Design calculations

Tee Casting

* casting weight - 2900 grams
* over flow weight - 500 grams
* Runner weight - 1800 grams
* Shot weight - 5200 grams
* Density - 2.6 $gram/cm^3$
* Plunger diameter - 100 mm
* Active Sleeve length - 680 mm

1) Tonnage Calculation

T = projected area of Component [including runner and over flow] × specific casting pressure × Factor of Safety

$$T = \overset{\rightarrow mm^2}{130392.45} \times \frac{\overset{kgF/mm^2}{700}}{100} \times \overset{\rightarrow FOS}{1.2}$$

$$T = 1095296.58 \text{ kgF} \Rightarrow \frac{1095296.58}{1000} = 1095.29 \text{ T}$$

$$\boxed{T = 1095.29 \text{ Ton}}$$

2) Shot volume

$$= \frac{\text{Shot weight}}{\text{Density}} \Rightarrow \frac{\overset{\rightarrow grams}{5200}}{2.6 \rightarrow g/cm^2} \Rightarrow 2000 \text{ cm}^3$$

$$\boxed{\text{Shot volume} = 2000 \text{ cm}^3}$$

3) Sleeve volume

$$= \frac{\pi}{4} \times D^2 \times L \quad \Rightarrow \frac{3.14}{4} \times 10^2 \times 68 \Rightarrow 5338\,cm^3$$

($D \rightarrow$ Plunger dia, $L \rightarrow$ Active sleeve length; $10^2 \rightarrow cm^2$, $68 \rightarrow cm$)

$$\boxed{\text{Sleeve volume} = 5338\,cm^3}$$

4) Fill ratio

$$= \frac{\text{Shot volume}}{\text{Sleeve volume}} = \frac{2000}{5338} = \cancel{\text{8338}}\ 0.3746$$

($2000 \rightarrow cm^3$, $5338 \rightarrow cm^3$)

$$= 0.3746 \times 100 = 37.46\,\%$$

$$\boxed{\text{Fill ratio} = 37.46\,\%}$$

5) Fill time

k = Conductivity [For H13 = 0.0346 sec/mm]

t = casting wall thickness mm

T_i = Temp of metal when Enters in die

T_F = Solidification point of metal 570°c const

T_d = Die temperature before Shot.

S = Solidification Factor [For HPD = 25% Const]

Z = Unit Conversion Factor [For Z = 3.8 °c/%]

$$F_T = k\left[\frac{T_i - T_F + (SZ)}{T_F - T_d}\right] \times t$$

$$= \underset{s/mm}{0.0346}\left[\frac{\overset{[°C\ -\ °C]\ +\ \%\ °C/\%}{640 - 570 + 25 \times 38}}{\underset{°C\qquad °C}{570 - 170}}\right] \times \overset{mm}{4}$$

$$\boxed{F_T = 0.057 \text{ sec}}$$

6) <u>Discharge</u>

$$Q = \frac{\text{weight after gate}}{\text{Density} \times \text{Fill time}}$$

$$= \frac{3400 \rightarrow g}{\underset{g/cm^3}{2.6} \times 0.057 \text{ sec}} = 22941.97 \ cm^3/s$$

$$\boxed{Q = 22941.97 \ cm^3/s}$$

7) <u>Plunger area</u>

$$= \frac{\pi}{4} \times D^2 = \frac{3.14}{4} \times 10^2 \overset{cm \times cm = cm^2}{=} 78.5 \ cm^2$$

$$\boxed{\text{Plunger area} = 78.5 \ cm^2}$$

8) <u>S1</u>

$$S1 = L - [S_2 + [\text{Biscut thickness}]]$$

$$S_2 = \frac{\text{Weight after gate}/2.6}{\text{Plunger are}} = \frac{\overset{g}{3400}/2.6 \ g/cm^3}{78.5 \ cm^2}$$

$$S_2 = 16.6 \ cm \Rightarrow 166 \ mm$$

$$\boxed{S2 = 166 \ mm}$$

$$S1 = L - [S_2 + \text{Biscut Height}]$$

$$S1 = \underset{mm}{680} - [\underset{mm}{166} + 30]$$

$$\boxed{S1 = 484\ mm}$$

9) Velocity (v_2)

$$v_2 = \frac{\text{Discharge}}{\text{plunger surface area}} = \frac{\overset{cm^3/s}{22941.97}}{\underset{cm^2}{78.5}}$$

$$v_2 = 292.25\ cm/s$$

$$\boxed{v_2 = 2.92\ m/s}$$

10) <u>Gate area</u> :- <u>Method 1</u>

$$G_A = \frac{\text{weight after gate}}{\text{Density} \times \text{Fill time} \times \text{gate velocity}}$$

Considering Gate velocity = 40 M/s => 4000 cm/s

$$G_A = \frac{3400 \rightarrow gram}{\underset{gram/cm^3}{2.6} \times \underset{sec}{0.057} \times \underset{cm/sec}{4000}} = \frac{3400}{592.8}$$

$$G_A = 5.73\ cm^2 \Rightarrow 5.73 \times 100 = 573\ mm^2$$

$$\boxed{G_A = 573\ mm^2} \Rightarrow \text{Method : 1}$$

10(b)) Gate area [Method :2]

