

# Experimental Analysis of Turning Operation on CNC Machine using Single Point Cutting Tool (Mild Steel (EN19) Material)

Professor. Suhas A. Rewatkar<sup>1</sup>, Ashish A. Wahane<sup>2</sup>, Ankush P. Hiranwar<sup>3</sup>, Kamesh L. Bhojar<sup>4</sup>, Ashley R. Collins<sup>5</sup>, Ahfaz H. Siddiqui<sup>6</sup>

<sup>1</sup>Assistance professor JD College of Engineering Nagpur Maharashtra (India)

<sup>2,3,4,5,6</sup>Student J D College of Engineering Nagpur Maharashtra (India)

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**Abstract** - The paper presents an experimental study of surface roughness generated in turning operation of MS EN19. In modern industry the goal is to manufacture low cost, high quality products in short time. Automated and flexible manufacturing systems are employed for that purpose along with computerized numerical control (CNC) machines that are capable of achieving high accuracy and very low processing time. The study shows the influence of three cutting parameters- cutting speed, depth of cut and feed rate. A good quality turning surface can lead to improvement in strength properties such as fatigue strength, corrosion resistance and thermal resistance. In this study, a Taguchi method, a tool signature optimization for surface roughness, is used to find the optimal cutting parameters for turning operation.

- Low operation costs
- Lower setup times (time to prepare tooling for production)

In this paper, in alternative approach based on the Taguchi method (7-9) is used to determine the desired cutting parameters more efficiently. Basically, the Taguchi method is a powerful tool for design of high-quality system. It provided a simple, efficient and systematic approach to optimize design for performance, quality and cost. The methodology is valuable when the design parameters are qualitative and discrete. In Taguchi method there are different types of arrays to determine surface roughness. And in this operation, we have selected L9 array.

**Key Words:** HSS M7 (S-400), Turning Operation, Tool Signature, Surface Finishing, Taguchi Method.

## 1.1 Material

## 1. INTRODUCTION

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a CNC machine, work piece, cutting tool. In turning operation, it is an important task to select cutting parameter for achieving high cutting performance.

A material is a chemical substance or mixture of substances that constitute an object. Materials can be pure or impure, a singular composite or a complex mix, living or non-living matter, whether natural or man-made, either concrete or abstract. Materials can be classified based on different properties such as physical and chemical properties (see list material which is use for materials properties, geological, biological or philosophical properties. In the physical sense, materials are studied in the field of materials science. In industry, materials are inputs to production or manufacturing processes. They may either be raw material, that is unprocessed or processed before being used in the material which is used for substance more advanced production processes, either by distillation or synthesis (synthetic materials).

We have sleeted Mild Steel EN19 as our working material and High-Speed Steel (HSS-M7 S400) as a cutting tool material. EN19 is a high-quality alloy steel with tensile strength. With a combination of good ductility and shock resistance. With a combination of good ductility and shock resistance, EN19 is suitable for application with very high loading such as engine gear boxes. Popular in the automotive sector it is possible to machine the material in the Oil & Gas sector. The material lends itself well to any application where strength is a primary consideration.

### • Work piece materials

The primary reason for selecting machining over the other two primary shaping processes are that machining are:

The metal cutting industry produces an extremely wide variety of components machined from many different materials. Each material has its own unique characteristics that are influenced by alloying elements, heat treatment, hardness, etc. which is a high-quality alloy steel with tensile strength EN19 is a suitable for application with very high loading, in recent year mild steel EN19 has become an established material in the oil and gas sector. The material lends itself well to any application where strength each a primary consideration. The case hardening or surface hardening is a process of hardening the surface of metal,

