Effect of Spindle Speed, Feed Rate and Cooling Medium on the Burr Structure of Aluminium through Milling

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Abstract. The burr is formed during milling, when the tool exits the work piece in any machining operation. The burr formation on a milling machine with the use of end mill cutter with different speed and different cooling mediums like air, water, and cutting fluid are discusses. The tool used for the machining operation is an end mill cutter tool. This work is taken up to examine the effect of different speeds and different cooling mediums on burr formation in the milling operation of aluminium in a dry and wet atmosphere. Results are found on the exit edge of the work piece, found during the milling operation. This paper manages with the aspects that influence the formation of burr and type of burr formed while doing experiment. The parameters considered are, the maximum length of stroke, drive speed (step cone pulley), range of speed arrangement groove and the selection of a cooling medium. The drive speed of the milling machine was measuring by Tachometer in all drive stages. The pictures of produced burrs were taken with the support of a digital microscope and digital camera.

1. Introduction

Burr control and evacuation have been among the most relevant economic considerations in machining processes and so have been the objective of research in metalworking activities over the past five decades [1]. Milling machines are mechanical devices which by method for chip evacuation give work pieces the ideal shape, measurement and surface accomplishment. They produce, for the most part, level surfaces, shoulders, grooves, and comparative shapes. It is, notwithstanding, additionally possible to make circularly curved surfaces. The cutting is affected with single-edged tools in the interfered with cut with a working stroke and an arrival stroke. Milling machine is one of the utmost adaptable and predictable machine tools with a varied variety for the capability of metal cutting. Most of the complex operations such as straddle milling, gang milling, indexing and making of gears and slots etc. can be passed out on a different type of milling machine as per the requirement of operation. This preparation module is proposed to give you a decent valuation for the kind of milling machines and the different sorts of processing forms. Accentuation is set on its mechanical applications, activities, and the determination of suitable cutting instruments. Since molding can be comprehended as turning of workpieces with boundlessly huge distance across, there are numerous comparable perspectives among shaping and turning and shaper and turning devices. The primary reason for milling is much of the time to expel generally enormous measures of material as chips. This is applied, for instance, to evacuate the aluminium scale and to get flat and adjusted surfaces or to cut long or substantial parts (for machining plate edges in addition to other things). There are different types of operation which have been performed
on milling machine; they are horizontal surfaces, upright surfaces, sharp surfaces, asymmetrical sides, cutting holes, channels and keyway, and gear cutting. The size of the milling machine is determined by the dimensions of table, speed of spindle and the feed rate, ram travel, ram rotation angle, spindle rotation angle are available. In this investigation the formation of the burr on a milling with different speed measures and different cooling mediums like air, water and cutting fluid. The added, non-productive deburring process is employed for the subtraction of burr in practice. The tool used for the machining operation is an end mill cutter tool, and the various experimental outcomes have been performed on the formation of burr for its amount. This work is taken up to examine the effect of different speeds and different cooling mediums on burr formation of aluminium in a dry and wet atmosphere, and validating the experimental results. Numerous researchers have been worked on the formation of burr to minimize the deburring method usually on the development and deburring of burr. He finds that the price of process of deburring had been about 30% of the total cost of production of precise component.

In direction of drilling holes though, the specific material component of the stacks places very different demands with favor to cutting edge design and optimal process parameters. To one side from that, the requirements of quality are very high which is concerning the consistency for the assembly of joints. The results of errors on drilling parameters of surface roughness and roundness were inspected in drilling of material Al 6061 alloy using with the help of twist drill of high-speed steel (HSS) by Reddy Sreenivasulu and Srinivasa Rao [2].

Eynian presented a connection between the cutting forces during the machining and the wear condition of twist drills and the relation between the forces during the cutting process as well as between the formation of burr and the quality of surface for titanium alloys. As per a result of his study, Eynian found that the normal force on the tool and the feed force on the tool improved to approximately four times of the amount with growing of wear. Torque, still, rise only slightly nearby 70 % with the growing wear [3]. Bajpai et al. inspected that formation of burr of titanium alloy “Ti6Al4V” in high speed micro-milling. They determined that most critical and larger type of burrs is side exit burr in up milling sideways. The height of burr decreases when the feed and speed of spindle increase. With the increment in depth of cut the stature of burr rises. The width of burr is only affects the depth of cut. The width of burr rises with the increasing in depth of cut. The proportions of burr does not change knowingly by the tool diameter and the number of flutes.[4]

Most of the work was done on the mechanism of formation of burr via the finite element method, and the simulation is to validate the mechanism [5-6]. Saha and Das investigational found out that there is a considerable effect of exit edge beveling on the formation of burr in milling [7,8]. Saha and Das and Das et al. [12-13] performed an experimental examination and analysis of stress via the finite element method to figure out the influence on orthogonal machining operation for the exit edge bevel angle on the burr and formation of foot through machining process [9,10].

