A Review Paper on Inconel 718 Stress Analysis

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Abstract— This paper reviews some of the Critical issues in machining of difficult-to-cut materials are often associated with short tool-life and poor surface integrity, where the resulting tensile residual stresses on the machined surface significantly affect the component's fatigue life. This study presents the influence of cutting process parameters on machining performance and surface integrity generated during dry turning of Inconel 718 and austenitic stainless steel AISI 316L with coated and uncoated carbide tools. A three-dimensional Finite Element Model was also developed and the predicted results were compared with those measured.

Keywords: High Speed Machining; Inconel 718; Tool Wear; Surface Roughness

I. Introduction

Heat resistant super alloys are most widely used in industries such as aerospace, automotive, gas turbine and others. Their advantages are strength and hardness at high temperatures and corrosion resistance. These main properties influence their machinability, which is still very bad. During machining the cutting edge is stressed by very high heat treatment and high pressure which depend on the hardness of the material. This causes the most problems during the machining and influences the type and style of the tool wear. In our case Inconel 718 was tested which belongs to the group of nickel based alloys? For example, this group of materials is used in the aircraft industry. They currently constitute over 50% of the weight of advanced aircraft engines. The trend is that this will increase in new engines in the future.

The factors affecting surface roughness are cutting tool geometry, depth of cut, cutting velocity, feed rate, work material chemical composition, and rigidity of machine tool. During the machining process, if the tool material and cutting parameters are not selected properly then the cutting tool wears out quickly or experiences catastrophic failure. A good combination of cutting parameters, tool materials and cutting environments assures better surface quality. Material built-up at the edge of the cutting tool due to high temperature during turning/machining of Inconel 718 cannot be avoided completely. The rate can be minimized by using a proper cooling/lubrication environment that help to reduce the friction between the tool and work material, and carry the chips and heat away from machining zone, which results in improved surface integrity to some extent. While machining with carbide inserts, coatings allow an increase in cutting speeds up to 100 m/min. Application of coatings on the substrate is an approach to increase the efficiency of machining Inconel 718. Typical surface alterations such as phase transformations, micro hardness, and residual stresses during machining of Nickel based alloy materials are discussed and correlated with the functional performance of the machined products.

II. Literature Review

In this section research papers are discussed related to the present work. Published papers are highlight in this section.

A. J.C. Outeiro, J.C. Pina, M. Saoubi

Presented work on surface integrity in terms of residual stresses generated in turning of two major difficult-to-machine materials: Inconel 718 and stainless steel AISI 316L. 3D numerical modelling of turning operation provides a good comparison of cutting force (Fc) and the thermal fields developed. Measured residual stresses on both materials consistently show the appearance of high tensile residual stresses at the machined surface and compressive residual stresses in the sub-surface below 10–25 mm. Higher surface residual stresses are generated when machining with the uncoated tool than the coated tool. Also, higher residual stress values were obtained on the transient surface than on the machined surface.

B. Miroslav Zetek, Ivana Česáková,

Presented work on to show what it is important to monitor during the optimization process. The main focus was on different cutting edge radiuses where polishing methods and standard finishing surface processes were used. If we want a complex view of the cutting tool and cutting process it is necessary to use suitable devices and correct measuring methods. Because a minimal difference between the edge radius causes a big difference in tool life. Other results show how it is very important when machining Inconel 718 to choose a correct tool substrate and apply the correct tool geometry. In experiments were used a cutting tool with sharp tip and blade with protected radius or facet. These parameters influence the type of tool wear formation. In terms of reliability it is desirable to have linear tool wear without maxim tool wear and notches or other defects. This will increase the overall safety, reliability and cutting tool efficiency, and this is desirable when machining superalloys. These conditions are met by cutting tool with the protect facet and optimal rectification process. In our case, when different cutting tools were used, problems started and the tool wear was not linear.

C. D.M. Addonaa, Sunil J Raykarb

Presented work on Issues related with surface roughness and tool wear during high speed machining of Inconel 718 has been reported in this paper. Turning trials are conducted at various speed ranging from low to high (60 m/min, 90 m/min, 190 m/min and 255 m/min). It is found during investigation that both speed levels i.e. low speeds and high speeds gives good machined surface as values of surface roughness are low for all the speeds. For fresh inserts surface roughness is almost same at low as well as at high speed. Speed 190 m/min gives best result for surface roughness for the conditions under investigation. While machining Inconel 718 at high speed surface quality may deteriorate because of rapid tool wear rate for subsequent cuts. During the investigation no major signs of tool damages are observed while machining Inconel 718 at low speeds i.e. at 60 and 90 m/min. Wear patterns observed at these cutting speeds are uniform along the nose radius along with some traces of peeling coating. Comparatively at high cutting speeds tool gets worn out at very faster rate with major tool failure patterns like heavy notching. Also at high speed because of very high amount of heat is generated in cutting zone while machining Inconel 718 burns marks are visible on the tool. This can be one of the major criterion which leads the tool wear. Tool wear during machining of Inconel 718 is complex phenomenon which needs to explored further which may help to improve the machinability of Inconel 718.

D. D. M. Anthony Xavior, M. Manohar

Presented work on The temperature generation during high-speed turning of Inconel 718 is found to play a major role in tool wear, which ultimately affects the surface quality of the machined component. The cutting parameters, tool materials, and cutting environments also play a major role in surface roughness changes. It is found that cutting velocity is the major factor that influences the induced residual stresses. At the low cutting velocities the residual stresses are tensile on the machined surface and become compressive in subsurface depths. At higher cutting speeds, the induced residual stresses are found to be purely compressive. The main factors responsible for the generation of compressive residual stresses are cutting velocity and tool geometry. With an increase in cutting speeds the stresses are more compressive in nature. Carbide inserts under flood cooling at a cutting speed of 100 m/min results in minimum surface roughness while cBN under the same cutting conditions at 100 m/min, induces a minimum surface residual stress value. Therefore a cutting speed of 100 m/min and flood cooling can be considered as the optimum parameters for machining Inconel 718. The MQL cutting condition showed minimum residual stress values for all tool materials and cutting velocities. This indicates that even a small amount of lubrication helps to reduce the degree of residual stresses

E. E. Anil A. Chavan, P.V. Deshmukh

Though the machinability of Inconel 718 is poor, it could be machined satisfactorily at cutting speed of 25 m/min, feed of 0.06 mm/tooth and depth of cut up to 0.2mm. Worst cutting condition is observed at cutting speed of 75 m/min, feed of 0.12 mm/tooth and depth of cut of 0.6 mm.

Cutting forces in slot milling decrease as the cutting speed increases while cutting forces increase with either an increase in feed or axial depth of cut. Cross feed force (Fx) was observed to have higher force magnitude than feed force (Fy). Forces in slot milling of inconel 718 were seen to be reduced in case of both the coated tools in comparison with the uncoated tools, however TiAlSiN coated tool was observed to have more force reduction than TiAlN coated tool.

III. CONCLUSION

From the literature review It is found that both speed levels i.e. low speeds and high speeds gives good machined surface and At the low cutting velocities the residual stresses are tensile on the machined surface and become compressive in subsurface depths. At higher cutting speeds, the induced residual stresses are found to be purely compressive. Deterioration of uncoated tool occurred at premature stage due to chipping of cutting edge and flank face. TiAlN coated tools failed due to abrasion of flank face, chipping of cutting edge and flank face, formation of BUE is also one of the mechanism for deterioration of TiAlN coated milling cutter but its influence is not that much high like abrasion and chipping.

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