REVIEW ARTICLE ON ASSESSMENT OF MACHINING PARAMETERS WITH FEM SIMULATION OF HARD METALS ON DEFORM-3D

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Abstract

Simulation tools are very effective for trying the different machining parameters during various types of operations and working conditions. DEFORM 3D provides an easy and effective way of analyses and conclusion. It provides a green and lean approach for industrialization. Due to the freeness of defining the tool and workpiece, mesh generation becomes very easy and results from comparison become easy and more near to actual experiments.

Keywords: Cutting insert type; Meshing; Stress analysis.

Introduction

In industries most essential manufacturing processes is machining. By continuously enhancing the carbide cutting tool insert geometries, the effectiveness and productivity of the machining process can be improved. To machine, a hard material under required machining conditions and process variables, require optimal machining factors and geometry of cutting insert. Though, for the pre-selection of tool geometries and machining factors, model wear test by utilizing finite element methods [1] would be significantly useful. This research aims to examine the outcome of cutting insert geometries [2,3] such as relief angle, nose radius, and cutting insert shape [4,5] on output response specifications. The machining specifications like feed rate, depth of cut and cutting speed may be taken as constant. The various shapes of commonly available tools utilized for the machining process are shown in Fig 1.

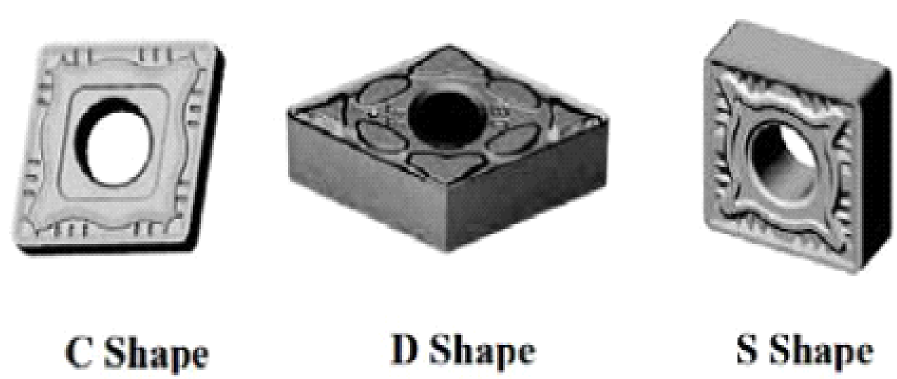


Fig. 1: Commonly available shapes of cutting inserts [4].

Due to the properties of low maintenance, relative cheapness, and resistance to corrosion of stainless steel make it is being widely used for commercial applications. Nowadays it has been used for producing various parts of aerospace and automobiles. It is also being used in preparing many types of equipment for industries. The main reason for such applications is its high plasticity, light in weight, high-temperature bear. Due to its high cutting force, a large tool wear occurs during its machining and very poor surface finish is obtained [6]. That is why it is named as hard to cut metal. So, to proceed with milling operation, cutting parameters such as feed rate, depth of cut, tool geometry and cutting speed are to be estimated. Simulation and modeling of the machining method based on the Finite Element Method (FEM) are continually attracting researchers to get a better knowledge of heat production in cutting areas and chip formation mechanisms. Estimation of the physical factors like the stress distribution and temperature precisely plays a significant part in the predictive method engineering of machining operations. The most important and precise way for the estimation of process factors is Finite Element Analysis and advancements in processing and computational power of comp utters has made this feasible [7].

DEFORM 3D is a better and effective simulation system that is being utilized in the study of the 3D flow of complex metal processes. It easily saves the trial experimentation cost. This tool mainly has three types of steps to be followed. They are categorized as pre, post, and simulation. Along with this, the configuration of the computer system used to run the software decides the running time [8].

