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Review on Milling Machine

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ABSTRACT: Milling process is used to remove material by a rotating cutter. This machining procedure is commonly employed by industries, and it involves cutting away any unneeded material. On a part, a milling machine is used to create a variety of characters. a The goal of this research is to determine the optimum surface roughness, which is a machine parameter. One of the most particular customer needs in a machining process is surface roughness. Surface roughness refers to minor texture abnormalities on the surface. In the machining process, surface roughness is also caused by the tool chip contact and feed marks. In measuring the productivity of machine tools and machined products, the quality of the surface plays an essential role. Several milling process factors, including as cutting speed, feed, cutting depth, rate of material removal, also known as MRR, and machine time, all play a crucial impact in surface roughness. Many investigations have focused on these factors, and it has been discovered that the process parameters cutting speed, depth of cut, and feed are essential characteristics that determine the work piece's surface roughness. So, in terms of optimization, these three process parameters (feed, cutting depth, and cutting speed) should be chosen. To discover the best value of parameters for cutting and minimizing surface roughness, an appropriate optimization approach is required. To achieve the best surface roughness, the Taguchi method will be utilized. To identify the parameter setting, Taguchi's orthogonal array should be employed. The results will be analyzed using analysis of variance (ANOVA). Mild steel will be utilized in milling machines with water cooling to carry out the machining operation.

KEYWORDS: Surface roughness, Milling, Optimization, Process Parameter, Taguchi method, ANOVA.

1. INTRODUCTION

The work piece is fed against a rotating multi-point cutter on a milling machine, which removes metal. With the help of several cutting blades, the milling cutter revolves at a high speed and eliminates metal at a rapid rate [1]. On the arbour of a milling machine [2], one or more cutters can be placed at the same time. It is for this reason that a milling machine is often used in manufacturing. Flat surfaces, contoured surfaces [3], surfaces of rotation, external and internal threads, and helical surfaces of various cross-sections are all machinable using a milling machine. Milling machines have even replaced shapers and slotters because of their better output rate and accuracy. Milling machines are extremely adaptable. They're most commonly employed to create flat surfaces on square or rectangular parts, but they can also create a variety of unusual and irregular surfaces. They can also drill, bore, create slots, pockets, and a variety of other shapes. A variable speed vertical spindle, knee-mill with a swiveling head (sometimes known as a "Bridgeport") is the type of milling machine used in the UCR Mechanical Engineering Machine Shop [4]. Despite the fact that there are various other types of milling machines, this document will solely discuss vertical milling machines.

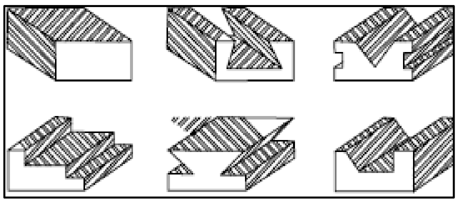

Figure 1: Job surfaces obtained by Milling machine

Milling is a cutting procedure that removes material from the surface of a work piece using a milling cutter. A milling cutter[5] is a rotary cutting instrument that usually has several cutting points. Surface roughness is frequently a reliable indicator of mechanical component performance. Because of the large number of machining operations and the factors that influence each operation, developing models to anticipate the cutting phenomena is difficult. To solve the same problems as those listed below, other solutions are used.

1.1 Analysis of variance (ANOVA)[6] is used to evaluate the magnitude of response in percentage (percent) for each orthogonal array parameter. It's utilized to measure and determine the source of various trial findings from various trial runs (i.e. different cutting parameters). The ANOVA is a statistical approach for determining the differences between groups. Prof. R.A. Fisher was the first to coin the word, and it was then expanded upon by Prof. Snedecor and others. The overall sum of the squares (total variation) is equal to the sum of the SS (sum of the squares of the deviations) of all condition parameters and error components in ANOVA.

