

Chip Morphology Predictions While Machining Hardened Tool Steel Using Finite Element and Smoothed Particles Hydrodynamics Methods

Key words:

Chip Morphology, Finite Element (FE), Smoothed Particles Hydrodynamics (SPH)

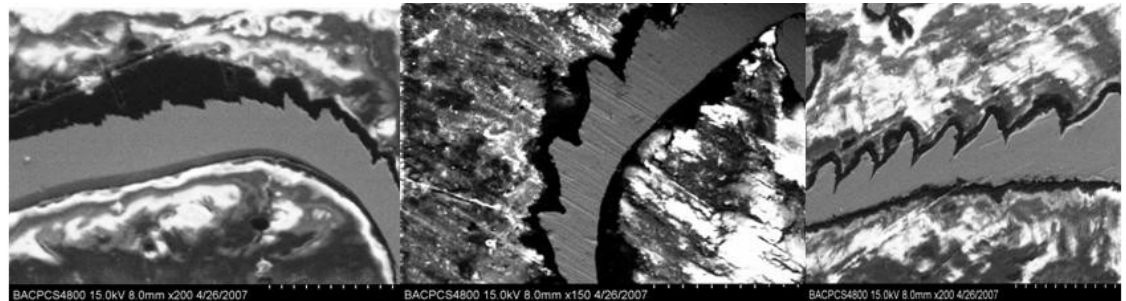
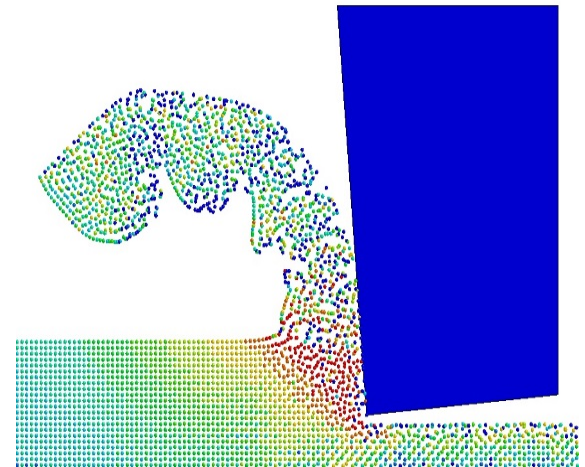
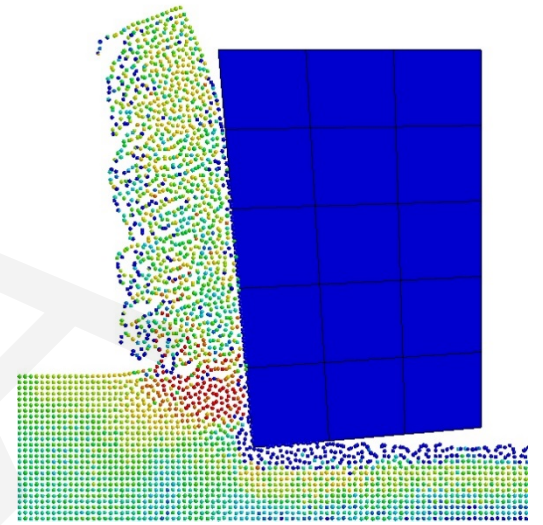
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Chip morphology predictions give variety of information regarding the turning process

- ✚ Stability of the process
- ✚ Surface integrity of the workpiece
- ✚ Variation of the cutting forces
- ✚ Severity of the tool wear



Experimental Setup

Cutting Parameters

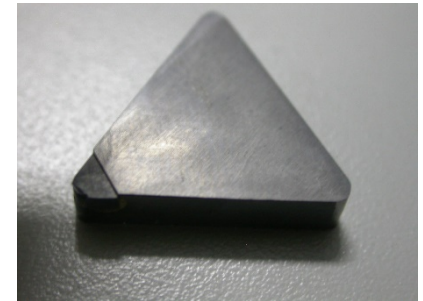
Cutting speed V (m/min)	Feed rate f (mm/rev)	Depth of cut a_p (mm)
150	0.15	2
200		
250		
150	0.25	
200		
250		

Workpiece and tool properties

	Density kg/m^3	Elastic modulus GPa	Poisson ratio	Thermal Conductivity $\text{W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$	Specific heat $\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$	Hardness HRC
H-13	7800	211	0.28	37	560	49
PCBN	3399.5	652	0.128	100	960	--

