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Full factorial method for optimization of process parameters for surface roughness and MMR for 316L material during turning operation

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Abstract— Quality and productivity play significant role in today's manufacturing market.In machining operations, achieving desired surface quality features of the machined product, is really a challenging job on cnc machine. Because, these quality features are highly correlated and are expected to be influenced directly or indirectly by the direct effect of process parameters. There are a number of parameters like cutting speed, feed and depth of cut etc. which must be given consideration during the machining of SS 316L. The prediction of optimal machining conditions for good surface roughness and material removal rate plays a very important role in process planning.

Keywords- Full factorial, CNC machine, MRR, Surface roughness

I. INTRODUCTION

1.1 Project Background:

In industries machining process, Surface finish is one of the most significant technical requirements of the customer. A good surface finish is desired to improve the properties, fatigue strength, corrosion resistance and aesthetic appeal of the product. Nowadays, manufacturing industries specially concerned to dimensional accuracy and surface finish. The challenge of modern machining industries is mainly focused on the achievement of high quality in term of work piece dimensional accuracy and surface finish. Surface texture is concerned with the geometric irregularities of the surface of a solid material they are defined in terms of surface roughness, waviness, lay and flaws. Surface roughness consists of the fine irregularities of the surface texture, including feed marks generated by the machining process like turning operation. The quality of a surface is significantly important factor in evaluating the productivity of machine tool and machined parts. In any machining process, apart from obtaining the accurate dimensions, achieving a good surface quality and maximized metal removal are also of utmost importance. The surface roughness of machined parts is a significant design specification that is known to have considerable influence on properties such as wear resistance and fatigue strength. It is one of the most important measures in finishing cutting operations. Good surface finish not only assures quality, but also reduces manufacturing cost. Surface finish is important in terms of tolerances, it reduces assembly time and avoids the need for secondary operation, thus reduces operation time and leads to overall cost reduction.

1.2 Cnc Turning:

A CNC Lathe produces parts by "turning" rod material and feeding a single-point cutter into the turning material. Cutting operations are performed with a cutting tool fed either parallel or at right angles to the axis of the work piece. The tool may also be fed at an angle relative to the axis of the work piece for the machining tapers and angles. The work piece may originally be of any cross-section, but the machined surface is normally straight or tapered. Have many possible shape can produce in CNC turning such as variety of plain, taper, contour, fillet and radius profiles plus threaded surfaces. CNC turning also can be used to create shafts, rods, hubs, bushes and pulleys.

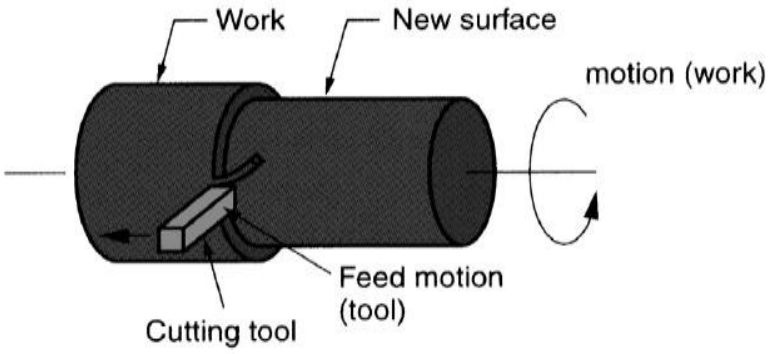

Fig. 1: Turning operation

1.3 Problem Statement:

Optimization of turning parameters is usually a difficult work where the following aspects are require such as like knowledge of machining and the specification of machine tool capabilities. The level of parameters is the main point because it will affect the surface of the work piece, it also to avoid from scratch marks or inaccuracies in the cut. In a turning operation, it is important task to select a good combination of parameters level for achieving high cutting performance. Generally this combination is hard to find.

In turning operation, the performances of cutting tools are depending on a few cutting conditions and parameters. The proper selection of feed rate has direct effect to the product surface roughness. Turning process by maximizing cutting speed and depth of cut will optimize the cutting process and minimize the production cost. The tool life, machined surface integrity and cutting forces are directly dependent on cutting parameters and will determine the cutting tool performances. The study of surface roughness form will resolve the characteristic and phenomena happening during the machining process.

