M.E. Ph.D. Qualifier Exam
Fall Semester 2003

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2003

Manufacturing
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

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

Fall Semester 2003 Ph.D. Qualifying Written Examination
Manufacturing

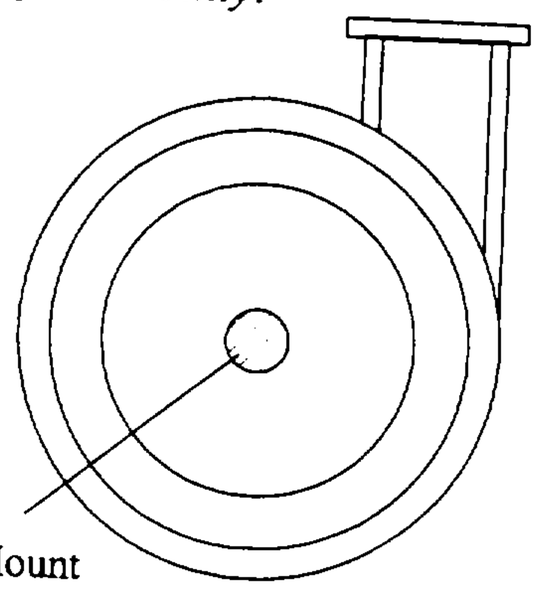
1. Turbine blades in jet engines are manufactured primarily by two types of casting processes yielding very different crystalline microstructures. In the first process conventional casting methods are used where the molten material is poured into a mold cavity to solidify resulting in a *polycrystalline* structure having numerous grains and associated grain boundaries. The second process uses a special single crystal growth technique to form turbine blades made from a *single* crystal structure.

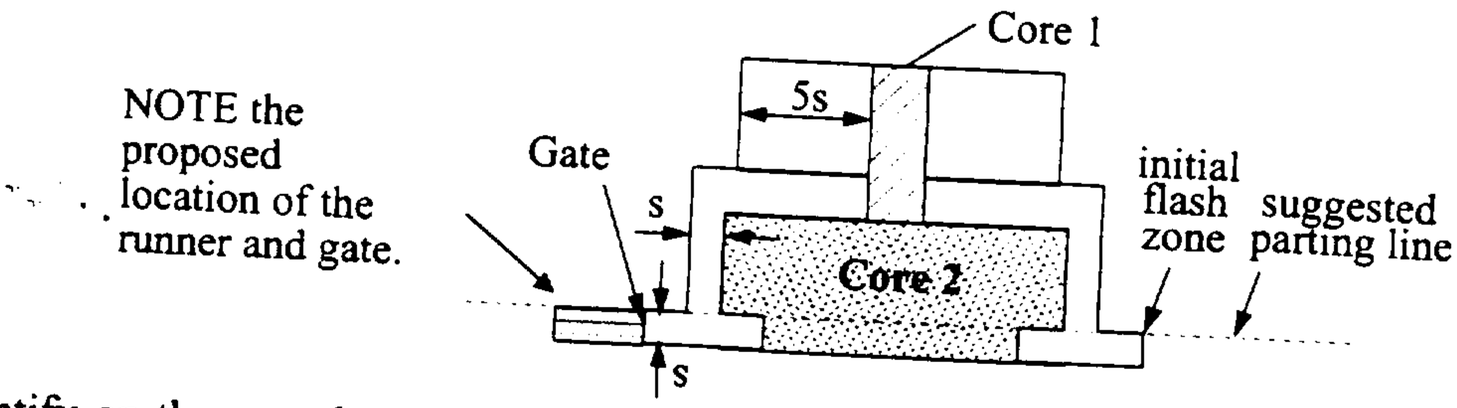
(a) For turbine blades made of the same material, sketch the engineering stress-strain curves one would expect to get from a simple tension test on the respective cast structures.

(b) Briefly explain the significance of the two types of microstructures on plastic deformation of the turbine blades with respect to the physical mechanisms governing deformation.

(c) Briefly explain the process required to cast the single crystal turbine blade structure. Be specific regarding how the mold is structured, the crystal orientation is determined, and the single crystal is formed.