$G_A\ G_V = P_A\ P_V$

G_A = Gate area

G_V = Gate velocity

P_A = Plunger area

P_V = Plunger velocity

$$G_A = \frac{P_A \times P_V}{G_V} = \frac{\overset{cm^2}{78.5} \times \overset{\to cm/s}{292}}{4000\ cm/s} = 5.73\ cm^2$$

$$\boxed{G_A = 573\ mm^2}$$

11) Velocity (V_1) [Method :1]

$$V_1 = \frac{\sqrt{\text{Plunger dia}}^{\,mm} \times \text{Coefficient Factor}^{\to 0.7 \text{ constant}}}{\text{Fill ratio } \%}$$

$$V_1 = \frac{\sqrt{100}^{\to mm} \times 0.7}{37\ \%}$$

$$\boxed{V_1 = 0.189\ m/s}$$

11(b)) Velocity (V_1) [Method :2]

$$V_1 = C_c \left[\frac{100\% - \text{Fill ratio } \%}{100\ \%}\right] \times \sqrt{d_t}$$

C_c = Curved constant $[0.579 \times 2]$ m/s

d_t = Plunger dia in m

$$v_1 = 0.579 \times 2\left[0.3746\right] \times \sqrt{0.1}$$

$$\boxed{v_1 = 0.136\ M/s}$$

[Note :- For v_1 calculation there is a problem with unit cancellation and there is no constant formula]

12) Pressure hydraulic

$$P_s = \left[\frac{D_H}{D_P}\right]^2 \times P_h$$

P_s = Specific casting pressure

D_H = Hydraulic cylinder piston diameter on selected Machine

D_P = Plunger diameter

P_h = Hydraulic pressure

Recommended pressure

Standard part	=	400 bar
Technical part	=	400 to 600 bar
pressure tight part	=	800 to 1000 bar

$$P_s = \left[\frac{D_H}{D_P}\right]^2 \times P_h$$

$$\underset{bar}{700} = \left[\frac{160\ \cancel{mm}}{100\ \cancel{mm}}\right]^2 \times P_h$$

$$700 = 2.6 \times P_h$$

$$P_h = \frac{700}{2.6}$$

$$\boxed{P_h = 269.23\ bar}$$

13) vent area [Method : 1]

$$\text{Vent area} = \frac{\text{Discharge}}{\text{Air velocity}}$$

Air velocity = 200 to 300 M/s => 200 00 cm/s

$$\text{Vent area} = \frac{22941.97 \rightarrow cm^3/s}{20000 \rightarrow cm/s} = 1.147\,cm^2$$

$$\boxed{\text{vent area} = 114.7\,mm^2}$$

13 (B) vent area [Method : 2]

$$V_A\,V_r = P_A\,P_r$$

$$V_A = \frac{P_A \times P_r}{V_r} = \frac{\overset{cm^2}{78.5} \times \overset{cm/s}{292}}{20000\,cm/s}$$

$$\boxed{V_A = 1.146\,cm^2} \Rightarrow 114.6\,mm^2$$

$$\boxed{V_A = 114.6\,mm^2}$$

14) Gate and Runner design

As per calculation Gate area is = 573 mm^2

Runner area = [1.2 to 1.3] times x Gate area (→ Assumption)

Assuming Runner area = 1.2 x Gate area [Condition - 1] by dividing into 4 gates $= \frac{573}{4} = 143.25$ mm²

Gate:1 [considering gate thickness 3m] $= (\overset{\text{width}}{4}8 \times \overset{\text{depth}}{3}) = 144$ mm²

Runner area = Runner width × Runner depth [Condition - 2]

Runner width = 1.5 times × Runner depth

[So according to Condition - 2]

Runner area = 1.5 times of Runner depth × Runner depth

Runner area = $1.5 \times Rd \times Rd$

$\boxed{\text{Runner area} = 1.5 \times Rd^2}$ → [Condition - 2]

Runner area (Condition - 1) = 1.2 times of gate area

Substuting ~~in~~ Condition - 2 in Condition - 1

So

$1.5 \times Rd^2 = 1.2 \times 575$ mm²

$1.5 \times Rd^2 = 690$

$Rd^2 = \frac{690}{1.5} = 460$

$Rd^2 = 460 \Rightarrow \sqrt{460}$

$Rd = \sqrt{460} = 21.5$ mm²

$\boxed{\text{Runner depth} = 21.5 \text{ mm}^2}$

Runner width = 1.5 times of x Runner depth

= 1.5 x 21.5

$\boxed{\text{Runner width} = 32.25 \text{ mm}^2}$

15) Cooling calculation

a) Heat input = H x G x N

H = Heat factor for H13 Steel 143 k cal/kg

N = Total no of Shot produced per hour [hourly out of specific die in specific machine]

G = Shot weight in kg

Heat input = $\underset{\text{k cal/kg}}{143} \times \underset{\text{kg}}{5.13} \times \underset{\text{h}}{45}$

$\boxed{\text{Heat input} = 33011.55 \text{ k cal/h}}$

B) Heat accumulated

Assuming heat loss 50% by Conduction and by Spray cooling

Heat accumulated = Heat input x $\frac{50}{100}$

Heat accumulated $= 3301\cdot 55 \times \frac{50}{100}$

$$\boxed{\text{Heat acc} = 16505\cdot 775 \text{ Kcal/h}}$$

c) Amount of cooling water req

$$A_w = \frac{\text{Heat accumulated}}{k \times [T_o - T_i]}$$

k = Thermal Conductivity of H13 steel is $0\cdot 64$ k cal / hr. m. c

T_o = outlet temperature of water in °c

T_i = inlet temperature of water in °c

$$A_w = \frac{16505\cdot 775}{0\cdot 6 \times (24 - 40°)} = \frac{16505\cdot 775}{9\cdot 6}$$

$$\boxed{A_w = 1719\cdot 35 \text{ lits per hour}}$$

$A_w = 1719\cdot 35 / 60$

$$\boxed{A_w = 28 \text{ lits per minute}}$$