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Brief Overview of Turning Process

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ABSTRACT

Turning is primary metal cutting process use in each and every production industry to remove the extra unwanted material in desired shape and size from rotating workpiece .In this process a single point cutting tool penetrated toward the workpiece and removed the extra material in the form of chip .Almost all known materials in the form of chips. Almost all known material can be machined by this process in different form like external turning internal turning plain/ cylindrical turning , step turning ,taper turning , face turning etc .With selection of appropriate cutting tool for particular material . The aim of this paper summarised report on turning process including present and past research works .This paper present a brief overview of turning operation considering the different aspects and focus the future scope of works in the same area , which is beneficial for the researcher who work in the same field .

Keywords – Cutting , Composite , Finishing , Machining , Material , Surface , Tool , Turning

I. INTRODUCTION

Turning is primary metal cutting process used in most of the production industries .In this process single point cutting tool used to remove the extra unwanted material in form of chips[1] .In this machining process is perform on different type of machine and different –different workpiece material , different – different cutting tool used to perform a turning operation .In this process single point cutting tool penetrate toward the rotating workpiece , and unwanted material remove in form of chips as shown in Figure-1 . The basic purpose of turning process is to reduce the diameter of the workpiece, get the specified dimension and produce a smooth surface finish [2] .Generally, it is used to machine external as well as internal surface of cylindrical workpiece in term of plain turning , taper turning , step turning and face turning . In some cases, it is used to produce gears, cams , shaft and other components also [3] . The metal cutting is one of the important and widely accepted machining methods to meet the demands of industries. Generally, the performance of cutting technology depends on cutting tools geometry materials including ferrous, non-ferrous metal and their alloys , heat treated metals and alloys, ceramics

and composites etc. Due to the important of turning, researchers always make effort to improve the efficiencies of the process to get the desired quality of product at low cost .The aim of present paper is also an effort in that direction .

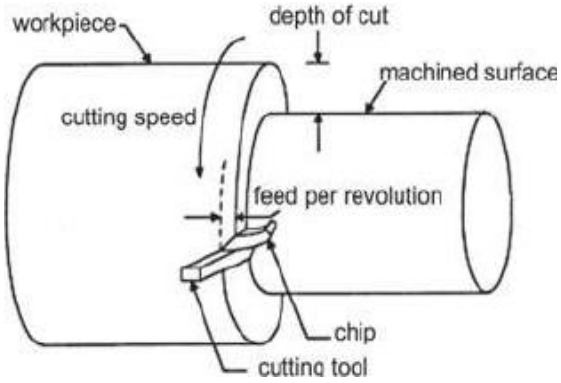

Figure-1 Turning Operation [1]

In this turning operation as shown in Figure-1 single point cutting tool remove the extra unwanted material from the desired workpiece material in form of chips .Turning is primary metal removal processes used in most of production industries cut the material in specified dimension of an object.

II. RESEARCH AND DEVELOPMENT OF TURNING

In this section the published work related to the turning process used in machining of different material process used in machining of different material like steel and their alloy , cast iron , titanium alloy , Inconel , metal matrix composites (MMCs) etc . summarised and discussed.

A Research in Turning of Ferrous Metals and Their Alloys

Ferrous metals and its alloy are most popular commercial material used in many engineering applications. Many researcher were focused their studied on turning of these material with application of different cutting tool material with application of different cutting tool material. Ueda et al [8] investigated that cutting temperature is highly affected by cutting speed while negligible effect of feed rate and depth of cut during turning of different steel alloys with cubic born nitrate (CBN) cutting tool . Sachin and Motorcu [9] investigated the machining characteristics of the mild steel with coated carbide cutting tool .They observed that cutting tool and feed rate were highly influenced on the surface finish .Suhail et al [10] also worked on turning of the mild steel and optimized the controlled parameters using grey relational analysis (GRA) technique .

