An Optimization of Cutting Parameters in Hot Turning Machining Process- A Review

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1. ABSTRACT

The aim of this study is to provide an overview of the various machining techniques based on the lathe machine hot turning operations. The major goal of today's manufacturing industries is to manufacture the high-quality products at low cost and for improvement in product quality, the selection of machining parameters plays a vital role. For evaluating material removal rate, surface roughness of workpiece, cutting tool wear specifically for the dry and hot turning operation, the cutting operation variables like cutting speed, feed rate, depth of cut and temperature are taken as a input parameters to produces products at lowering overall manufacturing cost and tool wear, high quality within time bound. hot machining process has been developed in industries to remove large amount of materials without compromising machining and quality. This paper gives some background of optimization technique applied to various Hot turning processes for improving Material Removal Rate and Surface Roughness.

2.KEY WORD

Chip formation, hot machining, Hot turning operation, material removal rate, PVD coating, surface roughness, Tool Wear.

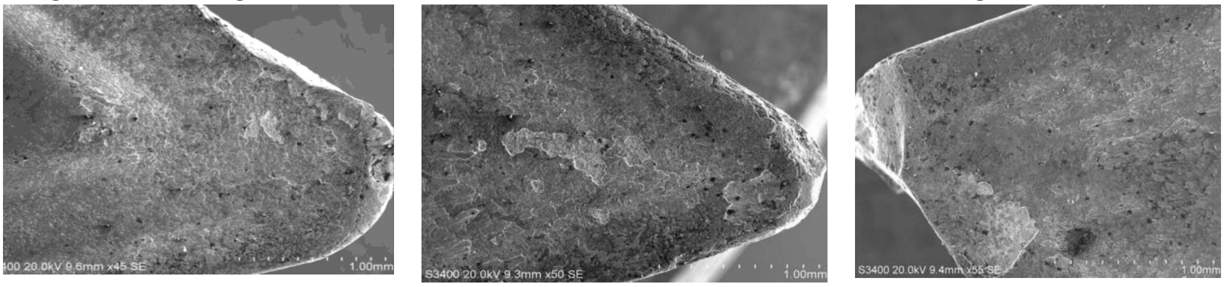
3.INTRODUCTION

As per modernization the manufacturing lines, subsequently required to update and integrate most modern technologies in order to keep the business competitive. In such way, we can assure cheaper products, shorter manufacturing times, lowering of the production costs, high dimensional accuracy, good surface finish, high-production rate, minimum tool wear, economical machining and improving the performance of the product with reduced environmental impact Tool wear is one of the major factor that contribute to surface quality, productivity and accuracy in machining [1]. With the development in the technology and science in the world there is requirement of such type of material which have very high strength and hardness. So different type of material which fulfill such properties are manufactured. Hot turning comes into existence for increasing tool life, to improve the surface finish, to reduce cutting power required and for improving the machinability [2]. A high temperature plasma arc is used to and metallurgically undamaged [3].

4.SUMMARY

In [4] this experiment for optimization of cutting parameters for hot turning of AISI 316 stainless steel with tungsten carbide (WC) inserts was done. The experimental results were analyzed with analysis of variance (ANOVA), the cutting speed and depth of cut are statistically significant factor influencing the tool wear for 200^0 C hot turning of 316 SS.

Figure-1. SEM image shows the tool wear on the rake face of WC insert when hot turning at 200°C. 400°C & 600°C.[4]



In [5] Three nickel base alloys (Inconel 718, Inconel 625 and Monel-400) studied for chip formation in the hot turning process using flame heating. Kennametal SNMG square insert is used. The tool life of machining of Inconel718 was less compared to Inconel 625 and Monel-400 under same cutting conditions, due to less thermal conductivity of Inconel 718 and high cutting temperature at shear zone. The high cutting force was obtained for Inconel 718 and feed force for Inconel 625, whereas low cutting and feed force obtained for Monel-400 on machining at room and heating conditions. The surface finish of Inconel 718 was better as compared to other two materials under same cutting conditions.

