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Study of Parameters Affecting Tool Life

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Abstract — *In order to shape the metal into required form and to get the good dimensional tolerances machining is an important aspect in the field of manufacturing. Chip, cutting tool and Work piece are thee three basic elements in which the cutting tool is one of the major considerable factors. In Manufacturing Industry during machining operations the tool wear is a major problem encountered. Tool life prediction has a great influence on productivity industrial activities. Manufacturing cost and operation time is intended to reduce by the High material removal rate, while the productivity in terms of machining cost and operation time for an expected work piece strongly depends on tool wear. Feed rate has the most significant effect on tool life followed by spindle speed and depth of cut.*

Keywords- *tool, cutting, fluid, angle, oil, machining, emulsion, curve, tool life, temperature.*

I. INTRODUCTION

Due to concern regarding the safety of the environment the Machining without the use of any cutting fluid (dry machining) is becoming increasingly more popular. Because of this use of coolants are decreases where as the demands for tool life increasing. Cutting tools are subjected to wear and fails to reduce the production cost we need to consider the optimum utilization of tool by enhancing the tool life by best practices. The types and properties of modern tool materials are considered as well, as a closely related topic, as these properties define to a great extent the limitations on tool geometry. The most popular and most common high production tool materials available today is cemented carbide. Hard coating deposited on cutting tools allows for improve the tool life, and more consistent surface roughness of the machined work piece. In the age of automation, Optimization of the process and accurate estimation of tool life has become indispensable. The combination of the following parameters will help to achieve saving in power consumption, increase in tool life, correct lubrication method and improved surface quality. The study present in this paper will help in optimization of tool life. A definite relationship between spindle speeds, feed rate, depth of cut and tool life has been established experimentally. A symbolic improvement can be achieved by optimization of process parameters in process efficiency that identifies and determines the areas of critical process control factors leading to desired. Outputs or responses within acceptable variations which ensures a lower cost of manufacturing. This paper contains the study of parameters affecting tool life.

II. Factors affecting tool life

While doing the machining operation with a worm tool, the friction between the work piece and tool increases which cases poor surface finish and hence progression of tool wear is needed to monitored [1]. A definition for a worm out tool is – "A tool is considered to be worm out when the cost of replacement is less than the cost for not replacing the tool". It is said that tool failure occurs when the tool doesn't perform the desired function whereas tool failure is defined as the entirely removal of cutting edge, a condition is get when catastrophic failure occurs [2].
Following are the various factors affecting the tool life

- Tool geometry
- Machining Parameters
- Work piece material
- Cutting tool material
- Utilization of cutting fluid

2.1. Tool geometry

Tool geometry of metal cutting is control by three main elements

- Rake angle
- Lead angle
- Clearance angle

2.1.1. Rake angle

Rake angle control the cutting forces, cutting forces changes nearly 1% per degree of rake angle (mild steel). The optimum value of rake angle is -50 to +100. If the rake angle in tool is large the edge of cutting tool is weakened. Negative rake provides robust cutting edge. If the rake angle increases in the positive direction the contact between the chip and the rake face of the tool will be less. This reduces the heat generated and the cutting forces hence the increasing tool life is obtained.

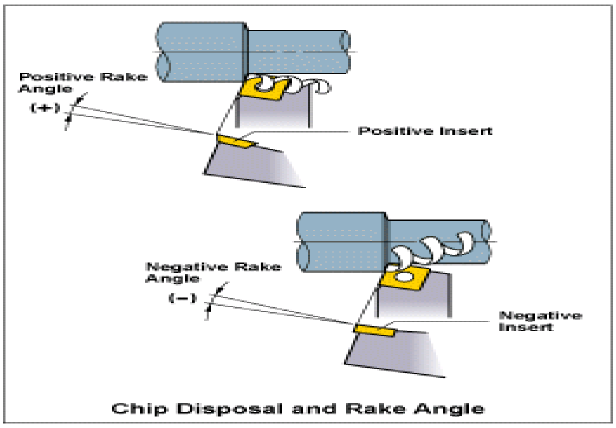

Figure.1 Rake Angle's

2.1.2. Lead angle

It is the angle between the helix and plain of rotation. Increasing the lead angle, hold the forces more into the radial plains. The greater the angle higher is the rigidity. The lead angle decreases the impact load and effects the amount of feed force, back force and chip thickness.

