ME361 – Manufacturing Science and Technology

Mid-semester exam

Exam duration: 2 hours

Exam is worth 30% of your final grade

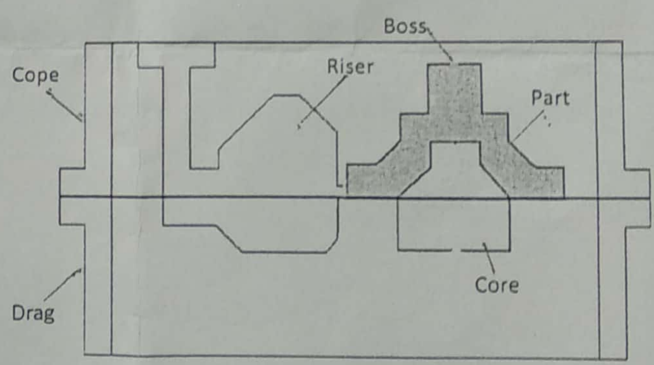
Notes: (i) Exam has six questions. (ii) Question paper spans one page (back-to-back) (iii) One double-sided A4 formula sheet is allowed in. Please submit the formula sheet along with your answer sheet (iv) Use of calculator is permitted (v) Make and state all assumptions as necessary. No clarifications will be provided in the exam (vi) Please answer each question on a new page

Question 1 [5]

A sprue is 200 mm long, and has a diameter of 50 mm at the top, where the metal is poured. The molten metal level in the pouring basin is taken as 40 mm from the top of the sprue for design purposes. If a flow rate of 600 cm^3/sec is to be achieved, what should be the diameter of the bottom of the sprue? Will the sprue aspirate? Explain.

Question 2 [2]

Porosity develops in the boss of the casting shown on the right. Show that by simply repositioning the parting line of this casting, this problem can be eliminated. Redraw the full schematic with the corrected parting line to help avoid porosity in the boss.



Question 3 [5]

A cylindrical riser is to be used for a sand-casting mold. For a given cylinder volume, determine the diameter-to-length ratio that will maximize the time to solidify. Show all steps/reasoning.

$t \Rightarrow C l^2$ $\quad t_s = C\left(\frac{V}{A}\right)^2$ $\quad V \Rightarrow T$

$\frac{dt}{dV} \times \frac{dV}{dl}$ $\quad V \Rightarrow (l, d)$

$dV \Rightarrow \frac{dV}{dl} d + l \frac{dV}{dd}$

$-\left(\frac{dV}{dl}\right) d = l \left(\frac{dV}{dd}\right)$

Question 4

[8]

Consider thick plate welding using the corresponding explicit formulas for temperature profiles (given in the notes, and discussed in class). For welding alloy steel, you may take $\lambda = 0.049\ \text{sec/mm}^2$ and $k = 38\ \text{N/sec}\ ^\circ\text{C}$. The traversing velocity is $v = 5\ \text{mm/sec}$. Melting temperature for the alloy steel under consideration is $T = 1510\ ^\circ\text{C}$, and the initial temperature is $T_o = 20\ ^\circ\text{C}$.

a. Determine the input power, q' (mW), at the surface, i.e. for $z = 0$, and in the Y, Z plane, i.e. at $\xi = 0$, for a weld width of $y = 10\ \text{mm}$

b. Determine the distance ξ behind the arc, at which the cooling gradient, $\frac{dT}{dt}$, is the steepest. Hint: For this, you may need to first derive the expression for the temperature profile in the ξ, z plane, for $z = 0$, and for $\xi < 0$. (Additional hint: you may also need to use the coordinate transformation from x to ξ, and its derivatives, i.e. $\frac{\partial \xi}{\partial x}$ and $\frac{\partial \xi}{\partial t}$ for obtaining $\frac{dT}{dt}$, the gradient)

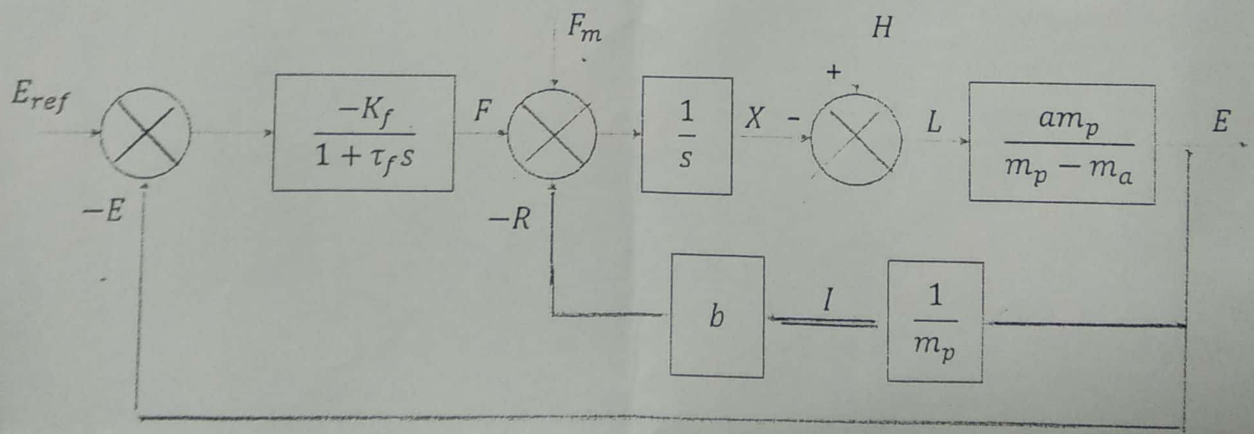
c. Determine the cooling rate ($\frac{dT}{dt}$) at the above obtained point.

d. Comment on what you could possibly do to slow down (decrease) the cooling rate

Question 5

[5]

Shown below is the block diagram of the servo control of a submerged arc welding process (SAW). It includes a feed-drive servomotor with gain K_f, and time constant τ_f. Desired arc voltage, E_{ref} is used as an input. Express the relationship between E and F only for the internal loop in terms of a transfer function, i.e. obtain: $\frac{E}{F}$ =? You may assume that the disturbances, H, and F_m are zero, and for simplicity, you may define, if you like, $k_{il} = \frac{a}{m_p - m_a}$.



Question 6

[5]

Determine the percentage change in the machining time for an ultrasonic machining (USM) operation cutting tungsten carbide (WC) plates when the tool material is changed from copper (Cu) to stainless steel (SS). You may assume that everything else remains the same. And, in the case that you need to know, WC is much harder than Cu and/or SS, i.e. $\frac{H_{WC}}{H_{Cu}} \gg 1$, and/or $\frac{H_{WC}}{H_{SS}} \gg 1$, and the hardness of copper is ~80 BHN, and that of SS is ~225 BHN.