Department of Mechanical Engineering – Clemson University

PhD Qualifying Examination

Manufacturing

January 2010

IMPORTANT:

- **You are to answer ALL EXAM QUESTIONS.**
- **Each problem will be WEIGHTED EQUALLY for grading purposes.**
- **The examination is CLOSED BOOK.**
- **No formula sheets allowed**
- **TWO HOURS are allotted for the exam**

Student Identifying Number______________________

(Please indicate your identification number on all pages.)

1. Polymer processing

(a) Assume that you are injection molding a round ball using a mold with spherical cavity, please sketch and discuss how you will model this injection molding process to estimate the whole molding cycle for a part. You may list all possible known inputs and unknown information to define this problem.

(b) A plastic part manufactured by injection molding experiences warpage due to residual stresses. What might cause these residual stresses?

2. Materials

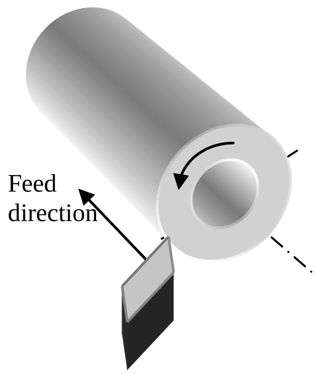
Recovery, recrystallization, and/or grain growth may occur in heat treating cold worked metallic materials. Describe each of these including how the residual stress, strength, hardness, ductility and grain size change with the increasing temperature during heat treatment. Use graphs and sketches to assist your description.

3. Forming

A drop hammer is used to upset a cylindrical workpiece. A hammer of mass, M, drops a distance, H, onto a cylindrical workpiece which is initially diameter, D, and height, h_0. The yield strength of the material is Y and is constant. Assume a frictionless contact between the hammer and the workpiece and no redundant work. Explain, either in words, or using equations, how you would calculate the amount the workpiece deflects, Δh, after this blow, and the average force exerted on the workpiece.

4. Machining

In a single point turning operation, the cylinder shown below is being machined. The rough workpiece has an initial outer diameter of 150mm, inner diameter of 100mm, and is 250 mm long. The required finish outer diameter is 142mm. The radial depth of cut for each pass is 1mm. The axial feed rate is 200 mm/min, and the spindle speed is 2000 rpm. The specific cutting energy of the workpiece material is K_s = 1300 N/mm^2.



a.) What is the volume of material to be removed from the rough workpiece?

V = ______________mm^3

b.) What is the tangential component (perpendicular to feed direction and tangent to the cylinder) of the cutting force?

F_t = ______________N

c.) What is the material removal rate during the first pass?

MRR = ______________ mm^3/min

d.) What is the minimum time required to machine the part? (Ignore the time needed to reposition the tool for multiple passes.)

T = __________________ min

e.) What is the minimum spindle power required?

P = __________________ W