Input parameter: Cutting Speed, Depth of cut, Feed rate

Output parameter: Surface roughness, MRR

1.4Project Scope:

The study has been conducted on the following scopes:

- CNC Turning machine employed for experimental work.
- Stainless Steel solid bar SS316L used as a work piece material.
- Dimension of the work piece is Ø45 X 35 mm.

-Cutting speed, feed and depth of cut are the process parameters to be optimized.

-Performance will be primarily in terms of surface roughness and material removal rate will also be briefly discussed.

-Design of Experiment technique is used.

2. LITERATURE SURVEY

[1] Kanase Tanaji Jadhav D. B were carried out "Enhancement of Surface Finish for CNC turning Cutting Parameters by Using Taguchi Method" They investigated the effects of machining

parameters, including different cutting tools for different materials, depth of cut, cutting speed and feed rate.

The three different types of cutting inserts are used in this experimentation and they are carbide, ceramic and CBN. Also three different types of materials are used Stainless Steel (Type 304), Carbon Steel (EN9) and Alloy steel (SAE 8645). The three tool used were T1 (Carbide) T2 (Ceramic) T3 (CBN).

The design of experiment used for this experiment is taguchi method. It is found that the parameter of the taguchi method provides a simple, systematic, & efficient methodology for the optimization of the machining parameters.

CBN Tools gives better surface finish compare to ceramic and carbide tools at all speeds, feeds and depth of cut.

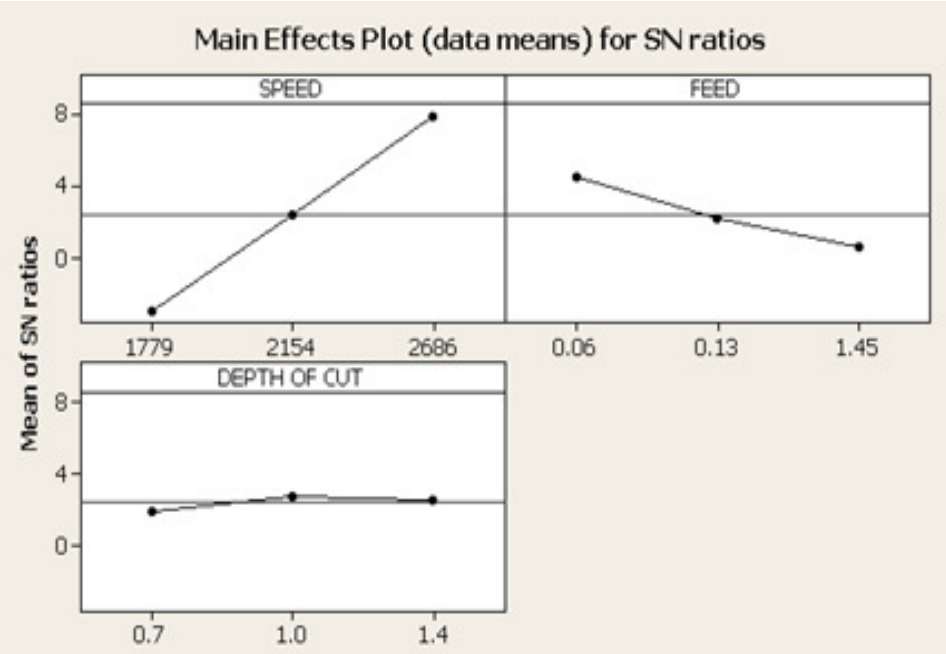

Figure: 2.1 effect of CBN Tools on speed, feed and depth of cut

[2] Meenu Sahu were carried out "Optimization of Cutting Parameters on Tool Wear, Work piece Surface Temperature and Material Removal Rate in Turning of AISI D2 Steel" They investigated the an optimization method of the cutting parameters (cutting speed, depth of cut and feed) in dry turning of AISI D2 steel to achieve minimum tool wear, low workpiece surface temperature and maximum material removal rate (MRR). The experimental layout was designed based on the Taguchi's L9(3^4) Orthogonal array technique and analysis of variance (ANOVA) was performed to identify the effect of the cutting parameters on the response variables. The results showed that depth of cut and cutting speed are the most important parameter influencing the tool wear.

