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DESIGN AND DEVELOPMENT OF ALTERNATE METHOD OF TURNING TO ACHIEVE HIGH PRODUCTION RATE

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Abstract *- Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear. Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces (that is, holes, of one kind or another) is called "boring". The major conditions which will be must to carry our turning operation is that the tool material should be harder than work material and the tool or the work or both should move relative to each other in order to accomplish the metal cutting. Generally conventional turning involves one single point cutting tool (SPCT) which moves linear to the work piece (feed motion) and the work piece is having a rotational motion as it is fixed in the spindle of the lathe machine. The present paper focus the possibility of employing one more single point cutting tool in the operation and then checking its effect on overall productivity of the component.*

Keywords*- Turning, single point cutting tool, productivity etc*

I. INTRODUCTION

Machining is a form of subtractive manufacturing in which a sharp cutting tool is used to physically remove materia l to achieve a desired geometry. Most of the engineering components such as gears, bolts, screws, nuts need dimensional and form accuracy for serving their purpose, which cannot be obtained through casting or deformation process like forging, rolling, etc. Following figure schematically illustrates the basic principle of machining.

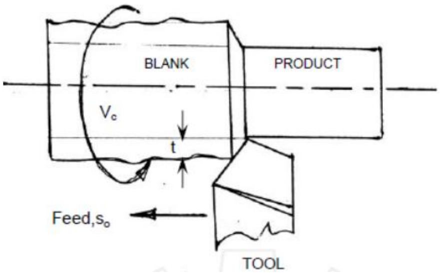

Fig. 1 Basic turning process

A wide variety of machining processes are available today that can broadly be classified in three main categories: conventional machining processes that are used for all kinds of bulk material removal operations, grinding processes that are primarily employed to obtain a desired surface finish, non-conventional or advanced machining processes that are used for special kind of material removal operations. As per the name suggests, non-conventional machining processes do not follow the principle of relative hardness as conventional machining, where the tool material must be harder than the work material for proper removal of material. The processes that remove material by melting, evaporation, chemical and/or electrochemical action etc. are generally referred as non conventional machining processes. Electro-discharge machining, electrochemical machining, laser and electron beam machining are some of the common examples of non-conventional machining processes. The advantages of machining process are manifold. Some of these broad merits of machining processes are listed below.

- The machining processes can produce a wide variety of dimensions with fine form accuracy.
- Almost all kind of engineering materials and plastics can be machined,
- The machining processes can be easily automated to achieve an excellent productivity
- The role of the process parameters and their control to obtain a desired part with good dimensional accuracy are well established in most of the machining processes.

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the nonmathematical sense). Usually the term "turning" is reserved for the generation of *external* surfaces by this cutting action, whereas this same essential cutting action when applied to *internal* surfaces (that is, holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of (essentially similar) processes. The cutting of faces on the work piece (that is, surfaces perpendicular to its rotating axis), whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset.

Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is computer numerical control, better known as CNC. (CNC is also commonly used with many other types of machining besides turning.)

When turning, a piece of relatively rigid material (such as wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 1, 2, or 3 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside (also known as boring) to produce tubular components to various geometries. Although now quite rare, early lathes could even be used to produce complex geometric figures, even the platonic solids; although since the advent of CNC it has become unusual to use non-computerized tool path control for this purpose.

The turning processes are typically carried out on a lathe, considered to be the oldest machine tools, and can be of four different types such as *straight turning*, *taper turning*, *profiling* or *external* grooving. Those types of turning processes can produce various shapes of materials such as *straight*, *conical*, *curved*, or *grooved* work piece. In general, turning uses simple *single-point cutting* tools. Each group of work piece materials has an optimum set of tools angles which have been developed through the years.

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 turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped 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, 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.

Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Parts that are fabricated completely through turning often include components that are used in limited quantities, perhaps for prototypes, such as custom designed shafts and fasteners. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that turning can offer, it is ideal for adding precision rotational features to a part whose basic shape has already been formed.

A. Cutting parameters:

In turning, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the work piece material, tool material, tool size, and more.

