Effect of Cutting Speed and Feed Rate on Tool Wear Rate and Surface Roughness in Lathe Turning Process

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***Abstract*—Machining is a vital part of the production process in the manufacturing industries. Turing operation was carried out on the mild steel to produce shaft of various diameters. The conditions applied during the turning operation include varying the cutting speed and feed rate while keeping other cutting variables like depth of cut constant. The results affirms that an increase in the cutting speed causes a decrease in the tool life, increase in the feed rate also affects the surface finish obtained.**

Keywords—**Microstructures, feed rate, cutting speed, tool life, depth of cut.**

I. Introduction

Turning is a form of machining operation a machining removal process which is used to create rotational parts by cutting away unwanted material and it requires a turning machine or lathe and cutting tool. The work piece is a pre-shaped material that is secured to a fixture, which itself is attached to the turning machine and allowed to rotate at high speed. The cutter is typically a single-point cutting tool that is also secured to the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape. Investigation into the metal cutting process tends to be very difficult due to the complexity arising from the many variables involved. The variables are those of the main quantities involved in the process such as the work piece, tool and machine tool. Other variables in terms of the composition and geometry of tool are also considered and that of the work piece include its diameter, chuckling conditions and microstructures. Machine tool variables include the spindle speed, thermal expansion, feeds, lubrication, cutting forces, power and vibration. Other quantities are cutting speed, depth of cut, surface finish and metal remover rate [1].

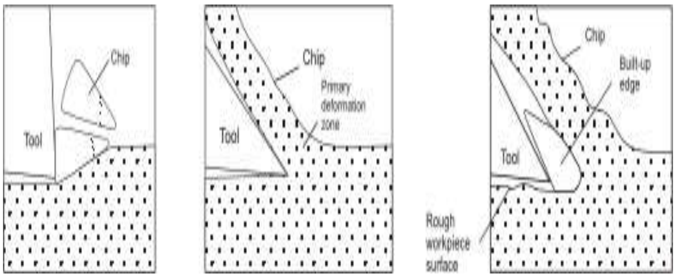
Research in metal cutting had been widely explored [2], [3], after the introduction of the first machine tools. Tool life is the span of time the tool can machine properly before it will require regrinding or replacement. It depends on the nature of material of which the tool is made of as well as the condition of cutting.

Steel is an alloy of Iron and Carbon and it is by far the most important, multi-functional and most adaptable materials used in manufacturing processes to produce electricity-power-line towers, natural-gas pipelines, machine tools and so on and it has low production costs compared to other materials of its type. Steel undergoes various processes like metal cutting process to give the final products [4]. Metal cutting processes are industrial processes in which metal parts are shaped or the removal of unwanted materials. In the study of metal cutting. A significant improvement in output quality may be obtained by optimizing the cutting parameters and this also ensures low cost manufacturing. The product quality depends on surface roughness. Carbon steel is a metal alloy, a combination of two elements that are iron and carbon. The feasibility of using carbon steels depend on whether or not their properties (tensile, yield and fatigue, strength, impact resistance, need for heat treating etc.) are suitable for parts to be used [5].

Lathes are generally considered as the oldest machine tools. Lathe machine is a machine which work is held so that it can be rotated about an axis while the cutting tool is traversed part of the work from one end to the other thereby forcing it to the required shape by removing bids referred to as Chips. The common operations performed on a lathe are; facing, parallel turning, knurling, threading, drilling, reaming and boring and boring. The various parts of the lathe machine are;

- Spindle, which various work holding attachments such as three jaw chucks, collets and centres can be held.
- Bed, a heavy rugged casting made to support the working parts of the lathe.
- Headstock, is attached to the left side of the bed.
- Tailstock, is made up of two units. The top half can be adjusted on the base by two adjusting screws for aligning the tailstock and headstock centre for parallel turning.

The primary goal of metal cutting research has been to develop methods of predicting tool life from a consideration of tool failure mechanism and cutting speed analysis. Hence high speed steels were gradually replaced by cast alloys, carbides, ceramics and cementite to increase productivity [6]. The cutting techniques used in the lathe machine are the orthogonal cutting, is when the tools cutting edge is perpendicular to the direction of relative motion and oblique cutting, where the tool cutting edge is inclined at an angle less than 90^0 to the direction of tool travelled [1].



Discontinuous, Continuous and Continuous chip formation Chipwith built-up-edge[7].

Fig. 1. Diagram showing the typical chips formed during metal cutting operation.

