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A COMPARATIVE STUDY OF OPTIMIZATION PROCESS PARAMETER OF CNC MILLING

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ABSTRACT:
Among several CNC industrial machining processes, milling is a fundamental machining operation. End milling is the most common metal removal operation encountered. It is widely used in a variety of manufacturing in industries. The quality of the surface plays a very important role in the performance of milling as a good-quality milled surface significantly improves fatigue strength, corrosion resistance, or creep life. Taguchi's robust design method is suitable to analyze the metal cutting problem as described in the present work. In end milling, increase in cutting speed, decrease in feed rate and increase in depth of cut will decreases the surface roughness within specified test range. In end milling, use of high cutting speed (358.8m/min.), low feed rate (0.08mm/tooth) and high depth of cut (0.3mm) are optimized parameters to obtained better surface finish for the specific test range in a H13 material. In end milling, increase in cutting speed, increases in feed rate and increase in depth of cut will decreases the MRR within specified test range. The feed rate and cutting speed are by far the most dominant factor then the depth of cut for surface finish. High feed rate (0.15mm/tooth), high depth of cut (0.3mm) and high cutting speed (358.8m/min) are optimized parameters for higher value of resultant Material removal rate for the specific test range.

KEYWORDS: Milling Process, Roughness, Anova, Taguchi Design

INTRODUCTION:

This experiment gives the effect of different machining parameters (cutting speed, feed, and depth of cut) on Surface Roughness and Material Removal Rate in end milling. The demand for high quality and fully automated production focus attention on the surface condition of the product, surface finish of the machined surface is most important due to its effect on product appearance, function, and reliability. For these reasons it is important to maintain consistent tolerances and surface finish.

Among several CNC industrial machining processes, milling is a fundamental machining operation. End milling is the most common metal removal operation encountered. It is widely used in a variety of manufacturing in industries. The quality of the surface plays a very important role in the performance of milling as a good-quality milled surface significantly improves fatigue strength, corrosion resistance, or creep life. The surface generated during milling is affected by different factors such as vibration, spindle run–out, temperature, tool geometry, feed, cross-feed, tool path and other parameters. During finish milling, the depth of cut is small. [28]. Technological parameter range plays a very important role on surface roughness [1]. In end milling, use of high cutting speed, low feed rate and low depth of cut are recommended to obtained better surface finish for the specific test range in a specified material [2].Material removal rate (MRR) is an important control factor of machining operation and the control of machining rate is also critical for production planners [27]. MRR is a measurement of productivity & it can be expressed by analytical derivation as the product of the width of cut, the feed velocity of milling cutter and depth of cut [7]. Cutting feed is the most dominated factor for surface finish. The most important interactions, that effect surface roughness of machined surfaces, are between the cutting feed and depth of cut, and between cutting feed and cutting speed [11]. Surface Roughness is affected negatively if the applied force is increased [14]. Surface roughness at the same feed rate becomes higher when a small nose radius is used [13]. Effort to increase productivity and MRR was maximized by optimal selection of feed rate, geometric boundary conditions [4].

OVERVIEW OF MILLING PROCESS

MILLING

Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine.

Milling is an interrupted cutting operation: the teeth of the milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to withstand these conditions. Cutting fluids are essential for most milling operations.

MILLING OPERATION:

The cutter is lifted to show the chips, and the work, transient, and machined surfaces.

