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REVIEW ON TOOL WEAR OF VARYING TURNING OPERATION PARAMETERS

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Various methods apply to reduce and observing the wear levels on the cutting tool on-line while engaged in cutting have been attempted. The quality of the machined piece and tool life are greatly influenced during machining operation. Various researchers have approached to solve this problem with experimental, analytical and numerical analysis are discussed in this work. It is challenging to prophesy on performance of tool for the machining process. Various reviews work are studied on tool wear in this paper and requirements of improve has been suggested.

1. INTRODUCTION

Tool wear has a large influence on the economics of the machining operations. Prediction of tool wear is complex because of the complexity of machining system. The cutting tool is one of the vital components in realizing the total potential out of any metal cutting operation. Turning is an important machining process within which a single point cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. Product quality has been found as the most important part of the manufacturing industry and it continues to improve, depend up on the competition and buyer strategies. The recent trend is toward higher quality, lower cost and smaller batch sizes, it is necessary to find out new technology that can help us to improve the business field. Turning is employed to reduce the diameter of the work piece, typically to a nominative dimension, and to produce a smooth finish on the metal. The rest are used for the special purpose jobs due to their constraints (application requirements, cost-effectiveness, production capabilities and customer needs) [8]. The turning parameters are depending up on the material selection and the machining conditions. The Computer Numerical Control (CNC) lathe operation is the most convenient way to compare the conventional lathe operation. Researchers and manufacturers are continuously working on tool optimization by preventing, maintaining on break down or an early predicting the tool wear effect.

2. Review Work

Akincioglu et al. reviewed the cryogenically treated tools that deals cryogenic treatment is an effective method that enhances the tool life and wear resistance of cutting tools. Important parameters in cryogenic treatment which affect tool performance are cutting tool type, cooling speed, soaking period, soaking temperature, and tempering process. Nitrogen constitutes a significant portion (78.03 %) of the atmosphere, and liquid nitrogen, the most commonly used gas in cryogenic treatment applications is generally abbreviated as liquid nitrogen. Cryogenic tool treatment increases the hardness, wear resistance, toughness, abrasive resistance, and tool life of cutting tools. [1]

Ambilkar et al. present work is to review the paper on performance of multi-layer coated tool in machining of hardened steel (AISI 4340 steel) under high speed turning. The influence of cutting parameters (speed, feed, and depth of cut) on cutting forces and surface finish has been analyzed. Under the different cutting conditions, forces were measured using dynamometer. Cutting force and MRR are mostly affected by speed and feed. Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as cutting speed, feed rate and depth of cut on cutting force components. The gap indicates that the depth of cut is the dominant factor affecting cutting force components. The depth of cut influences tangential cutting force more than radial and axial forces.[2]

Arumugaprabu et al. focused on surface texturing in materials is one of the current process that satisfying the industrial needs and providing ample support to the production managers in machining. During machining for producing various products the major task is the reduction of materials waste, assessment of tool wear and its happening. Tool wear affects the production cost severely also incurring the material waste. One of the effective methods to reduce this problem and improving the tool life considerably is the surface texturing process. This can be carried out in work piece material neither the tool also. Surface texturing done on the surface of the tool or the work piece material to give aesthetic look also mainly enhances the performance in various aspects. Many industrialists and researchers carried out the surface texturing process for various machining applications such as lathe, milling with various surface texturing techniques.[3]

Astakhov analyse geometrical characteristics of tool wear are subjective and insufficient. First, they do not account for the tool geometry (the flank angle, the rake angle, the cutting edge angle, etc.), so they are not suitable to compare wear parameters of cutting tools having different geometries. Second, they do not account for the cutting regime and thus do not reflect the real amount of the work material removed by the tool during the tool operating time, which is defined as the time needed to achieve the chosen tool life criterion. [4]

Das et al present work on optimization of surface roughness in hard turning of AISI 4340 Steel using coated carbide inserts. The work piece used in this paper is AISI 4340 and the tool material is multilayer coated carbide insert (TiN/TiCN/Al2O3/ZrCN) CNMG 120408 insert. Feed was found to be most significant parameter for the work piece surface roughness (Ra) with a percent contribution of 52.55%.[5]

