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A Review On Optimization Of Machining Parameters For Surface Roughness And Material Removal Rate For Ss 316 In Cnc End Milling Process

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ABSTRACT
Quality and productivity play important role in today's manufacturing market. Now a day's due to very stiff and cut throat competitive market condition in manufacturing industries. The main objective of industries reveal with producing better quality product at minimum cost and increase productivity. CNC end milling is most vital and common operation use for produce machine part with desire surface quality and higher productivity with less time and cost constrain. To obtain main objective of company regards quality and productivity. In the present research project an attempt is made to understand the effect of machining parameters such as cutting speed (m/min), feed rate (mm/min),depth of cut (mm), no of cutting flute that are influences on responsive output parameters such as Surface Roughness and Material Removal Rate by using optimization philosophy. The effort to investigate optimal machining parameters and their contribution on producing better Surface quality and higher Productivity.
Keywords: CNC end milling, Surface roughness, MRR, SS 316.

I. INTRODUCTION

Milling is the process of machining flat, curved, or irregular surfaces by feeding the work piece against a rotating cutter containing a number of cutting edges. The milling machine consists basically of a motor driven spindle, which mounts and revolves the milling cutter, and a reciprocating adjustable worktable, which mounts and feeds the work piece. Among several CNC industrial machining processes, milling is a fundamental machining operation. End milling and face milling is the most common metal removal operation encountered. It is broadly used in a variety of manufacturing industries including the aerospace, automotive sectors, where quality is vital factor in the production of slots, pockets, precision molds and dies.

To understand full automation in machining, computer numerically controlled (CNC) machine tools have been implemented during the past decades. CNC machine tools require less operator input; provide greater improvements in productivity, and increase the quality of the machined part.

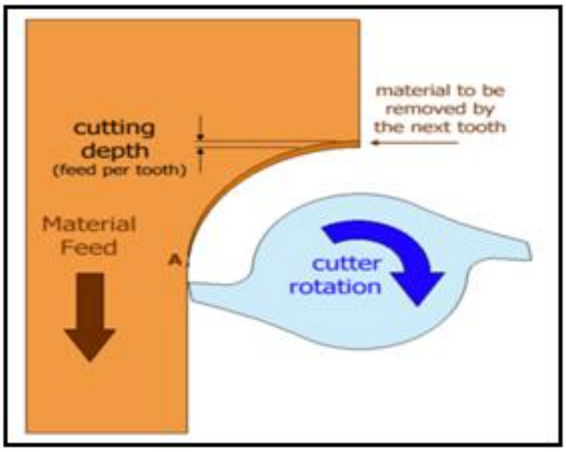

Fig.1.1 Introduction of Milling

Surface roughness is an important measure of the technological quality of a product and a factor that greatly influences manufacturing cost. 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. In addition, surface roughness also affects surface friction, light reflection, ability of holding a lubricant, electrical and thermal contact resistance. Consequently, the desired surface roughness value is frequently specified for an individual part, and specific processes are selected in order to achieve the specified finish.

METHOD OF MILLING

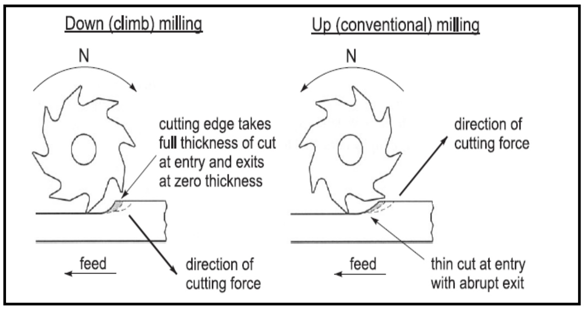

Fig.1.2 Method of Milling

Down (climb) milling: when the cutter rotation is in the same direction as the movement of the workpiece being fed. 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.

Up (conventional) milling: in which the work piece is moving towards the cutter, opposing the cutter direction of rotation. In up milling, the cutting force tends to lift the workpiece. The work conditions for the cutter are more favorable. Because the cutter does not initiate to cut when it makes contact (cutting at zero cut is impracticable), the surface has a natural waviness.