Literature

T Tamizharasan and S. Kumar attempted in reducing and making it a minimum for the wear of non-coated carbide insert. They have done the machining AISI 1045 steel using the finite element analysis in software. The main reason that results in the low-grade surface finish is the tool wear and is the cause behind the dimensional precision of the machined surface. For any manufacturing industry, the standard of the component produced determine its competitiveness and effectiveness. They studied the effect of different tool geometries on surface roughness, cutting forces and wear. They have taken three levels of relief angle, insert shape and nose radius. Taguchi's Design of experiments (DOE) has been used. A preferable L9 Orthogonal Array is chosen to get three parameters and levels. DEFORM-3D, analysis software and a machining simulation are used in simulation analysis depending on the designed experiment. Also, Analysis of Variance (ANOVA) and Signal-to-Noise (S/N) statistical techniques are used to analyses the output quality characteristics. Experimental verification on the derived optimum tool geometry is also done by conducting a validation finite element simulation.

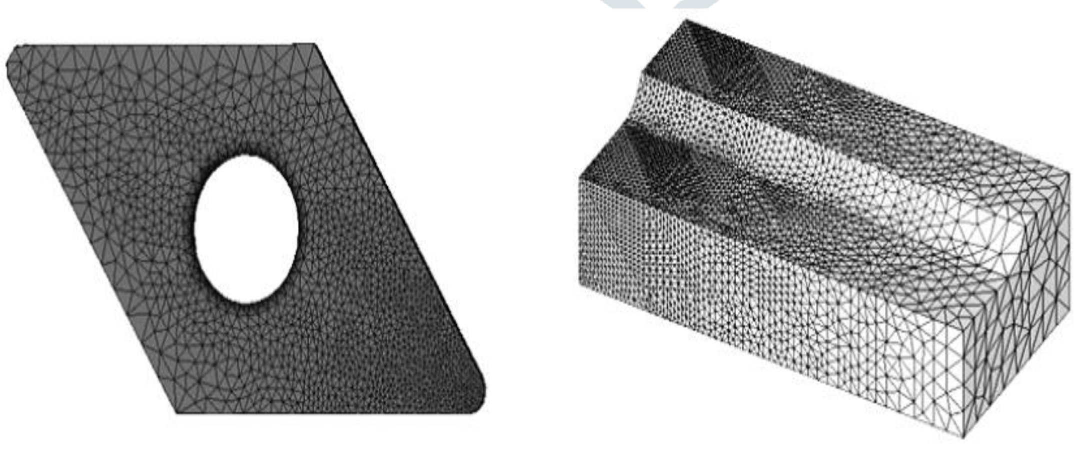


Fig. 2: Mesh of cutting insert and workpiece [9].

Mesh generated in cutting insert and workpiece are shown in figure 2. It can be done in absolute or relative type. Figure 3 shows the representation of turning operations using the optimum insert in machining [9].

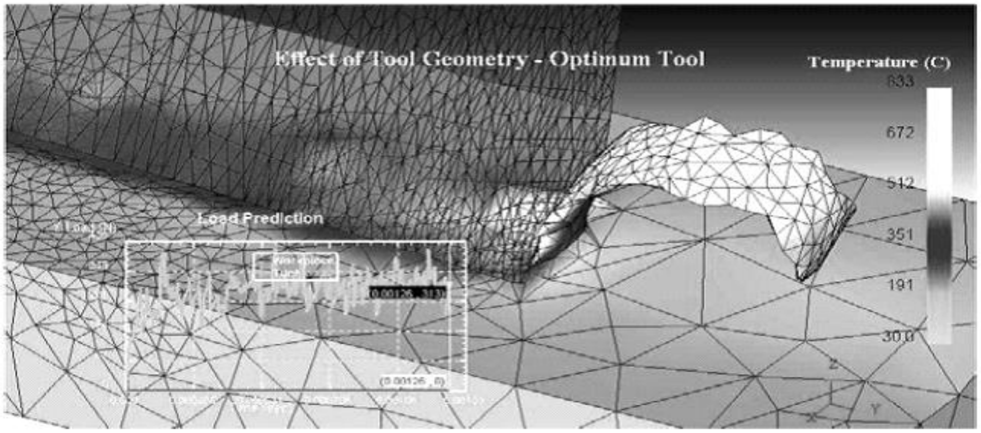


Fig. 3: Turning operation using optimum insert [9].