In [2] for optimization of cutting parameters, high carbon high chromium steel (Die steel) was heated with the flame and was machined under different cutting parameters by tungsten carbide insert (WC), four control factors and three levels per factor according to Taguchi method And L9 taguchi design. very high improvement in the surface quality as the work piece is heated. It results in less cutting power requirements which were highly required in conventional machining.

In [6] it was found that cutting speed is most influence parameter for Inconel 718 as work piece material The cutting tool used uncoated carbide SNMG 438 type. Taguchi's L9 orthogonal array is used for experimental design.

In [7] The two Inconel 718 workpieces and three different cutting tools (WC, TiN coated WC, and TiAlN coated WC) are used. Experiments are planned according to Taguchi L27 using Minitab17 software. Machining residual stresses obtained at 300°C and 600°C are low compared to machining at room temperature with the same cutting conditions. the axial residual stress is more compressive in nature using TiN coated cutting tool at speed 150 m/min, feed 0.11 mm/min, depth of cut 0.3 mm, and temperature at 25°C. In contrast, residual hoop stress is more compressive in nature using TiAlN tool at speed 50 m/min, feed 0.16 mm/min, depth of cut 0.3 mm, and temperature of 300°C.

In[8] In the present work DEA (data envelopment analysis) coupled with Taguchi method has used for optimization in process parameters of hot turning operation. Depth of cut is the most significant parameters influence the responses. Cutting speed is least significant parameters influence the responses. The material removal rate and surface finish, are to be studied with respect to machining at 450^0 C temperature by heating Inconel 625. Uncoated WC (tungsten carbide) insert was used for machining operation.

In [3] there is a reduction in the spindle power requirements in the hot machining process over conventional machining process. Workpiece material is SS 410, Alloy steel, Forged stainless steel used. For SS 410, the percentage reduction in the spindle power consumption is 4% at 1 mm depth of cut and 25% at 25 mm depth of cut. For alloy steel (3.75 Cr, 2.72 Mo) this range is varying from 16% to 21%. The feed rate may be playing a role for better results with SS 410 and poor results with alloy steel (2.25 Cr, 1.0 Mo). It is observed from the tests conducted on stainless steel indicate that hot machining leads to 1.8 times gain in metal removal rate and 1.67 times improvement in tool life.

In [9] The depth of cut is highly influencing factor on material removal rate for both CVD and PVD coated tool. the turning operation is carried on AISI 321 Austenitic Stainless Steel with CVD and PVD coated tool. The contribution of cutting speed is 26.94%, feed rate is 27.72% and depth of cut is 37.65% for PVD coated tool, similarly in case of PVD coated tool the contribution of cutting speed is 30.34%, feed rate is 30.13% and depth of cut is 31.32%. 3D surface plots show that material removal rate increase with increase in cutting speed, feed rate and depth of cut.

In [10] The present study aims to investigate the wear mechanisms of a TiN-coated mixed ceramic tool under different machining conditions during hard turning of hot tool die steel.The flank wear rate increased with increasing depth of cut but reported a downward trend with increasing work piece hardness. Adhesion of work piece material followed by plastic flow was clearly visible in addition to notching at low work material hardness. Chipping and brittle fractures were observed at very low and higher depth of cut, resulting in rapid tool wear.

In [11] Present work, Material removal rate and surface roughness increases with increase in feed rate and depth of cut and decreases with decrease in feed rate and depth of cut. AISI 316 stainless steel with uncoated carbide tool during turning process. material removal rate increases with increases in cutting velocity while cutting velocity has negligible effect in case of surface roughness.

