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# Optimization of cutting tool material in lathe machine by T-test

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***Abstract:*** *Modern manufacturers, seeking to remain competitive in the market, rely on their manufacturing engineers and production personnel to quickly and effectively set-up manufacturing processes for new products. T-test method is a powerful and efficient method for optimizing quality and performance output of a manufacturing process, thus a powerful tool for meeting this challenge. This paper discusses an investigation into the use of t-test method for optimizing controlled dia of workpiece in a lathe machine. Control parameters being considered in this paper are spindle speed, feed rate and depth of cut. After experimentally turning sample work pieces using the selected parameters, this investigation produced an optimum combination of controlled parameter for the cutting tool.*

***Keywords****: Depth of cut, Dia of work, Feed rate, Spindle speed, T-test*

## I. INTRODUCTION

In lathe machine, a cylindrical workpiece rotates along its axis and the tool removes material from the workpiece to form it into a specific shape. On metal working lathes, the cutting tools are held rigidly in a tool holder that is mounted on a movable platform called the carriage. The tool is moved in and out by means of hand cranks and back and forth either by hand cranking or under power from the lathe. The result is that material is removed from the workpiece under very precise control to produce shapes that are truly precision made. Because of the inherent rotational nature of a lathe, the vast majority of the work produced on it is basically cylindrical in form. Single point tools are used in turning, shaping, planning and similar operations, and remove material by means of one cutting edge. Cutting tools must be made harder than the material which is to be cut and the tool must be able to withstand the heat generated in the metal cutting process. Also the tol must have a specific geometry, with clearance angles designed so that the cutting edge can contact the workpiece without the rest of the tool dragging on the workpiece surface.

### 1.1 Turning Process

Turning is a form of machining, a material removed process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, workpiece, fixture and cutting tool. The workpiece is a piece of preshaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single point cutting tool that is also secured in the machine. The cutting tool feeds into the rotating workpiece and cuts away material in the form of small chips to create the desired shape.

### 1.2 Turning Machine

This machine typically referred to as lathe can be found in a variety of sizes and designs. While most lathes are horizontal turning machines, vertical machines are sometimes used, typically for large diameter workpieces. Turning machines can also be classified by the type of control that is offered. A manual lathe requires the operator to control the motion of the cutting tool during turning operation. Turning machines are also able to be computer controlled, in which case they are referred to as a computer numeric control (CNC) lathe. CNC lathes rotate the workpiece and move the cutting tool based on commands that are preprogrammed and offer very high precision. In this variety of turning machines, the main components that the workpiece to be rotated and the cutting tool to be fed into the workpiece remain the same.

### 1.3 Turning Cutting Tool

All cutting tools that are used in turning can be found in a variety of materials, which will determine the tool’s properties and the workpiece materials for which it is best suited. This properties include the tool’s hardness, toughness and resistance to wear. The most common tools that are used include the following:

### 1.3.1 High Speed Steel

These are so named primarily because of their ability to machine materials at high cutting speeds. These are complex iron-base alloys of carbon, chromium, vanadium, molybdenum, tungsten or combinations thereof, and in some cases substantial amounts of cobalt. The carbon and alloy contents are balanced at levels to give high attainable hardening response, high wear resistance, high resistance to the softening effect of heat, and good toughness for effective use in industrial cutting operations. The recognized standard high speed tool steel, which serves almost all applications under mild to severe metal cutting conditions.

### 1.3.2 Silicon Carbide

This is also known as carborundum is a composed of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass-produced since 1983 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics which are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. The high sublimation temperature of SiC (approximately 2700°C) makes it useful for bearings and furnace parts. Silicon carbide does not melt at any known pressure. It is also highly inert chemically. There is currently much interest in its use as a semiconductor material in electronics, where its high thermal conductivity, high electric field breakdown strength and high maximum current density make it more promising than silicon for high powered devices. SiC has a very low coefficient of thermal expansion ($4.0 \times 10^{-6}$ K) and experiences no phase transitions that would cause discontinuities in thermal expansion.

