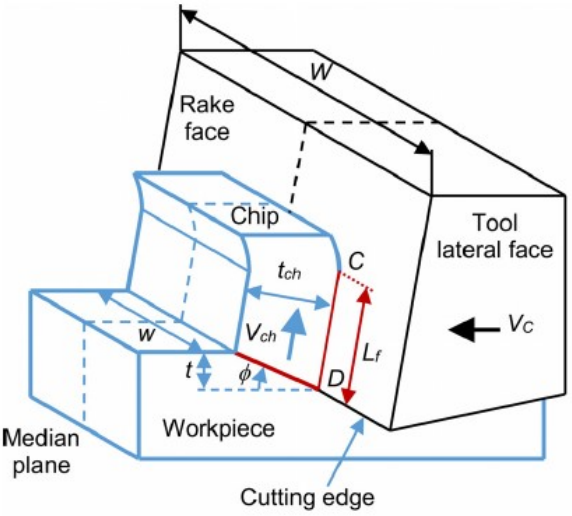
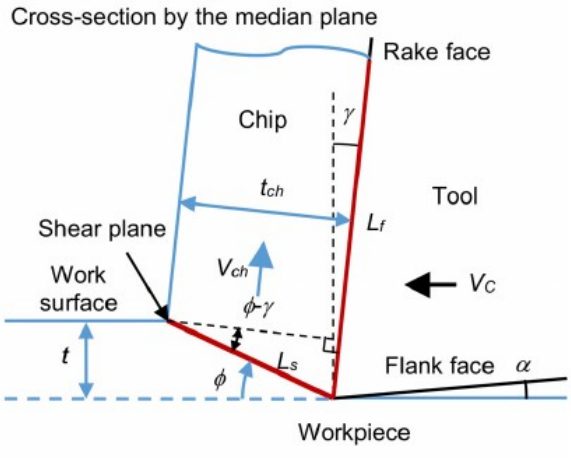
ME 756 – Numerical Modeling of Manufacturing Processes

Sample Problems (Machining) - Transient heat conduction

1. Following pictures schematically show - (a) a 3D view of orthogonal cutting process, and (b) geometry of orthogonal cutting process - cross-section by the median plane, and (c) the cutting forces and speeds.

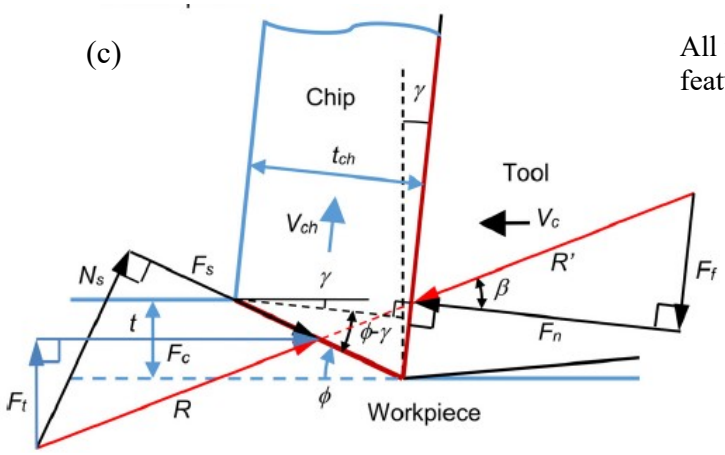


(a)



(b)

(c)



All the legends in Figs (a-c) refer to the standard features as clear on the schematic figure.

The cutting tool is primarily heated due to friction along the tool-chip interface. This heat source can be assumed to be rectangular with dimensions as ($L_f \times w$) where L_f is the contact length between the tool and chip along the rake face. As a result of the frictional heating, the heat flux along the tool-chip interface can be estimated as ($F_f \times V_{ch}$) / ($L_f \times w$).

Consider a high-speed steel cutting tool is used for an orthogonal machining operation, as described above. For a cutting speed of 45 m/min, metal removal rate of 11.25 cm3/min and specific unit power of 37×10-3 kW/cm2/min, the cutting power is obtained as 416 W. Assume that around 20% of this power is used for heating of the tool, which is having an uniform thickness of 10 mm. Set up a two-dimensional transient heat conduction analysis of the cutting tool using triangular or quadrilateral element to compute the temperature field experienced by the cutting tool. Assume the heat input to the tool at a point located close to the tool tip on its rake face.