In [12] present work the influence of cutting parameters on material removal rate (MRR) and surface roughness of TiAlN/WC-C, TiAlN coated tool during CNC turning of AISI 1015 mild steel. Taguchi optimization method has been employed with L9 Orthogonal Array for maximization of MRR. From the results of ANOVA, Depth of cut is the most influential factor (51.26%) on surface roughness, while number of layer deposited contributed significantly (30.56%) to surface roughness.

In [13] studied that Spring type, tubular, continuous and close coiled helical chips were observed at low levels of machining parameters, but these became open coiled helical and near to spiral on increasing feed and cutting depth.

In [14] Inconel 600 is used as a workpiece and TiAlN coated carbide insert used as a cutting tool. An adhesion of chip on the cutting inserts were observed during turning of Inconel 600 alloy.

In [15] To simulate hot turning of Inconel 625, DEFORM software which is based on updated 81 Langrangian formulation is utilized in present case. The experimental trials are performed with the same cutting simulation conditions. Highest tool life is observed at higher cutting speed with high heating temperature condition. Adhesion, notch wear, and built-up-edge formation are observed at both room and heating temperature condition. The forces exerted on the cutting tool are lower at heating compared to room temperature machining conditions.

In[16] hot turning of stainless steel (type 316) Based on the Taguchi method and ANOVA, feed rate has a dominant effect of almost 46.2% in contribution ratio, while cutting speed has 22.7% and workpiece temperature has 14.6% influence on the surface roughness, tool life, and metal removal rate in hot turning of stainless steel (type 316).

In [17]a multilayer of TiN/TiCN/Al2O3 formed on a cemented carbide insert used for martensitic stainless steel designated as X20Cr13, and Analyzed in four stage in sequence orthogonal array (L16) of Taguchi, regression analysis objective function, using grey relational analysis.

for MRR value for EN-24 alloy steel with TNMG tool giving the optimal value of MRR.it proves that TNMG gives most optimum value which is obtained from the experimental as well as calculation work[18].

The speed is the most influencing parameter for maximum MRR which is followed by cutting speed and depth of cut[19].

The cutting speed is affects the surface roughness and flank wear is created by depth of cut, material removal rate is affected by feed rate[20].

In[21] comparing four optimization methods and, individual and composite desirability of each method for cutting force, MRR, and feed rate were calculated. Accordingly, RSM - Response surface methodology and H-ABC(Harmonic artificial bee colony algorithm) provide higher composite desirability with 72.1% and 64%, respectively, compared to Taguchi (40.2–43.4%) and Harmonic bee algorithm -HBA (47.2%). Because RSM and H- ABC prove the validity with additional experiments, good desirability ratios make them useful for simultaneous optimization.

In [22] Higher feed rate increases the cutting temperature resulting in oxidation of TiN binder, exposing some of the CBN particles on flank wear land which are severely abraded by the hard carbide particles of workpiece material, and thereby accelerating the tool wear.

In [23] the longest tool life of Ti(C7N3)/WC/TaC cermet cutting tool iand the best surface roughness were 169 min and 0.58 μm, respectively, when machining the 17-4PH martensitic stainless steel at the cutting speed of 300 mm/min, feed of 0.1 mm/min, and depth of cut of 0.25 mm.

In [24] an increase in cutting speed, feed rate and depth of cut, lead to an increase of flank wear. However, an increase in temperature up to a specific limit decreased the tool wear and after that, the flank wear increased with the increase of temperature. The temperature was the most influential factor which affects flank wear, whereas cutting speed was the most affecting factor influencing the surface roughness.

In [25] The cutting forces decreased when flame heating is employed compared to room temperature cutting conditions. the reduction of shear strength of Inconel 718 at the heating condition.

In [26] a comparative study on Single coating of TiN, TiCN and TiALN and multilayer coating of TiN/Al2O3/TiCN on cutting tool and uncoated carbide inserts tool used for investigate a flank wear of tool and surface roughness of EN 24T steel under dry machining conditions experimentally and analytically. Single layer and multilayer coated inserts gives improved surface roughness and reduced flank wear of tool significantly compared to uncoated insert. Machining time improved from 8 minutes to 42 minutes for single layer and multilayer coated inserts compared to uncoated insert.

