GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2000

Manufacturing
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

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

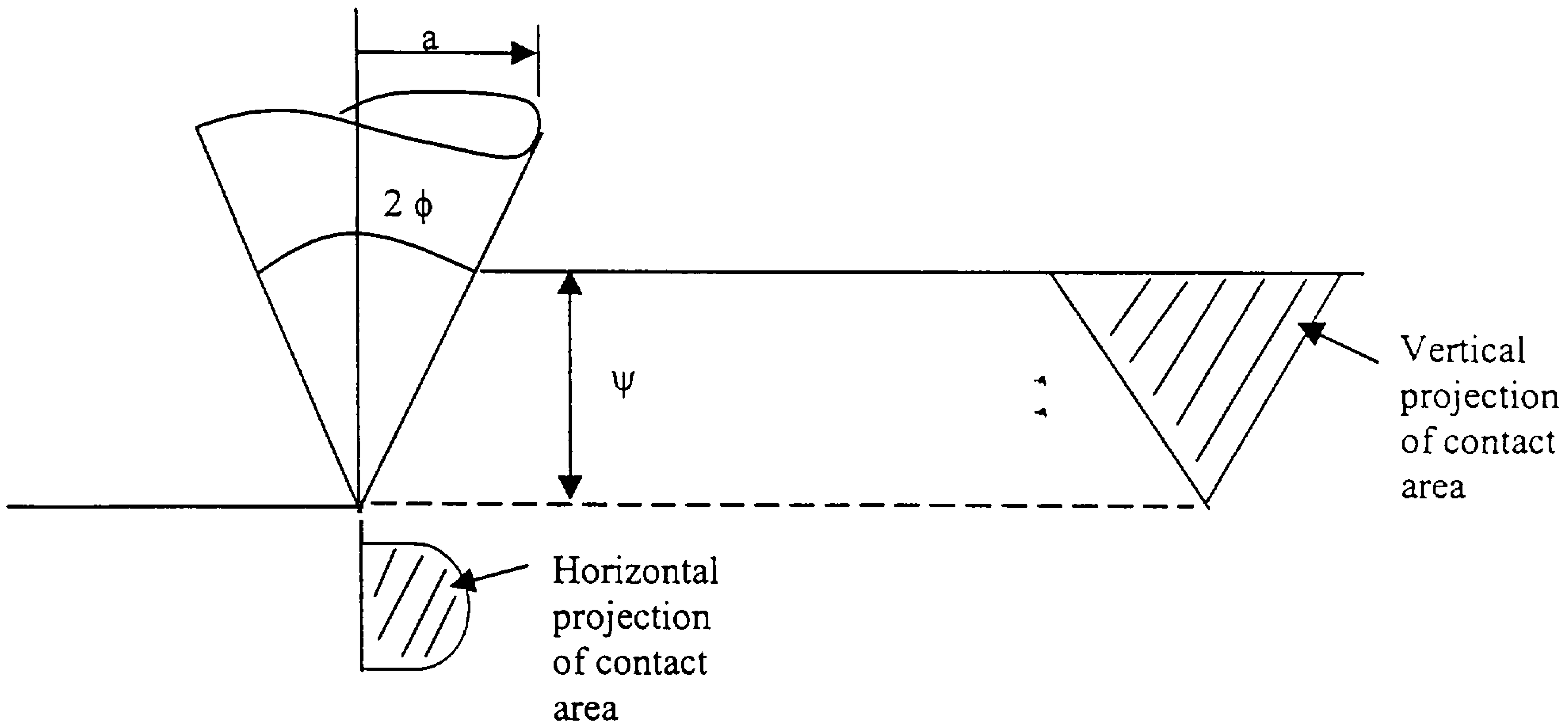
Ph.D. Written Qualifying Examination-Manufacturing Area
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Fall 2000

Note: Answer two, and not more than two, of the following questions:

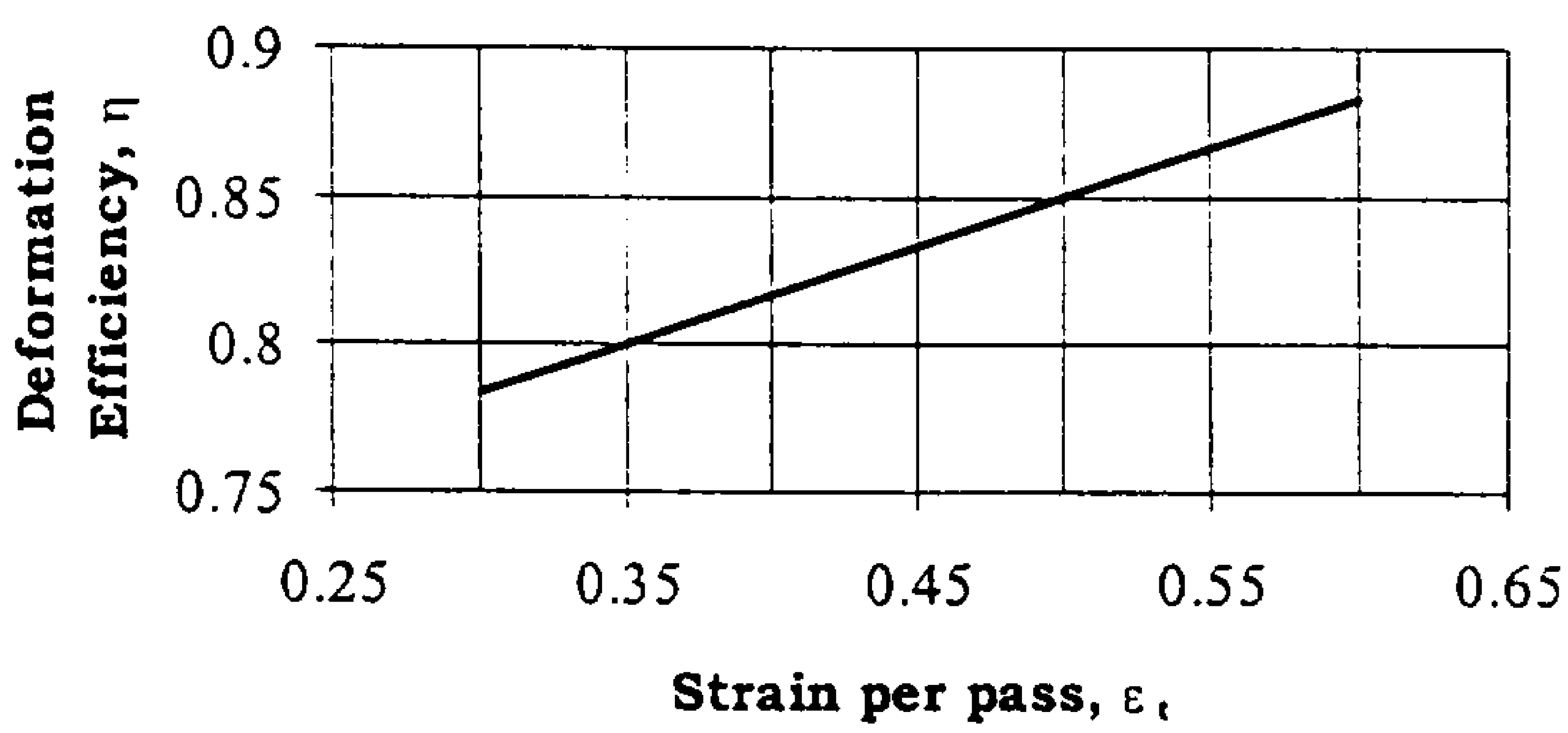
1. Grinding is a multipoint machining operation where each individual grit particle sweeps out a given volume of material. Using the figure below

    (a) Derive an expression for the volume removed per contact (sliding) distance in terms of the load and geometry of the particle. Assume that the grit particle is harder than the metal workpiece, whose yield strength is σ_y.