Dogra et al. investigated in machining of AISI H11 steel using CBN, TiCN, TiN-coated carbide and untreated carbide insert tools under dry conditions. The researchers reported that free surface roughness in the CBN tools was lower than in the other tools. They reported that the wear value of the carbide tools in the subsequent machining periods was close to the wear values obtained in the CBN tools. It was concluded that, at low cutting speeds and feed rates, the carbide tools were comparable to the CBN tools in terms of life. The tool life of cryogenic treated coated carbide inserts was improved by 16–23 % in different cases in comparison with the untreated coated carbide inserts.[6]

Gendele et al. worked concerned an experimental study of turning on chromium – molybdenum case hardening alloy steel of AISI 4140grade. The purpose of this thesis is to study the effect of speed, feed, and depth of cut on material removal rate, metal surface and tool wear in machining AISI 4140 alloy steel using tungsten carbide tipped cutting tool. The range of each parameter is set at four different levels. Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as cutting speed, feed rate and depth of cut on output responses. After taking the responses grey relation analysis apply on all experiment to optimize the input parameter for optimum response.[7]

Kaynak & Gharibi focuses on various cooling strategies and lubrication-assisted cooling strategies to improve machining performance in the turning process of AISI 4140 steel. Liquid nitrogen (LN2) and carbon dioxide (CO2) were used as cryogenic coolants, and their performances were compared with respect to progression of tool wear. Minimum quantity lubrication (MQL) was also used with carbon dioxide. Progression of wear, including flank and nose, are the main outputs examined during experimental study. This study illustrates that carbon dioxide-assisted cryogenic machining alone and with minimum quantity lubrication does not contribute to decreasing the progression of wear within selected cutting conditions. This study also showed that carbon dioxide-assisted cryogenic machining helps to increase chip breakability. Liquid nitrogen-assisted cryogenic machining results in a reduction of tool wear, including flank and nose wear, in the machining process of AISI 4140 steel material.[8]

Lahiff et al. investigate on tool wear has a large influence on the economics of the machining operations. Prediction of tool wear is complex because of the complexity of machining system. Tool wear in cutting process is produced by the contact and relative sliding between the cutting tool and the workpiece and between the cutting tool and the chip under the extreme conditions of cutting area; temperature at the cutting edge can exceed 1000 °C. Thus, knowledge of tool wear mechanisms and capability of predicting tool life are important and necessary in metal cutting.[9]

Kannan et al. analysed on machining process for residual stress in turning of AISI4340 steel. The residual stresses that can be found in a cutting tool insert are mainly generated at the final step of the machining process. Feed, speed, depth of cut are the input parameter. The residual and the tool wear are the output responses. Cryogenic treatment will improve the performance and made significant of wear resistance, better residual stress and product quality of cutting tool. This is the study of review the literature from performance of cryogenically treated cutting tool insert in varying nose radius and the soaking period. The level of the generated residual stress depends on the machine materials and on the process parameters used. The overall goal of the present paper is to identify an analytical relationship between residual stress and turning process parameters accounting also for the material being machined.[10]

Lohar and Nanavaty analyse the Performance evaluation of minimum quantity lubrication using CBN tool during hard turning of AISI 4340 with dry and wet Turning the work piece used in this paper is AISI 4340 and the tool material is CBN insert TNMA160404 Grade PB250 There is 40% decrease in cutting forces during MQL and wet flood condition it was about 26% more than MQL and 19% less than dry condition It is concluded that the cutting temperature in hard turning of hardened AISI 4340 is less as compared to dry and wet turning and gives 36 % decrease in cutting temperature.[11]

Liu et al presented tool nose radius affected the residual stress distribution significantly. It was further investigated that as the tool wear increased, the residual stress at the machined surface shifted to tensile stress range and the residual compressive stress beneath the machined surface increased greatly. Cutting speed 120 m/min, Feed speed: 0.1 mm/rev, Depth of cut: 0.1, 0.2mm.The tool nose radius affected the residual stress at the machined surface significantly at early cutting stage. The residual stresses at the machined surface shifted to tensile range with the increase of the tool nose radius. It was concluded that the effect of the nose radius on the residual stress distribution decreased greatly with the increase of the tool wear.[12]