1.2 Taguchi method[7] involves reducing the variation in process through robust design of experiment. A Genetic Algorithm is a method for solving both constrains and unconstraint optimization problems based on natural selection process that mimics biological evolution. Response Surface Methodology (RSM) is a collection of mathematical and statistical techniques for empirical building. By careful design of experiments the objective is to optimize output variable.

1.3 Finite Element Analysis (FEA) [8]is a computerized method for predicting how a product reacts to real world forces, vibration, heat, fluid flow and other physical effects. Ant colony optimization (ACO) is probabilistic technique for solving computational problems which can be reduce to finding good paths through graphs.

2. DISCUSSION

The metal is sliced in a milling machine by a rotating cutter with several cutting edges. The work piece is fed against the rotary cutter during the cutting process. Metal is removed in the form of trochoid-shaped chips as the work piece travels against the milling cutter's cutting edges. In one or more passes of the work, a machined surface is created. The work piece is clamped in a vice, rotary table, three-jaw chuck, index head, between centers, special fixture, or bolted to the machine table. The cutting tool's rotating speed and the work piece's feed rate are determined by the type of material being machined.[9]

The work piece is resting on the machine's worktable. The feed of the work piece against the rotating cutter is controlled by the table movement. The cutter is attached to a spindle or arbour and rotates at a rapid rate. The cutter has no other motion except spinning. The cutter teeth remove the metal from the work piece's surface as it advances, resulting in the desired shape.

Milling methods:

Up-Milling or Conventional Milling Procedure:

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A cutter revolving against the direction of motion of the work piece removes the metal in the form of small pieces. The chip thickness is minimum at the start of the cut and maximum at the end of the cut in this form of milling. As a result, the milling cutter's cutting force varies from zero to the maximum value per tooth movement (Figure 2). The tendency of the cutting force to remove the work from the fixtures and the poor surface finish obtained are the two key drawbacks of the up-milling operation. However, because it is a safer type of milling, it is widely employed [10].

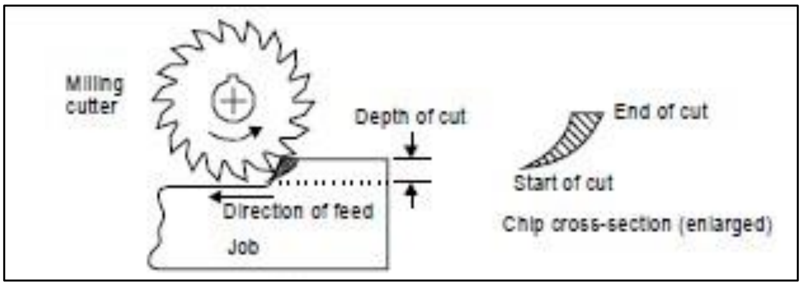

Figure 2: Up- milling

Down-Milling or Climb Milling:

A cutter that rotates in the same direction as the work piece feeds removes the metal. The result is that the teeth cut downward rather than upward. Chip thickness is greatest at the beginning of the cut and lowest at the end. It is stated that with this procedure, there is less friction and, as a result, less heat is created on the cutter and work-piece contact surfaces. It's used to enhance the number of pieces sharpened per sharpening while also improving the polish (Figure 3). Climb milling also consumes somewhat less energy because the table does not have to be driven against the cutter [11].

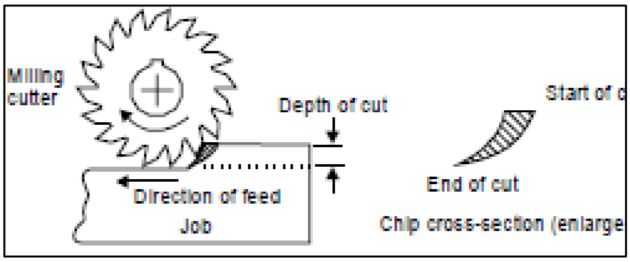

Figure 3: Down milling

Types Of Milling Cutters

The figures below show some types of milling cutters along with work-pieces. Milling cutters are made in various forms to perform certain classes of work, and they may be classified as:

- Plain milling cutters
- Side milling cutters
- Face milling cutters
- Angle milling cutters
- End milling cutters

- Fly cutter
- T-slot milling cutter
- Formed cutters
- Metal slitting saw

Milling cutters may have teeth on the periphery or ends only, or on both the periphery and ends. Peripheral teeth may be straight or parallel to the cutter axis, or they may be helical, sometimes referred as spiral teeth.

***Types Of Milling Machine*:**

Milling machine rotates the cutter mounted on the arbor of the machine and at the same time automatically feed the work in the required direction. The milling machine can be classified in several forms, but choice of any particular machine is determined primarily by the size of the work- piece to be undertaken and operations to be performed. Milling machines are made in variety of types and sizes. They are:

Column and knee type milling machines which include hand milling machine, horizontal milling machine, Universal milling machine and vertical milling machine. It is the most commonly used milling machine used for general shop work.

1. **Planer milling machine**: It is a heavy-duty machine. It resembles a planer and like a planing machine it has a cross rail capable of being raised or lowered carrying the cutters, the heads, and the saddles, all supported by rigid uprights. The use of the machine is limited to production of work only and is considered ultimate in metal removing capacity.

2. **Fixed-bed type milling machine** which include Simplex milling machine, Duplex milling machine and Triplex milling machine

3. **Machining centre machines**

4. **Special types of milling machines** such as Rotary table milling machine, Planetary milling machine, Profiling machine, Duplicating machine, Pantograph milling machine, Continuous milling machine, Drum milling machine and Profiling and tracer controlled milling machine. It is developed to suit special purposes.

Depth of Cut

The depth of cut in milling machine is defined as “the thickness of the material removed in one pass of the work under the cutter”. Thus, it is the perpendicular distance measured between the original and final surface of the work-piece, and is expressed in mm.

Indexing and Dividing Heads

Indexing is the operation of dividing the periphery of a piece of work into any number of equal parts. In cutting spur gear equal spacing of teeth on the gear blank is performed by indexing. Indexing is accomplished by using a special attachment known as dividing head or index head. The dividing heads are of three types:

- Plain or simple dividing head
- Universal dividing head

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- Optical dividing head

Operations Performed on Milling Machine

A milling cutter begins with a sliding action between the cutter and the job, rather than a continuous cut. The chip is subsequently removed using a crushing operation, followed by a cutting operation. A milling machine can execute a variety of processes, including:

i. *Plain milling or slab milling:* It is a method of producing a plain, flat, horizontal surfaceparallel to the face of the axis of rotation of the cutter.

ii. *Face milling:* It is a method of producing flat surface at right angles to the axis of the cutter.

iii. *Side milling:* It is the operation of a flat vertical surface on the side of a work-piece by usinga side milling cutter.

iv. *Angular milling:* It is a method of producing flat surface making an angle to the axis of thecutter.

v. *Gang milling:* It is a method of milling by means of two or more cutters simultaneously having the same or different diameters mounted on the arbor of the milling machine.

vi. *Form milling:* It is a method of producing a surface having an irregular outline.

vii. *End milling:* It is a method of milling slots, flat surfaces and profiles by end mills.

viii. *Profile milling:* it is the operation of reproduction of an outline of a template or complexshape of a master die on a work-piece.

ix. *Saw milling:* It is a method of producing deep slots and cutting materials into the requiredlength by slitting saws.

x. *T-slots milling*

xi. *Keyway milling*

xii. *Gear cutting milling:* It is a method of producing gears.

xiii. *Helical milling:* It is a method of producing helical.

xiv. *Flute milling:* It is a method of grooving or cutting of flutes on drills, reamers, taps, etc.

xv. *Straddle milling:* It is a method of milling two sides of a piece of work by employing twoside-milling cutters at the same time.

xvi. *Thread milling:* It is a method of milling threads on dies, screws, worms, etc. both internallyand externally.

