Department of Mechanical Engineering – Clemson University

PhD Qualifying Examination

Manufacturing

January 2009

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.)

Manufacturing Ph.D. Qualifying Exam Student ID # _____
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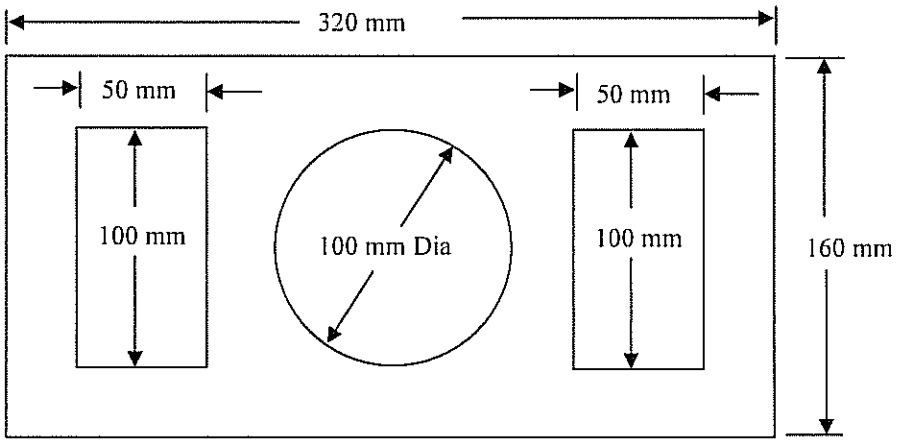
1. A face plate for an instrument is to be punched out of aluminum sheet. The sheet thickness is 1.5 mm and the yield stress of the material is Y = 105 MPa. The plates are produced at the rate of 900 per hour. The penetration factor is p = 0.35.



a) What punch force is required? (Note: both the external perimeter and the internal holes are punched from a larger sheet at the same time)

F_{punch} = _____N

b) What is minimum motor power required for the machine?

P_{ave} = _____Kw

2. Welding

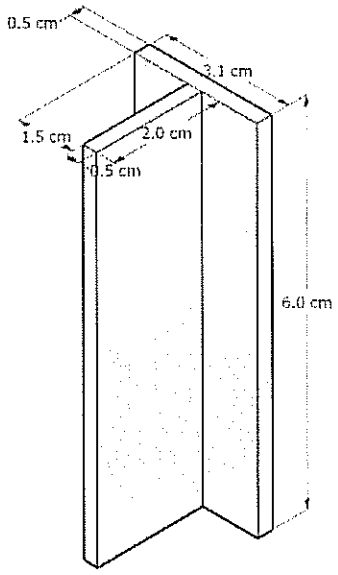
a) Briefly describe the primary characteristic that distinguishes "welding" from "brazing".

b) Two 10 mm thick steel plates are being arc-welded together in an automated production process. The total length of the weld for each assembly is 300 mm. The weld bead is 10 mm thick by 6 mm wide. The process uses a constant voltage power supply with V = 25 Volts. The specific energy of the material is 10.1 J/mm^3, and the efficiency of the process is 80%. If the goal is to produce 5 assemblies per minute, what current is necessary?

I = _____ amps

Student ID # _____

3. A simple T-bracket shown below is made through injection molding. Examine the part and its dimensions to select the appropriate parting planes to minimize the clamping forces (sketch/label the parting plane). What is the minimum clamping force assuming that the peak pressure is 40 MPa?

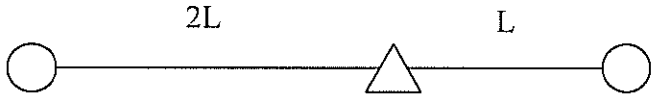


a) What issues are important to consider in molding this part and how might these issues drive the choice of parting plane?

b) Sketch an appropriate mold, labeling all cores and cavities as appropriate.

Student ID # _____

4. A simple two gate + runner system (**Error! Reference source not found.**) is configured so that the lengths of the two runners from the sprue (triangle) are not equal, but the parts (circles) at either end are the same (T-bracket). Determine the runner diameters such that the parts fill equally. Assume a Newtonian flow through a round channel $Q = \frac{\pi P r^4}{8 \mu L}$. If necessary, assume a melt viscosity of 350 Pa s.



5. A slab-milling operation is being carried out on a 30-in.-long, 6-in.-wide high-strength-steel block at a feed of 0.01 in./tooth and a depth of cut of 0.15 in. The cutter has a diameter of 3 in., has eight straight cutting teeth, and rotates at 150 rpm. The unit power of this steel is 3 Ws/mm^3 or 1.1 $hp\text{-}min/in^3$.

a) Calculate the material removal rate and estimate the power required.

b) Estimate the cutting time required.

6. Casting quality depends on different casting conditions. It is important to understand some general rules as follows.

a) We know that pouring molten metal at a high rate into a mold has certain disadvantages. Are there any disadvantages to pouring it very slowly? Explain.

b) It has long been observed by foundry-men that low pouring temperatures, i.e., low superheat, promote equiaxed grains over columnar grains. Explain these phenomena.