- *Cutting feed* - The distance that the cutting tool or work piece advances during one revolution of the spindle, measured in inches per revolution (IPR). In some operations the tool feeds into the work piece and in others the work piece feeds into the tool. For a multi-point tool, the cutting feed is also equal to the feed per tooth, measured in inches per tooth (IPT), multiplied by the number of teeth on the cutting tool.
- *Cutting speed* - The speed of the work piece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM).
- *Spindle speed* - The rotational speed of the spindle and the work piece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the work piece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant, then the cutting speed will vary.
- *Feed rate* - The speed of the cutting tool's movement relative to the work piece as the tool makes a cut. The feed rate is measured in inches per minute (IPM) and is the product of the cutting feed (IPR) and the spindle speed (RPM).
- *Axial depth of cut* - The depth of the tool along the axis of the work piece as it makes a cut, as in a facing operation. A large axial depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is typically machined in several passes as the tool moves to the specified axial depth of cut for each pass.
- *Radial depth of cut* - The depth of the tool along the radius of the work piece as it makes a cut, as in a turning or boring operation. A large radial depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is often machined in several steps as the tool moves over at the radial depth of cut.

B. Equipment for turning:

Turning machines typically referred to as lathes, 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 work pieces. 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 the turning operation. Turning machines are also able to be computer controlled, in which case they are referred to as a computer numerical control (CNC) lathe. CNC lathes rotate the work piece 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 enable the work piece to be rotated and the cutting tool to be fed into the work piece remain the same. These components include the following:

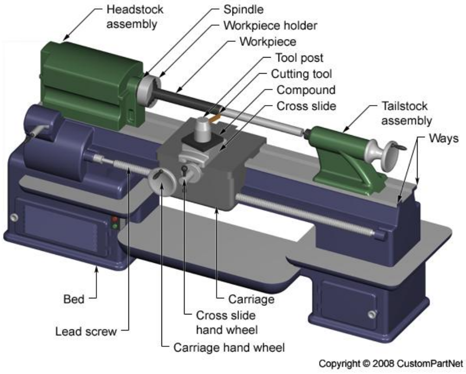

Fig.2 Typical lathe machine

- **Bed** - The bed of the turning machine is simply a large base that sits on the ground or a table and supports the other components of the machine.
- **Headstock assembly** - The headstock assembly is the front section of the machine that is attached to the bed. This assembly contains the motor and drive system which powers the spindle. The spindle supports and rotates the work piece, which is secured in a work piece holder or fixture, such as a chuck or collet.
- **Tailstock assembly** - The tailstock assembly is the rear section of the machine that is attached to the bed. The purpose of this assembly is to support the other end of the work piece and allow it to rotate, as it's driven by the spindle. For some turning operations, the work piece is not supported by the tailstock so that material can be removed from the end.
- **Carriage** - The carriage is a platform that slides alongside the work piece, allowing the cutting tool to cut away material as it moves. The carriage rests on tracks that lay on the bed, called "ways", and is advanced by a lead screw powered by a motor or hand wheel.
- **Cross slide** - The cross slide is attached to the top of the carriage and allows the tool to move towards or away from the work piece, changing the depth of cut. As with the carriage, the cross slide is powered by a motor or hand wheel.
- **Compound** - The compound is attached on top of the cross slide and supports the cutting tool. The cutting tool is secured in a tool post which is fixed to the compound. The compound can rotate to alter the angle of the cutting tool relative to the work piece.
- **Turret** - Some machines include a turret, which can hold multiple cutting tools and rotates the required tool into position to cut the work piece. The turret also moves along the work piece, feeding the cutting tool into the material. While most cutting tools are stationary in the turret, live tooling can also be used. Live tooling refers to powered tools, such as mills, drills, reamers, and taps, which rotate and cut the work piece.

II. LITERATURE SURVEY

[1] S. S. K. Deepak, “Cutting Speed and Feed Rate Optimization for Minimizing Production Time of Turning Process” International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.5, Sep-Oct. 2012 pp-3398-3401ISSN: 2249-6645. In this research paper, the cutting speed and feed rate were modeled for the minimum production time of a turning operation. The maximum cutting speed, the maximum feed rate, maximum power available and the surface roughness was taken as constraints. The results of the model show that the proposed method provides a systematic and efficient method to obtain the minimum production time for turning. This approach helps in quick analysis of the optimal region which will yield a small production time rather than focusing too much on a particular point of optimization.