G. G. Reddy et al. have done a comparison of various obtained values during the milling operation of steel alloy (AISI 420). They have compared it with the simulated values. The main parameter selected was the temperature only. A coated tungsten carbide tool is used for the operation. Using DEFORM 3D software, Finite Element Analysis is carried out. Milling operation has been selected and three times the speed of mill cutter was changed. John-cook's equation is used to define the material in the software. The results got from the simulation and experimental work were proved as valid after comparison [10]. Z. Wanga et al. (2014) have done the thermal-Mechanical finite element method (FEM) model is used in the machining of metals. DEFORM 3D is used for simulation of milling of steel material. To predict the milling force DEFORM-3D software could be used.

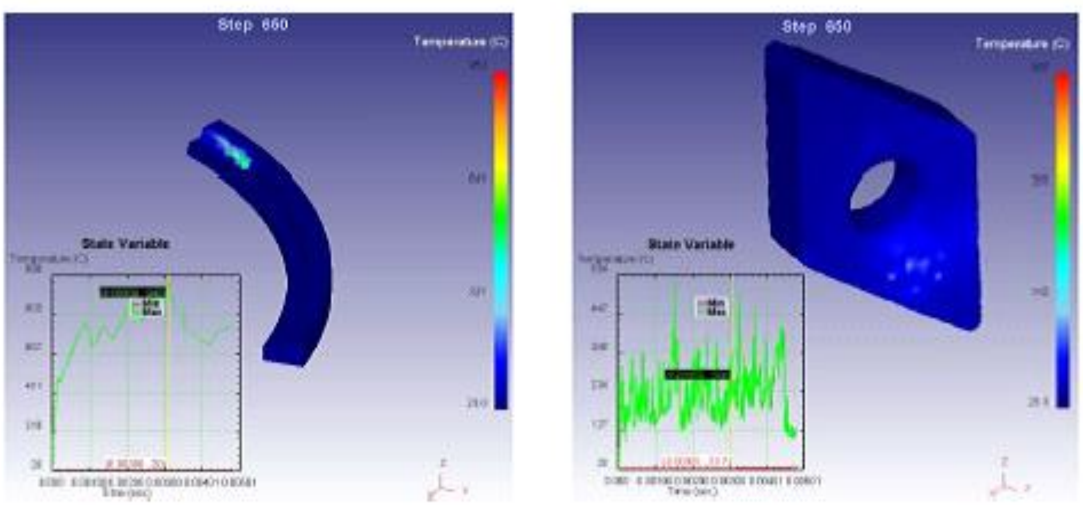


Fig. 4: Variation of temperature in workpiece and tool [11].

In this, the prediction of the model was proved experimentally and the experimental and numerical results got were found were following each other. Figure 4 shows the variation of temperature in the workpiece as well as in the tool [11]. C. Zhuo et al. have used Titanium materials which are simulated perfectly using DEFORM-3D. The influence of cutting depth on cutting force was got with analysis. Additionally, the precision of the DEFORM-3D simulation is validated by carrying out a cutting force experiment. The result of the research indicates that the estimated cutting strength values of DEFORM-3D are quite accurate [12].

