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Research on Machinability of 55si2mn Steel

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Abstract - **This work investigates the effect of machining parameters such as Speed, depth of cut and Feed Rate on the surface roughness in End Milling of 55Si2Mn steel under dry cutting process. Sixty four experiments were carried out on Manganese 55Si2Mn. The experiments were conducted on CNC Vertical Milling Machine with carbide cutting tool inserts. The surface roughness obtained from each Experiment was measured using surface roughness tester (Mitutoyo SURFTEST.500). Response Surface Methodology (RSM) was employed in the experimental design using Design Expert. Analysis of variance (ANOVA) was used to determine the significance of cutting parameters on surface roughness. The analysis was carried out with the aid of Origin Pro 8.5.1 software.**

Key Words：- 55Si2Mn, Surface roughness, ANOVA, RSM

I. INTRODUCTION

In modern Manufacturing and Automobile industry, The improvement of productivity, reliability, time consumption and cost minimization, create a new and small product of higher quality of manufacturing systems has more and more important. Sufficient calculation of machining performance can improve selection of correct machining, save operation time, decrease waste, and reduce the time required for test cuts in NC program verification. Material cutting also known as machining is one of the most used techniques for producing different component. In the machining processes a cutting tool removes material from a work piece of a less resistant material. The removed material called chip or swarf slides on the tool face and leaves the workpiece material. As a result of this process the cutting tool would be subjected to high normal and shear stresses [1]. In a machining process, in order to improve machining efficiency, reduce the machining cost, and improve the quality of machined parts, it is necessary to select the most appropriate machining conditions. The present experimental investigation of the influence of cutting parameters (speed, feed, and depth of cut) surface roughness and Material removal rate (MRR) has been analyzed in a Milling machine.

Austenitic Manganese Steel was discovered by R. A. Hadfield in 1882 and since then it has become one of the most important steels where erosion of components takes place by continued abrasion and impact. It is 1.2% Carbon 12% Manganese alloy steel heat treated to an austenitic condition, which is stable at room temperature. Outstanding toughness, high strain hardening capacity and Para magnetism are the principle virtues of manganese steel. Although austenitic manganese steels are universally known as the most useful abrasion resistant material. There is a general misconception amongst both the manufacturer and the user about the basic characteristic of manganese steel for its choice for usual applications.

The primary reason for selecting manganese steel for any particular application is not abrasion resistance. It does have a good abrasion resistance, but if abrasion resistance is the only criterion, there are a number of materials available which are much superior e.g. martenstic white cast irons. The overriding reason for its choice is the tremendous toughness of manganese steel to most people toughness means the ability to withstand severe impact conditions without fracturing. Manganese steel has this ability and its huge reserve of impact toughness as compared to other wear materials even in applications where other materials possess sufficient toughness for normal conditions, Mn steel may be chosen because of the danger of occasional high impact. If impact & shock is absent, as in pipe carrying sand-laden water, white cast iron is a better choice. For light or moderate impact, hardened steel is justified. For heavy impact or for large safety factor Mn steel is the logical choice. [2]

II. METHODOLOGY

A. EXPERIMENTAL SET-UP

In this unit detail methodology of the experiment has been described. The detail aspect of machine tool used, equipment facilities, work piece material, cutting tool, machining parameters and experimental set-up has been discussed. The experiment was conducted on CNC vertical milling machine using a Carbide cutting tool. The work piece of 150mm by 80mm by 55 mm was hardened to 55Si2Mn by the use of heat treatment (heating, quenching and normalizing).

Fig.1 Milling Machine

In order to analyze the effect of spindle speed, feed rate and depth of cut on the surface roughness (Ra). The equipment used for measuring the surface roughness was a surface roughness tester (Mitutoyo SURFTEST.500). In a factorial design creates 4^n training data, where n is the number of variables. In these studies, three variables such as cutting speed (V), feed rate (f) and depth of cut (ap) had total of 4^3 =64 experiment runs. Where four cutting speeds (VC) (22.29, 25.47, 28.66 and 31.84M/min), four Feed Rate (fz) (14, 24, 36 and 50mm/z) and four depths of cut (ap) (0.02, 0.03, 0.04 and 0.05 mm) were selected.

Fig2. Surface roughness (Mitutoyo) Tester

B. EXPERIMENTAL DETAILS

i. *Working Material*

The work piece material used in the machining test was 55Si2Mn steel or spring steel. The spring steel is defined as due to the flexibility in the quenched and tempered condition, which is specialized for the manufacture of steel springs and elastic components. The elasticity of the steel depends on the ability of its elastic deformation that is within the limits prescribed by the elastic deformation of the ability to withstand a certain load, the permanent deformation after load removal.