[2] Dr. C. J. Rao , Dr. D. Nageswara Rao, P. Srihari, presented a paper on “Influence of cutting parameters on cutting force and surface finish in turning operation” in the International Conference On DESIGN AND MANUFACTURING, IConDM 2013. This research reports the significance of influence of speed, feed and depth of cut on cutting force and

surface roughness while working with tool made of ceramic with an Al_2O_3+TiC matrix (KY1615)and the work material of AISI 1050 steel (hardness of 484 HV).
The results have indicated that it is feed rate which has significant influence both on cutting force as well as surface roughness. Depth of cut has a significant influence on cutting force, but has an insignificant influence on surface roughness. The interaction of feed and depth of cut and the interaction of all the three cutting parameters have significant influence on cutting force, whereas, none of the interaction effects are having significant influence on the surface roughness produced.

[3] U. D. Gulhane, S. P. Ayare, V.S.Chandorkar, M .M . Jadhav presented their work titled "Investigation of turning process to improve Productivity (mrr) for better surface finish of Al- 7075-T6 using DOE" in International Journal of Design and Manufacturing Technology (IJDMT), ISSN 0976 – 6995(Print), ISSN 0976 – 7002(Online) Volume 4, Issue 1, Jan-Apr, 2013. From the current study it can be concluded that the Feed has a greater influence on the Surface Roughness followed by Speed. Depth of Cut had least influence on Surface Roughness. And that the cutting speed has a greater influence on the Surface MRR followed by feed rate. Depth of Cut had least influence on MRR. Also he has given the optimum combination of the cutting parameters speed, feed and depth cut as Cutting speed (15.102 m/min), feed rate (0.3207 mm/rev.) and depth of cut (0.5 mm) are cutting parameters for higher MRR with better surface finish.

[4] C.J.Rao, D.Sreeamulu, Arun Tom Mathew revealed their work titled "Analysis of Tool Life during Turning Operation by Determining Optimal Process Parameters" in the 12th Global Congress On Manufacturing And Management, Gcmm 2014.
It can be concluded from the study that, by varying the different parameters like depth of cut, speed and feed at different conditions the tool life, surface finish, cutting force and other parameters were calculated. The results showed that the tool life is decreasing as the cutting force, MRR and cutting speed increases. The MATLAB results showed that the best surface finish is approximately equal to average of three stages output. The optimum process parameters obtained from MATLAB program will give a reasonable surface finish with better life.

[5] Meenu Sahu and Komesh Sahu carried their work titled "Optimization of Cutting Parameters on Tool Wear, Workpiece Surface Temperature and Material Removal Rate in Turning of AISI D2 Steel" and presented it in International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 3 (2014), pp. 291-298. After the study has been made the authors reach to the following conclusion- The results showed that depth of cut and cutting speed are the most important parameter influencing the tool wear. The minimum tool wear was found at cutting speed of 150 m/min, depth of cut of 0.5 mm and feed of 0.25 mm/rev. Similarly low w/p surface temperature was obtained at cutting speed of 150 m/min, depth of cut of 0.5 mm and feed of 0.25 mm/rev. Whereas, at cutting speed of 250 m/min, depth of cut 1.00 mm and feed of 0.25 mm/rev, the maximum MRR was obtained.

[6] S. Thamizhmanii*, S. Saparudin, S. Hasan carried out the research work named "Analyses of surface roughness by turning process using Taguchi method" and presented the same in Journal of achievements in materials and manufacturing engineering volume 20 issue1-2 Jan-Feb 2007. The conclusion of the current study is- the depth of cut is the only significant factor which contributes to the surface roughness. i.e. 14.467 % contributed by the depth of cut on surface roughness. The second factor which contributes to surface roughness is the feed having 9.764 %. It is recommended from the above results that depth of cut of 1 to 1.5 mm can be used to get lowest surface roughness.