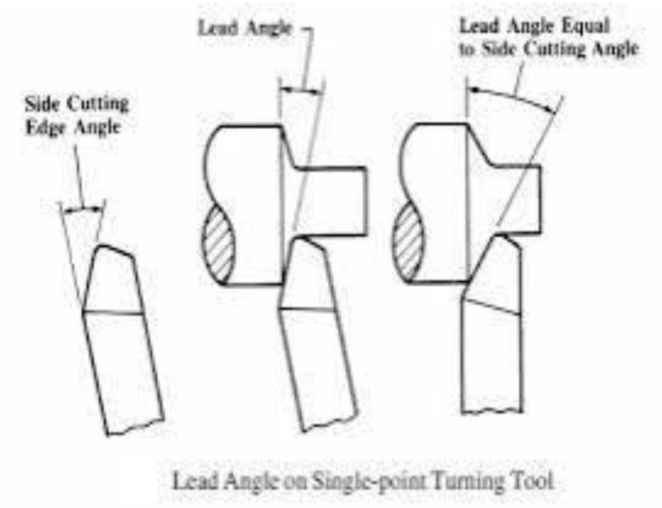

Figure.2 Lead angle

2.1.3. Clearance angle

Clearance angle is provided to keep away rubbing between the tool and work piece. Reducing the clearance angle also reduces the wear produce and temperature on the flank surface. A large clearance angle can reduce the tool life. The optimum value of clearance angle varies from 50 to 80 degree.

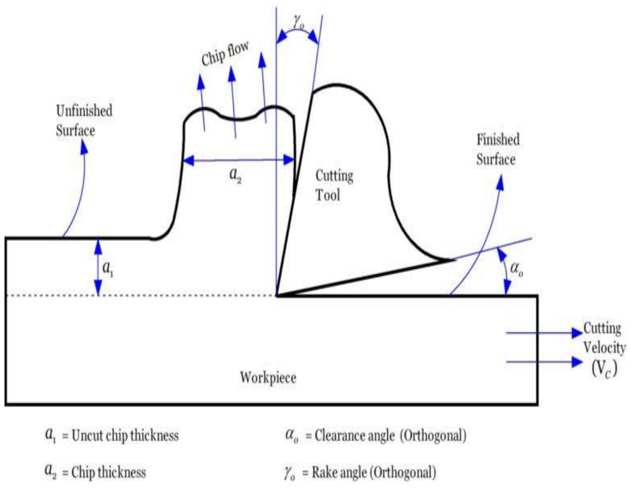

Figure.3 Clearance Angle & Rake Angle

2.2. Machining Parameters

Amalgamation of the tool and work piece there is a cutting temperature also known as optimal cutting temperature (θ), minimum tool wear is obtained as said by makarow [3]. With the help of correct cutting speed and feed optimum temperature can be achieved [4]. In milling the tool performance is depended on path of cutting tool which is used in machining. The moment of tool path at which machining is done is known as machining strategy. The commonly applied cutter path strategy in industry is offset, raster and single direction raster. Cutter path strategies are mainly analyzed on the evolution and determination of the best cutting angle position on plain surface. Huge amount of literature survey amphasys on the entrance and exit effects when the cutter enters or exit a corner. It can be concluded that tool life is optimum when the position vertically upward and work piece is hold at inclination of 15º. When machining at a work piece inclination angle of 45º, or above, the general consensus is that downward position in particular the horizontal downward orientation is preferable in terms of longer tool life [5].

2.3. Work piece material

In machining operation more attention is paid toward the improvement of the life of tool by increasing the life of tool by increasing optimized hard coating, another technique is by changing the tool geometry but other than this very less attention is paid toward the influence of work piece material in increment of tool life. While performing forming operation fracture strain were developed under different stress condition which could be predict by using ductility curve. The curve can be obtained by two simple material test. Curves can be utilizing to study chip breaking. By this we can understand that sometimes tool life could be increase by using harder work piece material. Decreasing the friction between chip and tool can be effective. Another work piece material which can be used in increasing the life of tool is its strain rate dependency on the flow stress.

2.4. Cutting tool material

The cutting tool is considered small and relatively inexpensive but it is one of the most critical factor. Following are the commonly use cutting tool material.

- Low alloy steel and Plain Carbon
- High speed steel
- Cemented Carbide
- Ceramics
- Boron Nitride and Diamond

2.4.1. Low alloy steel and Plain Carbon

Previously 1900, all machining was performed with cutting tools made from either low alloy steel or plain carbon. A main disadvantage of these tool steels is their poor hot hardness. The cutting edges of tools made from carbon steels can withstand a maximum temperature up to 260° C. Operation at low cutting speeds can be done by tools made from these materials.