The machine used is JOBBER-XL CNC lathe, Work specimen Materials is AISI D2 steel (Φ50 mm x 120 mm).

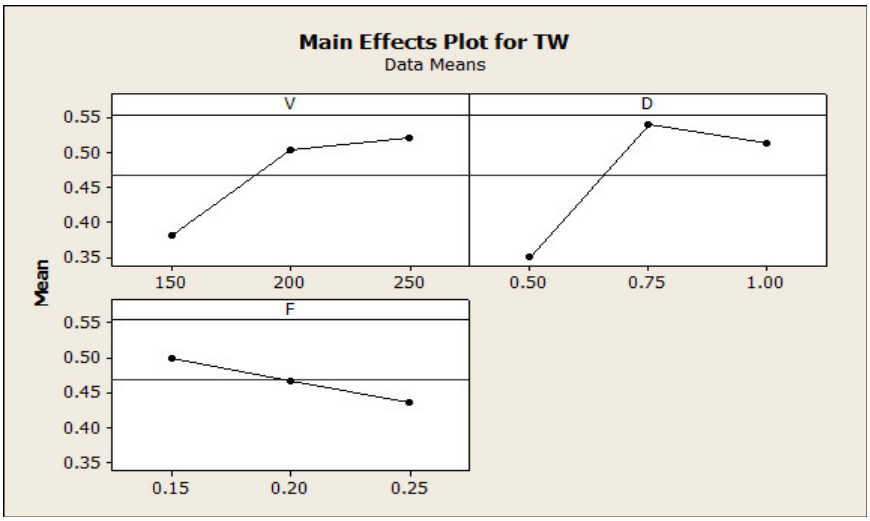

Figure: 2.2(a): Effect of Toolwear Rate

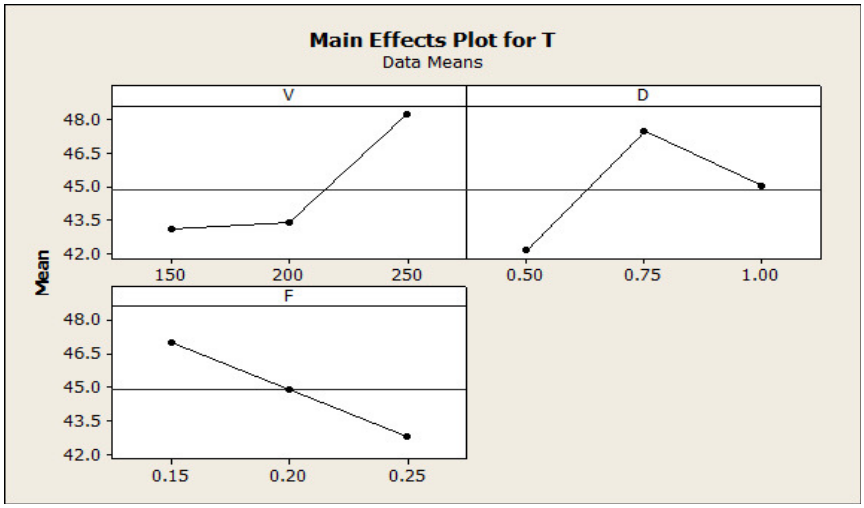

Figure: 2.2(b): Effect of Surface Temperature

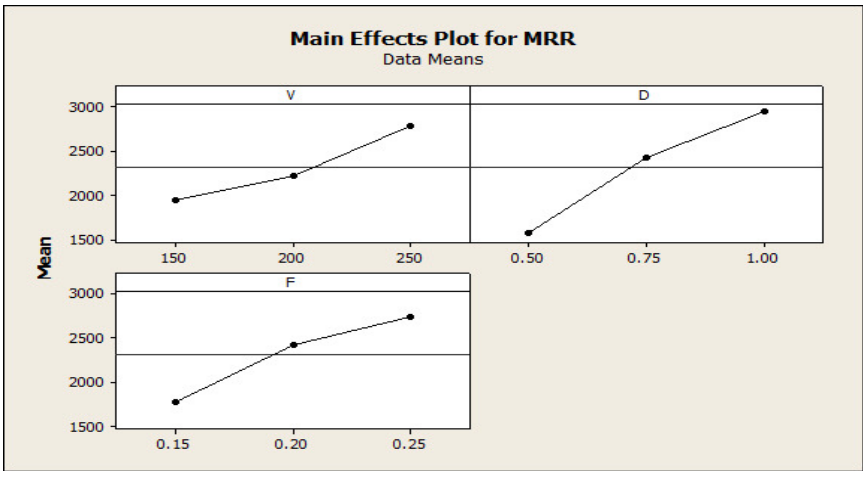

Figure: 2.2(c): Effect of Material Removal Rate

[3]M. Naga Phani Sastry worked out "Optimization of Performance Measures in CNC Turning using Design of Experiments(RSM) ".The investigated the effect of turning process parameters (cutting speed, feed rate, and depth of cut) on the metal removal rate and surface roughness as responses or output parameters. Response surface methodology (R.S.M), which is a part of DOE, is used to determine and present the cause and effect of the relationship between true mean response and input control variables influencing the response as a two or three dimensional surface. R.S.M has been used for designing a three factor with three level central composite factors design in order to construct statistical models capable of accurate prediction of
responses. The results obtained showed that the application of R.S.M can predict the effect of machining parameters on MRR and surface roughness. A case study in straight CNC turning of aluminum bar using HSS tool is being considered. The study aimed at evaluating the best process environment which could simultaneously satisfy requirements of both quality and as well as productivity. The predicted optimal setting ensured minimization of surface roughness and maximization of MRR (Material Removal Rate).Optimal result was verified through confirmatory test.

