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Review Paper on Performance Of Milling Machine For Optimising Surface Roughness Using Taguchi

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Abstract
Milling is a machining process that uses a rotating cutting tool to remove material from a workpiece, typically to shape it into desired dimensions or features.Surface roughness is one of the most specified customer requirements in a machining process.The objective of this paper is to identify the process parameter which gives optimum surface roughness. There are many milling machine process parameters like cutting speed, feed, depth of cut, material removal rate (MRR) and machining time etc. are used.So it is required to find a suitable optimization method which can find optimum value of cutting parameters for minimizing surface roughness.

Keywords : Milling process , Surface roughness, process parameters, optimization

1.Introduction

The milling process involves the use of rotating cutting tools to remove material from a workpiece. It's a critical part of manufacturing and is often used to create complex parts with high precision. Milling can be done on materials such as metals, plastics, and wood and it can be done in different directions, including horizontal and vertical milling.In milling operation metal is removed by a rotating multipoint cutter which is fitted on the arbor of the milling machine.

1.1 Components: The main parts of a typical milling machine includes: (i)The base , foundation of the milling machine. It supports all other components and absorbs vibrations during the machining process. It is usually made of heavy-duty cast iron for stability.(ii)The column , mounted on the base and houses the vertical spindle and other mechanical parts. It provides support to the machine and contains the drive mechanism that moves the cutting tools.(iii)**Knee**, positioned on top of the column and supports the saddle and table. It allows vertical movement and can be adjusted to raise or lower the workpiece or cutting tool(iv)**Saddle,** sits on the knee and supports the table. It can move horizontally, allowing the table to be positioned along the X-axis.(v)**Table,** where the workpiece is mounted for machining. It can move both horizontally (X-axis) and vertically (Y-axis) and provides a surface for holding and positioning the material during the milling process.(vi)**Spindle**, the rotating component that holds the cutting tool. It is powered by the motor and can be moved vertically (Z-axis) to adjust the cutting depth. Spindles can be vertical or horizontal, depending on the type of milling machine.(vii)**Tool Holder,** to secure the cutting tools in place within the spindle. It ensures that the tool remains securely attached during the milling process.(viii)**Power Feed Mechanism ,to** provides automatic movement of the table, saddle, or knee. It can be programmed to move along different axes, allowing for precise control over the machining process(ix)**. Quill:** the part of the spindle that moves up and down within the column. It provides a fine feed adjustment to control the depth of cut.**(x)Ram,** part that is sometimes found in horizontal milling machines. It holds the spindle and can move in and out to adjust the position of the cutting tool.(xi)**. Hand Wheels,** used by the operator to manually move the table, saddle, or knee along the X, Y, or Z axes. These allow for fine adjustments and precise positioning of the workpiece. (xii)**Feed Mechanism,** moves the cutting tool or workpiece during the milling process, determining the speed and feed rate at which material is removed. It can be operated manually or automatically.(xiii)**. Coolant System,** used to cool the cutting tool and workpiece, reduce friction, and extend the life of the tools. (xiv) **Vertical/Horizontal Head,**to hold the spindle and can be adjusted for different cutting positions and angles. (xv)**Chips and Collection Area ,** that gathers the chips, which are then removed or discarded.(xvi)**. Control Panel,** communicates with the machine's computer to execute commands.

1.2 Types of Milling:

1. **CNC Milling (Computer Numerical Control)**: This is the most common form of milling, where machines are controlled by computers to make precise cuts and shapes.
2. **Manual Milling**: Operated by hand and requires a skilled operator to control the movement of the cutting tool.
3. **Vertical Milling**: The spindle rotates vertically, and the cutting tool moves up and down.
4. **Horizontal Milling**: The spindle is horizontal, and the cutting tool moves across the workpiece.

5. **Precision and Accuracy**: Milling can produce parts with high precision, which is vital for industries that require tight tolerances like aerospace, automotive, and medical device manufacturing.
6. **Versatility**: Milling can be used to create a wide range of shapes, from flat surfaces to intricate contours, gears, and holes.
7. **Efficiency**: The process is highly efficient for mass production as it allows for consistent and repeatable results, making it ideal for large-scale manufacturing.
8. **Complex Shapes**: Milling can create complex features such as pockets, grooves, and threads, which would be difficult to achieve with other processes.
9. **Surface Finish**: Milling provides an excellent surface finish compared to other methods, often requiring little to no post-processing.
10. **Material Removal**: It can effectively remove large volumes of material, especially when used with high-speed tools.

2. Taguchi Method:

The Taguchi Method is a powerful tool for improving product and process design, reducing variation, and enhancing the quality and reliability of manufacturing systems.To optimize parameters of a process and improve the components quality, that are manufactured Taguchi Method is used which is actually statistical approach. Taguchi's efforts have been acknowledged by statisticians especially in the development of designs for studying variation. Desired results are successfully achieved by careful selection of control factors and divide them into control and noise factors.Control factors must be selected in such a way that it eliminates the effect of noise factor. Proper control factors are recognised by Taguchi method and optimum results of the process are obtain by this method. To conduct a set of experiments orthogonal array (OA) are selected. To analyze the data and predict the quality of components produced, results of that it eliminates the effect of noise factor. Proper control factors are recognised by Taguchi method and optimum results of the process are obtain by this method. Taguchi's method is based on the concept of the **Quality Loss Function**. This function measures how deviations from the target (nominal value) result in a loss of quality. The idea is that any deviation, whether above or below the target, results in a loss of quality or customer dissatisfaction.