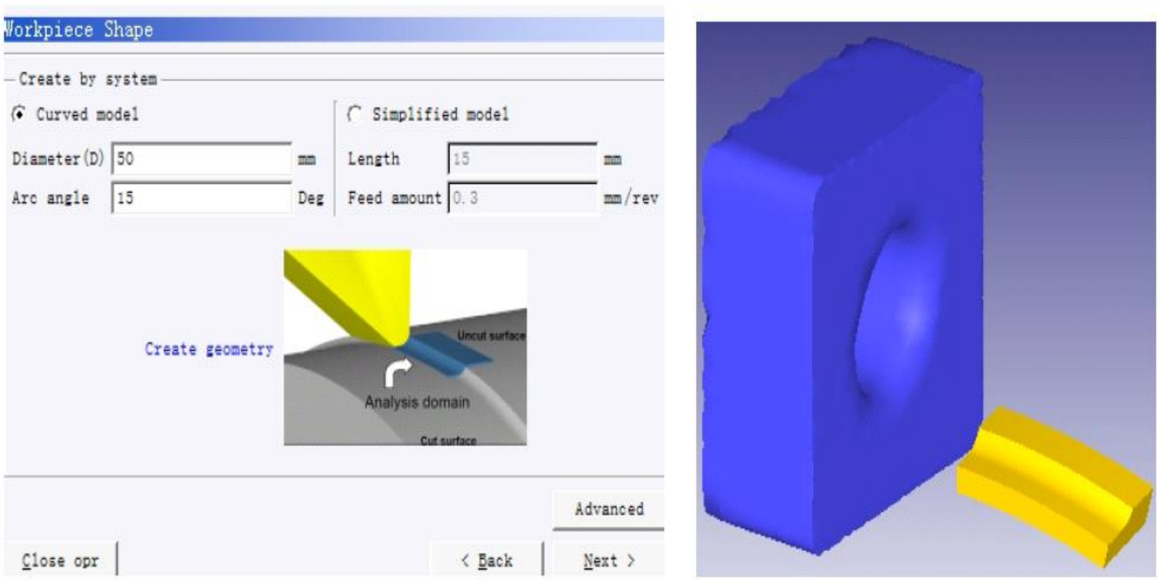
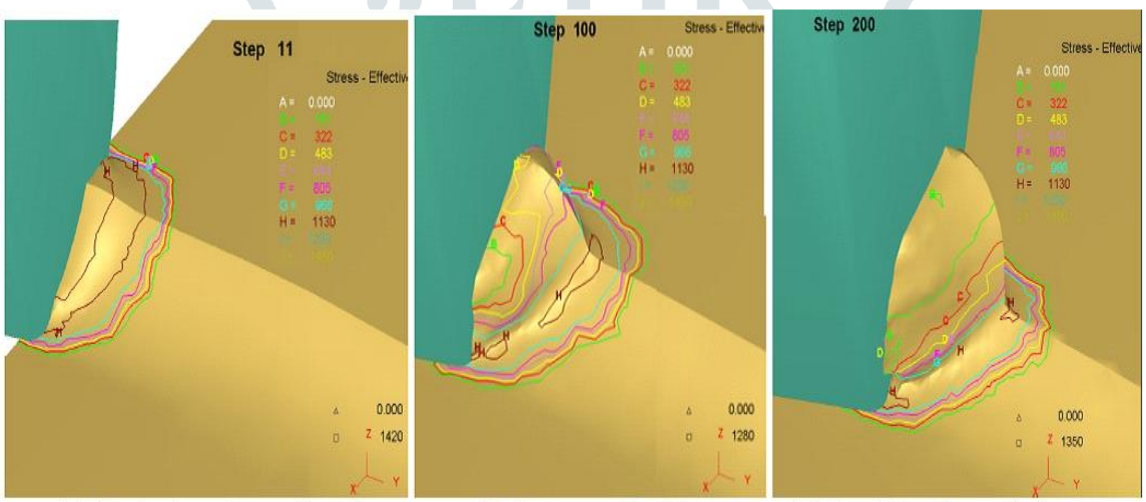


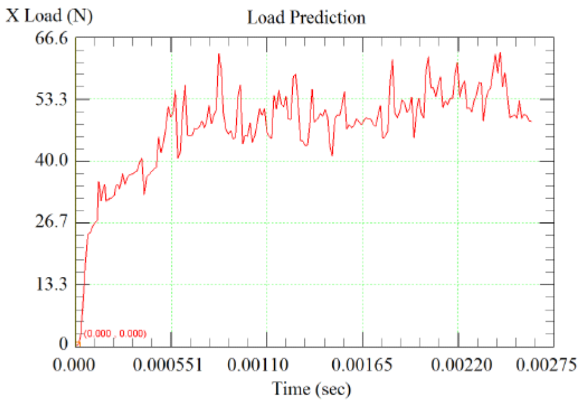
Fig. 5: Defining workpiece dimensions with a sketch [12].



