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AN EXPERIMENTAL INVESTIGATION ON BURR HEIGHT AND MACHINING TIME IN DRILLING FOR METALLIC AND NON-METALLIC SPECIMENS

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Abstract: Drilling is one of the most conventional types of machining operations to make holes. In this experimental work drilling has been performed on metallic (low alloy steel) and non metallic (bakelite) blocks by a radial drilling machine. At the exit side of the workpiece adhesive and wax were pasted to reduce the burr height and machining time. Experiment has been carried out in different rpm. It has been found that adhesive is very effective to reduce burr height for metallic specimen and machining time for non-metallic specimen. Wax is very effective to reduce machining time for metallic specimen and burr height of non metallic specimen.

Keywords: Drilling; burr height; machining time; low alloy steel; bakelite.

1. INTRODUCTION

Drilling is most commonly used machining operation to make circular holes of different diameters. In drilling operation holes are made on the job by removal of material with the help of rotating tool, called drill bit. Two cutting edges of drill bit make an angle with its axis. Drills are mainly classified into three main types, e.g. flat drill, straight fluted drill and twist drill [1, 2]. A piece of round still is forged to shape and ground to size to get the shape of flat drill, then hardened and tempered. The cutting angle, clearance of cutting edge maintained at 90^o and 3^o to 8^o respectively. Diameter reduction when drill is ground is the main disadvantage of this type of drill. Among the all twist drill is the most used one now a day's [3]. Burr is formed in form of fine wire either at the edge of sharpened tool or raised portion of the workpiece in different machining operations (e.g. drilling, milling, etc.) It is usually desirable to reduce burr formation and machining time of drilling operation.

Many researchers had explored to reduce burr height and machining time of drilling operation by applying different methods. Shanmughasundaram and Subramanian [4] tried to find the effect of geometries of step drills and cutting parameters on the burr height in drilling of Al–Gr composites. Step drill's geometries and spindle speed were found to be the most influential parameters for burr height formation. Bhandari *et al*. [5] developed micro-drilling burr-control chart (M-DBCC) for a standard copper-clad laminated-PCB with laminated fiber-reinforced plastic (FRP) substrate. They considered burr geometry, burr formation mechanisms, burr height and drill bit breakage to classify different types of burr. Kundu *et al*. [6] successfully minimized the drilled burr height of aluminium alloy using HSS drill bit with a back-up support. Approximately a reduction of 33% in burr height and uniform burr formation was achieved.

In some other work, Biermann and Hartmann [7] used cryogenic process of cooling with CO_2 snow jet to influence the burr formation in drilling in spite of lubricated or dry machining on steel and aluminum alloy. Successful reduction in burr height with good surface quality in comparison to lubricated or dry machining was achieved for considerable drilling depth. Segonds *et al*. [8] suggested a new analytical model based on slip plane theory to predict the burr formation type in case of drilling ductile materials. Based on developed model, experimental results showed a good agreement between the predicted burr thickness and experimental burr thickness along with close burr prediction accuracy.

Pilny *et al*. [9] experimentally investigated and optimized burr height formation by drilling on 2mm wrought aluminium sheets. With varying cutting data, clamping condition and drill geometry, burr reduction was successfully achieved with high drilling speed and reduced feed rate. Also a properly constructed clamping system led to significant burr reduction. Gaitonde *et al*. [10] presented a new concept on membership function, a methodology of Taguchi optimization based on ANOM and ANOVA to reduce burr height and bur thickness. ANOVA result showed the maximum influence of point angle on optimum burr for different drill diameter, and a good agreement between the predicted and experimental burr height and thickness was achieved which validated the result strongly. Pena *et al*. [11] used internal signals from spindle torque to detect undesired burr formation in drilling. Selected signal features were found to be sensitive to exit burr height and totally insensitive to change in process parameters. Simon and Gary [12] designed an ultrasonically vibrated workpiece holder for controlling burr size in metal cutting in the direction of feed in which these high frequency low amplitude vibrations were used, as a result, a considerable reduction in burr height and width was obtained. Kim *et al*. [13] developed burr control charts to predict and control drilling burr size. A new set of cutting condition variables and drill diameter were developed, resultant burr size showed greater dependence over developed parameters regardless of drill diameter. Ko *et al.* [14] minimized drill burr size using step drill. Here normal drilling was done with front cutting edge (normal cutting edge) and enlargement of hole size was done using step edges. Considerable reduction in burr size was achieved through this procedure. Sangkee *et al*. [15] proposed burr control chart for low alloy steel in drilling. They proposed uniform, transient and crown types of burr greatly dependent on cutting conditions.

