and surface roughness. The modern and powerful technique IR camera was used to measure the temperature while scanning electron microscopy was utilized to study the texture of finishing surface. The results showed that the optimum temperature in contact area of workpiece is (55.1°C) and the most significant factor for CuZn28 brass effect on ARa for MAF process was the cutting speed followed by current in the inductor, finishing time and working gap.

Kev words: MAF. temperature rise. chance in surface roughness. MINITAB 1°. time. inductor

INTRODUCTION

Surface finish has a vital influence on functional properties such as wear resistance and power loss due to friction on the most of the engineering components. Magnetic Abrasive Finishing (MAF) is one of the advanced finishing process in which a surface is finished by remov ing the material in the form of microchips by abrasive particles in the presence of magnetic field in the finishing zone (Mulik and Pandey, 2011). Magnetic abrasive technique applied to machine building, radio industries, aerospace, electro industry and other industries.

An experimental study was conducted for measuring the surface roughness in MAF technique on brass alloy plate which is very difficult to be polish by a conventional machining process where the cost is high and much more susceptible to surface damage as compared to other materials (Moosa, 201°).

The interface temperature between workpiece material and abrasive material is an important parameter in finishing processes. The subsurface damage and alteration in the metallurgical structure in the machined/finished surface is mostly dependent on the interface temperature (Komanduri and Hou, 2001).

MAF process has several advantages over the commonly used finishing process such as low cost, high surface quality and it is well suited for finishing magnetic and nonmagnetic, hard and soft materials. It has been successfully used for finishing of internal as well as external surfaces of complicated designs (Kumar *et al.*, 2013).

Taguchi technique involves greatly the reduction of variation in a process through robust design of experiment. The objective of Taguchi technique is to produce high product at low cost for both design and production and increasing the profit by finding the most influential parameters. Taguchi suggests two different methods for analys ing results; Signal to Noise (S/N) ratio and ANOVA for carrying out the complete analysis of the obtained data from the runs to optimize the process parameters that give good quality with a saving cost and time (Vidal *et al.*, 2013).

Temperatures of MAF process is less studied than other micro-cutting processes. There are many sources of heat generation in the working zone which include the current in the conductor and the friction generated between surface of workpiece and grain of abrasive powder. The total amount of heat generated depends on many cutting parameters like speed, time, gap and current.

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Shinmura *et al.* (1985, 1990) studied the pressure acting on the workpiece surface which is a function of magnetic flux density, number of abrasive particles and the permeability of abrasive medium. It was found that magnetic pressure on the abrasive particles causes penetration of the abrasive particles on the workpiece surface. Due to micro cutting operation, temperature on the surface of the workpiece increases. Very high increase in temperature may deteriorate the surface quality of the workpiece.

Mishra *et al.* (2014) determined work-brush interface temperature in magnetic abrasive finishing process. Transient thermal analysis of workpiece domain has been performed to predict the temperature rise due to frictional heat flux. The predicted temperature on work-brush interface was found in the range of 34-51 °C.

The temperature rise is important in contact area during MAF process, the surface roughness is a function of temperature rise and the temperature affects the performance of workpiece to be finished, so, multi regression model has been developed. The finishing process can be controllable because the temperature is controlled by change in the technological parameters.

MATERIALS AND METHODS

Design of experiments for MAF process

Selection the technological parameters, ranges and their levels: In the present work, four variable technological parameters (cutting speed, finishing time, working gap and the current in the inductor) with four levels for each parameter are used to study the effect of technological parameters on temperature rise and the change in the surface roughness in MAF process for CuZn28 brass alloy plates. The invariable parameters of MAF process (i.e., abrasive powder, grain size, amount of abrasive powder) are selected by carrying out trial MAF process to find the best invariable technological parameters. The selected technological parameters for the MAF process, ranges and their levels according to large range of parameters are listed in Table 1.

Determining OA of experimental design: Knowing the number of parameters and their levels, the Orthogonal Array (OA) can be determined. Using the software through DOE-Taguchi-Create Taguchi Design, the levels and the number of factor, OA can be found. Therefore, an OA L16 (4’) for the four parameters with the four levels is used in the current work to perform the most effective experiments (16 test) and (Lakshminarayanan and Balasubramanian, 2008). Sixteen tests with different details of experimental MAF array will be conducted according to OA are represented in Table 2.

Table 1 : The technoloqical parameH’s values and llieir levels

Technological parameters Paramelers	Code	Levels 1	2	3	4
Cutting speed (rpm)	A	240.0	550.0	860.0	1150.0
Finishing time (min)	B	3.0	6.0	9.0	12.0
Working gap (mm)	C	0.5	1.0	1.5	2.0
Current in The inductor Iamp)	D	1.0	1.5	2.0	2.5

Table 2: Experimental design of technological parameters based on fire OA *Y16(4’)*

Exp	Cod	A	Cod	B	Cod	C	Cod	D
1	1	240	1	3	1	0.5	1	1.0
2	1	240	2	6	2	1.0	2	1.5
3	1	240	3	9	3	1.5	3	2.0
4	1	240	4	12	4	2.0	4	2.5
5	2	550	1	3	2	1.0	3	2.0
6	2	550	2	6	1	0.5	4	2.5
7	2	550	3	9	4	2.0	1	1.0
8	2	550	4	12	3	1.5	2	1.5
9	3	860	1	3	3	1.5	4	2.5
10	3	860	2	6	4	2.0	3	2.0
11	3	860	3	9	1	0.5	2	1.5
12	3	860	4	12	2	1.0	1	1.0
13	4	1150	1	3	4	2.0	2	1.0
14	4	1150	2	6	3	1.5	1	1.5
15	4	1150	3	9	2	1.0	4	2.5
16	4	1150	4	12	1	0.5	3	2.0

Table 3: The mechanical prop erties of test specimens 3rass allov CuZn28)

Material	Tensile strength be/mm')	Vickers hardness	Density be/mm')	Shear strength Sq /mm')
CuZn28	38-39	89-105	84	28

Experimental prosedure of MAF process: In this research, sixteen different tests is designed based on the Taguchi OA L16 are listed in Table 2. The dimensions of the flat workpiece were (100 50 3). The mechanical properties of the flat workpiece from CuZn28 Brass alloy are listed in Table 3.

The model of the conventional Turret vertical Milling Machine is MDM 4VS/4H S/4S. Its spindle is used to fix the Magnetic inductor. The electromagnetic coil was calculated and implemented in the following specifications, the number of wire turns equals to 4000, material of core is C15 low carbon and diameter of wire is 0.9 mm. There are two power supplies, one for control the current and the other to control the velocity of spindle. The general view is shown in Fig. 1.

Experimental tests for all samples begun with the measured Ra for the workpiece, before experiments at (three random points) for each sample. The workpiece is fixed on the table of the machine, the working gap was filled with magnetic abrasive powder (tungsten carbide with iron, mesh 250 qm) with amount of volume (4 cm') and then the other condition of the process was adjusted according to OA. After machining, the area of finishing the Ra was measured by profile meter at three random