[7] Hari singh , Pradeep Kumar carried out a research work in the field of " Tool wear optimization in turning operation by using Taguchi method" and presented their work in Indian journal of Engineering and material sciences vol. 11, February, 2004.
It is concluded by the authors from the current study that percent contribution of each parameter to the variation of tool wear characteristics of TiC coated carbide tools are as follows:

- The percent contribution of cutting speed on flank wear width is 35.12% and on crator wear depth is 84.27%.
- The percent contribution of depth of cut on flank wear width is 24.38% and on crator wear depth is 5.97%.
- The percent contribution of feed on flank wear width is 10.49% and on crator wear depth is 2.48%.

[8] Patil C V presented his work titled "problems in improving the production rate in turning operation" in the International journal of research in engineering and technology in Feb, 2014. The conclusion of the study is that in order to increase the production rate one has to give up with the quality of the surface being machined, the effective tool life of the cutting tool and ultimately, the cost of production. Every metal working industry is facing the problem of improving the production rate without sacrificing these parameters. The present study reveals the facts about why one cannot increase the cutting parameters of the turning process in order to achieve the higher rate of production. Further there may some another methods which ensures improving of the production rate without affecting the above said factors i.e. tool life, surface finish and cost of production. Such methods should be ideal one for the mass production industry where there is a large number of quantities being machines with little or no variations at all.

III. OBJECTIVES OF THE PRESENT STUDY:

After investigating various parameters on which the turning process depends and in order to provide the best possible solution to the today's machining industries where there is huge competition going for the betterment of the process in order to enhance the product quality at least time and at least cost which yields maximum profit to the organization, one have to concentrate on some alternate method for turning which gives better productivity as compared to the conventional one.

A. Introduction:

Conventionally turning is done by holding a work piece rigidly in the work holding device called chuck which is attached to the spindle of the lathe machine. The spindle rotates about the axis which is perpendicular to the spindle. The tool which is generally single point cutting tool is fixed onto the tool post which is free to move linearly in the direction parallel and perpendicular (in facing operation) to the direction of the axis of rotation of the spindle. As the tool material is harder than the work piece material, when the relative motion between the tool and the work piece occurs, the material shears along the shear plane. Thus some material is removed in the form of chip from the work piece leading to the formation of the desired part. The fig below shows the conventional setup for the turning operation.

Fig. 3 Conventional Turning Setup

The turning operation can also be done by employing another second single point cutting tool from the opposite side of the first tool. Here introduction of the second tool not only reduces the time to machine a particular work piece but also higher surface finish is obtained as the shear force required to cut the metal reduces at the tool chip interface of second tool. The setup for such turning process is shown below:

B. Experimental setup:

The experimental setup for such turning operation is described in the following figure. It consists of two single point cutting tool mounted on the two tool posts which are located in front of one another. For the simplicity of understanding we call the first single point cutting tool as tool A and the second single point cutting tool as tool B. The first tool that is tool A is fixed in the tool post in conventional manner while the second tool that is tool B is fixed in the second tool post which is mounted on the same carriage but in opposite direction of the first tool post. Both the tool posts are attached or slides over the same lead screw with the help of single handle.