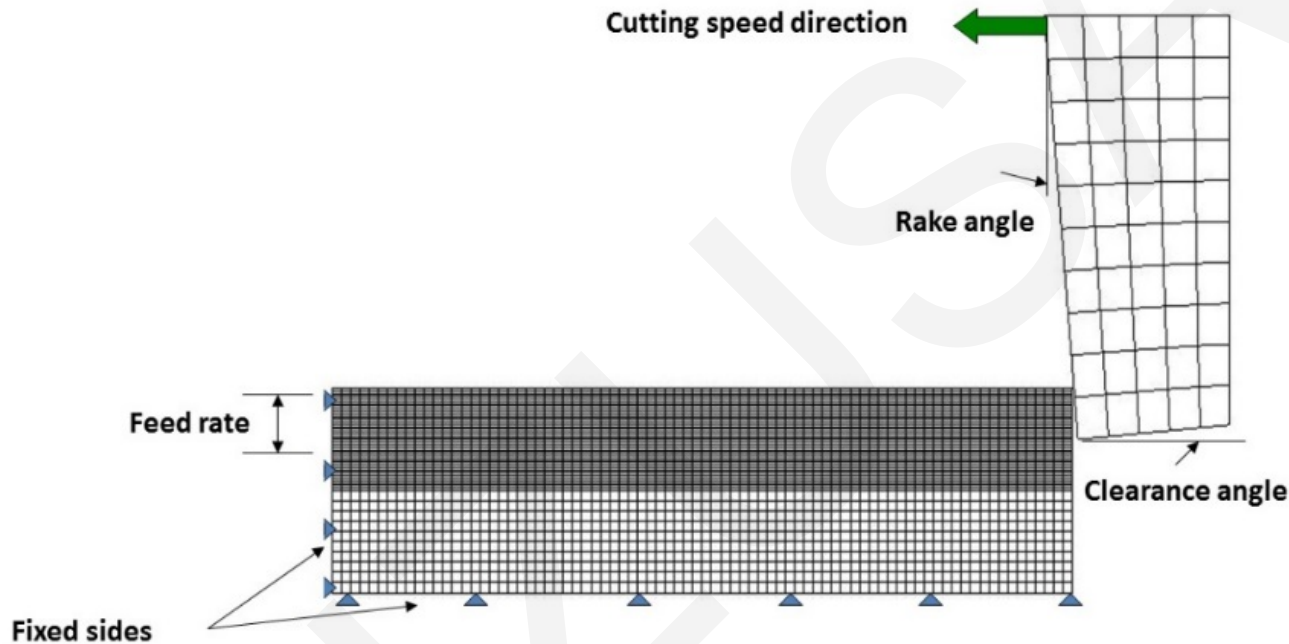


Kistler 9257B for Cutting forces measurements



PCBN cutting inserts

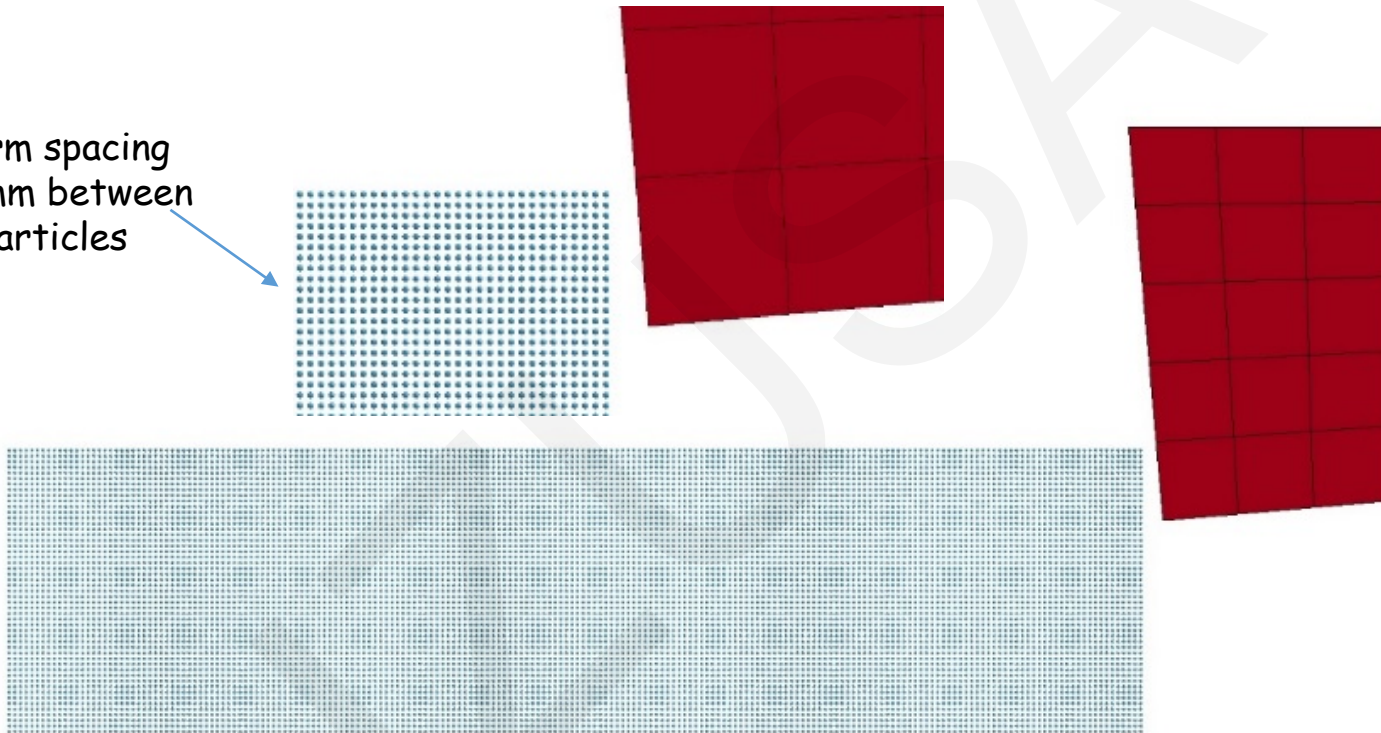
Finite Element Model



A total of around 4000 CPE4RT (continuum plain strain, reduced integration with temperature degree of freedom) elements were designed on the workpiece and the cutting tool for the FE model