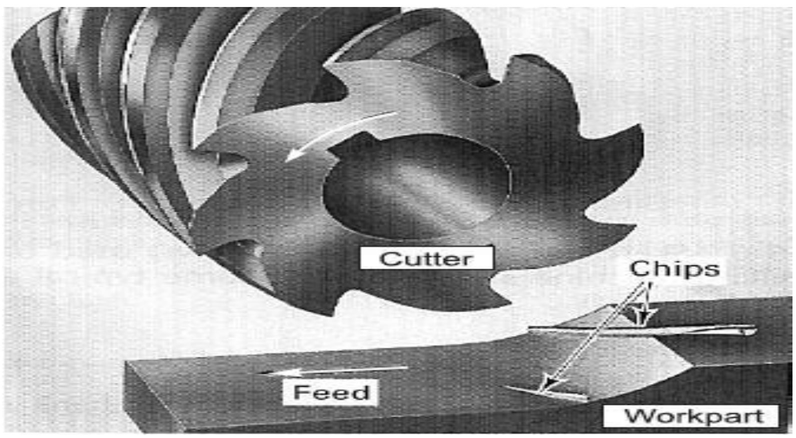


Fig.1. Milling operation

TYPES OF MILLING PROCESS

There are two basic types of milling process, as shown in the figure

1. Down (climb) milling, when the cutter rotation is in the same direction as the motion of the work piece being fed, and
2. Up (conventional) milling, in which the work piece is moving towards the cutter, opposing the cutter direction of rotation:

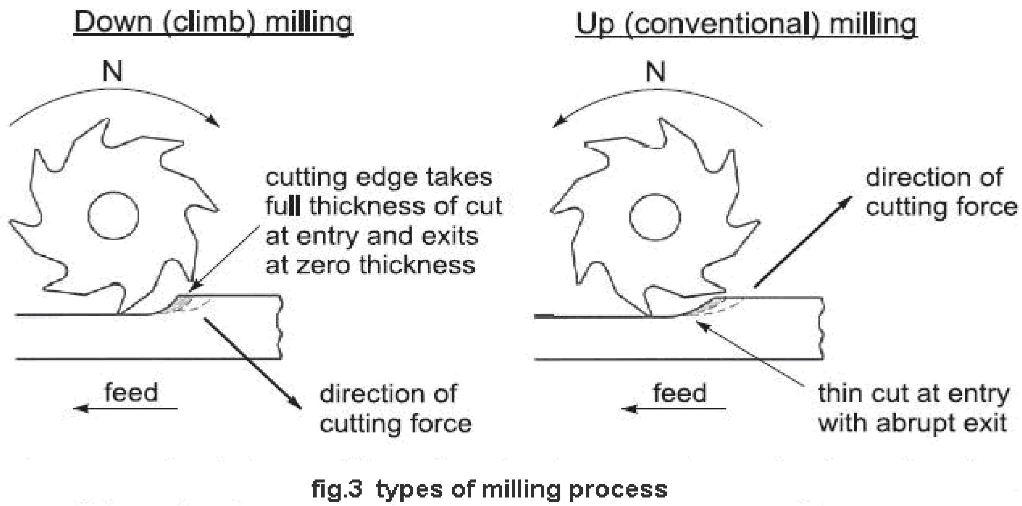


Fig 2. Types of milling process

In down milling, the cutting force is directed into the work table, which allows thinner work parts to be machined. Better surface finish is obtained but the stress load on the teeth is abrupt, which may damage the cutter. In up milling, the cutting force tends to lift the work piece. The work conditions for the cutter are more favorable. Because the cutter does not start to cut when it makes contact (cutting at zero cut is impossible), the surface has a natural waviness.

As per results obtained, effects of various input parameters on output characteristics have discussed.

EFFECT OF VARIOUS INPUT PARAMETERS ON OUTPUT CHARACTERISTIC (SURFACE ROUGHNESS)

The average value of surface roughness (µm) at each parameter (cutting speed, feed rate, depth of cut) is computed and the results are tabulated, similarly the result obtained for S/N data (db) is given. The main effect along with the corresponding S/N ratio value is plotted.