END MILLING OPERATION

The cutter, called end mill, has a diameter less than the workpiece width. The end mill has helical cutting edges carried over onto the cylindrical cutter surface. End mills with flat ends (so called squire-end mills) are used to generate pockets, closed or end key slots, etc. End milling is the most common metal removal operation encountered. It is widely used to mate with other part in die, aerospace, automotive, and machinery design as well as in manufacturing industries.

Fig.1.3 End milling operation

CNC MACHINING CENTER

The machining centre, developed in the late 50's is a machine tool able to perform multiple machining operations on a work part in one setup under NC program control

A machining center is a highly automated machine tool able to performing multiple machining operations under CNC control. The features that make a machining center unique include the following:

- ✓ Tool storage unit called tool magazine that can hold 80 - 120 different cutting tools.
- ✓ Automatic tool changer, which is used to exchange cutting tools between the tool magazine and machining center spindle when required. The tool changer is controlled by the CNC program.
- ✓ Automatic work part positioning. Many of machining centers are equipped with a rotary worktable, which precisely position the part at some angle relative to the spindle. It permits the cutter to perform machining on four sides of the part.

Fig.1.4 CNC Machining Center (VMC 850)

CHARACTERISTICS OF CNC MACHINE

- Flexibility in automation
- Change-over (product) time, effort and cost are much less.
- Less or no jigs and fixtures are needed
- Complex geometry can be easily machined
- High product quality and its consistency
- Optimum working condition is possible
- Lesser breakdown and maintenance requirement.
- Faster deliver a product.
- Reduce WIP inventory.

MATERIAL REMOVAL RATE (MRR)

Material removal rate in milling operation is the volume of metal removed in unit time.

$$MRR\ (mm^3/min) = w*d*f$$

Where,

w = width of cut, mm
d = depth of cut, mm
f = feed rate, mm/min

SURFACE ROUGHNESS

Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface. Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has an impact on the mechanical properties like fatigue behavior, corrosion resistance, creep life, etc.

CUTTING PARAMETER

- Cutting velocity (Vc): It is the peripheral speed of the cutter is defined by,

$$V = \pi DN$$

Where, D is the cutter outer diameter, and N is the rotational speed of the cutter.

- Feed per tooth fz: The basic parameter in milling equivalent to the feed in turning. Feed per tooth is selected with regard to the surface finish and dimensional accuracy required.
- Feed per revolution fr: It determines the amount of material cut per one full revolution of the milling cutter. Feed per revolution is calculated as

$$fr = fz*z$$

z being the number of the cutter's teeth.

- Feed per minute fm: Feed per minute is calculated taking into account the rotational speed N and number of the cutter's teeth z,

$$fm = fz*z*N = fr*N$$

II. LITRETURE REVIEW

Many investigators have suggested various methods to explain the effect of machining parameter on surface roughness and MRR in CNC end milling process.

B. C. Routara, et al, [1] were carried out "Roughness modeling and optimization in CNC end milling using response surface method: effect of workpiece material variation". They describe use and steps of Full factorial design of experiments to find a specific range and combinations of machining parameters like spindle speed, feed rate and depth of cut to achieve optimal values of response variables like Roughness parameters (Ra, Rq, Rsk, Rku and Rsm) in machining of three different materials like 6061-T4 aluminum, AISI 1040 steel and medium leaded brass UNS C34000. The second-order model was postulated in obtaining the relationship between the surface roughness parameters and the machining variables. The analysis of variance (ANOVA) was used to check the adequacy of the second-order model roughness modeling in milling is specific to the roughness parameter of particular Concern as well as to the work piece-tool material combination employed in the process.