Li and Liang [11] focussed their research in near dry and dry condition during of the AISI1050 hard steel with uncoated carbide tool .They found lower cutting force with near dry condition as compared to the dry condition. Asilturk and Akkus [12] also studied on dry turning during machining of AISI4140 steel with coated carbide tool and claimed that surface finish highly influenced by feed rate .Mandel et al .[13] found that the depth of cut has maximum effect on the tool wear during turning of the AISI4340 steel with Application of the zirconium –aluminium tool .

The effect of lubrication with other turning parameters were investigated by Abhang and Hameeddullah [14] during machining of steel with the application of the tungsten carbides cutting tool .They Claimed that surface finish was improved with application of lubricant during cutting process .The surface roughness was highly affected by tool nose radius of the cutting tool [15].The application of graphite powder as a solid lubricant during turning of AISI1040 steel was tested by Srikiran et Al [16].They observed that cutting force were increased with decreases in the size of the particle whereas surface finish deteriorates due to the size of the solid graphite particles .

Jhanpeng Wang et al [17] investigate in ultra – precision machining of ferrous materials, diamond tools are easy to graphitize due to chemical reaction with ferrous materials, which can cause serve tool

wear .The sharpness of the original cutting edge therefore cannot be maintained to machine mirror –level surface roughness .It cannot through a high –efficiency and low –cost way to obtain the workpiece surface integrity with high quality .Studying the wear mechanism of diamond tools and wear supervision method is very important to improve the cutting efficiency of ultra –precision machining . In the present research ,wear mechanisms and suppression schemes in diamond tools turning ferrous materials are reviewed and focusing on three major wear mechanisms and four effective suppression methods . In the end , this paper discussed the magnetism property of diamond –turnable materials , and introduces the feasibility of the magnetic field –assisted scheme to suppress diamond tool wear (DTW) .

B. Research inn Turning of Cast Iron

Cast Iron (CI) is also an important material of iron families that shows high hardness, high wear, temperature and corrosion resistance [18-19] .It is widely used in mining, power, cement, coal –coke, steel and foundry industries [20] . However, the machining of cast iron becomes more difficult due to the high hardness and high tool wears.Ezugwu and Tang [21] found that the round shaped cutting tool gives better surface finish with low damages as compared to the rhomboid shaped tool during turning of the cast iron of G-17 grade with application of the ceramic cutting tool .Even through, very poor cutting ability of the ceramic cutting tool was obtained during turning of the nodular cast iron [22] .

A comparative studies between dry and air cooled turning of grey cast iron with oxide added ceramic tool was carried out by the Sharma and Dixit [23].They found the lower cutting force and better surface finish during air cooled turning as compared to dry turning .Several researcher investigated that multilayer coated tool performed better as compared to the uncoated tool [24,25] .Souza et al .[26] tested the performances of silicon's nitride based ceramic tool during turning of grey CI and found high tool life, Gunay and Yucel [26] carried out experiments on white nickel based white CI with CBN cutting tool and optimized the surface roughness with the help of Taguchi technique .

C. Research in Turning of Inconel 718

Inconel 718 is nickel –iron based heat resting super alloy .It is has wide application in field of aerospace , nuclear vehicles , submarines ,power plants , oil and petrochemical industries due to their superior high temperature mechanical properties [27,28]. The turning of Inconel 718 is now a challenge for manufacturing engineers due to the poor thermal property high temperature strength work hardening tendency and high tool –workpiece affinity [29] .Thus the researchers focus their studies to machine Inconel effectively by controlling the tool material ,tool geometry and cutting condition . The other associated problem is detecting of carbide parties with cutting tool [30] .The major problem during turning of Inconel is work hardening of turned surfaces refers to the elongation in grain structure as a result tearing phenomena takes place as shown in the Figure-2