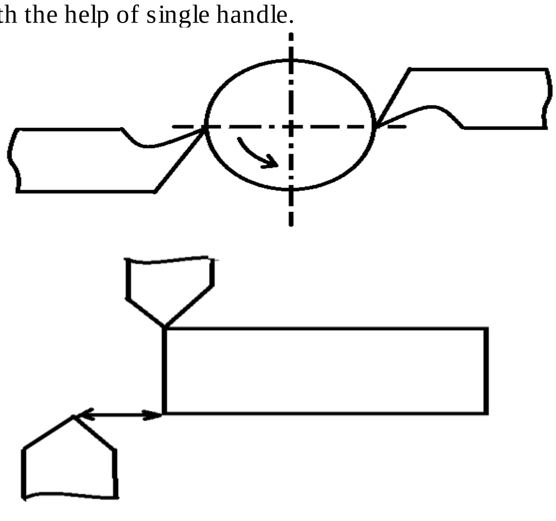

Fig. 4 Schematic representation of multi tool turning

The arrangement is made in such a way that when we rotate the handle, both the tool post along with the tools comes close to each other with the same distance. The center of the tool post is not at the center of the job but a little offset is given to the tool posts. The arrangement is made in such a way that when we give depth of cut of say 2mm to tool A, the tool B automatically provides the depth of cut of 4mm on the other side of the first tool post. Also both these tools are situated at some distance from each other if seen from top, which means tool B starts its operating only after the tool A travels some distance on the work piece or after sufficient interval of time. It is noted here that for accomplishing the metal cutting, tool B must be placed in the inverted direction in the tool post. So the tool post for the second tool B is situated lower than that of tool post for the tool A in order to achieve the centers of both tools in one plane. The arrangement is shown in the figure.

Fig. 5 Multi Tool Turning Setup

IV. OBSERVATION AND CALCULATION

Here all the observations are carried out in standard decided specimen of mild steel and tool used for machining process is HSS (High speed steel) because Mild steel and HSS tools has been using in many industries .
Observation for both the methods are taken on fix specific cutting conditions and constant cutting parameter which are given bellow :

- Diameter of work piece = 30mm
- Length of work piece = 60 mm
- Approach = 15 mm
- Depth of cut = 0.5 mm

B. Conventional Turning Method

Here in following table diameter after each pass and time taken for each pass while turning are enlisted bellow:

SN	**Diameter (mm)**	**Time (Sec)**
1	30	00
2	29	99
3	28	115
4	27	100
5	26	116
6	25	102
7	24	110
8	23	105
9	22	107
10	21	105
11	20	102

Table 1Readings of Conventional Turning Methods

B. Calculations For Conventional Turning Method

- Length=l+ approach + overrun=60+15=75 mm
- Time/cut=(length of tool travel)/(feed velocity)
- Average time per cut=1.76 min

- Average feed velocity (f) = length / avg time = 0.71 mm/sec
- No. of cut = (total dia. reduced) / (dia reduced per cut)
  = (30-20)/(2 ×0.5) = 10
- Total time required = (No. of cut) × (avg. time per cut)
  = 10 × 1.76 = 17.6 min

C. Duplex Turning Method

Here in following table diameter after each pass and time taken for each pass while turning are enlisted bellow:

SN	Diameter (mm)	Time (Sec)
1	30	00
2	28	110
3	26	105
4	24	111
5	22	106
6	20	106

Table .2 Readings of Duplex turning Methods

D. Calculations for Duplex Turning Method

- Length=l+ approach + overrun=60+15+2=77 mm
- Time/cut=(length of tool travel) / (feed velocity)
- Average time per cut =1.80 min
- Average feed velocity (f) = length / avg time = .71 mm/sec
- No. of cut = (total dia. reduced) / (diameter reduced per cut)
  = (30-20) / (2 ×1) = 5
- Total time required = (No. of cut) × (avg. time per cut)
  = 5 × 1.80 = 9 min

CONCLUSION:

The basic objective in any production process is to produce an acceptable component at the minimum possible cost. In order to achieve this objective in metal cutting or metal machining, many attempts have been made in several different ways; such as optimizing the tool life in order to minimize the production cost, maximizing the production rate to reduce the production cost, etc. but no single effort has been found fully successful because of the numbers of complexities involved in the process. For example, if cutting speed is reduced in order to enhance the tool life the metal removal rate is also reduced and therefore, the production cost increased. A similar effect is observed if the efforts have been made to increase tool life by reducing the feed rate and depth of cut. Against this, if the effort is made to increase the metal removal rate by substantially increasing the cutting speed, feed and depth of cut, the tool life shortens and therefore, tooling cost increases and so the total production cost is also increased
Generally conventional turning involves one single point cutting tool (SPCT) which moves linear to the work piece (feed motion) and the work piece is having a rotational motion as it is fixed in the spindle of the lathe machine. The present study focus the possibility of employing one more single point cutting tool in the operation and then checking its effect on overall productivity of the component.

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