- Improve dimensional tolerances
- Improve surface finish
- Produce complex geometries
- Produce low quantities economically because of more flexibility in tooling and featuring

often low carbon steel, by infusing element into the material surface, forming a thin layer of a harder alloy. The hardness test is performed when quick and reading is required and also when the materials have hardness beyond the range of Brinell hardness test. It differs from the Brinell hardness tests that in this test load for the making indentation are smaller and thus make small and shallow indentation. Due to this reason, the Rockwell hardness test is widely used in the industry. The Mild Steel EN 19 is a high tensile steel with good ductility and shock resistance. EN 19 is a high quality Quenched and Tempered Alloy Structural steel. Good ductility is a result of high-quality steel, high tensile strength and shock resisting properties in combination with resistance to wear.

edge. This will always be true as long as the tool shank is mounted at right angles to the work piece axis.

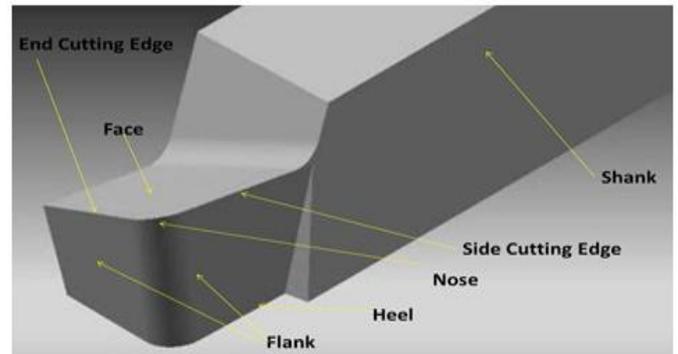


Fig: Single Point Cutting Tool

- i. The Material of this experiment is EN19.
- ii. It has high wear resistance property.
- iii. The cost of material is cheaper.
- iv. It has good ductility and shock resistance.

❖ Chemical Composition:

C(%)	0.35 ~ 0.45	Si(%)	0.10 ~ 0.35	Mn(%)	0.50 ~ 0.80	P(%)	≤0.035
S(%)	≤0.050	Cr(%)	0.90 ~ 1.50	Mo(%)	0.20 ~ 0.40		

● Cutting tool materials

Cutting tool materials are materials that are used to make cutting tools that are used in machining (drill bits, tool bits, milling cutters, etc.). In this Experiment we are using High Speed Steel (HSS-M7 S400) as a cutting tool material.

- i. High speed steel having temperature up to 500°C and high wear resistance.
- ii. It having higher strength.
- iii. It is used in drilling, milling, turning, boring.

❖ Component Element properties:  
 Carbon: 1.02 %, Chromium: 3.8%,  
 Iron: 82.18%, Manganese: 0.30%,  
 Molybdenum: 8.6%, Silicon: 0.40%,  
 Tungsten: 1.8%, Vanadium: 1.9%

1.2 Tool Signature of Single Point Cutting Tool

Convenient way to specify tool angles by use of a standardized abbreviated system is known as tool signature. It indicates the angles that a tool utilizes during the cut. It specifies the active angles of the tool normal to the cutting

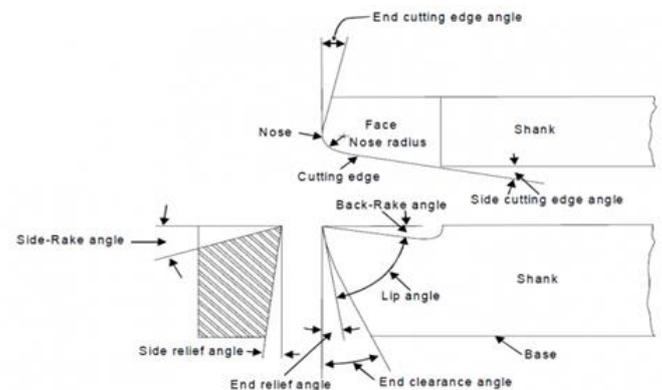


Fig: Elements of Tool or Nomenclature of SPCT

The seven elements that comprise the signature of a single point cutting tool are always stated in the following order:

1. Back rake angle (0°)
2. Side rake angle (7°)
3. End relief angle (6°)
4. Side relief angle (8°)
5. End cutting edge angle (15°)
6. Side cutting edge angle (16°) and
7. Nose radius (0.8 mm)

It is usual to omit the symbols for degrees and mm, simply listing the numerical value of each component in single point cutting tool:

A typical tool signature is 0-7-6-8-15-16-0.8

## 2. Aim

Aim is to finding the optimum surface finishing of work piece.