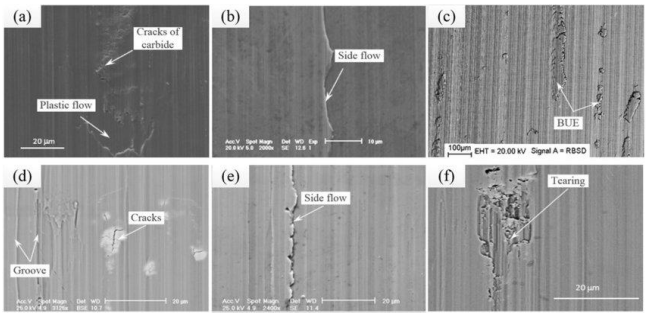

Figure -2 Turning of surface of Inconel 718

Many researchers focus their studies to improve the machining capabilities of Inconel 718. Arunachalam et al .[31] Suggested that coated carbide cutting tool in round shape with chamfered cutting edge, negative rake and small nose radius has been better

combination for turning of the Inconel 718.Satayanarayana et al.[32] optimized the cutting speed , depth of cut and feed rate to minimize the cutting force , surface roughness and tool wear with application of the Taguchi –GRA hybrid techniques for turning of Inconel 817 with application of the uncoated carbides cutting tool .

III. TURNING OF NON –FERROUS METALS

The present selection summarised a review report on the turning of the non-ferrous metal including titanium and composites. The analysis of published papers are presented and discussion after carefully studies.

A Research in Turning of Titanium Alloy

Titanium is the commercial name of Ti-6 Al-4V alloy .It is widely used in aerospace industries due to the superior mechanical properties .It is highly demanding in the military and commercial aircraft [33].It is generally used for a component which requires higher reliability with constant surface finish. It is generally used for a component which requires higher reliability with constant surface finish [34].claimed that very high temperature generated near to cutting edge of tool as result plastic deformation occurs. Hascahak and Caydas [36] were concluded that feed rate and cutting speed are highly influenced on surface finish and tool life .They also concluded that surface finish and tool life .They also concluded that surface roughness was slightly affected by cutting speed while depth of cut was highly affected the tool life of cutting tool .

B. Research in Turning of Metal Matrix Composites

Metal matrix composites (MMCs) is newly develop advance engineering material .It is used in various field of engineering like automobile, aerospace, railways, computers ,robotics sports etc .due to the their unique properties like light in weight high specific strength good wear resistance and low thermal coefficient [37-41]. Generally MMCs are consisting two district phases as matrix and reinforcements . The turning of MMCs lead to high tool wears due to presences of the reinforcements [37, 41-42] .Even through , sometimes graphite power are used to enhance the machinability of these material [43,44].

Generally diamond or diamond coated cutting tools are used for machining of the MMCs but they are very costly, During diamond turning of the MMCs but they are very costly .During diamond turning of the MMCs , the reinforced particles either pulled out or cut through and lead to the poor surface finish of turned surface [45].This phenomena has been shown in the Figure -3 Several researcher were compared the performance of poly crystalline diamond (PCD) cutting tool with chemically vapour coated (CVCD) cutting tools during turning of different composites material like aluminium silicon carbides (Al/SC) and aluminium –alumina (Al/Al2O3) and investigated that the coating on tool surface was worn out rapidly due to the abrasion action between tool and workpiece as a result very short tool life and rapid tool performances of PCD cutting tool with polycrystalline cubic boron nitride (PCBN) tools .They found that the PCD cutting tools showed better performances than PCBN cutting tools due to the higher abrasion and fracture resistance with lower abrasion property with the workpiece material .

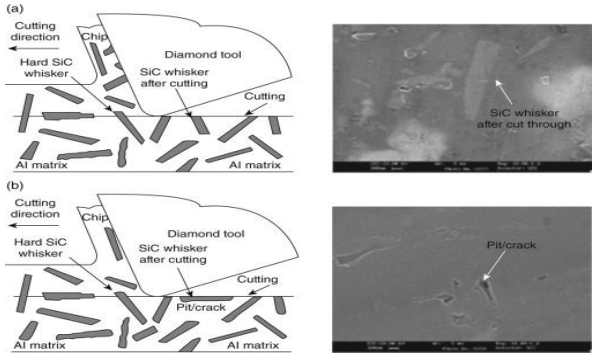

Figure-3 Turning of MMCs with formation [45]

Due to wide applicability and difficulties in machining of the MMCs, researchers are always made their effort to know the meaning capabilities of low cost cutting too material for machining of these difficult to machine material .In this way ,the performances of cubic boron nitride (CBN) cutting tool were studied by chief et al [49] .They experimentally proved that the tool wear (flank Wear) Was highly influenced by size of the reinforced particles .They also investigated that the AI/SiC composites reinforced with particles size 110 μm shown poor machinability and leads to high fracture at cutting edge and nose radius .Ramesh et al [50] also studied the machining performances of CBN cutting tool during machining performance of CBN cutting tool during machining performances of CBN cutting tool during machining of the aluminium – titanium carbide (AI/TiC) composites.

