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Effect Of Cutting Parameters On Tool Tip Temperature And Cutting Forces Of Copper Alloy

Akhil Joshi[1], N.Satish[2], Mrudula Prashanth[3] and B.S.Ajaykumar[4]

[1]Department of Mechanical Engineering.
Bangalore Institute of Technology, Karnataka, India
[2]Department of Mechanical Engineering,
Bangalore Institute of Technology, Karnataka, India
[3]Department of Mechanical Engineering,
Amrita School of Engineering, Bengaluru, Amrita Vishwa Vidyapeetham, India
[4]Department of Mechanical Engineering.
Bangalore Institute of Technology, Karnataka, India

ABSRACT

Due to its strong thermal conductivity, Copper is frequently utilized in various electrical and other industrial applications. Copper is subjected to several machining operations during the creation of such components As a result of these factors, the heat carriers that move heat from one place to another develop resistance routes. In turn, this causes the conducting metal's thermal conductivity to decrease, which affects how well the produced component works. The machinability of Copper depends on its alloying elements and its composition. The addition of alloying elements reduces machinability and hence the amount of heat generated also variable which is dependent on the composition of the alloying element and the machining parameters.

Keywords; Copper, Brass, Tool-Tip Temperature, Cutting forces and Surface Roughness

1. INTRODUCTION

The primary goal of the machining sector is to boost productivity at the expense of quality. Temperature rise causes tools to wear out faster at higher Cutting speed. When non-ferrous materials are machined with carbide tools, special attention is paid to high-speed machining. However, because of its toughness, it may cause the working material's surface quality to degrade as greater force is applied on job. In the present investigation an attempt has been made to add Brass material to the Copper.

The presence of Zinc in Brass has helped to reduce the temperature liberated during machining process. The amount of Brass in Copper has been selected at a rate of 2%, 5% and 8% according to Taguchi technique. The job is loaded on lathe machine tool and is subjected for variable machining parameters and recorded amount of temperature liberated during machining process (1-4).

2. EXPERIMENTAL METHODOLOGY

2.1 SELECTION OF MATERIAL.

The pure copper is used which is 99.3% or higher. Due to its excellent properties of ductility, non-corrosiveness and conductivity, it is one of the most widely used materials. Material can be heat treatable, formable, malleable, and ductile. So, it is used in lot of electrical, construction, home appliance, automobile application etc.

Table 1: Properties of Copper

Properties	Metric
Atomic weight	63.54 u
Atomic number	29
Density	8.94 g/cm^3
Melting point	1083°c
Boling point	2595°c

High corrosion resistant, good hardness brass is taken which is non-ferrous and it is an alloy of copper and zinc which contains 65% of copper and 35% of zinc. And it is yellow in color

Table 2: Properties of Brass

Properties	Metric
Copper	65%
Zinc	35%
Density	8.3-8.7 g/cm3
Melting point	900-940°c
Boling point	1100-1150°c

2.2 Fabrication of copper brass alloys

The elements of the alloy are put it into the crucible in the form of small rods and heated to the melting temperature of the alloy(11000C) in a coke hearth furnace. It is stirred for uniform distribution of alloy. The temperature of heating unit is maintained using a thermocouple. The duration of heating is decided based on the quantity of alloy to be melted. The setup of the hot coal melting furnace is as shown in the fig 4.5 below.

Figure 1.0: Hot Coal Melting furnace

2.2 Procedure to fabricate alloys:

Step 1: The Pure Copper is purchased in the form of rods and it is shown in the following fig.1.1

Figure 1.2 (a): Pure copper raw material

Step 2: Brass is also purchased in the forms of rods and it is shown in the following fig.4.7

Figure 1.2 (b): 65-35 Brass (raw material)

Step 3: Both the purchased materials are taken in the required quantity and put into the crucible and placed into the open furnace. It is heated in the crucible to a temperature of 1100°C and melted. During the process hexachloroethane is used to remove gases trapped during the melting process. The melt is thoroughly mixed with the brass to form the alloy. Similarly, other compositions of the alloys are fabricated for the study. The images of the metal being placed in crucible, metal being melted and poured in to the metal mould is as shown in the following Fig.No.1.3 (a), (b), (c), and (d) respectively.

