Sustainable Environment

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Enhancement of Machinability of Titanium Alloys using Micro-textured Tool: FE and Experimental Analysis

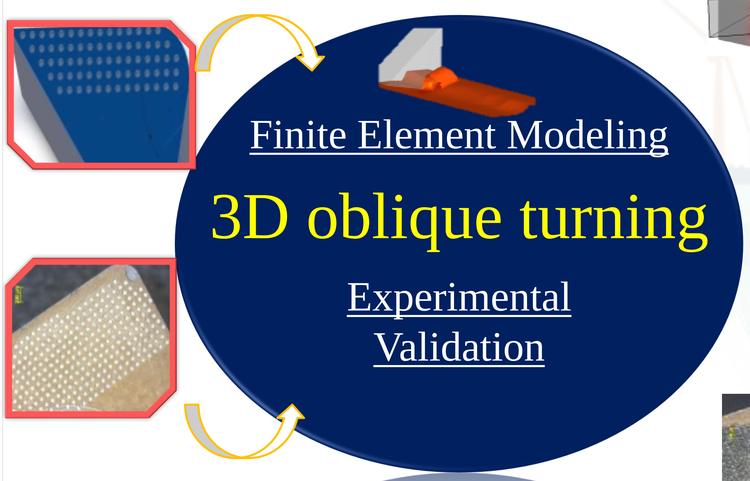
A. K. Parida, P.V. Rao*, and S. Ghosh*

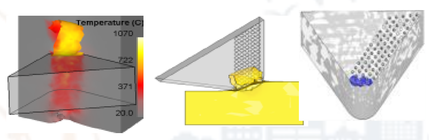
Mechanical Engineering Department IIT Delhi

Abstract

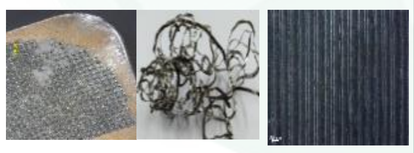
The purpose of this study is to simulate the turning of titanium alloy by textured and flat tool using DEFORM software and to make a confrontation with experimental test. The final aim consist to obtain cutting force, temperature, chip flow angle and coefficient of friction produced by texture tool and compare with flat tool. The simulated results are tested with the experimental data and good coherence has been obtained. This work try to extend this methodology with a commercial software using finite element methods.

Introduction





- Cutting force
- Chip tool contact
- Chip flow angle
- Coefficient of friction
- Tool wear



Materials and Methods

The experimental validation are lead on turning of Ti-6Al-4V using texture and flat tool. The measure of the cutting forces and, chip-tool contact length and chip thickness have been conducted using dynamometer, and optical microscope respectively.

Reduction in force 24% in texture tool than flat tool and 12% error with the simulation result

Conclusions

- The use of micro-textured tool enhance the machinability of Ti-6Al-4V by increasing surface finish, reduction in cutting force, coefficient of friction chip tool contact length, tool temperature, tool wear, chip flow angle and chip thickness as compared to flat tool.
- The numerical developments permit in depth analysis in machining process like cutting forces, effective stress, chip curling, damage and temperature, which are difficult to get in experimental case the improvements consist to create a simulation of an industrial case.

Industrial Significance

This study enable the solution to industries problem facing during machining of difficult to cut materials without using cutting fluids which make sustainable manufacturing environment and processing FEM method can reduce the cost.

Technology Readiness Level:

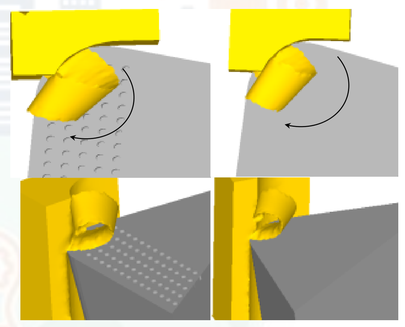
The proposed 3D FE model benefits the manufacturing industries in the flowing ways: It helps to reduce the number of experimental trials require to optimize the machining process. The predicted values can be extrapolated to analyse the machining behaviour even in very high cutting conditions.