IV. HARD TURNING PROCESS

Hard turning is machining process use to remove the material in form of chips .It is metal removal process solid cutting tool used to remove the extra unwanted material in form of chips .Hard turning refers to the process of single point cutting of hardened pieces within the 2 micron range with hardness between 58 and 70 HRC.The researchers and developer always focus to develop new approaches to fulfil the requirements of the industries without any loss in the characteristics of existing system .Hard turning is the one of them which is used to replace the grinding operations with effective application of the very hard cutting tools like ceramics and CBN. These cutting tools are capable to turn high hardened steels having hardness greater than 45HRC without any application of cutting tool are capable to turn high hardened steels having hardness greater than 45 HRC without any application of cutting fluid /coolant on a highly rigid lathe machine tool .

This process has been developed as an alternative to the grinding process in term of reduction in setup changes, product cost and lead times without loss in the surface quality of the product [51, 52] .It shows many advantages over grinding process like high metal removal rate, easily applicable at existing (lathe) machine, ability to machine thin wall selection with low cutting forces and eliminates the requirement of coolant during turning [53].

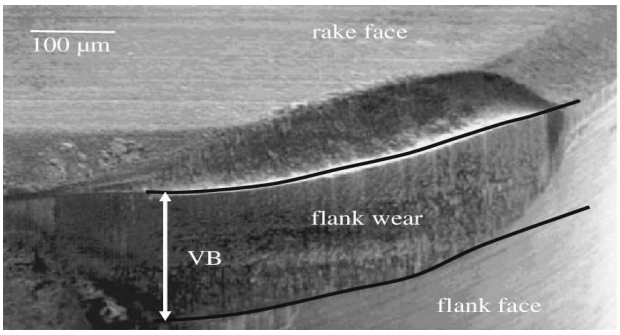

Figure-4 Flank wear during turning of AI/SiC with CBN tool [49]

A Research in Area of Hard Turning

Even through hard turning process having a lot of merits but cannot replace the grinding process due to the difficulties to achieve the high surface quality .To meet such challenges, further developments are required in the same field .Pavel et al.[53] shown that the machined surface highly affected by flank wear of cutting tool during hard turning of the hardened steel (117-steel) with CBN cutting tool .Aslan[54] compared the performances of CNG cutting tool with coated cement and ceramic cutting tool s during turning of the cold work tool steel (X210 Cr12) .They experimentally proved that CBN cutting tool shown better performances i.e flank wear and surface finish as compared to the other cutting tools .The effect of tool materials on flank wear different cutting tool material has been shown in the Figure-5.

To achieve the better machinability, the CBN cutting tools were tested in different conditions. Diniz and Oliveria [55] tested the performances of CBN tools

(low CBN content and high CBN content i.e 7020 ,7052) during hard turning of the AISI4340 steel (56HRC) in continuous, semi continuous and intercepted turning with chamfered and round cutting edge .They found that high grade CBN gave longer tool life as compared to the low grade CBN cutting tool. They also observed that chamfered edge cutting tool provided longer tool life during continuous turning .Oliveria et al.[56] show that the CBN cutting tool gave better surface finish compared to whisker-reinforced cutting tools during hard turning of the continuous and interrupted cutting .Katuku [57] suggested that the shear localization within the primary and secondary shear zones are responsible for the high wear rate of the cutting tool during turning of the ASTM garde-2 austempered ductile iron (ADI) steel with application of the CBN cutting tool.