Effect of cutting speed on SR

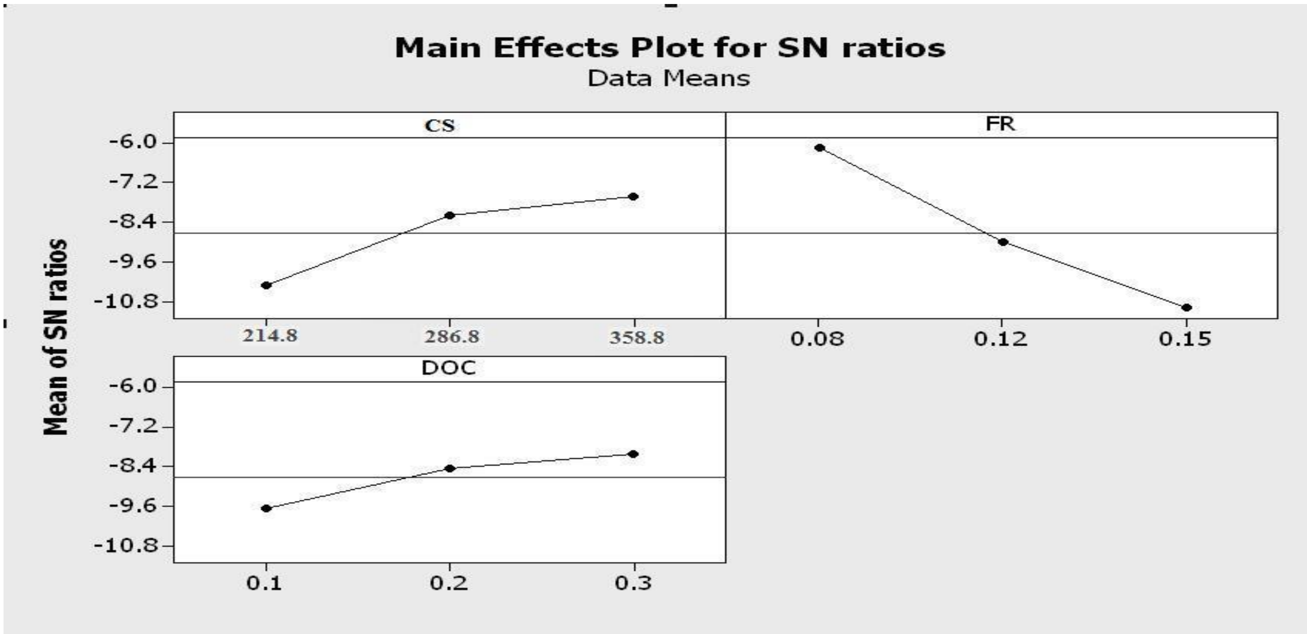
The higher the cutting speed less will be the surface roughness. Surface roughness is minimum at the higher level of cutting speed. The higher cutting speed causes the low burr size thus the surface finish increases.

Effect of feed rate on SR

With the decrease of feed rate, surface roughness also decreases. It is observed that the minimum surface roughness value obtained at the first level (.08 m/tooth). Higher the feed rate, higher will be the tool wear thus increases the value of surface roughness.

Effect of depth of cut on SR:

It is observed that the increased value of depth of cut will decrease the value of surface roughness. The level considered in this investigation is finishing range. At the lower depth of cut the tool deflection high and it will decreases with increase of depth of cut in.