2.4.2. High speed steel

This steel alloy is mainly made of carbon, chromium, molybdenum, vanadium, tungsten and cobalt. Used as cutting tool material drilling, Milling, Threading, Turning, Boring, Gear cutting. It has a high capacity of being heat treated at a very high temperature.

2.4.3. Cemented carbide

Cemented carbides were introducing in 1927 as new high performance cutting tool materials at the Leipzig trade fair under the WIDI. Material such as chilled cast iron which was found very difficult to cut with the help of High speed steel tool, but with the help of cemented carbide machining was done easily. Working with long chipping material likes steel was difficult for WC-Co due to large crater wear but could be done easily with alloying and TiC. After reducing the WC crystallite size to < 1 μm, both bending strength and hardness was increased with the same amount of binder [6] [7].

2.4.4. Ceramics

Ceramic is mainly used for the rough machining and finishing operation in cast iron and high temperature resistant nickel alloys to obtained high cutting speed, low wear and high tool life ceramics are used. It is further divided into oxides, nitrides and carbides with combination. Example: Al2O3, ZrO2, Si3N4, TiC, TiN etc.

2.4.5. Boron Nitride and Diamond

Diamond tools like polycrystalline or mono crystalline diamond are perfect tools for machining non-ferrous material and are largely used in metal cutting aluminum and composite machining. Diamond is the hardest material and has the good thermal conductivity. Diamonds have some disadvantages like its poor fracture toughness, high chemical affinity to ferrous material and thermal instability over 700ºC. Boron Nitride is the second hardest material and is having high wear resistance and good thermal stability [8].

2.4.6. Properties of tool material

- Wear resistant
- Low coefficient of friction
- Toughness
- Red hardness
- Good thermal conductivity and specific heat

2.5. Utilization of Cutting Fluid

Cutting fluids were developed in order to apply it in a cutting operation to make the operation economic and improve the work piece characteristics. Cutting fluids are being used for more than 200 years. The very first person was W.H. Northcott to write above the improvement in productivity due to use of cutting fluids. In 1868, Northcott published his research in London, England in book named **Treatise on Lathes and Turning.** Then after year by year numerous development in cutting fluids was observed, like use of mineral, vegetables and fatty oil to impart and extend the range of properties like bacterial attack resistance, good chemical stability, improve emulsibility and corrosion production.

2.5.1. Function of cutting fluids

The cutting fluids is use to reduce the frictional stress on tool and work piece. It minimizes the temperature of chips and work piece while undergoing cutting operation. It is use to reduce the cutting temperature. If the proper temperature of work piece and material is maintaining during the machining operation, then there is an appreciable increase in tool life.

2.5.2. Selection of cutting fluids

The proper selection of cutting fluids as important as selection of tooling, machining parameter, work piece stock is done in machining practice. Cutting fluids should be considered as integral part in material removal process so proper selection in use of cutting fluids can affect or notable cost in production. The various factors which can improve the tool life while selecting cutting are as follows:

- Machining time per part
- Number of rejects resulting from unacceptable surface finish and dimensional out of tolerance part
- Cutting fluids consumption per part
- Cutting fluids batch life
- Cutting fluids disposal or recycling cost

2.5.3. Types

- **Straight oils**

  Straight oils are those oils which are non emuslifiable and they are used in machining operation where they function in undiluted form. Generally, its composition is base mineral or petroleum oil. It also contains polar lubricants like vegetable oil, fats and easters.

  They may also contain additives like sulphur chlorine phosphorous.

- **Synthetic fluid**
  It doesn't have mineral oil base or petroleum. In place of it they are formulated from alkaline organic and inorganic compounds along with additives to prevent corrosion. It gives best results in diluted form. It is believing that synthetic fluid gives best cooling performance out of different cutting fluids.
- **Soluble oil**
  Soluble oil usually forms an emulsion after being mixed with water. The resulting concentration contains emulsion and a base mineral oil to give a suitable emulsion. It gives good performance while present in diluted form and gives good lubrication in addition to heat transfer performance. Soluble oils are cheap in price and is mostly used fluid in industry.
- **Semi-synthetic fluid**
  When soluble oils and synthetic fluids are mixed semi-synthetic fluid is obtained. Besides the heat transfer performance and cost of semi synthetic fluids falls between those of the soluble and synthetic fluid.

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