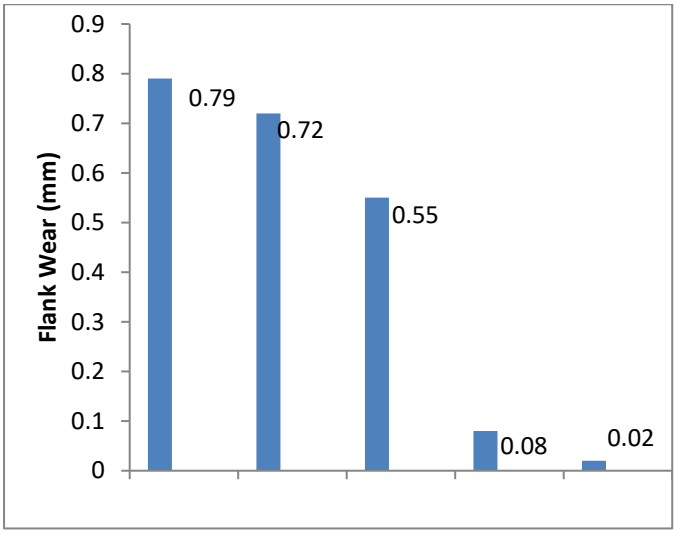

Figure -5 Effect of tool material on flank wear [54]

Several researchers tested the machining capability of carbides cutting tool in hard turning process .Bartarya and Choudhury [58] was used uncoated carbide cutting tool during hard turning of the hardened EN-31 steel (equivalent to steel of AISI52100 grade) and analysed . They claimed that depth of cut and feed rate were most significant parameters that effect the cutting forces. Chinchanika and Choudhury [59] compared the performances of the physical vapour deposited single layer TiAIN coated carbide cutting too with chemical vapour deposited multilayer TiCN/Al203 /TiN coated carbide cutting tool during turning of hardened AISI4340 steel (33-35HRC). They found that tool life was highly affected by cutting speed , which is followed by depth of cut and feed rate .The Cutting tool wear (flank wear) during hard turning of the AISID3 steel (58HRC) turned with coated carbides cutting tool [60] .

V. DUPLEX TURNING PROCESS

Duplex turning is primary metal cutting process used in most of the production industries. In this process two single point cutting tool used to remove the extra and unwanted material in form of chips. Dual turning is a novel metal cutting process to get the desired shape of the rotating workpiece. It is highly complex process due to application of two cutting tool at a time as which the selection of the optimum parameters is much difficult .Manufacturing industries are always facing a lot of difficulties like holding and clamping , chattering /vibration and dynamic instabilities etc. During machining of the rotating parts. Even through it is the one the most popular and industrialized process for machining of the circular rotating pats among various existing traditional machining processes [61, 62]. The basic purposes of turning process are to remove the extra /unwanted material from the external as well internal surface of rotating workpiece to get the specified dimensions and surface quality .The surface qualities of the turned parts mostly depend upon various parameters. These parameters are controllable (cutting velocity, feed rate, depth of cut, cutting fluid ,too material and tool signature etc) or uncontrollable (temperature ,humidity , material composition , machine efficiency etc). Among various controlled parameters, some process parameter like

cutting velocity , feed rate, depth of cut , work material , tool material and tool signature are highly affected the performances of the turning process[63 ,64].Dual turning process is an innovative cutting process in which two – number of single point cutting tools penetrate toward the workpiece from the opposite side to cut the extra material from the rotating workpiece as shown in Figure-6 .In this process both cutting tools are applied simultaneously on a single rotating surface .The purpose of secondary cutting tool is perform as a finish cut turn operation during turning of workpiece while the primary cutting tool performs as rough cut turning .The mechanism of metal removal of the dual turning is almost same as normal turning process i.e plastic deformation , shearing and tearing .The basic purposes of dual turning process are to eliminate the secondary finish cut operation , minimize the number of passes and increases in the overall productivity .

