ME 230 Simulation Assignment: Orthogonal Machining

The objective of this exercise is to simulate the 2D orthogonal machining process using a finite element solver (ABAQUS). The simulations will be used to predict chip formation, shear angle, cutting force, stresses, and temperature distribution in the workpiece material.

1 Problem

A rectangular block of workpiece material with dimensions 18 mm (L) by 4 mm (H) by 1 mm (W) is undergoing planing (orthogonal) operation using a sharp, rigid tool as shown in Fig. 1.

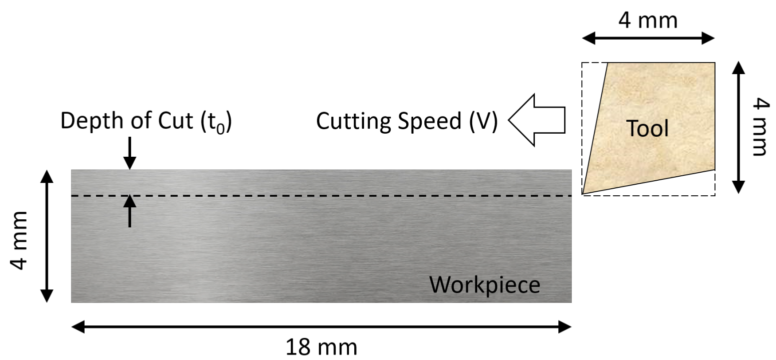

Figure 1: Schematic of orthogonal machining process with workpiece and tool geometries

2 Assignment

(A) **Effect of Material Properties:** Simulate the process of 2D orthogonal machining for the two workpiece materials (click here for material properties assigned to you) using the model parameters provided in Table 1. Use the step-by-step guidelines provided in the tutorial file (provided here) to build the finite element model in ABAQUS solver, run the model, and analyze the results.

With well-labeled contour plots from ABAQUS, analyze and compare the following for the two workpiece materials: (i) stress distribution and maximum stress (using 'Von Mises stress'), (ii) strain distribution and maximum strain (using 'plastic strain equivalent, PEEQ'), (iii) chip formation, (iv) shear angle, (v) cutting force as a function of time, (vi) maximum temperature as a function of time and its location. Explain the differences based on the material properties of the two materials.

(B) **Effect of Rake Angle:** Simulate the process of 2D orthogonal machining for two rake angles (α), 5^0 vs. 15^0. With well-labeled contour plots from ABAQUS, compare the following for the two rake angles: (i) stress distribution and maximum stress (using 'Von Mises stress'), (ii) strain distribution

Cutting Parameters	Value	Unit
Cutting Speed (V)	1	[m/s]
Depth of Cut (t_0)	1	[mm]
Rake Angle (α)	15	[deg]
Clearance (end-relief) Angle	10	[deg]
Coefficient of Friction	0.3	
Workpiece Properties	**Value**	**Unit**
Thermophysical Properties of Material 1	click here for values assigned to you	
Johnson-Cook Parameters for Material 1 (A, B, C, n, m, T_m, T_0)	(1098, 1092, 0.014, 0.93, 1.1, 1630, 20)	A, B in [MPa], T_m, T_0 in [^0C]
Johnson-Cook Fracture Parameters for Material 1 (d_1, d_2, d_3, d_4, d_5, ϵ_0)	(-0.09, 0.25, -0.5, 0.014, 3.87, 1)	
Thermophysical Properties of Material 2	click here for values assigned to you	
Johnson-Cook Parameters for Material 2 (A, B, C, n, m, T_m, T_0)	(352, 440, 0.0083, 0.42, 1, 520, 20)	A, B in [MPa], T_m, T_0 in [^0C]
Johnson-Cook Fracture Parameters for Material 2 (d_1, d_2, d_3, d_4, d_5, ϵ_0)	(0.13, 0.13, -1.5, 0.011, 0, 1)	
Tool Properties	**Value**	**Unit**
Density	15700	[kg/m^3]
Young's Modulus	705	[GPa]
Poisson's Ratio	0.23	
Thermal Conductivity	24	[$W/m/^0C$]
Sp. Heat Capacity	178	[$J/kg/K$]
Displacement at Failure for ALL materials	0.001	

Table 1: Model Parameters

and maximum strain (using 'plastic strain equivalent, PEEQ'), (iii) chip formation, (iv) shear angle, (v) cutting force as a function of time, (vi) maximum temperature as a function of time and its location. Use material 1 as the workpiece and the model parameters provided in Table 1.

3 Submission Process

Note that this is an individual assignment. Submit your report containing model details (properties, parameters, boundary conditions, etc.), the plots, and analyses of your simulation results based on Section 2 on MS teams. **The report should be a single PDF named 'XXX.pdf,' where 'XXX' is your IITB roll number.**