### 1.3.3 Alloy Steel

These are steels with alloying elements other than carbon and iron. When various alloying elements are added to steel, these usually become stronger and harder than plain carbon steels. As the alloy content increases slightly, then gradually ductility reduces and with a total alloy content of 2-4%, hardness of 250 HB and tensile strengths to 850 N/mm$^2$ are found. Alloy steels within this range are those which have been hardened and tempered to give enhanced tensile strengths. Also included are the highly alloyed tool steels in their annealed condition. Nickel-chrome alloy steels with a total alloy content of 3-4% can be heat treated to give various hardness and tensile strengths by tailoring the tempering temperature to give the desired balance between hardness and ductility. Alloy tool steels with high carbon levels and a total alloy content of more than 5% also fall into this grouping, provided they are in the fully annealed (softened) state.

### 1.4 Turning Material

In turning, the raw form of the material is a piece of stock from which the workpieces are cut. This stock is available in a variety of shapes such as solid cylindrical bars and hollow tubes. Custom extrusions or existing parts such as castings or forgings are also sometimes used. Turning can be performed on a variety of materials, including most metals. Common materials that are used in turning include aluminium, brass, magnesium, nickel, steel, thermoplastics, titanium and zinc. When selecting a material, several factors must be considered, including the cost, strength, resistance to wear and machinability. The machinability of a material is difficult to quantify, but can be said to possess the following characteristics:

- Should result in a good surface finish.
- Promotes long tool life.
- Requires low force and power to turn.
- Provides easy collection of chips.

## II. METHODOLOGY

### 2.1 Stylus Instruments

These instruments are based on the principle of running a probe across a surface in order to detect variations in height as a function of distance. One of the stylus instruments contains a transducer which converted vertical displacement into an electric signal. This signal can then be processed by the instrument electronics to calculate a suitable roughness parameter. This type of transducer used largely affects instrument performance. Piezoelectric crystal is often used as the transducer in the less expensive instruments. Other transducer mechanisms include moving coil transducers, capacitance transducers, and linear variable differential transducers. The resolution of a stylus instrument depends on its manufacturer and model.

### 2.2 Depth of Cut

The thickness of the material that is removed by one pass of the cutting tool over the workpiece. The depth of cut is the distance that a tool penetrates into the workpiece. It is calculated by

$$DOC = \frac{D_1 - D_2}{2}$$

Where $D_1$ = initial dia of work
$D_2$ = final dia of work

### 2.3 Tool Wear

It is one of the critical factors in machining process, affecting cost and productivity. The research on tool wear has improved the understanding of wear mechanisms for different work and tool materials in various machining operations. Machining is carried out under chatter conditions owing to very low dynamic rigidity of the machining system. This means that, in order to reduce the cycle time material removal rates higher than the stable limits are used. Tool wear includes:

- Flank wear in which portion of the tool in contact with the finished part erodes, can be described using the tool-life expectancy.
- Crater wear in which contact with chips erodes the rake face. This is somewhat normal for tool wear, and does not seriously degrade the use of a tool until it becomes serious enough to cause a cutting edge failure.

### 2.4 T-Test

A t-test is a statistical hypothesis test in which the test static follows a student's t-distribution if the null hypothesis is supported. It can be used to determine if two sets of data are significantly different from each other, and is most commonly applied when the test static would follow a normal distribution if the value of a scaling term in the test static were known. When the scaling term is unknown and is replaced by an estimate based on the data, the test static follows a student's t-distribution. A statistical test involving means of normal populations with unknown standard deviations; small samples are used, based on a variable t equal to the difference between the mean of the sample and the mean of the population divided by a result obtained by dividing the standard deviation of the sample by the square root of the number of individuals in the sample. A normal distribution plays a prominent role in tests of hypothesis that involve the mean of a population. In particular, if a random sample of observations is normally distributed, statistical inferences for the sample mean can be made by constructing a Z-test statistic that follows a standard normal distribution. However, the use of this statistic requires knowledge of the true variance of population from which the observations were sampled.

t value = (Difference between the group means)/ (Variability of the groups)

The higher the denominator, the lower will be the t value. The lower the t value, the less likely it is that the two means are different. The means are considered different if the t value is greater than the critical t value. It is the t value comparison with the critical t value that determines whether there really is a difference between the means. The t value's numerator and denominator are calculated in different ways for the different types of t tests. The t test has a number of variations but the most common t test is used to determine whether the means of two normally distributed populations are equal.