Spring steel has excellent overall performance, such as mechanical properties (particularly elastic limit, ultimate strength, yield ratio) reduction performance of ballistic resistance (i.e. resistance decreased elasticity of the performance, also known as anti-stress relaxation properties), fatigue properties; hardenability physical and chemical properties (heat resistance, low temperature resistance, oxidation resistance, corrosion resistance, etc.). In order to meet these performance requirements, the spring steel with excellent metallurgical quality (high purity and uniformity), good surface quality (strict control of surface defects and decarburization), the exact shape and size. Steel Classification Standard features in accordance with the basic performance and the use of one spring steel mechanical structural steel; in accordance with the quality and grade of special quality steel and that the production process requires strict control of quality and performance of steel. In accordance with our habits, the spring steel is special steel.55Si2Mn steel manufacturing medium and small automobile leaf spring, good use effect, and can also make other middle section size of leaf springs, coil springs. Use a very wide range of manufacturing all kinds of springs, such as automobile, motorcycle, tractor leaf springs, coil spring, cylinder safety valve spring and some important spring force to work in high stress, wear serious spring. 55Si2Mn because of boron, the quenching of light and medium car is obviously improved. [3]

Elements	Percentage Wt%
C	0.5~0.60
Si	1.50~2.00
Mn	0.60~0.90
S	≤ 0.035
P	≤ 0.035
Cr	≤ 0.35
Ni	≤ 0.35
Cu	≤ 0.25

Table 1:- Chemical composition of 55Si2Mn

i. *Cutting Tool*

Carbide end mill was employed throughout the experiment. It is selected because of its suitability in machining hard materials like carbon steel and stainless steel as well as its desirability in high production line because it produces better surface finish, and allows faster machining with no or little wear. It can also withstand higher temperature when compared with Standard high speed steel cutting tools. The material is usually called cemented carbide, hard metal or tungsten-carbide cobalt, because its matrix comprises of aggregate of tungsten carbide particle with metallic cobalt [4].

Table 2- Machining parameters and Levels

No	Parameters	Units	Level			
			1	2	3	4
1	Speed (Vc)	M/min	22.29	25.47	28.66	31.84
2	Feedrate (fz)	mm/z	14	24	36	50
3	Depth of cut (ap)	mm	0.02	0.03	0.04	0.05