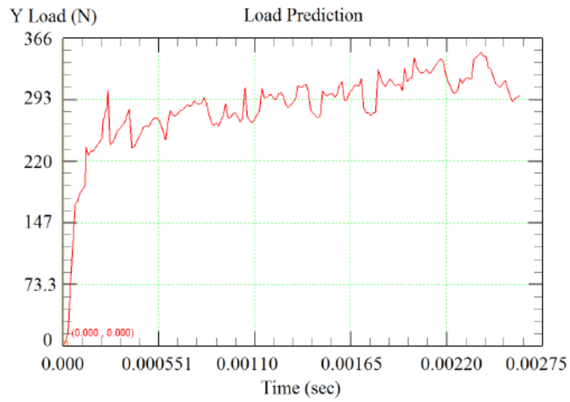
(a) Beginning stage of cutting (b) Process of cutting (c) Breaking through shear zone

Fig. 6: Stress contour in front cutting edge [12].

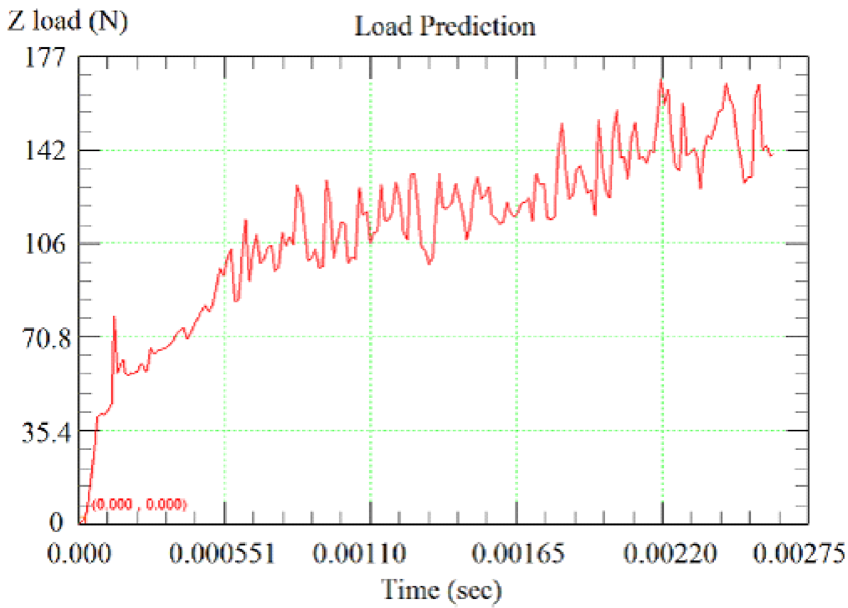
Figure 5 explains the steps of defining the workpiece in dimension and its layout to be selected for machining. When the part of machining is completed then the stress contour is shown in figure 6. As a part of result analysis, the primary, feeding and thrust cutting force graphs have been plotted concerning different load values and shown in figure 7. Finally, a cutting force comparison has been prepared in different line graph diagrams and shown in figure 8.



(a) Primary cutting force



(b) Feeding cutting force



(b) Thrust cutting force

Fig. 7: Graph of cutting force with parameter [12].

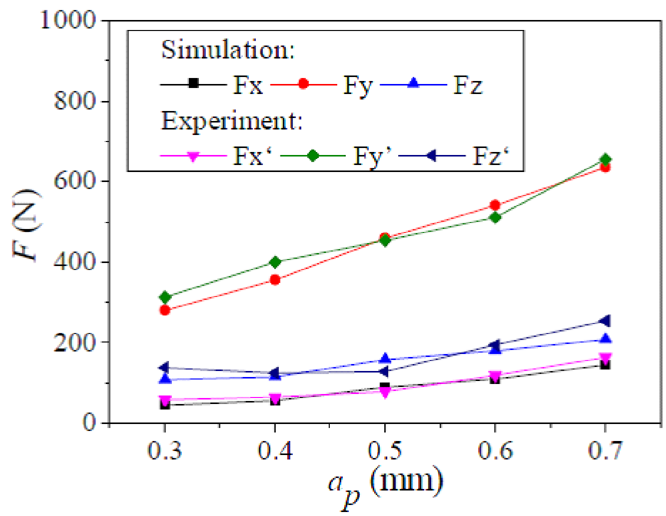


Fig. 8: Cutting force Comparison [12].