## III. Results And Discussion

It is seen that the work dia is maximum in high speed steel when rake angle is 2° and minimum in silicon carbide. Hence it is known that material removal rate is higher in silicon carbide than other materials due to which work dia is less in silicon carbide but in high speed steel work dia is more as high speed steel requires greater rake angle nevertheless tool wear occurs.

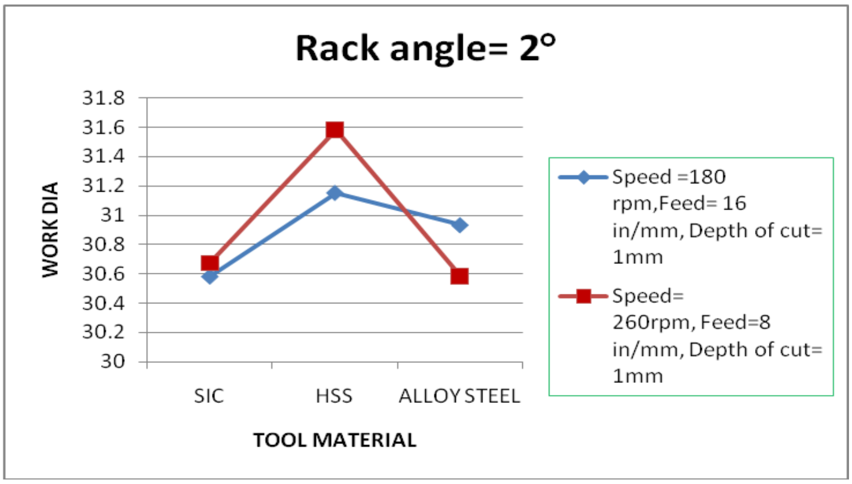


Fig 1: Effect of tool impact with rake angle=2° on work dia

It is seen that when rake angle is 10° work dia is maximum in HSS when speed is 180 rpm and maximum in SiC when speed is 260 rpm. It might be due to the fact that due to high thermal conductivity in SiC tool wear occurred due to which the work dia became more.

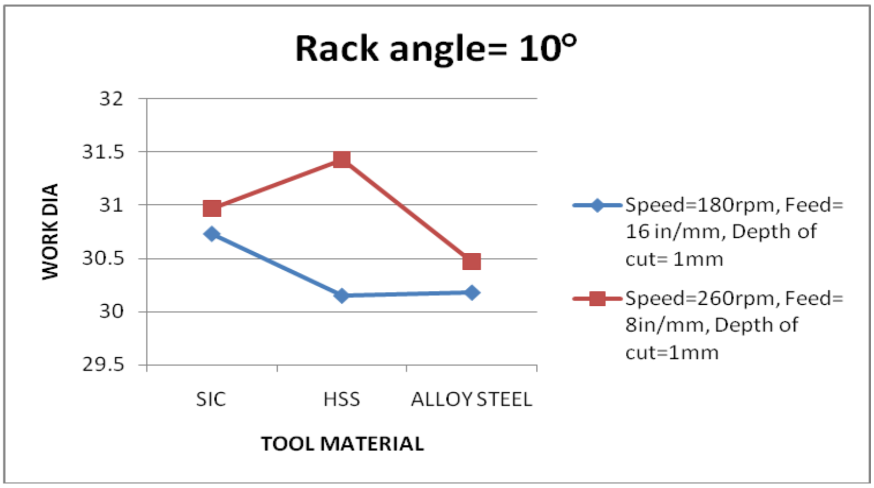


Fig2: Effect of tool impact with rake angle=10° on work dia

It is seen that when rake angle is 18° work dia is maximum in alloy steel and minimum in high speed steel. This is due to the machining speed of HSS greater material removal rate takes place and alloy steel tool wear occurred due to which work dia became more.

