A Review on Effect of Process Parameters on MRR & Surface Roughness in Milling Machine

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Abstract

In highly competitive manufacturing industries nowadays, the manufactures ultimate goals are to produce high quality product with less cost and time constraints. Milling machine is one of the most commonly used machine to machining different types of material. So our goal is to increase productivity without affecting product quality. So we need to increase material removal rate. For achieving this goal increase material removal rate at minimum level of surface roughness and increase the productivity. There are many work done for finding the maximum material removal rate for different materials. There are three different cutting parameters affect more on material removal rate such as a spindle speed, feed rate and depth of cut. In this review shows that the effect of different cutting parameters which influence on material removal rate and surface roughness. Also shows that different cutting parameters how much effect on material removal rate and surface roughness.
Keywords: Milling Machine, Cutting Speed, Feed Rate, Depth of Cut, Material Removal Rate, Surface Roughness.

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. Milling is one of the basic machining processes that allows large amounts of material to be removed quickly. At all types of milling machines, the cutting tool performs a rotational motion, which is the **cutting motion**. The rotation axis of the tool could be horizontal or vertical, depending on machine tool version. Geometrically complex & hard material components can be machined with an ease. High Product Accuracy, Surface finish. Auto Mobile Parts, Defense Equipment, General Machining Parts. Also it is automatic tool changer, so work faster compare manually machine. Better tool handling and less time consumption for tool changing. Different operation on single work piece can be easily done by automatic tool changer

The development of manufacturing system is evolving to the phase of integrated manufacturing systems, which is oriented towards the need of 21stcentury. Efforts are made to maintain and improve the vitality of manufacturing system. Keeping it as center stone of all economic activities and ensuring that manufacturing remains an attractive industrial area. Since it has been believed that only those industries capable of effective manufacturing would withstand international and global competition. Milling machine is controlled by motors by using manually. In the modern machining the challenge is mainly focused on quality in terms of surface finishing. Surface texture is concerned with geometric irregularities. The quality of surface is most significant for any product. The surface roughness is main affecting thing such as for contact causing surface friction, wearing, holding the lubricant etc. There are many factors which affect the surface roughness (SR) and material removal rate (MRR), i.e. tool (material, nose radius, geometry, tool vibration), work piece (hardness, mechanical properties), cutting condition (speed, feed, depth)etc. New products have been generally designed to be produced on milling machining. It is not sufficient to device a feasible procedure for manufacture of desired component. The procedure must be economically justified. Cutting conditions may be established which give satisfactory results.

Multipass operations are generally used to machine stocks that cannot be removed in a single pass. Some turning operations like external step turning and boring, and some of the milling operations, such as face milling and deep shoulder milling in which a significant amount of stock material is removed, are good examples of the operations which are commonly required to be machined using multipass operations. Determination of the optimal cutting parameters (cutting conditions) like the number of passes, depth of cut for each pass, speed, and feed is considered as a crucial stage of multipass machining as in the case of all chip removal processes and especially in process planning. The effective optimization of these parameters affects dramatically the cost and production time of machined components as well as the quality of the final products.

II. CUTTING PROCESS VARIABLE

Cutting speed and cutting feed:

The process of metal cutting or machining of metal work-piece is influenced greatly by the relative velocity between the work-piece and the edge of the cutting tool. The relative movement in the machining operations is produced by the combination of rotary and translator movement either of the work-piece or of the cutting tool or both. The translator displacement of the cutting edge of the tool along the work surface during a given period of time is called 'feed', while the rate of traverse of the work surface past the cutting edge is designated as 'cutting speed'. The presence of these motions e.g., feed and cutting speed permits the exertion of the process of cutting continuously. In machine tools with rotary priming cutting motion, the cutting speed is given by:

$$V = \frac{\Pi DN}{1000} \text{ m/min.}$$

Where, D is diameter of the milling cutter in mm,
N is the cutter rotational speed in rpm.