[4] Deepak Mittal, were carried out "An investigation of the effect of process parameters on MRR in turning of pure titanium (grade-2)". They investigate the effect of process parameters in turning of Titanium grade 2 on conventional lathe. A single point high speed steel (MIRANDA S-400) tool is used as the cutting tool. The round bar of Titanium grade 2, 40mm diameter and 50 mm length is used as the work piece. Three parameters namely spindle speed, depth of cut and feed rate are varied to study their effect on material removal rate and tool failure. The experiments are conducted using one factor at a time approach. A Total of 30 experiments were performed. The MRR was calculated by measuring the weight of the specimen before and after machining on the digital balance meter with a least count of 10 mg of Sansui (Vibra), model no. AJ3200E. Moreover, a few random experiments are also carried to study the phenomenon of tool failure. The study reveals that material removal rate is directly influenced by all the three process parameters. However the effect of spindle speed and feed rate is more as compared to depth of cut. An optimum range of input parameters has been bracketed as the final outcome for carrying out further research.

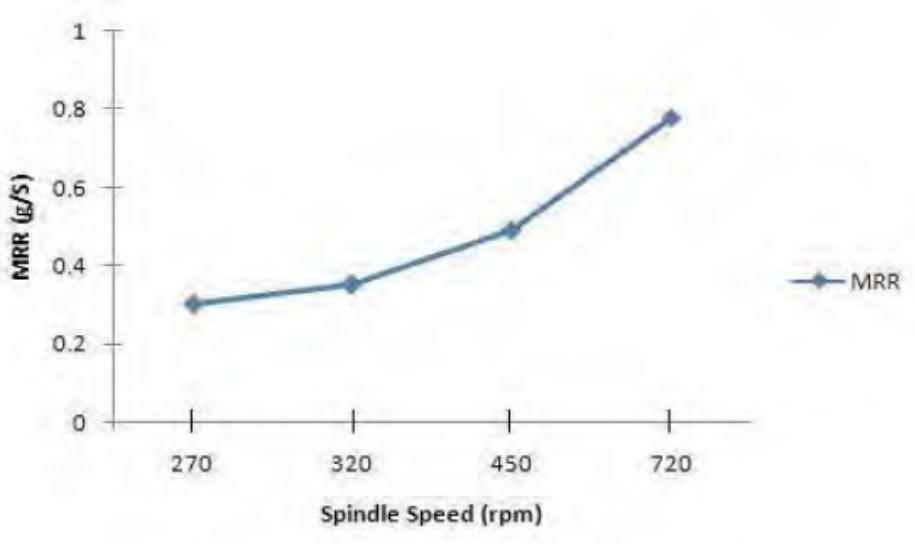

Fig: 2.3(a)