John D. Kechagias, et al, [2] were carried out "Parameter Optimization during Finish End Milling of Al Alloy 5083 using Robust Design". They describe use and steps of Taguchi design of experiments and orthogonal array L18 to find a specific range and combinations of machining parameters like Core diameter (50%), Flute angle (38^o), Rake angle (22^o), Relief angle 1^{st} (22^o), Relief angle 2^{nd} (30^o), Cutting depth (1.5mm), Cutting speed (5000 rpm), Feed (0.08mm/flute). The influence of cutter geometry and cutting parameters during end milling on the surface texture of aluminium (Al) alloy 5083 was experimentally investigated. Surface texture parameters (Ra, Ry, and Rz) were measured on three different passes on side surface of pockets and analyzed using statistical techniques. The results reveal that the cutting speed, the peripheral 2^{nd} relief angle, and the core diameter have significant effect in surface texture parameters. Once the relief angle 2^{nd} takes its optimum value (30^o) the surface roughness decreases while the cutting speed increases. This is accordance with the cutting theory.

Amit Joshi & PradeepKothiyal, [3] were carried out "Investigating Effect of Machining Parameters of CNC Milling on Surface Finish by Taguchi Method". The effects of various parameters of end milling process like spindle speed, depth of cut, feed rate have been investigated to reveal their Impact on surface finish using Taguchi Methodology. Experimental plan is performed by a Standard L9 Orthogonal Array on five blocks of aluminum cast heat-treatable alloy (100 X 34 X20 mm) with using HSS End mill tool. The results of analysis of variance (ANOVA) indicate that the feed Rate is most influencing factor for modeling surface finish. The graph of S-N Ratio indicates the optimal setting of the machining parameter which gives the optimum value of surface finish. The optimal set of process parameters has also been predicted to maximize the surface finish is 3.0723 μm.

M.F.F. Ab. Rashid and M.R. Abdul Lani, [4] were carried out "Surface Roughness Prediction for CNC Milling Process using Artificial Neural Network". The purpose for this research is to develop mathematical model using multiple regression and artificial neural network model for artificial intelligent method. Spindle speed, feed rate, and depth of cut have been chosen as predictors in order to predict surface roughness. 27 samples of 400mmx100mmx50mm 6061 Aluminum were run with using HSS End mill tool (No of flute = 4, Dia. D=10mm) carried out on FANUC CNC Milling α-T14E. The experiment is executed by using full factorial design. Analysis of variances shows that the most significant parameter is feed rate followed by spindle speed and lastly depth of cut. After the predicted surface roughness has been obtained by using both methods, average percentage error is calculated. The mathematical model developed by using multiple regression method shows the accuracy of 86.7% which is reliable to be used in surface roughness prediction. On the other hand, artificial neural network technique shows the accuracy of 93.58% which is feasible and applicable in prediction of surface roughness. The result from this research is useful to be implemented in industry to reduce time and cost in surface roughness prediction.

Bharat Chandra Routara, et al, **[5]** were carried out "Optimization in CNC end milling of UNS C34000 medium leaded brass with multiple surface roughnesses characteristics". The present study highlights a multi-objective optimization problem by applying utility concept coupled with Taguchi method through a case study in CNC end milling of UNS C34000 medium leaded brass as a workpiece material and Coated with TiAlN End mill Cutter (diameter, 8 mm; Overall length, 108 mm; Fluted length, 38 mm; Helix angle, 30°). The study aimed at evaluating the best process environment which could simultaneously satisfy multiple requirements of surface quality. In view of the fact, the traditional Taguchi method cannot solve a multi-objective optimization problem; to overcome this limitation, utility theory has been coupled with Taguchi method. Depending on Taguchi's Lower-the- Better (LB) response criteria; individual surface quality characteristics has been transformed into corresponding utility values. Individual utility values have been aggregated finally to compute overall utility degree which serves as representative objective function for optimizing using Taguchi method. Utility theory has been adopted to convert a multi-response optimization problem into a single response optimization problem; in which overall utility degree serves as the representative single objective function for optimization. The study of combined utility theory and Taguchi method for predicting optimal setting. Based on Taguchi's Signal-to-Noise ratio (S/N), analysis has been made on the overall utility degree and optimal process environment has been selected finally which corresponds to highest S/N Ratio. Optimal result has been verified through confirmatory test. The case study indicates application feasibility of the aforesaid methodology proposed for multi response optimization and off-line control of multiple surface quality characteristics in CNC end milling.

