GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1998

Manufacturing
EXAM AREA

____

Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

Please **p r i n t** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

Ph.D. Written Qualifying Examination-Manufacturing Area

George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

PLEASE ANSWER **FIVE**, AND ONLY FIVE, QUESTIONS FORM THE FOLLOWING:

1. Describe all you know about statistical process control, i.e., construction of control charts and their use.

2. During heating of a previously cold worked metal, recovery, recrystallization, and grain growth occur. Describe each of these including how the residual stress, strength, hardness, ductility, and grain size change with increasing temperature (or increasing time at a given temperature). Use graphs and sketches to assist your description.

3. A thin-walled tube made of 9445 steel is being turned longitudinally on a lathe as shown in the figure below.

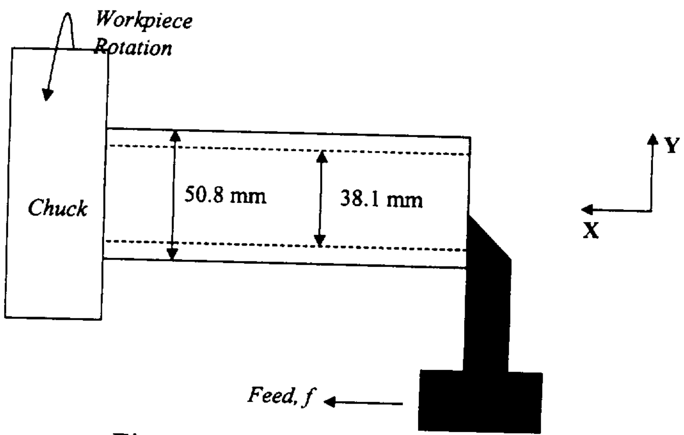


Figure. Top view of cutting process

The cutting tool is made of sintered carbide and has the following relevant tool geometry parameters: Rake angle, $\alpha = +10$ deg; Side cutting edge angle = 0 deg.

The cutting conditions being used for the above operation are as follows: Cutting Speed, V = 122 m/min; Width of cut, w = 6.35 mm; Undeformed chip thickness, t = 0.094 mm (= feed, f for the above process); .Dry cutting

Force measurements made during the cut with a piezoelectric force dynamometer yielded the following values for the three orthogonal components of the resultant machining force: $F_x = 1259$ N; $F_y \approx 0$ N, $F_z = 1601$ N

Observation of the continuous chip produced showed negligible evidence of side flow of the material, suggesting that deformation in the width direction (Y direction in the figure) can be ignored. Also, the mean deformed chip thickness, t_c, was measured to be 0.28 mm.

Based on the information and data given above, answer the following questions:

(a) Calculate the shear angle, ϕ

(b) Calculate the shear strain, γ

(c) Estimate the yield shear stress, τ, of the workpiece material

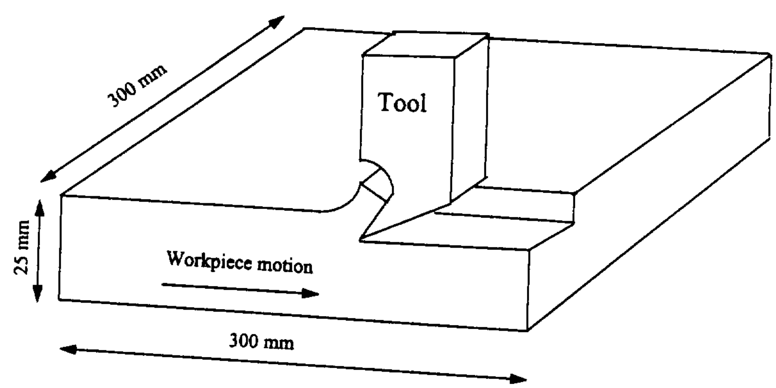
(d) Calculate the ratio of power dissipated in the shear zone to the total power dissipated in cutting.

(e) Sketch the Force Circle diagram and label all force components and angle.

(f) State at least three (3) assumptions of the underlying theory/model you used in answering (a) through (e).

(g) Is the theory/model you used above strictly valid for cutting of a highly brittle material? Give reasons for your answer.

4. A planing process is being used to machine a 300 mm x 300 mm x 25 mm flat mild steel block as shown in the figure below. The sharp single point cutting tool has a rake angle $\alpha = 10^\circ$. Other process parameters are as follows: cutting speed $V = 2$ m/s, undeformed chip thickness $t = 0.25$ mm, width of cut per pass $w = 2.5$ mm, and deformed chip thickness $t_c = 0.83$ mm. The cutting (F_c) and thrust (F_t) forces were measured during each pass with a cutting force dynamometer and found to be as follows: $F_c = 890$ N and $F_t = 667$ N. (Note: Planing is an orthogonal cutting process).



(a) Sketch (freehand is okay) the orthogonal cutting process and clearly label on the sketch the following: rake angle, cutting speed, undeformed chip thickness, deformed chip thickness, width of cut, shear angle, cutting force, and the thrust force.

(b) Calculate the percentage of total power dissipated in the primary zone of deformation (shear zone) per pass of the tool.

(c) Calculate the mean temperature rise in the chip if it is given that 10% of the shear zone power is conducted into the workpiece. Assume that the density (ρ) for mild steel is 7200 Kg/m^3 and the specific heat (c) is 502 J/kg.K. Also, assume that the cutting tool is insulated and no heat is lost to the environment.

5. In a die casting process, a pouring basin maintains metal melt of 1.5 inch height. The base of the basin is connected to a vertical sprue of 4 inch height. The cross-sectional area of the basin-sprue junction is 2 in^2. The die cavity to be filled has a volume of 230 in^3. Estimate the minimum achievable die filling time.

6. Describe the "V" molding process. What are its advantages and disadvantages over green sand molding processes?