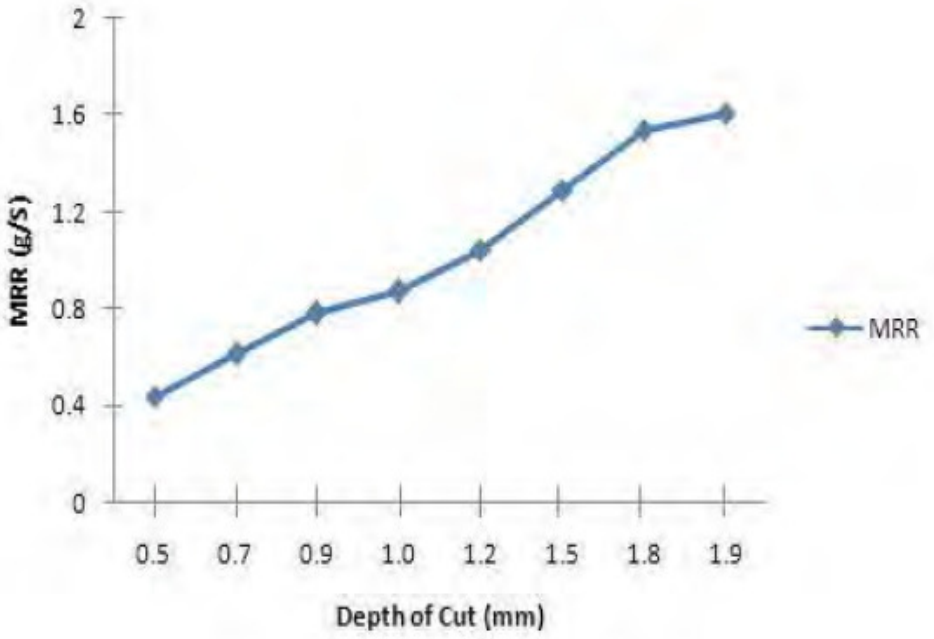

Fig:2.3(b)

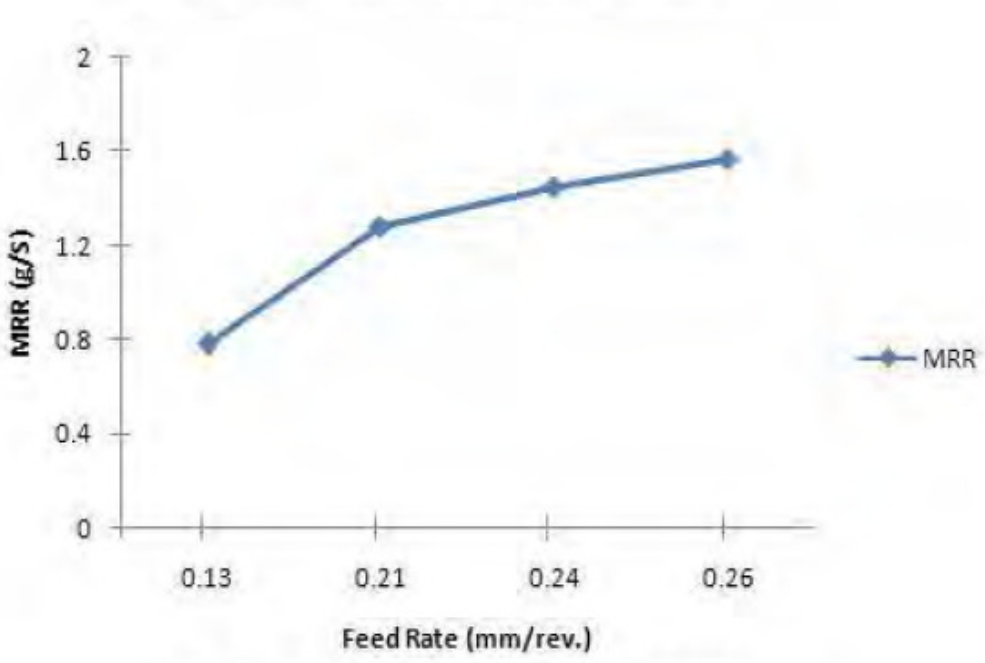

Fig:2.3(c)