- The Quality Loss Function is represented as:

L(y)=k×(y−T)2L(y) = k \times (y - T)^2L(y)=k×(y−T)2

where:

- L(y)L(y)L(y) is the loss,
- yyy is the actual value,
- TTT is the target value,
- k is a constant.

3. ANOVA:

ANOVA is a powerful tool for comparing the means of multiple groups to determine if there are significant differences. It is widely used in experimental design, quality control, and various fields like psychology, medicine, and business to assess the impact of different treatments or factors on outcomes.The evaluation of response magnitude in percentage (%) for each parameter of orthogonal array, analysis of variance (ANOVA) is used. It is used to quantify and identify the source of results of different trial from different trial runs (i.e. different cutting parameters). The ANOVA is basically a method in which the differences among the different groups are tested.. The basic property of ANOVA is that the total 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 the error components. ANOVA is used when we want to test:

1. Whether the means of several groups are equal.
2. Whether any observed differences in means are due to random variation or are statistically significant.

4. Literature Survey:

He Le HoangAnhet. Al. in their study demonstrated the effect of spindle speed, feed rate, and cutting depth on surface roughness has been found. The combination of the Taguchi method and PSI method has been applied to determine the optimal value of three input parameters to simultaneously ensure the two criteria of the minimum surface roughness and the maximum Material Removal Rate (MRR).

Selvam et al. have stated that the roughness of surface of mild steel is minimized by using generic algorithm and Taguchi technique. Carbide tools coated with Zinc are used in the experiment. The conduction of experiment was done on the CNC vertical machining centre of FANUC series. He stated that the cutting depth , number of pass, speed of spindle and rate of feed affect the roughness of surface in face milling operation. It is observed that the orthogonal array of Taguchies gives information of large amount even in experimentation of smaller amount. Through Taguchi technique, it is observed that all four parameters (number of pass, cutting depth, feed rate and speed of spindle) are predominantly contributing to response and all have been considered optimum machining parameter combination and fine tune with generic algorithm. Both techniques Results are compared and for optimum surface roughness, optimum machining parameter combination is suggested.

VermaNarendra Kumar et al. investigated that the roughness of surface is affected mainly by rate of feed, depth of cut and speed of spindle. He observed that with the increase in rate of feed, the roughness of surface also increases and as the depth of cut increases the surface roughness increase first and then decreases as the speed of spindle increases due to which surface roughness decreases. It has been found that rate of feed is the most significant factor which affect the work piece surface roughness. In this experiment AISI 1045 work piece is machined

Raj Ashok R et al observed that the surface roughness of EN 8steel plates are affected by major parameters like speed of cutting, depth of cut and feed. He stated that statically significant factor is cutting speed, which influence the roughness of surface in milling process. For machining of EN8 steel the best machining process is milling process other than conventional machining process. In his experiments for machining of EN 8 steel side and face milling cutter ware used which gives good quality of finished surface which is required.

Sukumar et al. investigated that surface finish of the work piece is mostly influenced by the process parameter cutting speed, feed and depth of cut.

ThakreAvinash 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.

J.A. Ghani et al. stated that in his paper Taguchi methodology is used for optimization. In the machining of hardened steel with AISI H13 and tin coated P10 carbide insert tool Taguchi method is used for optimization of cutting parameter. Cutting speed, feed rate and depth of cut are the milling parameter. To analyze the effect of milling parameter an orthogonal array, signal-to noise (S/N) ratio of Taguchi method and analysis of variance are used.

J AGhani et al. demonstrated that the milling parameters evaluated are cutting speed, feed rate and depth of cut. An orthogonal array, signal-to-noise (S/N) ratio and Pareto analysis of variance (ANOVA) are employed to analyze the effect of these milling parameters. The analysis of the result shows that the optimal combination for low resultant cutting force and good surface finish are high cutting speed, low feed rate and low depth of cut. Using Taguchi method for design of experiment (DOE), other significant effects such as the interaction among milling parameters are also investigated. The study shows that the Taguchi method is suitable to solve the stated problem with minimum number of trials as compared with a full factorial design.

5. **Methodology**:

One has toidentify the performance characteristics and select process parameter: the factors that are going to affect or influence the milling process and from those factors one has to identify the control and noise factors. The factors that affect milling operation on a milling machine are generally,(I) Control Factors : Cutting speed, Depth of cut, Feed rate,, Coolant (II) Noise factors :Vibration ,Raw material variation , Machine condition ,Temperature ,Operator skill .

Control factors are those which affect the milling process and which can be controlled and noise factors are those which cannot be controlled. The next step is to determine the number of levels for process parameter. After this ,Selection of Appropriate Orthogonal Array is done.To select an appropriate orthogonal array for conducting the experiments, the degrees of freedom are to be computed.Degree of Freedom (DOF) = Nombur of factors (no. of lavels-1) + 1 for the average + no. of interactions (no. of levels – 1)2 . Finally, Calculation of S/N Ratio is done.

6. Conclusion:

In summary, the milling process plays a vital role in modern manufacturing, helping to produce a wide variety of components with high precision, excellent surface finishes, and complex geometries.It is observed from the literature survey that six researchers have taken speed of cutting, depth of cut and feed for their study, two have taken speed of spindle, depth of cut and feed, one has taken number of pass, depth of cut, spindle speed and feed rate and one has taken spindle speed, depth of cut, feed rate, flow of coolant and diameter of drill tool..From control factors parameters like cutting speed, feed rate and depth of cut they significantly affect the performance of milling machine.Various researchers have used different parameters, using Taguchi method in the optimization of process parameter in milling machine. With this experiments the influence of the different process parameter on the surface roughness can be analyzed. The level of importance of the process parameters can be determined by using ANOVA analysis.

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