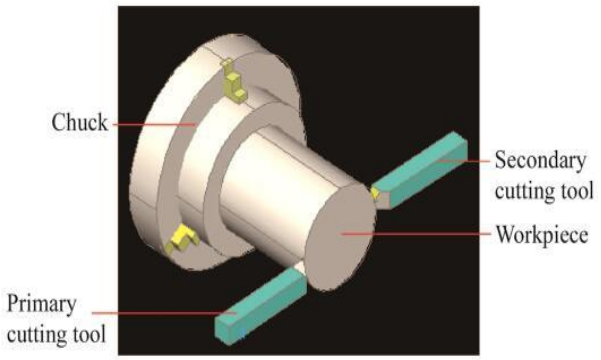

Figure-6 Dual Turning process [65]

A. Research Area of Duplex Turning

Ravindra Nath Yadav [65] This dupex turning process researcher aim of paper optimize the process parameter (cutting speed ,feed rate ,primary depth of cut and secondary depth of cut) to minimize the surface roughness using Taguchi methodology .For this the experiments were performed according to the L_9 design matrix on the dual turning setup at lathe machine .The result shows that optimal condition of the process parameters gives better surface finish as compared to the initial setting of the control parameters .

Ravindra Nath et al [66] In present work , experimental investigation were made to measure the distribution of cutting forces on primary and secondary cutting tools and average surface roughness (Ra) for duplex turning process The titanium alloy (Ti-6Al-4V) has been used as workpiece material for experimentation .The cutting parameters such as cutting speed , feed rate ,depth of cut (D1) and secondary depth of cut (D2) were taken as control parameters .The experimental results show the effectiveness of the duplex turning in term of better surface quality and reduction in cutting forces as compared to normal turning.

Ravindra Nath Yadav [67] In this study authors show productivity is always an important factor related to the industries for achieving higher productivity rate with better quality at low cost .In this report an effort has been made to improve the productivity of turning process with application of two cutting tools in place of single cutting tool and such developed process is named as duplex turning. Due to simultaneous application of two cutting tools on a shared rotating surface, the duplex Turning process becomes more complex .Due to complexity; the selection of suitable combination of the process parameters becomes a difficult task for manufacturer. The aims of present paper are to develop a mathematical model and optimize the parameters for duplex turning of alloy steel (AISI1040) with single point cutting tools made of high speed steel .The experiments were performed on centre lathe machine, which is equipment with duplex turning setup .The effort of cutting velocity, feed rate, primary depth of cut and secondary depth of cut has been analysed on average surface roughness .The hybrid approach of Taguchi Methodology –Response Surface Methodology (TM-

RSM) has been applied due to their potential for modelling and optimization of complex machining process .The optimum condition obtained from the TM has been used as central value in RSM for Modelling and Optimization ,The result show the significant improvement in surface finish with hybrid approach as compared to the Taguchi analysis.

VI. MODELING AND OPTIMIZATION OF TURNING PROCESS

Modelling is required to know the process behaviour and scientific study of a system based on experimental or theoretical analysis [68, 69]. The Theoretical modelling is more economically as compared to the experimental because of no need of experiments .Generally to develop a mathematical relation between input and output parameter in term of equation is known as modelling .Due the complexity in the turning process most of the researcher were developed experimental model in different turning conditions.

Optimization can be defined as maximum or minimum value of the objective, which refers deterioration in the optimum value with any changes in the input conditions. Many statistical as well as soft computing technique are used to optimize the parameters of different processes [70, 71].The basic needs of optimization are to get the better responses with application of the suitable combination of the process parameters at the low production cost. Generally, modelling and optimization are simultaneously applied to get the better results.

A Research in Modelling of Turning Process

Due to the complexity in turning most of the mathematically models were developed based on the experimental observations. Choudhury and Baradie [72] developed a second order mathematical model to predict the tool wear with any changes in cutting speed, feed rate, and depth of cut. Several researcher were compared the prediction capability of regression model with artificial natural network (ANN) model and found good prediction with ANN model [73,74]. Ozel et al [75] also found better performance with ANN model and found good prediction capability of regression model with artificial neutral network (ANN) model and found good prediction with ANN model [68-70]. Ozel et at. [71] also found better performance with ANN model as compared to the his developed mathematical model during analysis of tool wear and surface roughness with varying conditions of control parameters .Gupta [72] found that ANN and support vector regression (SVR) models were performed better as compared to the regression and response surface model (RSM) .