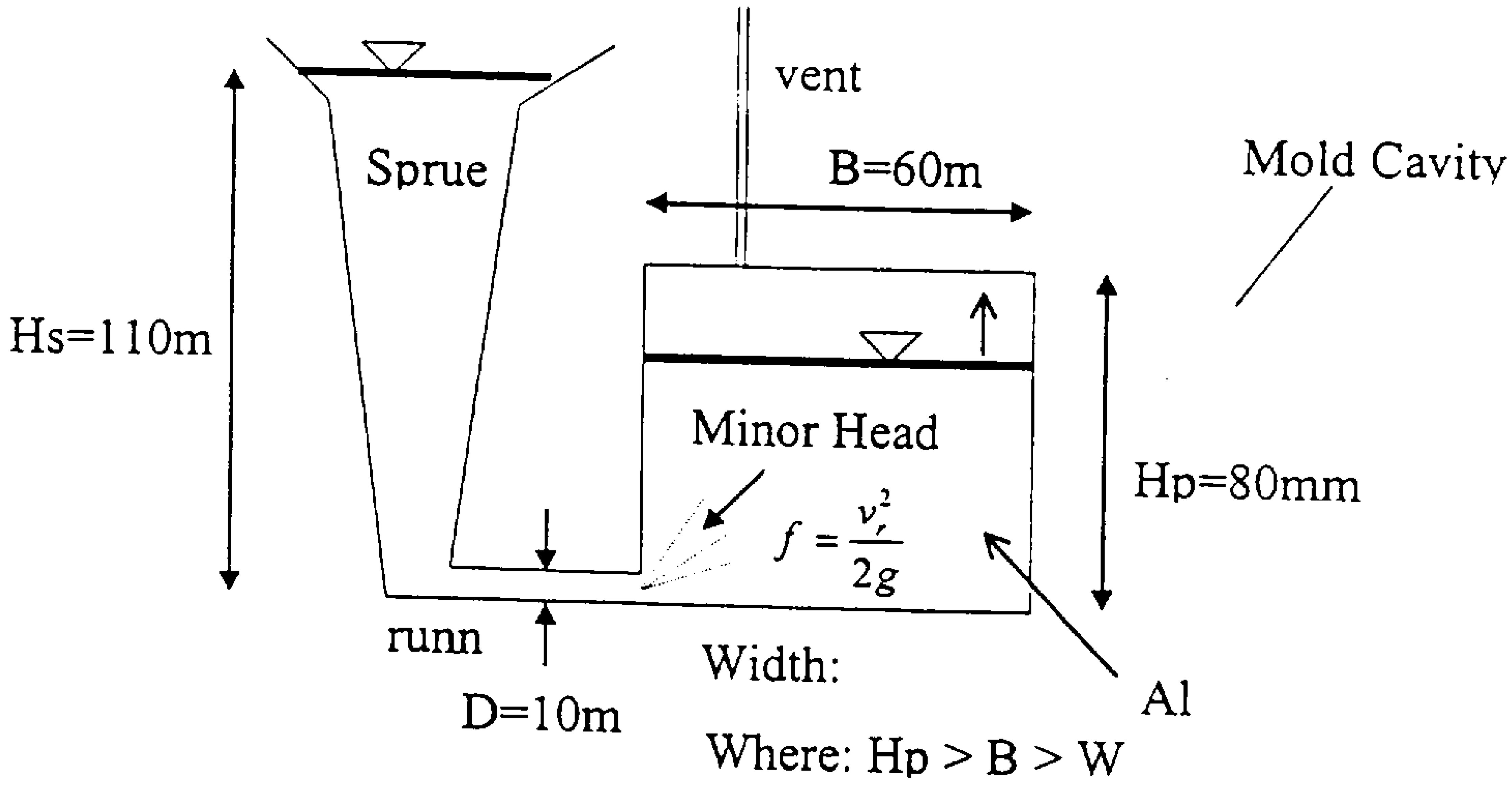
    (b) Extrapolate these expressions you have derived to a grinding wheel containing η particles/m^2 and describe the effect the sharpness and density of particles will have on the rate of material removal.



2. The Electric Wire Company is planning a wire-drawing operation to produce copper wire. You have been asked to determine the minimum number of drawing passes required to reduce copper wire from 0.635 mm diameter to 0.254 mm diameter. Laboratory experiments using the same die, die angle and lubrication that will be used in actual production have shown that the deformation efficiency, η, depends on the true strain induced in the material per pass, ε_t, as shown in the figure below. The deformation efficiency η is defined as the ratio of the ideal work of drawing to the total work of drawing (i.e. including friction and redundant work). To ensure that no drawing failures occur, assume that the deformation efficiency in actual production is 75% of that measured in the laboratory. Also assume that the drawn wire is annealed after each pass to recover its original mechanical properties. Determine the minimum number of drawing passes required in actual production (rounded to the next integer) such that the drawing stress, σ_d, in each pass never exceeds 60% of the flow stress of the wire material. The flow stress of annealed copper is given as $Y_f = 315\varepsilon_t^{0.54}$ MPa.



3. A relatively small rectangular part is being ***die cast*** as shown below. As a manufacturing engineer, you are asked to estimate the cycle time for casting the part.



(a) Estimate the Reynolds number for the flow in the runner. Base your subsequent analysis on the appropriate flow approximation (laminar or turbulent).

(b) Derive an expression to estimate the mold filling time. Note for the mold design given, the runner is short producing negligible flow losses. The head loss associated with the free expansion of the flow at the exit of the runner is significant and given by the factor $f = K\frac{v^2}{2g}$ where $K \approx 1.0$.

(c) Using this expression as a guide, suggest two mold redesign strategies (i.e., changes) that will decrease the casting cycle time, given that the dimensions of the part are fixed by the design specifications.

(d) If the runner solidifies in a time of t_{runner}=60s, derive an expression to estimate the cooling time of the ***die*** cast part and calculate the value. Note that the cooling rates for die cast parts and sand cast parts vary considerably.

(e) Based on the ratio of solidification times of the runner and the part, what additional feature(s) (list two possibilities) would you include in the mold design to prevent ***casting defects***.

(f) Sketch on a relative scale the temperature profiles across the mold/part system shown for both insulating molds, like sand casting, and high heat transfer rate molds like in die casting (approximate the temperature profile based on plane front solidification) Focus only on the part and adjacent mold walls.