Step 4: The casting is formed for 3 different compositions of Brass added to Copper. They are 2% Brass added to 98 copper, 5% Brass added to 95%copper, 8% Brass added to 92% copper. The casting so formed is as shown in the following fig.4.9, which shows the cast set material for study.

Figure 1.3(a): Melting of Metal in a crucible

Figure 1.3(b): Molten metal

Figure 1.3 (c): Pouring of molten metal

Figure 1.3(d): Metal Mould

Figure 1.4: Castings of different alloys.

Step 4: The castings are cut and machined to remove the outer scales and finished surface of the castings are as shown below in the fig. 4.10(a) and 4.10 (b) respectively.

Figure 1.5 (a): Cut pieces of castings

Figure 1.5 (b): Machined castings

The elements of the alloy are put it into the crucible in the form of small rods and heated to the melting temperature of the alloy (1100^{0}C) in a coke hearth furnace. It is stirred for uniform distribution of alloy. The temperature of heating unit is maintained using a thermocouple. The duration of heating is decided based on the quantity of alloy to be melted After casting of alloys, the material is tested for the confirmation of the material composition using Braid Spectrovac DV-4 Direct reading Optical Emission Spectrometer(4)

Table-3: Composition of alloys before and after subjecting it through Spectrometer test.

Alloys	Brass (Wt. %)	Zn content in Brass (65-35) (in wt. %) As expected	Zn content in brass (in wt. %) Actual	Copper Content (in wt. %) As expected	Copper Content (in wt. %) Actual	Others
A1	2	0.7	0.78	98+1.3=99.3	98.98	0.45
A2	5	1.75	1.82	95+3.25=98.25	97.80	0.38
A3	8	2.8	2.84	92+5.2=97.2	96.71	0.45

Parameters considered:

The parameters considered for study are Spindle speed, Feed and Depth of cut. These three parameters are taken and the design of experiment is done. Taguchi design is used to design the experiments. MiniTab software is used to set the design. L9 design is chosen to carry out the machining process. It is as shown in the table 4.2. Here the taguci design in which L9 is chosen where in the number of factors are 3 and the no. of levels are also 3. The variables or factors in the design are Spindle Speed, feed, depth of cut ((5).

Table 4.0: ANOVA (TAGUCHI) Design

Levels	Spindle Speed (RPM)	Feed (mm/min)	Depth of Cut (mm)
1	210	0.30	0.30
2	210	0.60	0.60
3	210	0.90	0.90
4	420	0.30	0.60
5	420	0.90	0.90
6	420	0.90	0.90
7	750	0.30	0.90
8	750	0.60	0.30
9	750	0.90	0.60

Further, the machining is carried out using lathe and a single point cutting tool (Carbide tipped tool) is used. During machining, the forces are noted down. Also using non-contact type temperature measuring device, the tool tip temperature is measured

3.0 Results and Discussion

The table no 4.1 to 4.4 shows the various parameters that are varied such as speed, feed, depth of cut and also shows the corresponding cutting forces measured along x, y and z directions such as fx, fy, fz and the temperature at the tool tip for different combinations of Copper and brass respectively

Table 4.1: The results of machining and its response for A-1 alloy

Experiments	N Speed RPM	F Feed in mm/rev	D Depth of cut mm	Fx Axial Force in KN	Fy Tangential force in KN	Fz Radial force in KN	T Temperature at the tool tip °C
L1	210	0.30	0.30	0.15	0.41	0.35	43.30
L2	210	0.60	0.60	0.59	0.97	0.11	45.20
L3	210	0.90	0.90	0.76	1.18	0.10	46.40
L4	420	0.30	0.60	0.63	1.01	0.08	41.40
L5	420	0.60	0.90	0.73	1.21	0.07	43.51
L6	420	0.90	0.30	0.74	1.22	0.09	44.72
L7	750	0.30	0.90	0.33	0.58	0.03	37.10
L8	750	0.60	0.30	0.61	1.02	0.02	41.10
L9	750	0.90	0.60	0.78	1.24	0.02	43.12

