MKT 4161 MANUFACTURING TECHNIQUES

HW-1

Due: October 19, 2017 (beginning of the lecture)

ATTENTION:

1. Hand-write the solution on A4 size paper sheets.
2. You may use a pen or a pencil.
3. Use backsides of the sheets
4. DO NOT use cover sheet. Make sure you print your name and ID on the top each sheet.

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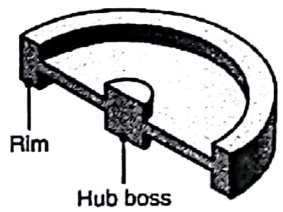
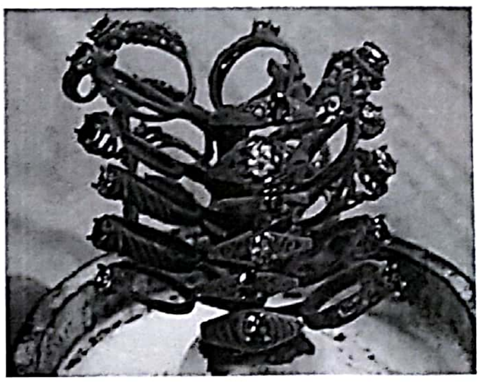
QUESTIONS

1. A cylinder with a diameter of 40 mm and height of 80 mm solidifies in 3 minutes in a sand casting operation. What is the solidification time if the cylinder height is doubled? What is the time if the diameter is doubled?
2. Pure copper is poured into a sand mold. The metal level in the pouring basin is 10 in. above the metal level in the mold, and the runner is circular with a 0.4-in. diameter. What are the velocity and rate of the flow of the metal into the mold? Is the flow turbulent or laminar?
3. For the cast metal wheel illustrated in figure, show how

   a) riser placement ; b) core placement; c) padding and d) chills maybe used to help feed molten metal and eliminate porosity in the isolated hub boss.



4. A jeweler wishes to produce 24 gold rings in one investment-casting operation, as illustrated in figure. The wax parts are attached to a wax central sprue 12 mm in diameter. The rings are located in four rows, each 12 mm from the other on the sprue. Estimate the weight of gold needed to completely fill the rings, runners and sprues. The specific gravity of gold is 19.3. (Assume a ring has 20 mm outer diameter, 15 mm outer diameter, 10 mm width)



1) $A = 2\left(\frac{\pi}{4}d^2\right) + \pi d h = \frac{\pi}{2} \cdot (20\text{ mm})^2 + \pi \cdot (20\text{mm}) \cdot (80\text{mm})$

$= 628{,}3 + 5026{,}54$

$\cong 5655 \text{ mm}^2 = 1800\,\pi \text{ mm}^2$

$\Rightarrow$ Volume $= \frac{\pi}{4} d^2 h = \frac{\pi}{4}(20\text{mm})^2 \cdot (80\text{mm}) = 25132 \text{ mm}^3$

$= 8000\,\pi \text{ mm}^3$

$\Rightarrow$ Solidification time: $C\left(\frac{V}{A}\right)^2 \Rightarrow \underline{3 \text{ min}} = C\left(\frac{8000 \cdot \pi}{1800\,\pi}\right)^2$

$\Rightarrow C = 0{,}1518 \text{ min}/\text{mm}^2$

If the height is doubled $\underline{\Rightarrow h = 160 \text{ mm}}$

$\Rightarrow A = 2\left(\frac{\pi}{4}\right)d^2 + \pi d h = \frac{\pi}{2} \cdot 20^2 + \pi \cdot 20 \cdot 160$

$= 3400 \text{ mm}^2 \cdot \pi$

$V = \frac{\pi}{4} d^2 h = \pi \cdot \frac{400}{4} \cdot 160 = 16000\,\pi \text{ mm}^3$

$\Rightarrow$ Solidification time $\Rightarrow C\left(\frac{V}{A}\right)^2 = 0{,}1518 \text{ min}/\text{mm}^2 \left(\frac{16000\pi \text{ mm}^3}{3400 \text{mm}^2 \pi}\right)^2$

$\boxed{= 3{,}36 \text{ min}}$

$\Rightarrow$ If $h = 80$ mm but $\underline{d = 80 \text{ mm}}$! $\Rightarrow$ We will use 40mm!

$A = \frac{\pi}{2} d^2 + \pi d h = 800\,\pi + 3200\,\pi = 4000\,\pi \text{ mm}^2$

$V = \frac{\pi}{4} d^2 h = \frac{\pi}{4} \cdot 1600 \cdot 80 = 32000\,\pi \text{ mm}^3$

$\Rightarrow$ Time $= C\left(\frac{V}{A}\right)^2 = 0{,}1518 \text{ min}/\text{mm}^2 \left(\frac{32000 \text{ mm}^3 \pi}{4000\,\pi \text{mm}^2}\right)^2$

$\boxed{= 9{,}7152 \text{ minutes}}$

2) $h_1 + \frac{V_1^2}{2g} = h_2 + \frac{V_2^2}{2g}$ ⇒ Assume that the pressure doesn't change in the channel!!

⇒ At first we assume that velocity at the top of the sprue is very low ⇒ $V_1 = 0$!