### 2.1 Objectives

- The main Objective of this project is finding checking the surface finish of work piece to see impact of tool signature on surface finishing.
- Selection of material of cutting tool and work piece.
- Finalize the different tool signature for turning operation.
- Turning of work piece by different single point cutting tool using varying tool signature.

### 3. CNC Machine

- The abbreviation CNC stands for computer numerical control, and refers specifically to a computer "controller" that reads G-code instructions and drives a machine tool (i.e., a powered mechanical device typically used to fabricate components by the selective removal of material).
- Computer Numerical Control (CNC) is a numerical control system in which the data handling, control sequences, and response to input is determined by a computer system at the machine tool.
- CNC is a form of programmable automation.
- CNC has touched almost every form of manufacturing process in one way or another.
- CNC is the process of manufacturing machined parts in a production environment.



Fig: CNC Machine

### 3.1 CNC Component:

- Machine tool
- Actuators (motors)
- Drive circuits to operate the actuators
- Sensors to provide feedback signals
- Conditioning circuits for the sensor signals
- Controller (PC-based and microcontroller-based)

Table-1: CNC Programing

Line	Code	Description
N01	M216	Turn on load monitor
N02	G00 X20 Z20	Rapid move away from the part, to ensure the starting position of the tool
N03	G50 S2000	Set Maximum spindle speed
N04	M01	Optional stop
N05	T0303 M6	Select tool #3 from the carousel, use tool offset values located in line 3 of the program table, index the turret to select new tool
N06	G96 S854 M42 M03 M08	Variable speed cutting, 854 ft/min, High spindle gear, Start spindle CW rotation, Turn the flood coolant on
N07	G00 X0.5 Z1.1	Rapid feed to a point 0.1" from the end of the bar and 0.5" from the side
N08	G01 Z1.0 F0.05	Feed in horizontally until the tool is standing 1" from the datum
N09	X0.0	Feed down until the tool is on center - Face the end of the bar
N10	G00 Z1.1	Rapid feed 0.1" away from the end of the bar
N11	X1.0	Rapid feed up until the tool is standing at the finished OD
N12	G01 Z0.0	Feed in horizontally cutting the bar to 1" diameter all the way to the datum
N13	M05 M09	Stop the spindle, Turn off the coolant
N14	G28 G91 X15 Z15	Home X axis in the machine coordinate system, then home all other axes
N15	M215	Turn the load monitor off
N16	M30	Program stop, pallet change if applicable, rewind to beginning of the program

### 4. Turning Operation

CNC Turning is a manufacturing process in which bars of material are held in a chuck and rotated while a tool is fed to the piece to remove material to create the desired shape. A turret (shown center), with tooling attached is programmed to move to the bar of raw material and remove material to create the programmed result. This is also called "subtraction machining" since it involves material removal. If the center has both tuning and milling capabilities, such as the one above, the rotation can be stopped to allow for milling out of other shapes.

- The starting material, though usual round, can be other shapes such as squares or hexagons.
- Depending on the bar feeder, the bar length can vary. This affects how much handling is required for volume jobs.
- CNC lathes or turning centers have tooling mounted on a turret which is computer-controlled. The more tools that that the turret can hold, the more options are available for complexities on the part.

- CNC's with "live" tooling options, can stop the bar rotation and add additional features such as drilled holes, slots and milled surfaces.
- Some CNC turning centers have one spindle, allowing work to be done all from one side, while other turning centers, such as the one shown above, have two spindles, a main and sub-spindle. A part can be partially machined on the main spindle, moved to the sub-spindle and have additional work done to the other side this configuration.