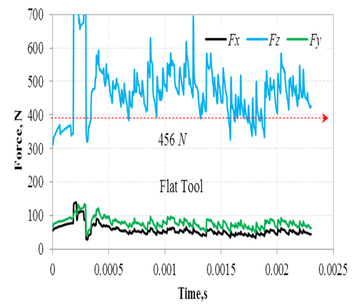
Result

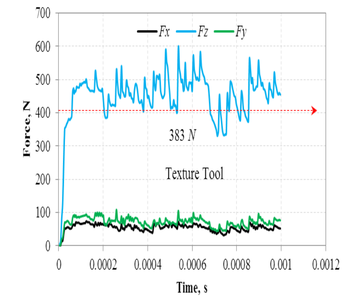
The numerical investigation make a simulation of texture tool in turning operation of Ti-6Al-4V. The cutting operations used are cutting speed (40-100 m/min), feed rate of 0.08 mm/rev and depth of cut 0.5 mm. The Ti-6Al-4V alloy material behaviour is modeled by Johnson-Cook law.

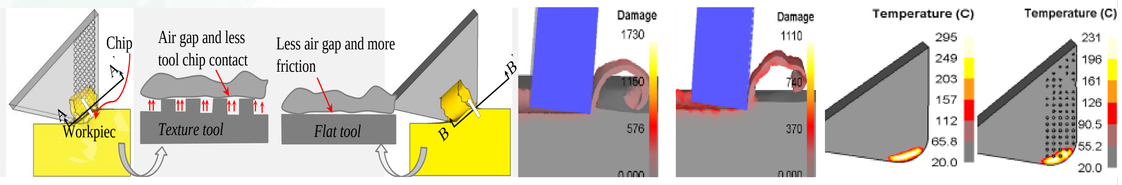
$$\sigma = \left(A + B\left(\bar{\varepsilon}\right)^{n}\right)\left[1 + C\ln\left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)\right]\left[1 - \left(\frac{T - T_{Room}}{T_{melt} - T_{Room}}\right)^{m}\right]$$

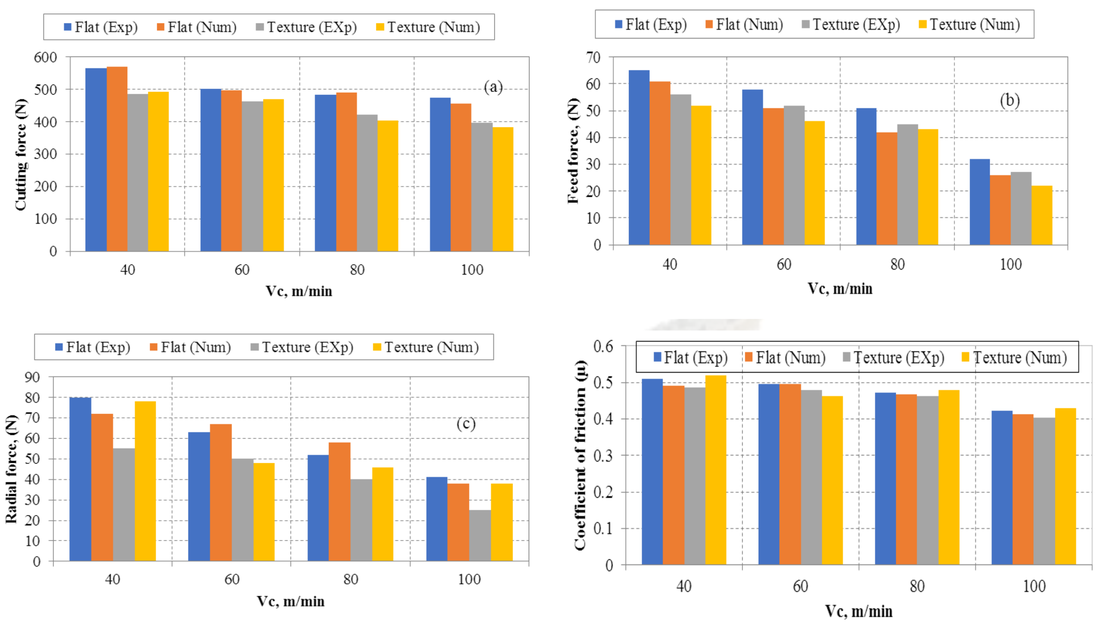
The simulation result are effective stress, temperature, force, chip flow angle and damage during machining with texture and flat tool.











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