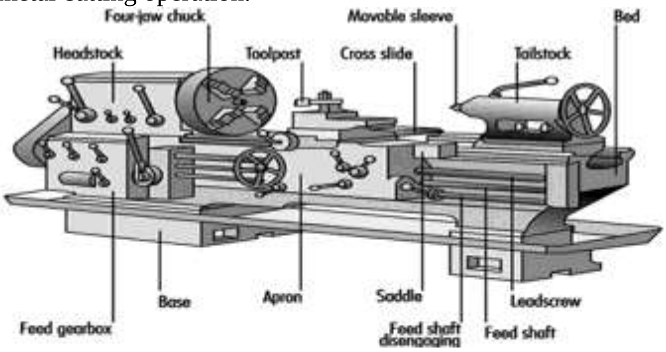


Fig. 2. Diagram of a Lathe machine

Discontinuous chips are formed during machining of brittle materials like cast-iron with low cutting speed and small rake angle of the tool. Continuous chips are produced during the machining of ductile materials like mild steel with high cutting speed and large rake angle of the tool. Continuous chip with built-up-edge(BUE) may occur when cutting soft, ductile materials under conditions which promote molecular bonding between the tool face and the compressed layer of chip incontact with it [8].

II. EXPERIMENTAL PROCEDURE

The centre lathe was cleansed and lubricated to allow easy and proper movement of parts. Making-out was done on the work piece to divide it into six (6) test pieces; each test piece measures 132mm. The work piece was mounted on the lathe machine and fastened properly. Using a drill bit of 2.5mm, the face of the work piece was aligned so that the tip of the cutting tool coincides with the tip of the resolving centre. The cutting tool is allowed to protrude 50mm long from the tool post to disallow vibration. With cutting tool mounted, and the work piece secured on the chuck, the machine was set to the required speed (315 r.p.m), the feed rate (0.5) and the depth of cut (2.0mm) was kept constant. The machine was set on motion and the machining operation commenced. The work piece was machined continuously without lubrication until one or more of the method of determining tool wear was noticed (i.e. tool tip fracture or crack, poor surface roughness, and unusual noise due to partial contact of tool with work piece). At this point, the machine was stopped and the time taken for the tool to wear was noticed from the stop watch and recorded. The cutting is tool is removed and reground to the required tool geometry for the next operation. The tool was mounted back on the tool post, observing the same tool setting procedure. The machine is then set to the required cutting condition (test cutting condition 2) and the machining operation is repeated until the tool wear. The time was again read and recorded. The procedure was repeated for all test conditions (table 1) and the time taken for the tool to wear was read and recorded.

III. RESULT AND DISCUSSION

Table 1. Result of Test cutting conditions.

Test condition	Spindle speed N (r.p.m.)	Feed rate (mm/rev)	Depth of Cut (mm)	Tool Cut (min)
1	315	0.5	2.0	8:23
2	315	1.0	2.0	5:51
3	500	1.5	2.0	2:13
4	500	2.0	2.0	1:49
5	630	2.5	2.0	1:24
6	630	3.0	2.0	1:21

With reference to Table 1, it shows that feed rate has a tremendous effect on the tool life. As the feed rate increases from 0.5 to 3.0 with other parameters been kept constant, the tool life decreases. This is due to the fact that as the feed into the work piece increases, leading to a high temperature build-up on the tool, thus resulting into tool wear which in turn reduces the tool life. It was seen that the depth of cut taken per time also have a great influence on both the tool life and surface finish. As the spindle speed increases the tool wear rate increases which leads to a reduced tool life. This shows that the tool life and cutting speed are inversely proportional. As the cutting speed increases from 315 to 630, the tool life reduces significantly down to a lower value. This is caused by the various factors responsible for tool wear.

IV. CONCLUSION

Considering the various cutting conditions applied in this experiment, it is observed and consequently concluded that the cutting speed (mm/min), feed rate (mm/rev) and depth of cut (mm) have a significant influence on the tool life of the cutting tool used (HSS) and surface finish of the work piece (mild steel). When a smooth finish is to be achieved, machining with high cutting speed and spindle speed has positive effect on surface roughness as against feed rate if the turning operation is the final step in the production process.

Lastly, cutting fluid increases the life of a cutting tool. This depends on the type and lubricating power of the cutting fluid, because tool life is directly proportional to the lubricating power of the cutting fluid used for machining.

V. RECOMMENDATIONS

During the course of this work, some numbers of limitations were encountered and the following recommendations are suggested to avert such limitations and enhance future investigation:

Machining was done using manual feeding due to poor state of the lathe machine. A well functional lathe machine should be installed and its functionality and operation should be made known to students.

Also students should be exposed to the uses and operation of modern machines especially the new trend of computer numeric controlled (CNC) machines.

Finally, materials and equipments for advance studies should be made available to enable further researches to be conducted in this aspect of engineering.

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