Nalbant et al. investigated the effects of cutting speed and cutting tool geometry on cutting forces. Inconel 718, nickel-base super alloy .Machining was carried out for four different cutting speeds such as 150 m/min, 200 m/min, 250 m/min, and 300 m/min, but the depth of cut of 2 mm and the feed rate of 0.20 mm/rev were kept constant. It was found from experimental result that, the lowest main cutting force, which mainly depends on tool geometry.[13]

Raj & Davis deals with a comparative analysis of the effects of heat treatment and turning process parameters on AISI4340 Steel .The work material used in this paper is AISI 4340 and the tool material is single point carbide coated cutting tool. Heat treated specimen have got mild and at different cutting parameters finishing of surface is better than non-heat treated specimen. After all surface roughness will depend upon the combined effect of cutting parameter and the contributing factors.[14]

Reddy et al. accompanied a machining study on AISI 1040 steel by applying cryogenic treatment to P-40 tungsten carbide tools. He found that deep cryogenic treatment enhanced the electrical conductivity of the carbide tools .The increase in thermal conductivity enhanced the heat dissipation capacity of the cutting tool and helped in decreasing the tool tip temperature, resulting in more hot hardness during machining, which led to less tool wear in the deep cryogenic treated tools compared to the untreated tools. They also found that tool life was increased by 27 % and the main cutting forces were decreased by 11 % with deep cryogenic treatment when compared to untreated inserts.[15]

Singh and Rao developed an analytical tool wear model for the mixed ceramic inserts during the hard turning of bearing steel incorporating abrasion, adhesion, and diffusion wear mechanisms. The new model developed reliably used to assess the wear of the mixed ceramic tools within the domain of the parameters. It was observed that tool wear was increasing with the increased cutting speed, feed, and effective rake angle. However, it was found to be slightly decreased with the increased in nose radius. The proposed model was validated by conducted experiments also they investigated experimentally the condition of the tool wear by studying signals acquired from vibration and force sensors. They explored the use of Frequency Band Energy (FBE) analysis and Fuzzy Clustering (FC) techniques for tool wear status recognition in metal cutting. Their results proved that superiority and effectiveness of this method over other method for tool wear status recognition. [16]

Singh et al. conducted the experimental analysis of cryogenic treatment on coated tungsten carbide inserts in turning. Three different tungsten carbide inserts coated with aluminum chromium nitride, titanium nitride and uncoated were taken and treated cryogenically. The inserts were subjected to tempering cycles to relieve the stresses induced by cryogenic treatment. Cryogenic treatment of TiN and AlCrN coated tungsten carbide inserts resulted better performance than uncoated when treated cryogenically. TiN coated inserts gave better performance followed by AlCrN coated as compared to uncoated of cryogenic treatment. Lower cutting forces have been observed in case of cryogenically treated TiN coated as compare to AlCrN coated and uncoated treated tools.[17]

Sonani et al. presented tool wear is the progressive loss of material from the surface of tool in the form of very small metallic particles. From decade tool wear rate mostly used as to predict the tool lift. However, tool wear weight assesses real damage to the tool and is also one of the criteria to predict tool life. This paper discusses the development of first & second order mathematical model to predict the tool wear rate and the validation of the result by experiment using Response surface methodology. There are many designs are available to optimize the response for example Taguchi design, Response surface design, Mixture design & factorial design. Each design method has different accuracy, complexity, no of run & operational machining cost. However, the response surface methodology (RSM) takes into account the simultaneous variation of the cutting variables and predicts the response very accurate as compare to other available method. This paper reviews the best design method by considering different factors.[18]

Sultana et al. focuses on the effect of drilling parameters on tool wear and hole quality in terms of diameter error, roundness, cylindricity, and surface roughness. In this work, the drilling was conducted using uncoated carbide tool with diameter of 4 ± 0.01 mm with point angle of 135º and helix angle of 30º. The drilling was done at different levels of spindle speed (18 and 30 mmin-1) and feed rate (0.03, 0.045 and 0.06 mmrev-1). Austenitic stainless steel AISI 316L was the workpiece material. Comparatives analysis was done on hole diameter, roundness, cylindricity, and surface roughness of the drilled holes by experimentation. From the result, the hole quality characteristics are mostly influenced by cutting speed and feed rate. An exception was for circularity error where a two tail t-test for circularity error indicates that cutting speed and feed rate give no significant influence on circularity error. As the cutting speed increases, the surface roughness decreases (1.09 μm). In terms of diameter error, feed rate influences more than cutting speed. Minimum diameter error was achieved when low cutting speed and low feed rate were employed.[19]