Material Removal Rate (MRR):

Material removal rate (MRR) is defined as the material is removed per unit time. Its unit is mm^3/sec.
MRR =V×f×d mm^3/sec
V = Cutting Speed (in mm/sec)
f = Tool feed (in mm)
d = Depth of cut (in mm)

Surface Roughness:

Surface roughness is defined as a group of irregular waves in the surface, measured in micrometers. It is produced by the fluctuations of short wavelengths characterized by asperities (local maxima) and valleys (local minima) of varying amplitudes and spacing. Surface roughness is defined by various characteristics of the surface profile such as center-line average R. peak-to-valley height Hand average roughness depth, but these have limitations. The randomness of the profile is no measured by any of these parameters. The randomness of the surface profile causes the roughness value to vary under the given cutting conditions and is caused by the random nature of the mechanism of formation of the built-up edge, side flow and tool wears. There are various methods used for the roughness measurement such as stylus profilometry, light sectioning and taper sectioning methods, scanning electron microscopy and transmission electron microscopy etc.

III. LITERATURE REVIEW

A. Jawaid, S. Sharif, S. Koksal (2000) study about face milling operations on titanium alloy by coated carbide tools, in this study Ti-6Al-4V. Titanium alloys used as work piece material and two different types coated , one is PVD-TIN coated and another is CVD-TICM+AI2O3 coated tools materials objectives of this study is to found higher material removal rate and tool life. In this study only cutting speed is taken as a variable parameter. Than conduct the experiments. By both the tool materials and found the surface roughness for each experiments. Then analysis of the experiments result and concluded that, At high cutting speeds of 80 m/min & 100 m/min the effect of feed rate on the tools was less prominent. Also found that the better result of surface roughness achieved when machining at the lower feed of 0.1 mm per tooth for all cutting speeds. Also found that at lower cutting speed 65 m/min and 55 m/min the value of surface roughness is less than the higher cutting speed. The tool material not more influence on the surface roughness for any cutting speed and feed rate.

H. S. Lu, C. K. Chang, N. C. Hwang, C. T. Chung (2009) use high speed end milling machine for found the higher material removal rate for rough cutting process. In this study author used SKD tool steel as a work piece material and top green AAE-SS4RD0880R050 tool material. The goal at the study is to increase the material removed rate and tool lite. For above goal milling type spindle speed feed rate, axial depth at cut and radial depth at cut taken as variable parameters. Author taken different value at variable parameters and do 18 experiments and measure material removed rate and tool lite for each experiment result by using grey relational analysis author found that milling type, spindle speed and feed per tooth contributed 79%, also found that at 12000 rpm cutting speed, 0.04 mm/tooth feed per tooth, 0.80 mm axial depth of cut and 1.00 mm radial depth of cut, maximum tool life, material removed rate and total removed volume achieved. At above input data tool lite increase by 26.31%, increase material removed rate by 27% and increase total removed volume by 60.39%.

Azlan Mohd Zain, Habibollah Haron, Safian Sharif (2010) used end milling machining process for minimizing surface roughness. In this study was carried out to observe the effect of cutting speed and feed rate on surface roughness. For above study there are three different types of tools used. Such as WC-co tool, Ti-ALM coated tool & super nitride coated tool. Authors do 24 experiments. For each tool and measured surface roughness for all experiments. And also found minimum surface roughness, maximum surface roughness and average surface roughness for each tool. For unrated tool the minimum surface roughness 0.236 µm, at 167.03 m/min cutting speed and 0.046 mm/tooth feed rate, maximum surface roughness is 0.386 µm. for

Ti-ALM coated tool minimum surface roughness is 0.232 um at 160 m/min cutting speed and 0.03 min/tooth feed rate maximum surface roughness is 0.656 µm at 144.22 m/min cutting speed and 0.83 mm/tooth feed rate and average surface roughness is 0.375 µm , for super nitride waited tool minimum surface roughness is 0.190 at 160 m/min cutting speed and 0.03 mm/tooth feed rate , maximum surface roughness is 0.696 µm at 144.22 m/min cutting speed and 0.083 mm/tooth feed rate and average surface roughness is 0.392µm.