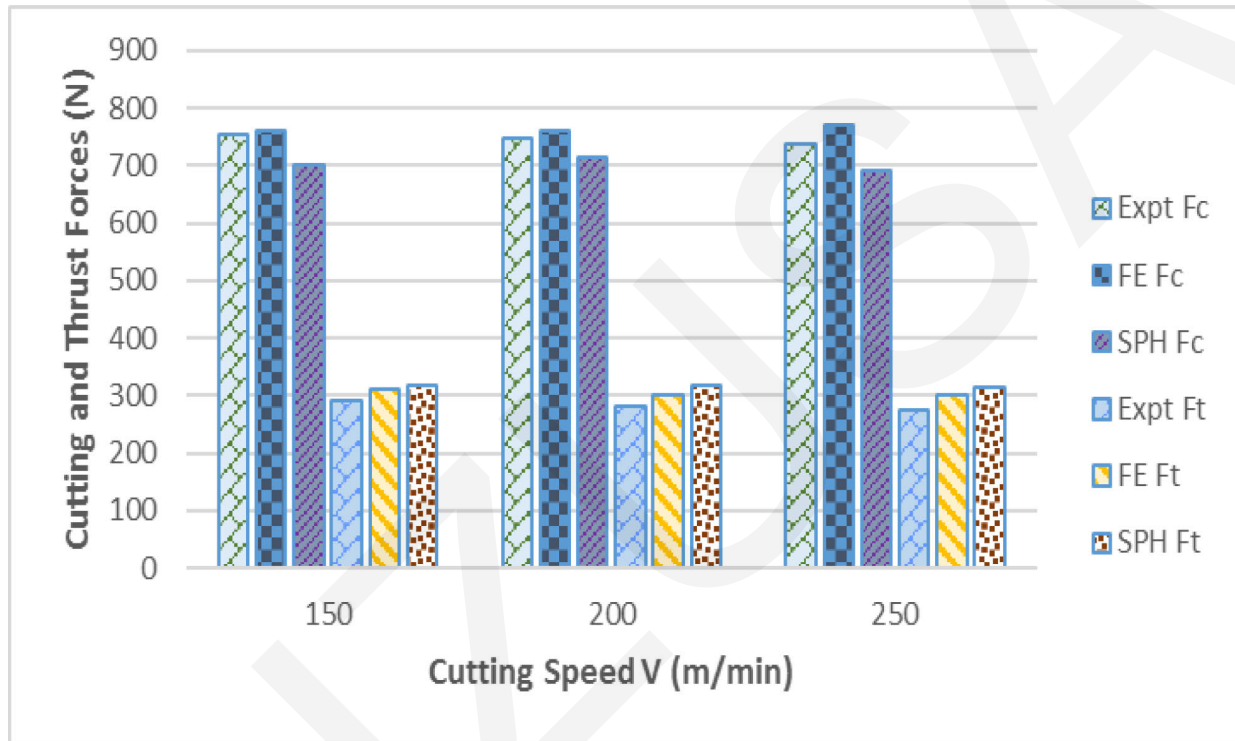
Smoothed Particles Hydrodynamics Model

Uniform spacing
0.02 mm between
SPH particles