$\Rightarrow h_1 = h_2 + \frac{V_2^2}{2g} \Rightarrow V_2^2 = (h_1 - h_2)\,2g$

$\Rightarrow V_2 = \sqrt{2g\Delta h} = \sqrt{2 \cdot 132{,}2\ ft/s^2\,(12\ in/ft)\,(10\ in)}$ (g)

$= 87{,}9\ in/s$

⇒ Opening diameter ⇒ 0,4 in!

→ $Q = V_2 A \Rightarrow A = \pi r^2 = \pi (0{,}2)^2 = 0{,}125\ in^2$

$\Rightarrow Q = 87{,}9\ in/s \cdot 0{,}125\ in^2$

$= 11\ in^3/s$

→ $\rho_{copper} = 8970\ kg/m^3 = 0{,}0668\ lb/in^3$ } from table!

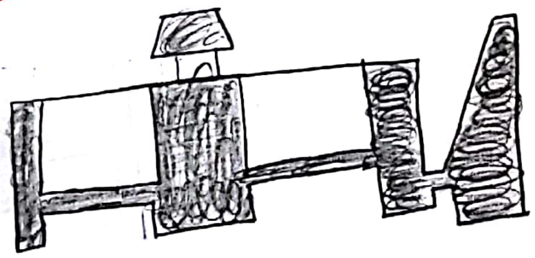
Viscosity of copper ⇒ $0{,}15 \cdot 10^{-6}\ lb\text{-}s/in^2$

⇒ $V_2 = 87{,}5\ in/s = 2{,}23\ m/s$

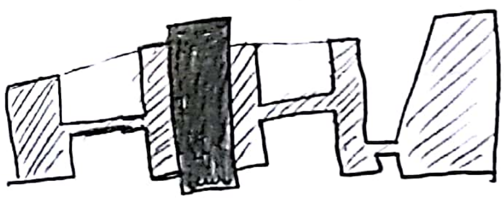
$A = 0{,}125\ in^2 = 0{,}807 \cdot 10^{-5}\ m^3/s$

* Flow is turbulent!

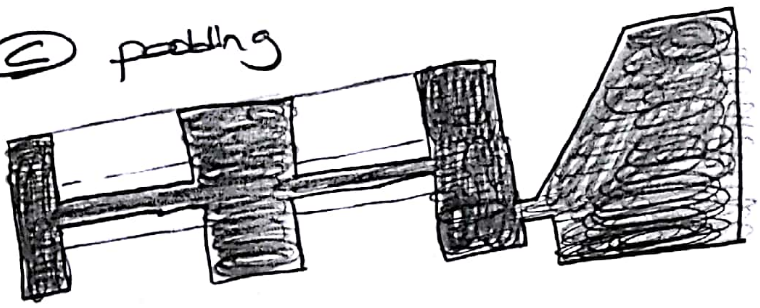
3) a) riser placement



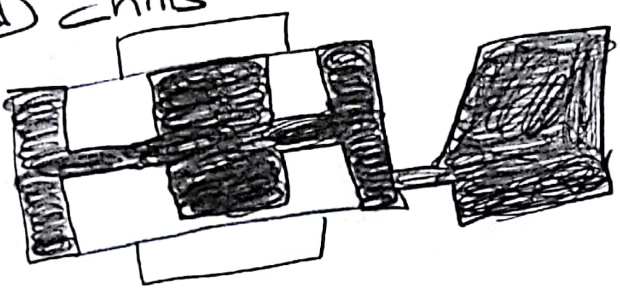
b) core placement



c) padding



d) chills



④ Outer diameter $\Rightarrow$ 20 mm   Width $\Rightarrow$ 10 mm

Inner diameter $\Rightarrow$ 15 mm

Typical ring as a tube!

$\Rightarrow$ Volume: $V = \frac{\pi(r_o^2 - r_i^2)}{4} . L = \frac{\pi(20^2 - 15^2)}{4} .10$

$= 1374,4 \text{ mm}^3$

$\Rightarrow$ 24 ring $\Rightarrow$ $24 . 1374,4 \cong \underline{32986,72 \text{ mm}^3}$

$\Rightarrow$ 24 runners: Assume the runner dimensions for sprue as: 4 mm diameter - 10 mm long runner : Central sprue length 40 mm

$V = \frac{\pi}{4} d^2 L = \frac{\pi}{4} (4 \text{ mm})^2 . 10 \text{ mm} \Rightarrow \frac{24 . 16 . 10 . \pi}{4} = \underline{3016 \text{ mm}^3}$

$\Rightarrow V = \frac{\pi}{4} d^2 L$ for central sprue $\Rightarrow V = \frac{\pi}{4} . 12^2 . 40 = \underline{4523,9 \text{ mm}^3}$

Finally total volume: $V_T = 32986,72 + 3016 + 4523,9$

$= 40,526,62 \text{ mm}^3$

If the spesific gravity of gold $\Rightarrow$ 19,3 $\Rightarrow$ $\underline{\rho = 19,300 \text{ kg/m}^3}$

so $m = \frac{19300 . 40,526,62}{10^9} = 0,782$ kg gold!