Fig. 2.3 Effect of (a) speed, (b) DOC and (c) feed rate on MRR

[5] Dr. C. J. Rao, were carried out "Influence of cutting parameters on cutting force and surface finish in turning operation". they describes the significance of influence of speed, feed and depth of cut on cutting force and surface roughness while working with tool made of ceramic with an Al2O3+TiC matrix (KY1615)and the work material of AISI 1050 steel (hardness of 484 HV). Experiments were conducted using Johnford TC35 Industrial type of CNC lathe. Taguchi method (L27 design with 3 levels and 3 factors) was used for the experiments. Analysis of variance with adjusted approach has been adopted. The results have indicated that it is feed rate which has significant influence both on cutting force as well as surface roughness. Depth of cut has a significant influence on cutting force, but has an insignificant influence on surface roughness. The interaction of feed and depth of cut and the interaction of all the three cutting parameters have significant influence on cutting force, whereas, none of the interaction effects are having significant influence on the surface roughness produced.

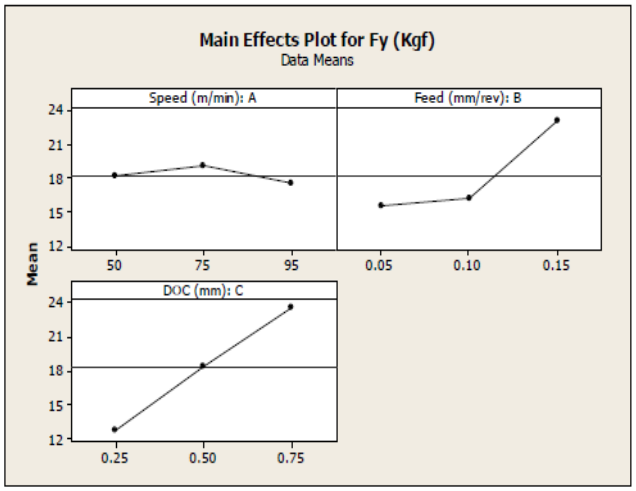

Figure. 2.4(A) Effect of Cutting Parameters on cutting force

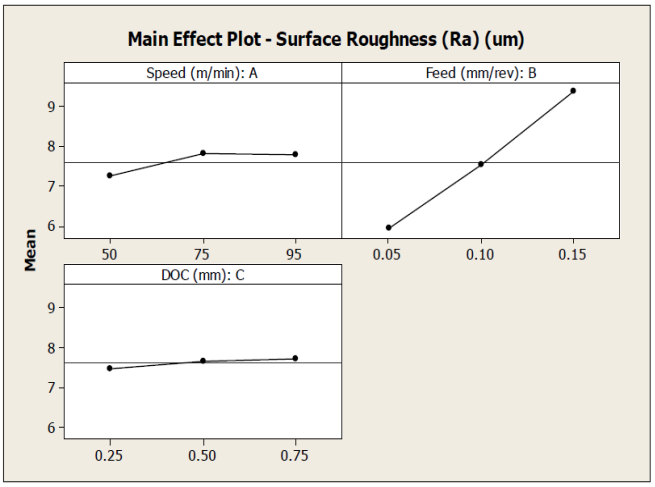

Figure. 2.4(B) Effect of Cutting Parameters on surface roughness

N. Satheesh Kumar [6], were carried out "Effect of spindle speed and feed rate on surface roughness of Carbon Steels in CNC turning." The effect of process parameters in turning of Carbon

Alloy Steels in a CNC lathe. The parameters namely the spindle speed and feed rate are varied to study their effect on surface roughness. The five different carbon alloy steels used for turning are SAE8620, EN8, EN19, EN24 and EN47. The study reveals that the surface roughness is directly influenced by the spindle speed and feed rate. It is observed that the surface roughness increases with increased feed rate and is higher at lower speeds and vice versa for all feed rates.

Effect of spindle speed : The surface roughness decreased with increased spindle speed.

Effect of feed rate : The surface roughness increased with increased feed rate.

The better surface finish may be achieved by turning carbon alloy steels at low feed rate and high spindle speeds.

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