2. The "Design" department sends you this drawing of a pump housing, part of the companies latest fluid distribution product line. Since it is a large part to be produced in low volume, you select sand casting as the base process. The design team suggests a ***parting line*** for the cast mold as shown which confines flashing between the cope and drag to the corners of the part. It is your task to *redesign the part for manufacturability*.



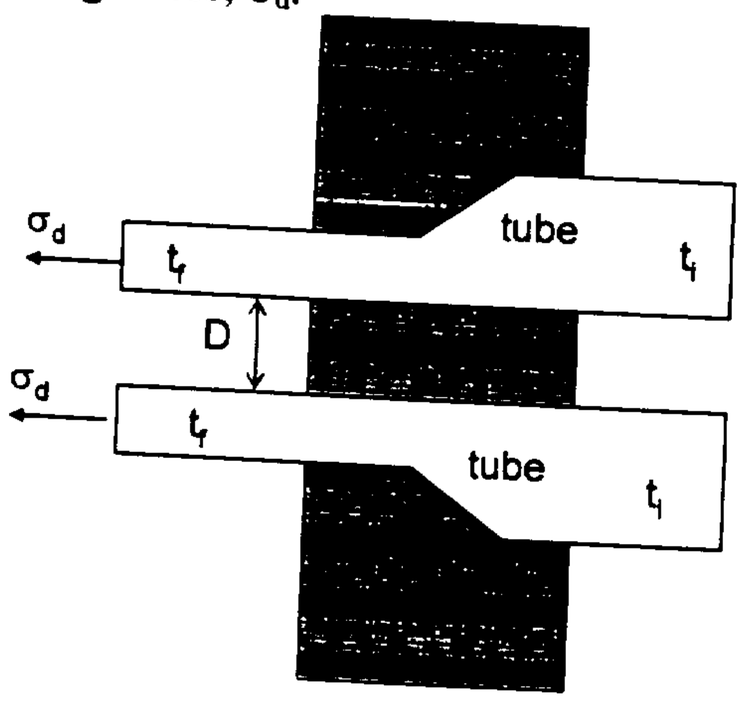


(a) Identify on the part drawing above AND list below, all the potential casting defects and or molding problems of the current design. Use terminology specific to casting defects.

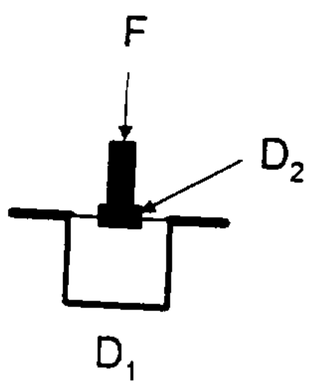
(b) In order to reduce the cost of the mold, sketch a part redesign and mold redesign (which could include gate location, parting line location/orientation, etc.) which eliminates the need for Core 2 and greatly reduces the likelihood of the defect/molding problems identified in part (a).

(c) Estimate the ratio of maximum to minimum solidification times for the original pump housing design. Calculate a specific number.

3. You are drawing a cylindrical tube from a strain hardening material at room temperature (see figure). The tube has initial thickness t_i , and final thickness t_f. The die has angle α, which is small. The coefficient of friction between the mandrel and the tube, as well as the die and the tube, is μ. Determine the drawing stress, σ_d.



4. Consider the cylindrical piercing operation shown below, performed in a container which prevents spreading. You may assume the process is performed at room temperature on a material, which can be modeled as strain hardening. The container has a diameter D_1 and the punch performing the piercing operation has a diameter D_2. Determine the piercing force, F.



5. A single point turning operation was performed to machine a 3" diameter low carbon steel cylindrical workpiece with a high speed steel cutting tool of 10^O rake angle. The process parameters are 0.02 in/rev feed, 0.1 inch radial depth of cut, and 3000 rpm spindle speed, and the required spindle motor power was 1.8 HP. If the process is to be performed under 0.02 in/rev feed, 0.35 inch radial depth of cut on a 2" diameter workpiece, what would be the spindle speed to maintain the power at 1.8 HP? In your calculation, what are the assumptions involved?

6. In the selection of cutting tool material for machining operations, what are the most important two tool material characteristics? What are the process performance issues that will be significantly affected by these two tool materials characteristics? In what way? List five cutting tool materials and rank the two materials characteristics of these tools.