N. Lebaal, M. Nouari, A. Ginting (2011) machining of titanium alloys on milling machine to found higher material removed rate. In this study author used titanium alloys as a work piece material and two different tool materials, one is alloyed carbide tool and another is end coated tool. For done above experiments. Author used four different variable cutting parameters, cutting speed, feed rate, axial depth of cut and radial depth of cut, for above all variable parameters set value range maximum and minimum. After selected range of parameters used L12 orthogonal array for found the experimental data. Then do all experiments and measure material removal rate surface roughness for all experiments after analysis all the experiments result. The range of surface roughness for alloyed carbide tools 0.39 µm to 0.72 µm and for CND coated tool 0.43 µm to 0.69µm. The optimum cutting parameters, cutting speed is 115 m/min, feed rate 0.165m/min and axial depth of cut 2.25 mm for maximum material removed rate at average level of surface roughness also found that coated tool give better surface roughness as compare to an coated tools also seen that cutting speed and feed rate are more affect on surface roughness.

Milon D. Selvam, Dr. A. K. Shaik Dawood, Dr. G. Karuppusami (2012) discuss about minimize surface roughness for face milling operation in a vertical CNC milling machine. Face milling operations carried out on mild steel as a work-piece material with three zinc coated carbide tools having 25mm diameter. FANUC series CNC vertical machining center used for machining of mild steel. The variable machining parameters used are Number of Passes, Depth of Cut, Spindle Speed and Feed Rate. All machining parameters taken as three different levels. After that by using L_9 orthogonal array, Taguchi Method used for selecting the experiments data. Each experiment carried our two times and measured surface roughness for both experiments and found the average surface roughness for experiment. Same procedure repeated for each experiment and found average surface roughness. After analysis the all experimental data the minimum value of surface roughness is 1.130 µm at, 4 number of passes, 2000 rpm spindle speed, 0.1 mm depth of cut and 400 mm/min feed rate. According to above result, better value of surface roughness found at higher spindle speed, lower depth of cut and medium feed rate.

S. Y. Chavan, V. S. Jadhav (2013) use CNC end milling machine for experiments. In this paper author use Al-Si7Mg as a work piece material with end mill cutter. In this paper author take three different levels value at, cutting parameters, cutting speed, depth of cut & feed rate at two different conditions, without coolant and with coolant , By the use of Taguchi method author found the experimental data, and done all experiments and found surface roughness and material removal rate for each experiment. After analysis experimental result, author found that coolant is effective for decrease surface roughness and increase material removal rate. By the experimental result author found two better result. First one is 5600rpm cutting speed, 2.7mm depth of cut and 0.045mm/rev. feed rate, the surface roughness is 0.36 m and material removal rate is 73.978 mm^3/s. second one is 5600rpm cutting speed, 2.7 mm and depth of cut and 0.015mm/rev, feed rate, the surface roughness is 0.33m and material removal rate is 36.989mm3/s. according to above result change in feed rate at constant cutting speed and depth of cut is more influence in material removal rate.

M. Durairaj, S. Gowri (2013) used CNC micro turning machine for improve the tool lite and surface finish. In this study, Inconel 600 alloy as a work piece material and titanium carbide coated as a tool material. In this study cutting speed, feed rate and depth of cut taken as a variable cutting parameters, for three different value at cutting parameters. Author found the experimental data by using full factorial design method of design at experiments, and do all experiments after each experiments . He measured tool wear and surface roughness. The surface roughness measured by using the coated type surface roughness tester (Model: SE 3500, Make: Surfcoder) for 0.8 mm cut of length. Also fool wear was measured using a noncontact video measuring system (VMS-2010f). By the analysis of result data, surface roughness increasing with increasing depth of cut and feed rate. The surface roughness varies within 0.5 to 1.25 µm. For machining speed 31 m/sec, surface roughness tends of marginally rise and sets around 1 um with increasing depth of cut.