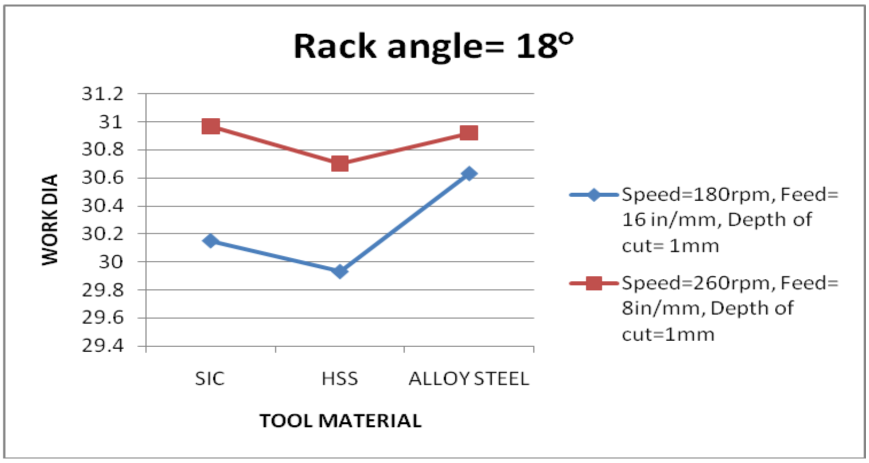


Fig 3: Effect of tool impact with rake angle=18° on work dia

The probability shows that silicon carbide tool is the best and optimum tool material in comparison to high speed steel and alloy steel on the basis of tool wear at different spindle speeds, feed rate and rake angle of the cutting tool. This graph also predicts that silicon carbide has a prolonged tool life than HSS and alloy steel for which accurate depth of cut and material removal rate to the extent is achieved.

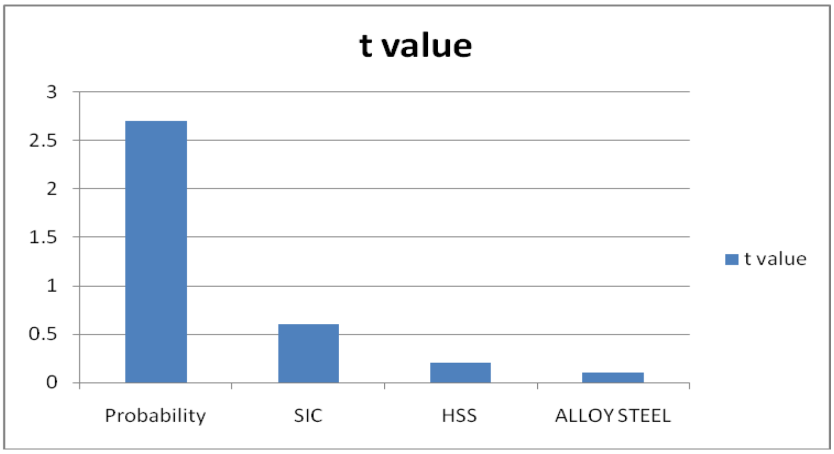


Fig 4: Comparison of probability used on t test with the effect of variation in work dia

## IV. CONCLUSION

The t-test conducted for the cutting tool showed that silicon carbide produced optimum material removal rate on the mild steel workpiece due to its toughness and anti-corrosion property than high speed and alloy tool steels. The t-test conducted for the cutting tool also showed that silicon carbide has the least tool wear after performing the operation on the mild steel workpiece since it is hard and has better wear resistance than high speed and alloy tool steels.

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