Different works were also done [6, 17-22] in a series of experimental investigations by a group lead by S. Das on reduction of drilling burr formation. Mondal et al. [17], Roy et al. [18], Kundu et al. [19-20, 22] and Misra et al. [21] experimented on the ways for the reduction of drilling burr by putting a back up plate at the exit end, beveling exit edge suitably, putting an adhesive back support, applying cutting fluid, selecting suitable cutting parameters, using special burr reducing drills, etc. for different workpiece materials like steels and aluminium alloys. At some specific cases, they reported to have achieved reduce drilling burr remarkably.

Aim of this experiment is to reduce exit burr height and machining time. Experiment has been carried out on four different blocks of low alloy steel and bakelite.

2. Details of Experimentation

In this research work, drilling being performed by a pillar drilling machine using a HSS cutter having a diameter of 6 mm. Experimental conditions and details about tool and workpieces are given in Table 1. Thickness of workpiece was 9.5 mm. Experiment has been carried out at four different rpm. Uniform feed was provided manually. At the exit side of the workpiece wax and adhesive were pasted in order to reduce burr height and machining time. Machining condition was dry. Machining time and burr height was measured with the help of digital stop watch and vernier-caliper respectively.

Table 1 Experimental conditions

Drilling Conditions	Machine: Radial drilling machine Make: Universal Machine Tools Corporation, Bangalore Type: Twist drill, Environment: Dry
Cutter	Material: H.S.S., Make: Addison Tool Manufacturer, Mumbai Size: ϕ6 mm × 85 mm No. of teeth: 02, Lip angle: 118^o
Work piece	Material: Low Alloy Steel, Hardness: HRB 90 Composition: C- 0.35%, Si- 0.80%, Mn- 0.38%, P- 0.09%, S- 0.8%, Fe- rest Size: 50 mm×40 mm×9.5 mm Material: Bakelite, Hardness: HRB 87 Size: 50 mm×40 mm×9.5 mm
Machining Conditions	Speed: 643, 703, 1186, 1932 rpm