B Research in Optimization of Turning Process

Many researcher optimized the control parameters of turning process to get the better result .Yang and Trag [4] optimized the process parameters to minimize the tool wear rate using Taguchi approach .Several researcher were also used Taguchi technique to optimize the turning parameters measures like cutting speed ,feed rate , depth of cut for performance measure like tool life cutting force and surface finish [12 ,14,26,53,73-75]. Nalbant. et al [75] optimized the nose radius , feed rate ,depth of cut to minimize the surface roughness for turning of the AISI 1030 steel with Taguchi technique .

The application of Taguchi –GRA hybrid optimization technique was tested in turning [32] .RSM and Taguchi Techniques for modelling and optimization of the parameters were tested by several researchers [78,79].The application of GRA optimization technique also tested to optimize the process parameter [10]. The application genetic algorithm in turning process are also tested by several researchers

to optimize the process parameter and get a lot of optimal solution within the range of selected parameters, which provided additional facilities to manufacturer to set the input turning condition according to the available resources or as per design requirements ,[2,79-80].

VII. PROCESS PARAMETERS AND PERFORAMCE MEASURES

Turning is complex metal cutting process, in which lot of factor s (controllable or non-controllable) directly or indirectly affecting the performances of the process. The performance measure (surface quality, forces, tool wear) depends upon various parameters like machine parameters, material (tool and workpiece) .The review of research work show that tool wear high affected by cutting speed and followed by feed rate and depth of cut [67]. Even through, increase in cutting speed , feed rate or depth of cut does influence the surface finish [22] . The feed rate and cutting speed were found most influential factors that affect the surface quality and tool life [32,36] .The tool life also found poor with coated tool due to high flank wear after coating rupture [47] .As compared to the coated tool , the uncoated tool gave the better surface finish and high tool wear [81] .On other hand , multi –layer coated cutting tool gives better performances in all the respects [24].

1-Machine Parameter
Cutting Speed
Feed Rate
Depth of Cut
2- Tool Material Parameters
Tool Material
Tool Geometry
3- Work Material Parameter
Hot Work
Cold Work
Hardness
4-Surafce Quality
5-Cutting Forces
6-Tool Wears

The workpiece hardness is also responsible for products quality because the hardness of materials also responsible for poor finish and tool wears [69] .The coating materials of cutting tools are also responsible for quality machining, such phenomena analysed by the Aslan [54]. Sarama and Dixit [23] investigated that air cooled turning gives better surface finish with low tool wear rate as compared to the dry turning. Cutting tool geometry is also responsible to cutting .The round shape coated (chamfered cutting Edge) tool with negative rake and small nose radius has been better option for turning of Inconel 718[31].

VIII. SUMMARY AND FUTURE SCOPE OF WORK

In present paper , a summary on the published research has been summarised .It has been found that turning is a good metal cutting method to get the desired shape .Advancement in technology , the cutting of the difficult to machine material are also possible with application of high strength cutting tool like ceramic , carbides , CBN and diamond .Even through the diamond cutting tools are not suitable for turning of ferrous metals . Development of the high speed cutting tools material, the turning process is capable to replace the grinding operation with effective application of the hard turning in dry condition. However , lot of research are required in field of hard turning process .It has been also analysed that most of work related to the studies of the effects of cutting speed , depth of cut and feed rate on performance measure .A title bit effort has made in area of tool geometry , turning of complex profile and

interrupted surfaces .That area requires more effort to meet the future demand by turning .

Modelling and optimization are another vital conditions to achieve the goal. Literature review show that most of the modelling /optimization made by statistical technique and a little effort has been made in area of soft computing while it show more advantages over statistical method .Thus , that area also needs more attention to meet the future challenges .

Finally an exhaustive review on turning process is presented which is beneficial for the researchers who work in the same field .It is also beneficial to analyse the present and past work related to the turning process .This paper also help to which researcher to work in duplex turning operation perform on lathe machine .

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