Attanasioa et al. have aimed for simulating tool wear by drilling of alloys based on nickel, specifically Inconel 718. The main concern while machining these kinds of alloys is to study the effect of mechanical and thermal behavior. Because of this, the effects of tool wear on the tool life, on the quality of the end part and power consumption and cutting force is important to examine. In a few cases, the wear mechanisms can be explained by analytical models that are functions of physical parameters involved in the process (such as, sliding velocity and pressure across the cutting area and temperature). Generally, commercial FEM software lets the implementation of these tool wear models except update in tool geometry. So DEFORM-3D FEA software was used to develop and implement a feasible subroutine taking tool geometry update, to do the simulation of tool wear, therefor overcome the above restriction, in drilling the Inconel 718. The accordance between in the measured as well as predicted tool wear value was good. For this simulation, a mesh generation study has been shown in figure 9. [13].

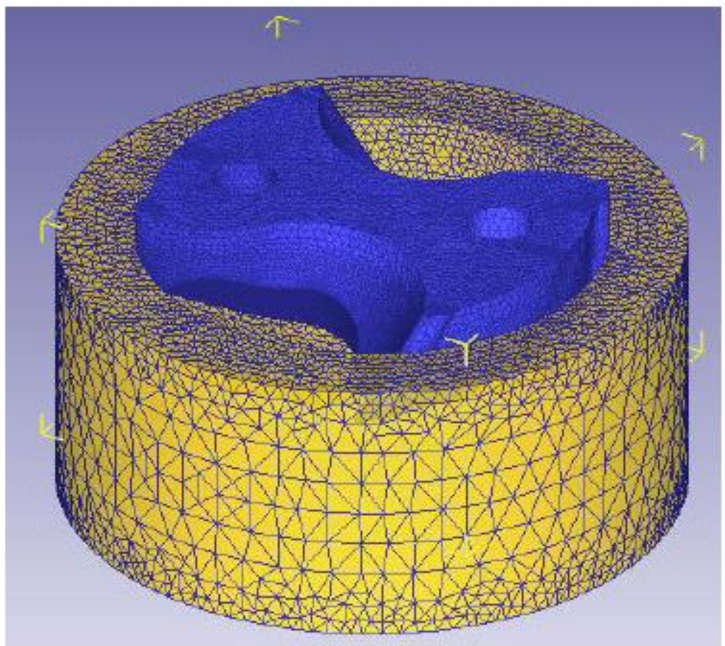


Fig. 9: Mesh generation for FEM Model [13].

R. Rajesh et al. have used cutting insert of tungsten carbide having a coating of Titanium, Aluminium oxide, and Titanium Carbo-Nitride (TiCN). Selected four parameters that are- cut depth, speed, federate and material. They have taken these factors at three different levels and get a total of 9 experiments. Taguchi's method was used to enhance all these experiments. After that best acceptable condition and factors were examined for the minimal quantity of tool wear in the turning process. After the simulation, the analysis of velocity has been performed and shown in figure 10. Similar to this an important factor has also been studied as shown in figure 11 and that is wear rate in machining [14].