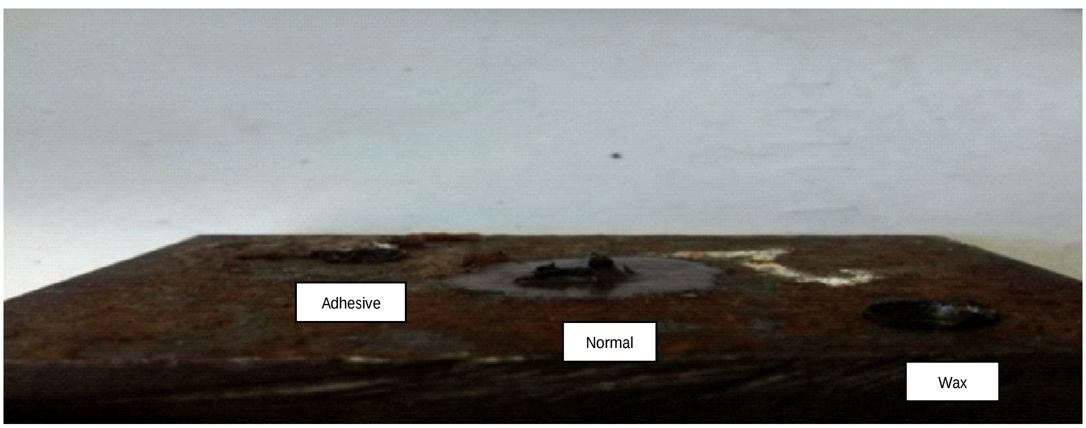

Fig.1 Significant burr height reduced in low alloy steel

3. Results and Discussion

Burr height at the exit side of the workpiece was measured by vernier-caliper. For four different speed levels burr height was measured differently for three different conditions (e.g. normal, adhesive, wax). Machining time was measured during drilling operation with the help of a digital stop watch. Comparative study of burr height and machining time has been done in between three different conditions, to find out the significance of pasting wax and adhesive at the exit side of workpiece.

From Fig. 2 it is clear that using of adhesive can significantly reduce the burr height at the exit side of the workpiece. As the rpm increases burr height decreases with the use of adhesive. Actually adhesive used to stick with the surfaces because of its greasy nature, so it obstructs the formation of burr at exit surface of the workpiece. Wax couldn't manage to reduce the burr height significantly at high speed. As workpieces are heated more with higher speed, causes wax to be melted and to paste to its surfaces.

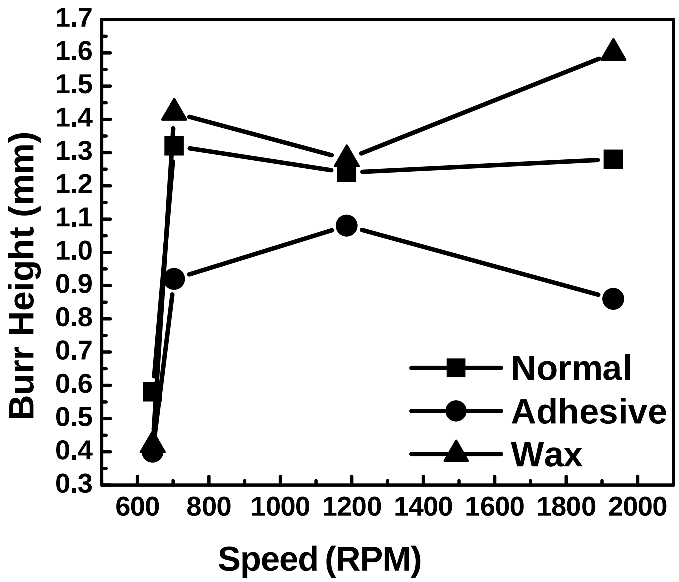

Fig. 2 Burr height vs speed plot for low alloy steel

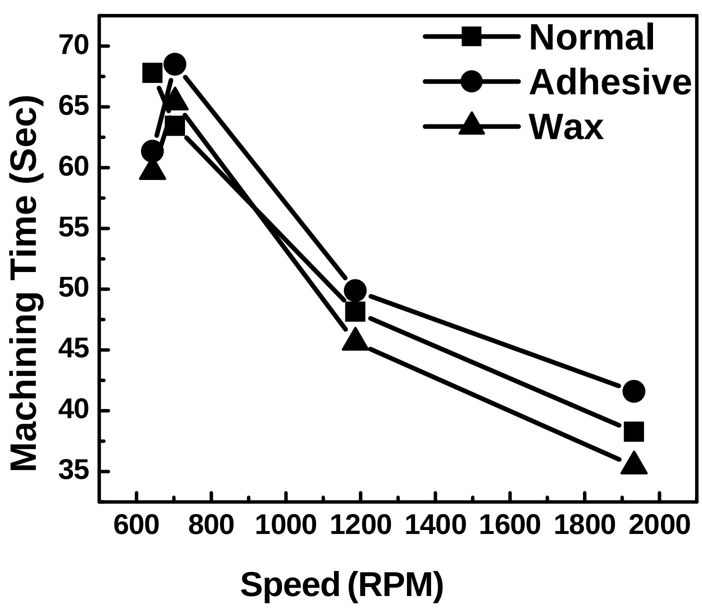

Fig. 3 Machining time vs speed plot for low alloy steel

Fig. 3 reveals that pasting wax at the exit side of the workpiece can significantly reduce machining time of drilling. As it is thermally non-conductive and high heat storing ability [16], generated heat would be more constricted within that area where wax is pasted. As the machining zone is more heated, machining time will be less.