Reddy Sreenivasulu (2013) machining of GFRP composite material in end milling machine and found the optimum surface roughness , also discuss the effect of cutting speed , feed rate and depth of cut on surface roughness on glass fiber reinforced polymeric material. (1) Author used by orthogonal array for found the experiment data and done all experiment and measure the surface roughness for all experiment. (2) after analysis the result of experiments author found minimum value of surface roughness is 2.066 µm at 1250 rpm cutting speed, 300 mm/min feed rate and 1.5 mm depth of cut according to result author also concluded that the cutting speed and depth of cut are most significant factors affecting on the surface roughness .the cutting speed contributed 26.84% in surface roughness and depth of cut contribute 40.44% in surface roughness. In this study experiment carried out on a CNC vertical machining center by using 300 mm * 50 mm* 25mm GFRP work piece material by K1O carbide , four flute end milling cutter for 10 mm slot. Each experiment was conducted three time and found the average value of surface roughness. Also surface roughness measured at five places on each slot then taken average surface roughness taken as final value of surface roughness for each experiment.

B. Ramesh, A. Elayaperumal, R. Venkatesh, S. Madhav, Kamal Jain (2014) use conventional vertical milling operation on beryllium copper alloy as a work-piece material with 6mm carbide end mill tool. The objective of this paper is to increase the material removal rate and decrease the surface roughness. To achieved above goal, three variable parameter, spindle speed, feed and depth of cut in three different level. By the use of Response surface methodology. Get the data for experiment and done 20 experiments. And found material removal rate and surface roughness for all the experiments. By the analysis of experimental result, surface roughness and material removal rate increases as speed and feed increases minimum value at surface roughness achieved at medium speed, lower feed and medium depth of cut, when higher material removal rate achieved at higher speed, higher feed ad lower depth of cut, also at constant speed, feed is more affected on surface roughness and at constant feed, speed is more affected on material removal rate. Also lower material removal rate will lead to higher surface finish.

Indira Gary Escamilla Salazar, Pedro Perez Villanueva, discuss about surface roughness of titanium alloy (Ti-6Al-4V) after machining. Now a days in aerospace industries, chemical and food processing, surgical instruments are made by using titanium alloy because of low density, higher corrosion resistance and higher strength. So the surface roughness is basic issue for machining. There are many different parameters affecting on surface roughness but more influence on surface roughness by cutting speed, feed rate and depth of cut. In this study cutting speed, feed rate and depth of cut are taken as variable cutting parameters. Each parameter select three different level value. The machining of Titanium alloy was carried out on Vertical Machining Center by using 3/8” diameter Aluminum Titanium Nitride coated tool for 47 mm length. The experimental data chosen by using design of experiments, 3 factorial 3 level design. Author carried out each experiments and measure the value of surface roughness by using a ZEISS Profilometers Surfcon 1500 SD2 with automatic control. Author measure three time surface roughness for each experiment and found average value of surface roughness for each experiments. The minimum value of surface roughness is 0.703 µm, at 2865 rpm cutting speed, 353 mm/min feed rate and 0.5 mm depth of cut.

IV. COCNCLUSION

From above observation we seen that, material removal rate and surface roughness is main requirement of the final machined product. It is possible, higher material removal rete achieved at higher cutting speed, higher depth of cut and higher feed rate, but at this stage the value of surface roughness is higher. Because of requirement of lower level of surface roughness it is not possible. Also the lower value of surface roughness is achieved at, lower feed rate, lower cutting speed and lower depth of cut, bat at this stage material removal rate is very low. So, it increase the production cost. If higher material removal rate is required at lower surface roughness then increase the cutting speed as well as feed rate. The feed rate and cutting speed is more influence on surface roughness. Also cutting speed, feed rate and milling type more influence on material removal rate.

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