III. RESULTS AND DISCUSSION

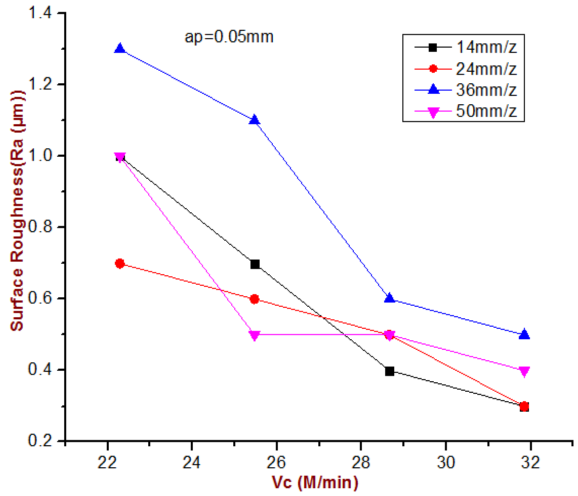

Fig3A. Cutting Speed vs Surface Roughness

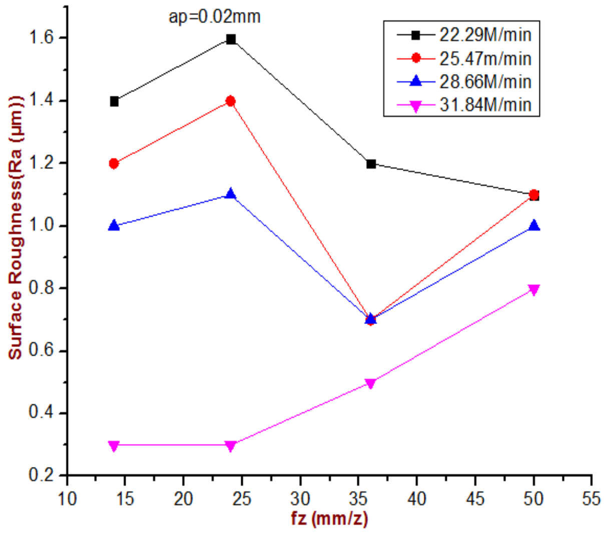

Fig3B.Feed Rate vs Surface Roughness

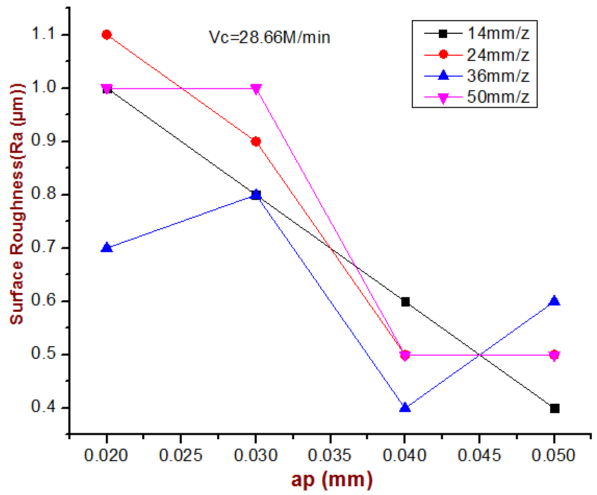

Fig3c.Depth of cut vs Surface Roughness

Graphical interpretation

Fig 3a. Shows that feed rate has less effect on the surface roughness. Increasing the spindle speed improves the surface finish. It is generally well known that an increase in cutting speed improves Machinability.

From Fig3b. Observed that feed rate has much effect on the surface roughness. At high feed reduces the rate at which roughness increased.

According to fig3c if the depth of cut <0.05 the depth of cut (ap) increase and surface Roughness (Ra) decrease.

ANALYSIS OF VARIANCE (ANOVA)

ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	P Value
CUTTING SPEED(Vc)	3	3.30297	1.10099	18.97307	1.17888E-8
FEED RATE(fz)	3	0.03922	0.01307	0.22528	0.87843
Model	6	3.34219	0.55703	9.59918	2.75946E-7
Error	57	3.30766	0.05803	--	--
Corrected Total	63	6.64984	--	--	--

At the 0.05 level, the population means of **CUTTING SPEED(Vc)** are **significantly** different.
At the 0.05 level, the population means of **FEED RATE(fz)** are **not significantly** different.

Means Comparisons

Powers

CUTTING SPEED(Vc)

	Alpha	Sample Size	Power
Actual Power	0.05	64	1

FEED RATE(fz)

	Alpha	Sample Size	Power
Actual Power	0.05	64	0.08992

Fig 4a. ANOVA for cutting speed and feed rate

ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	P Value
CUTTING SPEED(Vc)	3	3.30297	1.10099	35.29048	3.38807E-12
DEPTH OF CUT(ap)	3	1.53547	0.51182	16.40568	1.79331E-7
Interaction	9	0.31391	0.03488	1.11797	0.36873
Model	15	5.15234	0.34349	11.01002	7.54121E-11
Error	48	1.4975	0.0312	--	--
Corrected Total	63	6.64984	--	--	--

At the 0.05 level, the population means of **CUTTING SPEED(Vc)** are **significantly** different.
At the 0.05 level, the population means of **DEPTH OF CUT(ap)** are **significantly** different.
At the 0.05 level, the interaction between **CUTTING SPEED(Vc)** and **DEPTH OF CUT(ap)** is **not significant**.

Means Comparisons

Powers

CUTTING SPEED(Vc)

	Alpha	Sample Size	Power
Actual Power	0.05	64	1

DEPTH OF CUT(ap)

	Alpha	Sample Size	Power
Actual Power	0.05	64	0.99998

Fig 4b. ANOVA for cutting speed and depth of cut

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ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	P Value
FEED RATE(fz)	3	0.03922	0.01307	0.14221	0.93416
DEPTH OF CUT(ap)	3	1.53547	0.51182	5.56771	0.00232
Interaction	9	0.66266	0.07363	0.80094	0.61722
Model	15	2.23734	0.14916	1.62255	0.10285
Error	48	4.4125	0.09193	--	--
Corrected Total	63	6.64984	--	--	--

At the 0.05 level, the population means of **FEED RATE(fz)** are **not significantly** different.
At the 0.05 level, the population means of **DEPTH OF CUT(ap)** are **significantly** different.
At the 0.05 level, the interaction between **FEED RATE(fz)** and **DEPTH OF CUT(ap)** is **not significant**.

Means Comparisons

Powers

FEED RATE(fz)

	Alpha	Sample Size	Power
Actual Power	0.05	64	0.07421

DEPTH OF CUT(ap)

	Alpha	Sample Size	Power
Actual Power	0.05	64	0.92402

Fig4c. ANOVA for Feed Rate and Depth of Cut

CONCLUSION

A series of experiments has been conducted in order to begin to characterize the factors affecting surface roughness for the end-milling process. The effect of spindle speed, feed rate, depth of cut on surface roughness of 55Si2Mn steel samples was studied. We can say that the increasing the spindle speed improves the surface finish. It is generally well known that an increase in cutting speed improves Machinability, high feed reduces the rate at which roughness increased and also if the depth of cut <0.05 the depth of cut (ap) increase and surface Roughness (Ra) decrease.

Finally we can say that high cutting speed and low surface roughness will have a good surface quality, increase in depth of cut and decrease surface roughness will have good surface finish and also increases in feed rate and surface roughness will have poor surface finish.

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