Hedi Yangui, Bacem Zghal, Amir Kessentini, Gael Chevallier,Alian Riviere, Mohamed Haddar, Chafir Karra (2010) Carried out experimental investigation on influence of cutting and geometrical parameters on the cutting forces in milling.In this work it has been graphically shown the influence of parameters by changing various tool geometries on cutting forces and feed .

The second relation between two parameters has been shown as Cutting force increases when cutting depth increases.It has been shown the variation of cutting forces with parameters such as beginning angle, number of teeth ,up milling, down milling.

According Research Performed experiment on modeling and optimization of face milling operation based on response surface methodology and genetic algorithm. The experiment is conducted based on L27 orthogonal array with respect to full factor design. The three factors and each three levels with two replicates were considered base on machine tool specification and tool manufacturer's recommendation. Aluminum has been used as work piece material with size of 32mm cube. Diameter of tool was 50 mm and tungsten carbide insert is used named as APMT-16.

Ayman A. Abuniza(2013) In this paper,Thermal error modeling of three axes vertical milling machine using finite element analysis (FEA) FEA technique used to reduce thermal error up to 90% and roughness from 35 µm to within 4 µm .

FEA is carried out to predict temperature gradient and spindle thermal deformation which effects on surface roughness. This paper present FEA method of predicting thermal errors in a small VMC. Experimental work conducted to obtain thermal behavior of machine structure by running spindle, recording temperature gradient and displacement data.

The predicted temperature rise and displacement data from simulation fit the experimental data. FEA is used to predict errors under different operating conditions and to develop compensation model.

Thakre Avinash A. et al. stated in his paper that minimizing the surface roughness, parameters spindle speed, feed, depth of cut and coolant flow are considered. To perform the experiments on 1040 MS material CNC vertical milling machine with carbide inserts was used. He observed that coolant flow mainly controls the surface roughness. Also it can be noticed that the spindle speed and flow of coolant are the major factors which ensure better finish of surface. In this paper Taguchi method has been successfully applied in face milling operation for optimizing material removal rate and surface roughness. To study the significance of each machining parameter, Analysis of Mean and variance technique is employed on the surface roughness.

Maiyar Lohithaksha M et al. investigated that in machining of in conel 718 alloy in end milling the gray relational analysis is an effective optimization tool. It has been found that optimal cutting parameter for the machining process are speed of cutting, rate of feed, and depth of cut. For optimization of parameter, Taguchi method is used. Analysis of variance (ANOVA) shows that the velocity of cutting is the most important parameter of machining followed by rate of feed affecting the characteristics of multiple performances. It has been seen surface roughness is decreased when material removal rate (MRR) is increased at the same time.

3. CONCLUSION

Researchers used speed of cutting, depth of cut, and feed for their studies, two used speed of spindle, depth of cut, and feed, one used number of passes, depth of cut, spindle speed, and feed rate, and one used spindle speed, depth of cut, feed rate, flow of coolant, and

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diameter of drill tool, according to the literature review. As a result, the literature emphasizes three key parameters: cutting speed, feed rate, and cut depth. These three factors will be used to guide the rest of the research.

On MILLING, a great deal of study has been done on process factors such as cutting speed, feed, depth of cut, materials, and their dimensions. According to the results of the experiment, the highest cutting speed combined with the lowest feed and cut depth is recommended for improved surface roughness. The Taguchi method is the most commonly utilized methodology; however other methods such as RSM and GA hybridization are also successful. The study found that employing different combinations of cutting speed, feed rate, and depth of cut via different software technologies, a % decrease in surface roughness of diverse materials such as EN8 steel, stainless steel, titanium, and chromium may be achieved. It has been established that the bare minimum of surface.

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