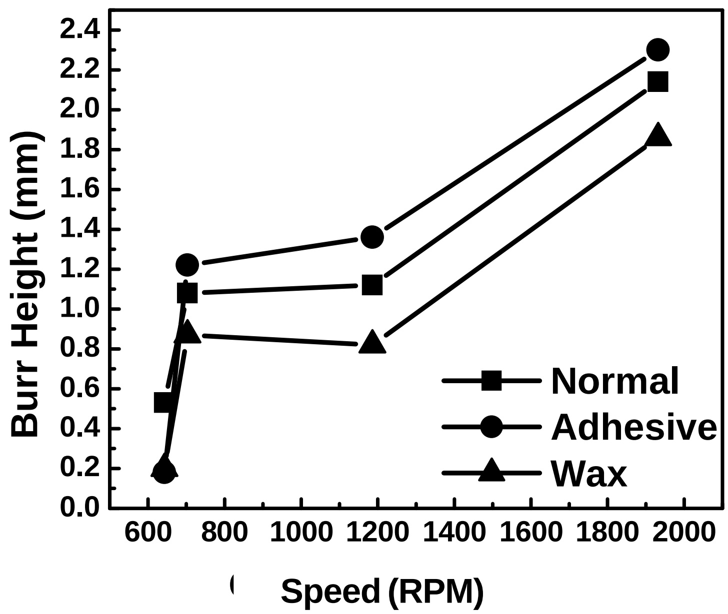

Fig. 4 Burr height vs speed plot for Bakelite

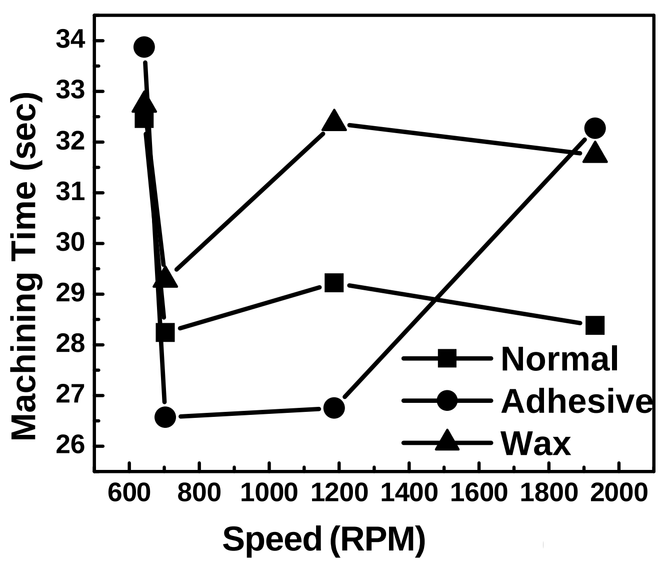

Fig. 5 Machining time vs speed plot for Bakelite

It is clear from Fig. 4 that for bakelite using wax is very significant to reduce burr height. As thermal conductivity of bakelite is less than low alloy steel, chances of melting of wax is less compared to previous case. But using of adhesive is not as significant as it couldn't stick properly with bakelite surfaces, as it is slippery in nature.

Fig. 5 states that using of adhesive at the exit side of the workpiece can reduce machining time significantly. Pasting of wax can also reduce machining time initially but as the speed increases machining time is also increases compared with normal condition.

4. Conclusions

From the present investigation, following conclusions may be drawn.

- Pasting of adhesive at the exit side of the workpiece can reduce burr height significantly for low alloy steel specimen.
- Wax can reduce the machining time for low alloy steel specimen significantly compared to normal condition.
- Wax is very significant to reduce burr height in case of non metallic specimen.
- Use of adhesive can reduce machining time significantly for non metallic objects.

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