According to [11], the machining of different ductile materials has a tendency to form bigger burrs, predominantly at a complex level of feed rate and cutting speed of tool. According to Ko and Lee [12], the properties of their material had added an outcome on the burr size while drilling than the feed rate. The investigative model proposed in [13] that were accomplished to forecast the type and size of ductile materials while machining operations were performing on milling, drilling, grinding machine of exit burrs.

Form the literature review it is originate that the groove and the development of burr are generally exaggerated by different parameters like depth of cut spindle speed and feed rate and the ram travel. Different coolants are used (air or water and a mixture of cutting oil and water), the material of the workpiece used and the tool used for the machining operation. All the said literature points visibly, which supports the declaration of influencing the aspects for the formation of burr in the process of milling. In these experimentations, there are three input parameters that well-thought-out the ram travel, speed of spindle type of tool angle of tool, angle of tool and feed rate and the selection of cooling medium. All of these parameters are self-determining to each other and distinct cases were occupied in
all these steps of examination. By the use of tachometer drive speed of milling machine is being measured in each of the cases, “while a channelized path was created for the cooling medium with the help of Drip-Case attached to the water bottle and the end mill cutter tool was taken for making the grooves”.

To conclude that the pictures of different produced burrs on different speeds and different cooling mediums were taken with the help of digital camera and digital microscope. “This experiment will support in choosing the suitable, material and tool, cooling medium for a particular milling machining process and upcoming work on other materials possibly will be done by varying the different limitations revealed above as per the necessity”.

There are different types of burrs on varying different speed on the vertical milling machine and different cooling medium. All of them lies below the group of horizontally or vertical burrs. They consist of unbroken burr. This kind of burr is insignificant and consistently spread around the groove. The following figures illustrate these figures in their particular order.

![Figure 1. Different types of burrs form on milling machine](image)

2. **Experimental Methodology**

This investigation, is carried out on the vertical milling machine and the parameters and working consideration of vertical milling machine are in the given Table.1.Different parameters like depth of cut and different spindle speed in Table 2, spindle feed rate, rotation of spindle angle, travel length of ram speed of milling and three cooling medium viz, air, water and the mixture of cutting oil and water have been used separately in a different way to understand the shape and size of burr which is formed on milling machine. 16mm end mill cutter tool is used for milling operation as shown in Fig 3. Different speed rates has been calculated and explained in the Table 3 and the operation on a milling machine is going thru with different speeds (rpm), and different cooling mediums, the machining operation is done with the use of end mill cutter tool freely. To ensure that the non-stop flow of water during the groove process, with the use of a drip case, has remained fixed to the bottle and the adjustment of knob for managing the movement (flow) of the cooling medium, and the burrs formed during without use cooling medium.

2.1 **Working Considerations**

Table 1 shows that the type of machine tool and tool used for machining, geometry of tool and its angles and type of material for machining operation and the physical and mechanical properties for material
which is aluminium, and the dimensions for the specimen and the machining conditions like type of machine, speed drive, depth of cut and environment for operation like air (dry), cutting oil + water (wet).

| Table 1. Working Considerations |
|---------------------------------|
| **Type of Machine Tool** | **Vertical milling machine** |
| Tool Used | High-speed steel (HSS) end mill cutter |
| Geometry of tool | Cutter dia 1/32, number of grooves 4, helical angle 35°, diameter 16mm, rake angle 7°, gash angle 40°, radial primarily clearance angle 8°, radial secondary clearance angle 15° |
| Material for workpiece and its properties | Aluminium, Density 2720 kg/m³, Melting point 650.5°C, Tensile Strength (50-600) MPa, Compressive Strength (100-600) MPa |
| Dimensions of workpiece | 10 mm thickness, 90 mm length, 75 mm width |
| Machining Conditions | Type of machining: Orthogonal shaping, Speed of spindle 260, 340, 550 (rpm) |
| Atmosphere: | Depth of cut (t): 4 mm, width of cut: 16 mm, Atmosphere: air (dry), cutting oil + water (wet) |