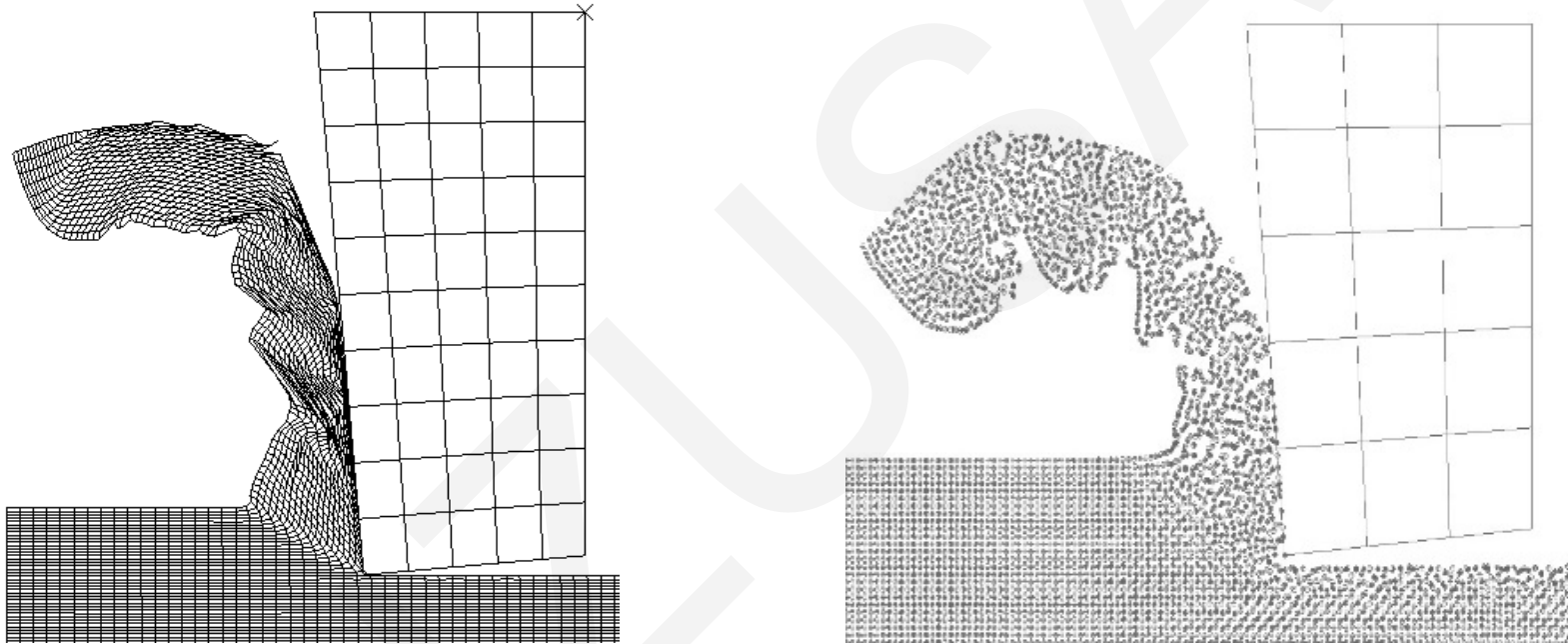
SPH models are tested because of FE models incompatibility for handling large deformations in serrated and discontinuous chips