#### 4.1 Factors

- CNC turning centres are generally good for prototypes to short-run volumes.
- For the CNC turning centres at Pioneer Service, the maximum OD for collected (bar feed-capable) parts is 2.5.
- Parts over 2.5" OD are chucked individually, which depending on volume, can contribute to price.
- Parts under 1.25" OD and medium to high volume may be a better fit for the Swiss screw machines.
- If a part can be made both on the CNC turning center and on a 32 mm Swiss Screw Machine factors such as projected volume and lead-time are critical for making the best call on which to use.

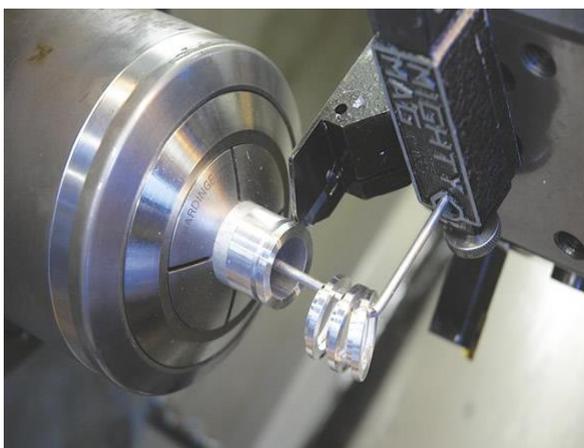


Fig: Turning operation on CNC Machine

#### 5. Taguchi Methods

Taguchi method are statistical methods, or sometimes called robust design methods, developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering.

Taguchi's work includes three principal contributions to statistics:

- A specific loss function
- The philosophy of off-line quality control
- Innovations in the design of experiments.

#### 5.1 Taguchi's rule for manufacturing

Taguchi realized that the best opportunity to eliminate variation of the final product quality is during the design of a product and its manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts. The process has three stages:

- System design
- Parameter (measure) design
- Tolerance design

**System design:** This is design at the conceptual level, involving creativity and innovation.

**Parameter design:** Once the concept is established, the nominal values of the various dimensions and design parameters need to be set, the detail design phase of conventional engineering. Taguchi's radical insight was that the exact choice of values required is under-specified by the performance requirements of the system. In many circumstances, this allows the parameters to be chosen so as to minimize the effects on performance arising from variation in manufacture, environment and cumulative damage. This is sometimes called robustification.

Robust parameter designs consider controllable and uncontrollable noise variables; they seek to exploit relationships and optimize settings that minimize the effects of the noise variables.

**Tolerance Design:** With a successfully completed parameter design and an understanding of the effect that the various parameters have on performance, resources can be focused on reducing and controlling variation in the critical few dimensions.

#### 5.2 Taguchi's Parameter Design Approach

In parameter design, there are two types of factors that affect a product's functional characteristic:

- a. Control Factor
  - b. Noise Factor
- a. Control Factors: Control factors are those factors which can easily be controlled such as material

choice, cycle time, or mold temperature in an injection molding process.

- b. Noise Factors: Noise factors are those factors that are difficult or impossible or too expensive to control.

### 5.3 8-Steps in Taguchi Methodology

1. Identify the main function, side effects, and failure mode
2. Identify the noise factors, testing conditions, and quality characteristics
3. Identify the objective function to be optimized
4. Identify the control factors and their levels
5. Select the orthogonal array matrix experiment
6. Conduct the matrix experiment
7. Analyse the data, predict the optimum levels and performance
8. Perform the verification experiment and plan and the future action

### 6. Conclusion

We have studied previous literature paper on surface finishing and by the help of Taguchi method we are performed Turning operation on CNC machine using single point cutting tool from that we got better surface finishing.

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