In [27] LASER assisted turning (LAT) process is carried out for LASER heating of Ti6Al4V and Al/SiC MMC (Metal Metrix Composites) investigated to reveal the effects of material thermal conductivities and heating time on rod's bulk temperature distributions, based on the experimental parameters. high cutting speed can reduce the heat transfer time from the surface of the part to its interior, and makes sure laser-induced heat is controlled in the work-piece's skin layer and then is immediately entirely removed by the chips during machining.

In [28] worked on optimization of the Surface Roughness using Genetic Algorithm and analyze the percentage of variation of the experimental result from the theoretical value. EN24T is the material and Carbide Insert was used as tool selected for the experiment. The variation is expressed in terms of percentage of error and the percentage of error is 17.10 %

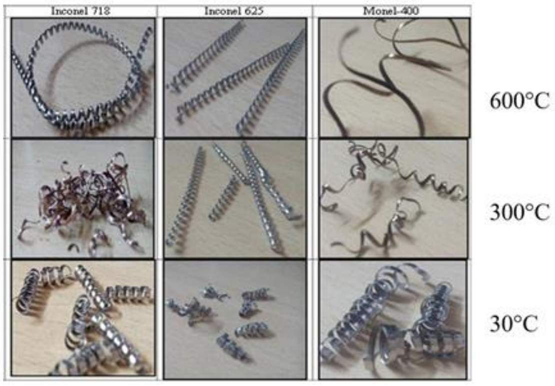
In [29] comparative study about conventional tungsten carbide tool inserts and textured tungsten carbide tool inserts. The Turning process has been done on mild steel rod (C-20) with these carbide tool inserts. the rise in temperature of textured tool insert is less in comparison to conventional tool insert. Wear is more in conventional tool inserts in comparison to textured tool inserts.

In [30] Principal component analysis, coupled with Taguchi's method, used to optimize the cutting parameters in hot machining of Inconel 625. workpiece is heated up to 600˚C using flame heating method, the responses are mostly affected by cutting speed.

5. CHIP FORMATION

In [5] It has been observed that at room temperature, the chip produced in all three materials are discontinuous and helical, whereas, when the heating temperature increase, the discontinuous chip con- verted into the continuous chip.

Figure 3. Chip formation in different three materials [5]



The chips formed during machining of Inconel 718 was quite continuous and spiral, whereas chip produced on Inconel 625 was spiral, but small or discontinuous and the chips produced from machining of Monel-400 was continuous and not spiral.

In [13] With the increase of spindle speed, the chips were continuous and flat at lower levels of feed and cutting depth; and on increasing these parameters, the chips became spiral in shape. Long, continuous and ribbon-like spiral chips were formed at higher level of spindle speed (1210 rpm).

In [14] all the cutting trials, the chips obtained were long and continuous in nature.

In [15] the simulated chip formed at room temperature is the segmented type, whereas at 600˚C it is continuous type chip.

In [25] With the increase of heating temperature from room temperature to 600˚C, the segmented chip converted to continuous chip.

6.Conclusion

On the basis of the experimental results and derived analysis, the various techniques for optimizing the cutting parameters like cutting speed, feed, depth of cut & temperature for increase Material Removal Rate (MRR), low surface roughness & cutting force. In Hot turning operation the workpiece is tends to soft and less cutting force and power is require. Analysis of variance (ANOVA) and Taguchi orthogonal Array are the systematic approach used to optimize designs for performance, quality and cost optimization methodologies. Different types of material are used for coating of cutting tools. cutting speed has the most dominant effect on the observed surface roughness, The surface roughness is continuously improved with the increase in cutting speed and Temperature. therefore, Increasing the productivity and the quality, the tool performance related to tool wear and cutting forces considering effect of work material hardness and type of coating material is need to be investigated.

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