Anish Nair & Dr. P Govindan, et al, [6] were carried out "Multiple Surface Roughness Characteristics Optimization in CNC End Milling of Aluminium using PCA". The present study highlights a multi objective optimization problem by applying the Principal components analysis method coupled with the Taguchi method .Total 27 experimental run conducting on 6061-T4 Aluminium with CVD coated carbide tool . The study is aimed at evaluating the best process parameters which could simultaneously provide multiple requirements of surface quality. In the present work individual response correlations have been eliminated first by means of Principal components Analysis (PCA). Principal components are found out which are independent quality indices. The principal component having the highest accountability proportion is considered as the objective function. Finally the taguchi method has been used to solve this objective function. In the current paper two surface roughness parameters (Ra and Rz) have been taken into consideration.

Reddy B. Sidda, et al, [7] were carried out "Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm". In this study, minimization of surface roughness has been investigated by integrating design of experiment method, Response surface methodology (RSM) and genetic algorithm. The experiments were conducted on AISI P20 mould steel (100x100x10 mm) with CVD coated carbide tool inserts (TN 450) and CNC Vertical milling machine 600 II, KENAMETAL tool holder BT40ER40080M 20 ATC by using Taguchi's L50 orthogonal array in the design of experiments (DOE) .Considering the machining parameters such as Nose radius (R), Cutting speed (V), feed (f), axial depth of cut (d) and radial depth of cut (rd). A predictive response surface model for surface roughness is developed using RSM. The response surface (RS) model is interfaced with the genetic algorithm (GA) to find the optimum machining parameter values. To achieve the minimum surface roughness, the appropriate process parameters are determined. Nose radius, cutting speed, feed rate, axial depth of cut and radial depth of cut are considered as process parameters GA has reduced the surface roughness of the initial model significantly. Surface roughness is improved by about 44.22%.

III. MATERIAL SELECTION

Stainless steel AISI 316 or SS316 solid round bar. Dimension of material is Ø50 X 35 mm.

CHEMICAL COMPOSITION

Table 3.1 Chemical composition

Grade	C	Mn	Si	P	S	Cr	Mo	Ni	N
316	-	-	-	0	-	16.0	2.00	10.0	-
	0.08	2.0	0.75	0.045	0.03	18.0	3.00	14.0	0.10

MECHANICAL PROPERTIES

Table 3.2 Mechanical properties

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR C) max	Brinell (HB) max
316	515	205	40	95	217

PHYSICAL PROPERTIES

Table 3.3 Physical properties

Grade	Density (kg/m³)	Elastic Modulus (GPa)	Mean Co-eff of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg K)	Elec Resistivity (nΩ.m)
			0-100°C	0-315°C	0-538°C	At 100°C	At 500°C		
316	8000	193	15.9	16.2	17.5	16.3	21.5	500	740

KEY PROPERTIES
- Higher strength
- Better creep resistance
- Excellent mechanical properties
- Excellent corrosion properties
- Superior oxidation resistance
- Good fabricability

APPLICATION
- Gasket, flanges, spring & exhaust manifolds
- Valve & pump trim
- Food preparation equipment in chloride environments.
- Laboratory benches & equipment.
- Coastal architectural panelling, railings & trim.
- Boat fittings, Furnace parts.
- Chemical containers, including for transport.
- Heat Exchangers

IV. CONCLUSION

From various literatures survey efforts to found out that many researchers have investigated only limited number of process parameters like as cutting speed, feed and depth of cut of CNC milling. Effort to find out that there is very few investigator research worked on SS316 stainless steel material so, we want to do work on this material. In this research work we want to investigate influences of input machining parameters like cutting speed, feed rate, depth of cut and no of flute on response parameters like surface roughness and MRR.

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