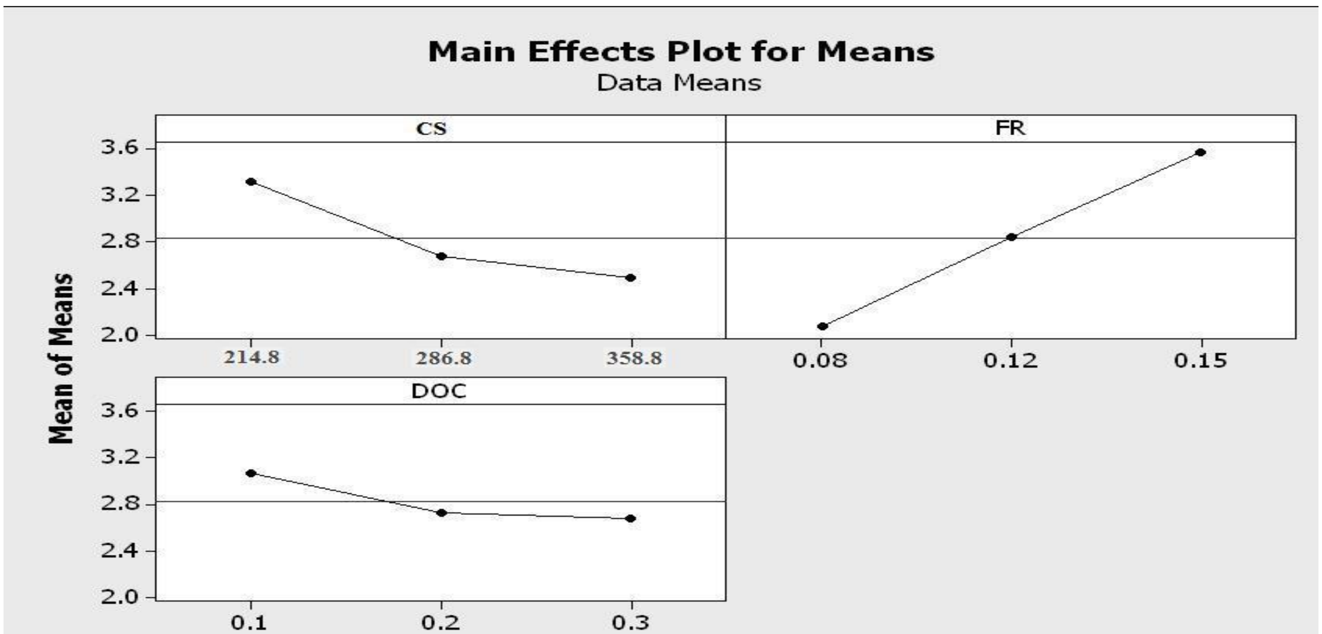


Figure 3 Main effects plot for SN ratios and mean (surface roughness)

This Figure shows that the highest value of cutting speed, lower value of feed rate and higher value of depth of cut gives the better surface finish (lower surface roughness). Therefore, the optimum cutting condition will be (Cutting speed 358.8m/min (A3), feed rate 0.08mm/tooth (B1), and depth of cut 0.3mm (C3).

EFFECT OF VARIOUS INPUT PARAMETERS ON OUTPUT CHARACTERISTIC (SR)

The average value of Material Removal Rate (mm^3 /sec.) at each parameter (cutting speed, feed rate, depth of cut) is computed and the results are tabulated. Similarly the result obtained for S/N data (db). The main effect along with the corresponding S/N ratio value is plotted.

Effect of cutting speed on MRR

It is seen that the MRR is higher at the third level of cutting speed (358.8m/min). As the cutting speed increases the processing time will decreases thus the material removal rate increases.

Effect of feed rate on MRR

With the increase in the feed rate, the MRR increases. It is seen that the highest MRR is obtained at the third level (0.15m/tooth). Higher the feed rate lower the processing time thus increases the MRR.

Effect of depth of cut MRR

It is seen that the MRR is maximum at the third level of depth of cut (0.3mm). As the depth of cut increases, the volume of material removal also increases thus the MRR increases.