Table 2 shows the different speeds of spindle of vertical milling machine.

| Table 2. Showing different speeds taken for experiment |
|------------------------------------------------------|
| No. | Speed of spindle in (rpm) |
|-----|--------------------------|
| 1.  | 260                      |
| 2.  | 340                      |
| 3.  | 550                      |

Different speeds of spindle of milling machine drive speed and different feed rates, time, number of rotations and depth of cut were occupied and revealed in the Table 3 for the investigation, and obtained dissimilar results. Technique for the accomplishment the different speeds of spindle of the vertical milling machine. The speed of the spindle of vertical machine is set on a specific spindle and the speed was record by means of the “tachometer” by engaging over the groove. Different speeds of spindle (rpm) and feed rates in (mm) have been recorded.

| Table 3. For measuring the different speeds and different rates |
|---------------------------------------------------------------|
| S.No | Rpm | Time (sec) | Feed rate (mm) | Depth of cut (mm) |
|------|-----|------------|----------------|-------------------|
| 1    | 260 | 124        | 0.037          | 4                  |
| 2    | 340 | 62         | 0.075          | 4                  |
| 3    | 550 | 40         | 0.204          | 4                  |

3. Types of cutting tools used for this experiment

In this experiment of finding the shape of burr, an end mill cutter tool has been used at each of the speeds as mentioned above as without a cooling medium and with the use of air-cooled medium and water-cooled medium and the mixture of cutting oil and Water, Fig 2 show the cutting edges of end mill cutter with 4 flutes and Fig 3 shows the end-mill cutter.
4. Results and Discussions

Here are the different forms of burr that can be shaped from machining process: “Poisson burr, rollover burr, and breakout burr”. The burrs which have been formed during the machining operation on vertical milling machine with the use of end mill cutter are the rollover burrs and the breakout burrs. One of the most common type of burr is rollover burr. The three cases of burr formation on aluminium workpiece with different speeds that are mention in Fig. 4. Slot 1 in Fig. 5 is done with cutting oil and slot 2 is done without cutting oil respectively.

In this we achieve that the formation of burr though machining on milling machine on different parameters like speed of spindle, feed rate, and depth of cut with different medium like air and cutting oil with water. While using cutting oil the formation of burr is less and the surface finish is good as compared to that of air medium.

4.1 Findings

The different processes parameters which effect the nature of burr formed like, depth of cut, type of tool and angle of the tool, speed of spindle, feed rate, and the proper proportion for the combination of the cutting fluid.

In situation of without using the cooling medium, the creation of burr is high when the speed is high while at the low speed the formation of burrs are uniform, rollover burrs are commonly forms in this. In case of using a cooling medium. The formation of burr is less because of cutting fluid and good surface finish, breakout burr is found in this practical investigation.
Figure 4. Formation of burrs on different speeds with cutting oil or without cutting oil.

From the above Fig 4 shows the three cases of burr formation on aluminium work piece with different speeds that are mention in Table 2 respectively.

Figure 5. Machining without cutting fluid or with cutting fluid

Fig 5 shows that the two conditions of burr formation on milling with the use of end-mill cutter the slot one show the formation of burr without using cutting fluid and the slot 2 with the use of cutting fluid we see that the in case 1 the burr are in large shaped and pointed structure burr like rollover burr and breakout burr. The depth of cut is 4mm. Fig 6 shows the manual deburring.
5. Conclusions
One and only of the most significant and valuable machining activities is milling establishes to 30-40% amongst all the forms of machining like “flat surfaces, vertical surfaces, precise surfaces, irregular surfaces, slot cutting, grooves and keyways, or gear cutting”. The arrangement of burrs is one of the most open and unwanted things that proceeds while performing machining tasks. The burr which is answerable for diminishing the at long last fabricated part and furthermore makes its quality terrible. In this way, it is attractive to evacuate the burrs formerly the last completing activity. Accordingly, to identify the type burr shaped and the parameters that influence the superiority of burr shows countless reputation.

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Figure 6. Manual De-burring
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