Results and Discussions



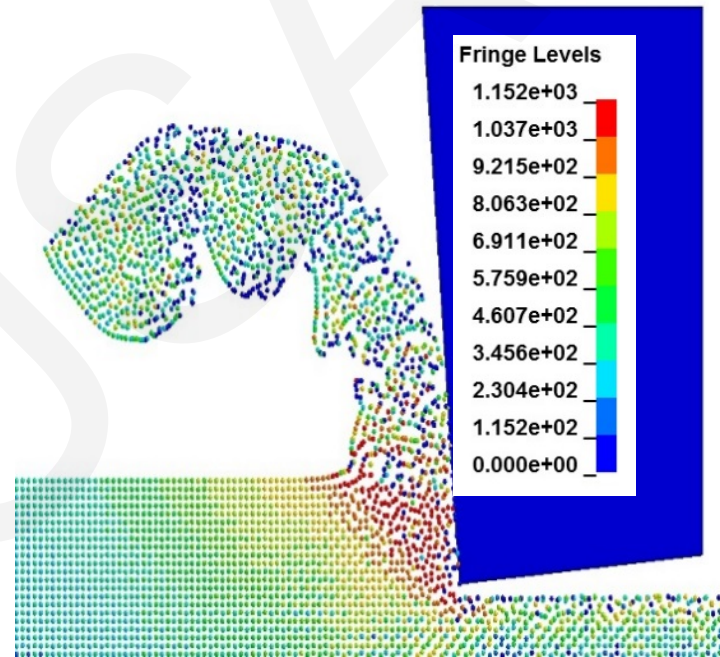
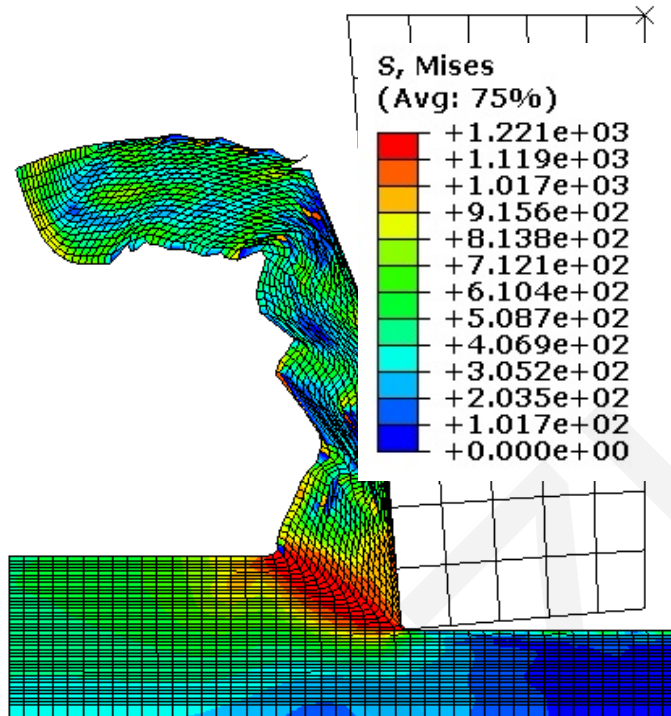
Cutting and thrust forces obtained at feed of 0.25 and mm/rev

Results and Discussions



Chip morphologies from FE (left) and SPH (right) models
at cutting speed 250 m/min

Results and Discussions



Mises stress for FE (left) and SPH models at feed rate of 0.25 mm/rev and cutting speed of 250 m/min

Conclusions

- ✚ The FE and SPH models developed in this research can simulate chip morphology and other process variables with reasonable degree of accuracy.
- ✚ Serrated chips are observed in the cutting speed range of 150 to 250 m/min and they are successfully simulated by FE and SPH models.
- ✚ Cutting forces in the high speed range are mostly unaffected by change in cutting speed. On the other hand feed rate has marked effect on cutting forces which is also predicted by FE and SPH model with an average error of around 5 and 8% respectively.
- ✚ The SPH and FE models can predict chip morphology changes from continuous to segmented and from segmented to discontinuous chips by varying the cutting speed.