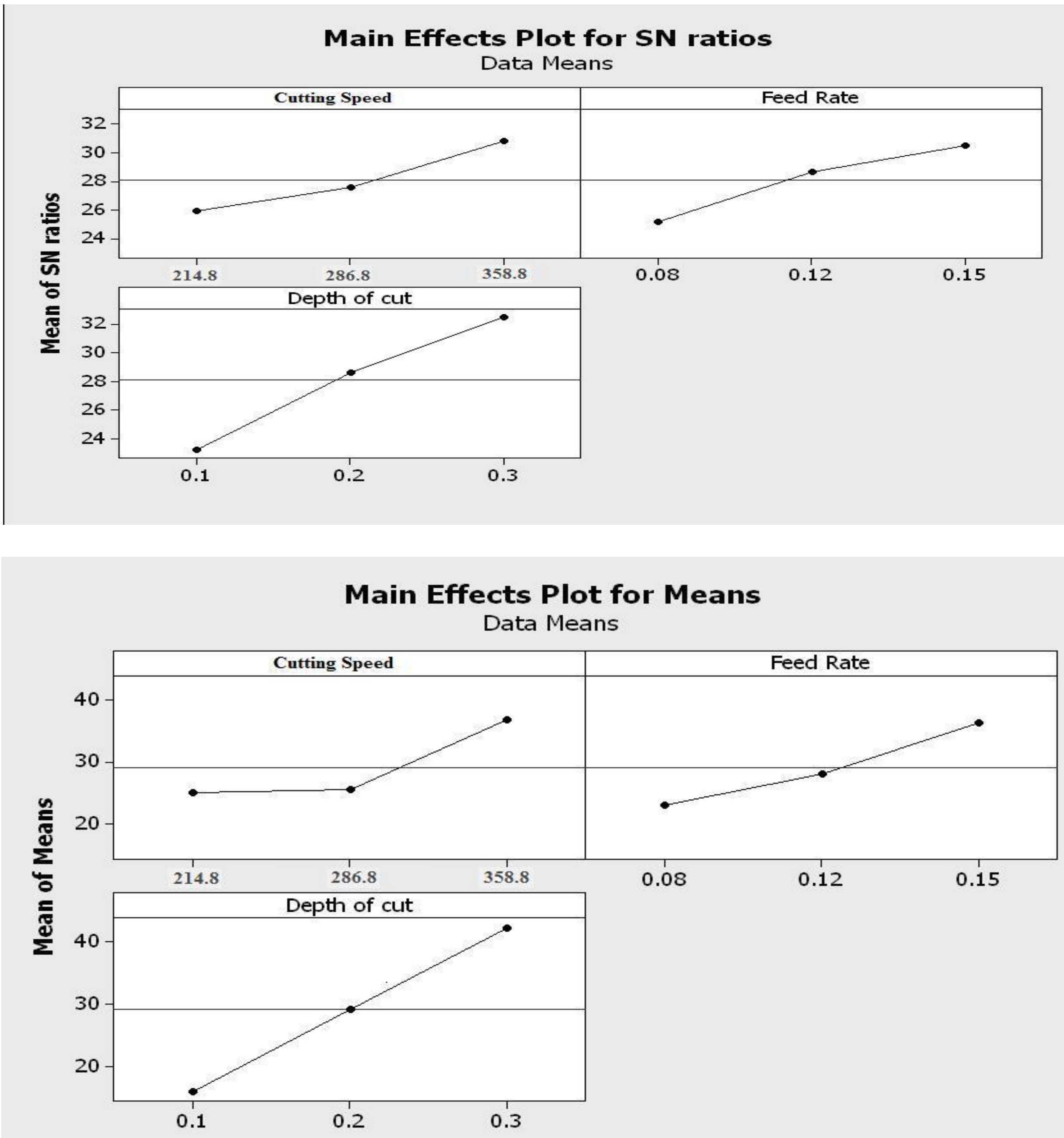


Figure 4.Main effect plots for SN ratio and mean data (MRR)

This figure shows that the higher value of cutting speed, higher value of feed rate and higher value of depth of cut gives the highest Material removal rate. Therefore, the optimum cutting condition will be (Cutting speed 358.8m/min (A3), feed rate 0.15mm/tooth (B1), and depth of cut 0.3mm (C3).

CONCLUSIONS DRAWN FROM THE WORK DONE IN THIS INVESTIGATION

Taguchi's robust design method is suitable to analyze the metal cutting problem as described in the present work. In end milling, increase in cutting speed, decrease in feed rate and increase in depth of cut will decreases the surface roughness within specified test range. In end milling, use of high cutting speed (358.8m/min.), low feed rate (0.08mm/tooth) and high depth of cut (0.3mm) are optimized parameters to obtained better surface finish for the specific test range in a H13 material. In end milling, increase in cutting speed, increases in feed rate and increase in depth of cut will decreases the MRR within specified test range. The feed rate and cutting speed are by far the most dominant factor then the depth of cut for surface finish. High feed rate (0.15mm/tooth), high depth of cut (0.3mm) and high cutting speed (358.8m/min) are optimized parameters for higher value of resultant Material removal rate for the specific test range. The depth of cut is by far the most dominant factor for material removal rate out of others studied. Low cutting speed should be used for long cutter life. High cutting speed and low feeds give best surface finishes; depth of cut should be low but not so low that it led to the vibration of tool. For hot die steel cutting speed should be 250-350m/min.

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