Sample Questions in Manufacturing Qualifiers

1. A carbon steel 10 inch diameter cylindrical workpiece is turned on lathe with 50 rake cutter. This process is done in one pass to reduce the workpiece diameter by 0.2 inch. It takes 30 seconds to complete the entire axial length of 6 inches at a spindle speed of 1000 rpm. The power required of spindle motor is 5 hp when no coolant is used. Assume that the coefficientof friction in dry contact is 0.3. A cutting fluid sales man has a fluid that reduces the friction coefficient at the tool-chip interface to 0.1. He claims that the application of this cutting condition will reduce the motor power requirement by 50%.
   1. Find the shear strength of the material
   2. Calculate the cutting forces (Fc and Ft) and chip thicknesses for both the cases
   3. Do you believe him? Calculate your estimate of required motor power?



Assume this process to be orthogonal and perfectly plastic. Lee-Shafer shear angle relationship is given by hp = 746 W and 1inch =25.4 mm



1. Assume that in orthogonal cutting operation the frictional force, F, is given by where K is a constant, is the material shear strength and can be either (a) uncut chip area; (b) cut chip area. If the rake angle is  and the shear angle is prove that the average coefficient of friction, for :
   1. If = uncut chip area:
   2. If = cut chip area:
2. You are grinding H-13 tool steel, which has a specific grinding energy (u) of 25 W-s/mm3. The grinding wheel rotates at 3000 rpm, has a diameter (D) of 120 mm, thickness (b) of 20 mm, and (c) 5 grains per mm2 (c). The transformation temperature of this steel is 840oC and coefficient K2 is 0.2oK-mm/N. The temperature rise beyond transformation temperature can induce detrimental (undesirable) microstructural changes. Room temperature is 20oC. The work piece moves (v) at 1.5 m/min. The chip thickness ratio (r) is 10.
   1. Derive the expression for maximum chip thickness, t, and its value for the above process conditions.
   2. Determine the grinding force and force per grain.
   3. Let the grain be a SiC grain modeled as a continuously varying circular beam as shown in Fig. 1. Assume the force/grain is acting as a point load in the end. Use cantilever beam theory to find the stress as a function of x and the magnitude and location of maximum stress. Are these stresses sufficient to fail the grain? What should be the strength of the binder to avoid uprooting the grain?

x

Assume sintered -SiC has a strength of 4.6 GPa. Fig. 1. SiC grain geometry.

1. Note that the unit production cost is ($/part) is given by:

*u* = *uo + um* + *ut* = *k*o*tp +* (*k*o *+ k*m) *tm +* [*k*t + *k*o*tc*] (*tm/T*). Machining time, *tm*, is given by , where  is a constant, f is the feed and V is the cutting velocity. Taylor tool life equation is:, *V* (m/min), f(mm/rev), T(min).

* 1. Prove that the optimal velocity is given by:



where *fm* is optimal feed.

* 1. Explain how the value of optimal feed is determined what two factors govern the feed value? If the maximum allowable motor power is Pm and maximum allowable depth of cut is dm. Assuming this process to be a turning operation find the expression for the revised optimal velocity taking into account the value of optimal feed.

1. During injection molding, a pressure driven flow in a rectangular runner of width w (perpendicular to the plane of paper) and length L is observed. The melt moves from the high pressure zone to low pressure under a pressure difference of ∆P. Assume that the pressure gradient along the runner is constant and equal to . The free body diagram of the fluid element ABDC is shown in Fig. 5 where P is pressure and τ is the shear stress.



B

C

D

A

Fig. 5 Free body diagram of the fluid element

Assuming that the shear stress in fluid observes the relationship: ; where u is the velocity in z direction at a distance y (along y-axis) from the center line. The volumetric flow (Q) in the runner is given by where dA is the cross-sectional area perpendicular to the velocity, u.

* 1. Find the relationship between the pressure gradient ( )and the shear stress (
  2. Prove that the total volumetric flow (Q) is given by:

1. The intensity (Power/area) distributions of parabolic rectangular and elliptical laser heat sources are given by Eqs. (1) and (2), respectively

(1)

(2)

where P=laser power, A=area of rectangle/ellipse, the bounds of both the rectangle and ellipse are –a ≤ x’ ≤ a and –b ≤ y’ ≤ b. Indicative figures of the distributions are shown in Fig. 6.



Fig. 6. (a) Parabolic rectangular heat source; (b) Parabolic elliptical heat source

Find the value of total incident power (P1)contained within the bounds mentioned above for:

* 1. The parabolic rectangular source
  2. The parabolic elliptical source

Use the following integral expression in part (b):