Tamizharasan et al. analysed the tool wear and surface finish in hard turning. In the experimental investigation the cutting speed had a considerable effect on tool wear. When the cutting speed was reduced by 50% and feed rate was increased by 50%, the material removal rate was same and tool life was slightly increased. The tool wear was affected by the cutting speed. The feed affected it to some extent. And the depth of cut had only negligible effects on tool wear. The grades of cutting tool affected tool wear to a considerable extent, relative to the effects of material of work-piece on tool wear.[20]

Umbrello et al presented a predictive model based on the artificial neural network approach that can be used both for forward and inverse predictions. The three layer neural network was trained on selected data from chosen numerical experiments on hard machining of 52100 bearing steel, and the numerical results showed that more compressive residual stress in both axial and circumferential direction of the machined surface were obtained if higher values of the feed rate were chosen.[21]

Usui et al. investigate on tool wear cutting operations involves complex wear mechanisms, researchers have attempted to directly correlate the results of tool life to the applied machining parameters (cutting speed, feed rate, and etc.). Many models are developed to describe tool wear in quantity. They can be categorized into two types: tool life models and tool wear rate models.[22]

Yen et al. focused on interface involves and increasingly new technologies of interface, such as the minimum liquid lubrication, have been developed to reduce the cost of coolant. The dynamic characteristic of the machine tool, affected by the machine tool structure and all the components taking part in the cutting process, plays an important role for a successful cutting. Instable cutting processes with large vibrations result in a fluctuating overload on the cutting tool and often lead to premature failure of the cutting edge by tool chipping and excessive tool wear.[23]

Yong et al. investigated the effect of cryogenic treatment on carbide tools in the orthogonal turning of ASSAB 760 medium carbon steel. The researchers found that cryogenic treatment enhanced the chipping and flank wear of the tool. He concluded in long-term machining, cryogenic treatment was reported to lose its character since the tool was exposed to high temperatures.[24]

Yuefeng et al. studied statistical relationships between the initial wear and uniform wear periods. Large amount of literature review of tool wear and questionaries' of manufacturers, 873 tool wear curves were taken as samples. Finally, statistical analysis was carried out to select the most suitable tool from all the tool materials suggested by the tool manufacturers. [25]

3. DISCUSSION

Tool wear is the important parameters in machining operation which are discuss about in this paper by review of variety of literature, types and mainly focus on Flank wear, Crater wear and Nose Wear. Tool wear is common phenomenon is metal cutting. Before discussing about tool wear we should learn about how a tool fails [6]. The cutting tools fail due to following three conditions. Initially two wear occur due to plastic deformation and is very harmful for both machine and work piece. So it should be totally eliminated by using favourable condition and taking high factor of safety.

Tool wear can be reduce by proper optimization parameters between tool and workpiece grade because the major cause of tool wear is friction and temperature rise due to friction. From the literature survey, future works in this field must try to develop tool wear monitoring system with this objective, through acoustic method that could be used in real applications, taking into account the conditions of machining processes in industry. Lubricate reduce friction between chips and tool which reduce tool wear. It can also be reduced by using high hardness and abrasion resistance tool and high resistance to adhesion and diffusion.

4. CONCLUSION

The tool wear resulted in increasing in residual stress and machining temperature. This method can help us to reduce the production cost by increasing cutting tool performance to achieve the maximum benefit applied under optimum condition. From the literature review, it is clear that variation in tool geometry is one of the major parameters to be considered in order to enhance the Turning productivity in terms of cutting zone temperature, flank wear and surface integrity. According to the tool material and machining condition cryogenic treatment applied to cutting tool insert enhances the tool wear resistance and better the residual stress due to the improves in the mechanical properties.

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