Table 4.2: The results of machining and its response for A2 alloy

Experiments	N Speed RPM	F Feed in mm/rev	D Depth of cut mm	Fx Axial Force in KN	Fy Tangential force in KN	Fz Radial force in KN	T Temperature at the tool tip °C
L1	210	0.30	0.30	0.13	0.36	0.33	33.00
L2	210	0.60	0.60	0.34	0.90	0.06	35.10
L3	210	0.90	0.90	0.56	1.16	0.10	36.10
L4	420	0.30	0.60	0.47	1.00	0.02	31.40
L5	420	0.60	0.90	0.36	1.17	0.02	33.34
L6	420	0.90	0.30	0.71	1.19	0.05	34.64
L7	750	0.30	0.90	0.13	0.28	0.03	27.40
L8	750	0.60	0.30	0.43	1.00	0.03	30.28
L9	750	0.90	0.60	0.68	1.20	0.05	33.24

Table 4.3: The results of machining and its response for A3 alloy.

Experiments	N Speed RPM	F Feed in mm/rev	D Depth of cut mm	Fx Axial Force in KN	Fy Tangential force in KN	Fz Radial force in KN	T Temperature at the tool tip °C
L1	210	0.3	0.3	0.05	0.23	0.13	24.8
L2	210	0.6	0.6	0.24	0.52	0.06	27.9
L3	210	0.9	0.9	0.50	0.90	0.20	29.45
L4	420	0.3	0.6	0.14	0.32	0.08	24.3
L5	420	0.6	0.9	0.07	0.32	0.05	26.8
L6	420	0.9	0.3	0.34	0.76	0.02	27.9
L7	750	0.3	0.9	0.04	0.15	0.01	22
L8	750	0.6	0.3	0.22	0.47	0.01	24.1
L9	750	0.9	0.6	0.43	0.65	0.05	26.9

3.1 Effect of Speed, feed and Depth of Cut on cutting forces during machining of different combinations of alloy.

Table 4.1-4.3 shows that as the cutting speed, depth of cut, and feed increase, so do the cutting forces needed to machine the various alloy combinations. However, it was discovered that the combination of Feed 0.3 mm/rev and Cut Depth 0.9 mm were less for all combinations of alloy when the Cutting Speed was 750 rpm. In compared to A-1 alloy, the axial force Fx and tangential force Fy have increased by 60% and 51% for A-2 alloy and 74% and 87% for A-3 alloy, respectively. An inclusion of Brass to alloy might have lowered the cutting forces are in concurrence with the earlier investigators. Effect of Speed, feed and Depth of Cut on Cutting forces for different combinations of alloy (6-7).

3.2 Effect of Speed, feed and Depth of Cut on Temperature liberated at Tool tip for different combinations of alloy.

Table 4.1 to 4.3 shows that the tool tip temperature raises as the cutting speed, depth of cut, and feed increase. When the Alloys A-1 to A-3 were machined at Cutting speed 750 rpm, Feed 0.3mm/rev, and Depth of cut accordingly, it was discovered that the tool tip temperature was lower. In compared to A-1 alloy, the tool tip temperature has dropped by 26% for A-2 alloy and by 40.7% for A-3 alloy. Increased zinc content in brass contributed to a rise in copper's thermal conductivity, supporting earlier researchers' observations (6-7).

4.0 Conclusion:

Through Results and Discussion, it can be concluded that Combination of 8% brass in copper (A-3 alloy as shown in Table-3) machined at Cutting speed 750 rpm, Feed 0.3mm/rev, and Depth of cut reduces the cutting forces by an amount 87% and Tool tip temperature by 40.7% in comparison with rest of the combinations increase the productivity and Tool down time.

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