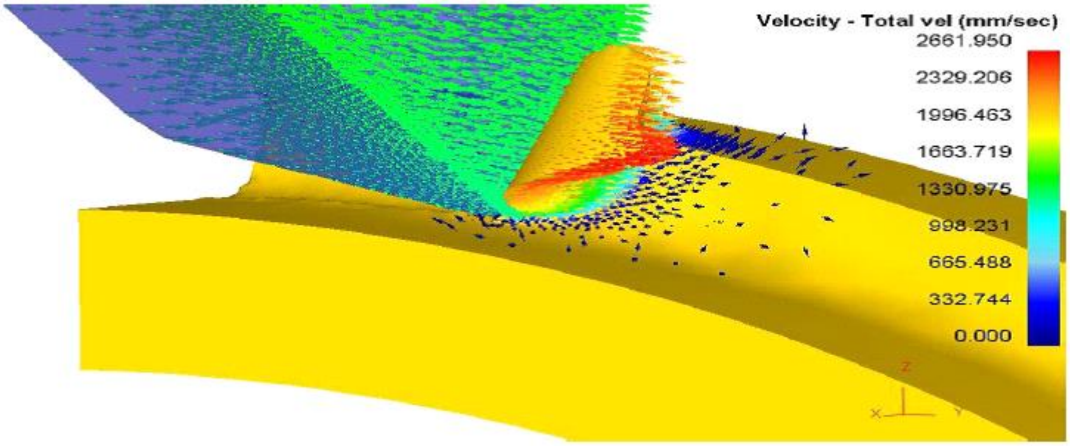


Fig. 10: Result in terms of velocity [14].

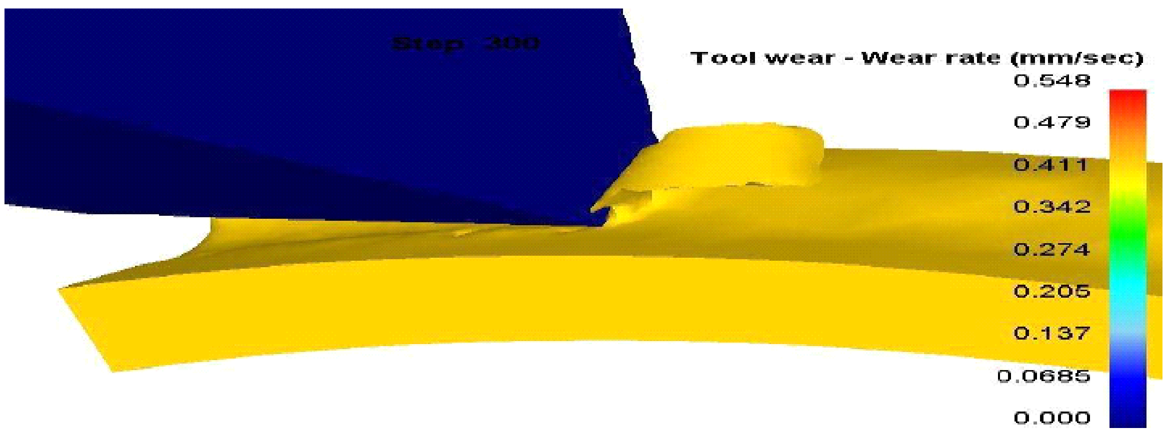


Fig. 11: Result in terms of wear rate [14].

A. S. Mohruni et al. have done FEM simulation utilizing DEFORM -3D so that error can be avoided in the thin-walled machining to obtain the characteristics across the thin-wall. In this investigation, like validation, the study was carried out with a helical end-mill of 42-degree. The outcome reveals that FEM simulation using DEFORM 3D has failed in approaching the experimental results. It might be due to the occurrence of vibration and the depth of cut was very small [15]. R. S. Parihara et al. (2017) tried to examine the impact on performance characteristics of significant machining variables, using ceramic tools in the turning of ASI H13, precise and accurate attempts were taken. To predict the temperature, cutting forces, etc by Langrangian model, DEFORM 3D which is a FEM based software was used as a 3D machining model. Good accordance was found between the obtained results of simulation and experimental results after their comparison. The results can help tool developers to understand completely without performing time-consuming and costly experimentation [16].

Conclusion

DEFORM 3D is an advance tool for optimization and result from the analysis of various machining parameters using a different tool and workpiece material and factors. It allows making the comparison of simulation data with experimental outputs. It also makes a clear 3D representation, graphical representation of results.

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