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Methodology of Die Design for HPDC

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Abstract - *HPDC die design is a very easy game, yes you can cast your casting as you desire. This can only happened when you can design casting feeding system scientifically, with the help of fluid mechanics principle, you should understand the thermal balancing of metal flow system, you should understand flow path of solidification. Your expertise require to maintain volume to surface area ratio in decreasing order from diffuser to casting filling end point. In this paper we will discuss machine tonnage, plunger size selection, gate area calculation and it's distribution, filling time calculation, biscuit thickness validation, air vent area, jet flow validation, runner size calculation, HPDC machine parameter calculation like plunger high speed, plunger slow speed calculation, intensification pressure , fast shot length , gate velocity, first phase length and intensification phase length.*

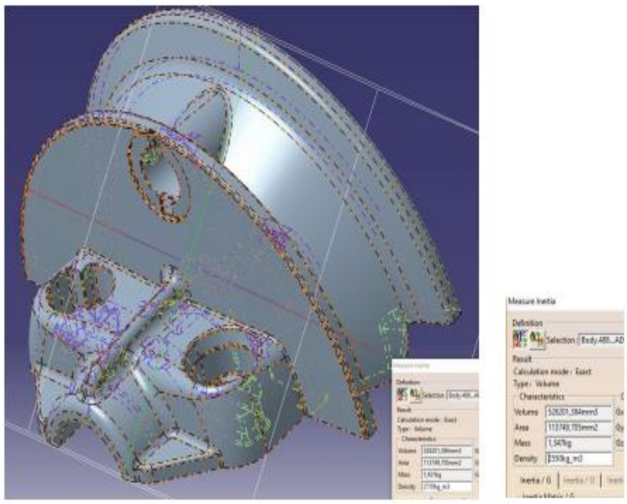
Key Words: Die design, hpdc, gate area, runner design, plunger high speed, machine tonnage, etc

1. INTRODUCTION

Welcome to Steady Die Casting Solutions, I got this opprtunity from my valuable customer I don't want to share his name. Through this paper I just want to give some understanding of calculated die design and hpdc machine running parameter. Die designer this is for you , you should design Hpdc machine parameter as you design your die your are the only one who knows your child better. You design casting biscuit thickness also don't let it be like it's production people job, no this is your job. Yes my dear die designer this your job you should tell him this much of biscuit thickness you have to maintain. So all the parameter I have calculated step by step in this paper

1.1 Part Detail Available

Part weight: 1431 gm



VOLUME: 528201,384mm3

MASS: 1,431kg (Density 2710kg_m3)

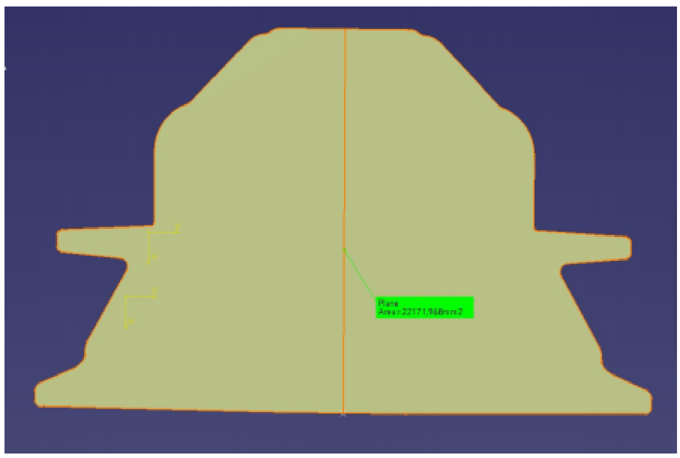
MASS: 1,347kg (Density 2550kg_m3)

CASTING PART MATERIAL:

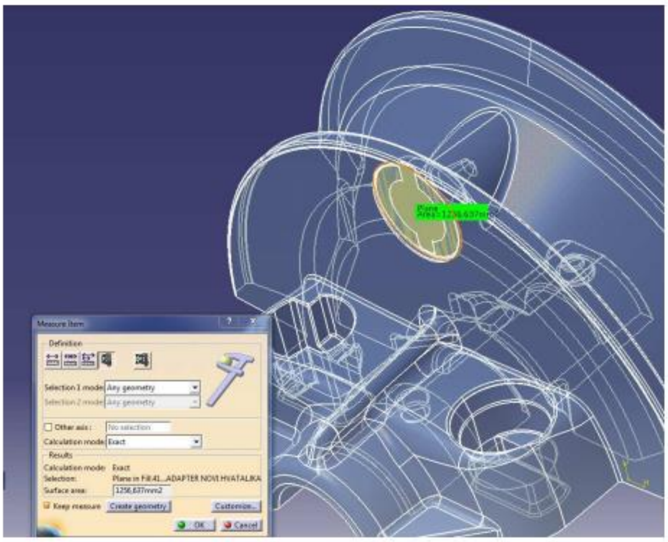
EN 1706; EN AC-43400 (EN AC-AlSi10Mg(Fe))

Part projected projected area: 22171.96 mm2

PROJECTED AREA: 22171,968mm2

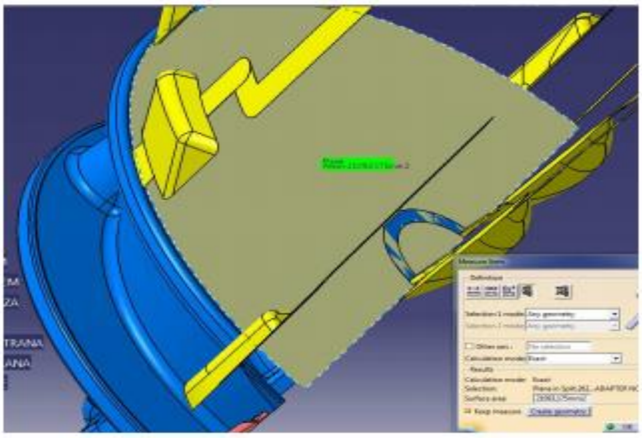


Core one projected area; 1256.63 mm2



PROJECTED AREA SMALL CORE: 1256,637mm2

Core two projected area; 21093.17 mm2



PROJECTED AREA LARGER CORE : 21093,175mm2

1.2 Calculation

Part projected area = 221.71 cm2
Overflow projected area @10% minimum and 15% maximum = 221.71*.15 = 33.25 cm2
Slide or core projection area

= 12.56 * tan20 + 210.93 * tan 20
= 12.56 * .36 + 210.93 * .36
= 4.52 + 75.6
= 80.12 cm2

Total part projected area = (Part projected area) + (Overflow projected area) + (Core projected area)
= 221.71 + 33.25 + 80.12
= 335.08 cm2

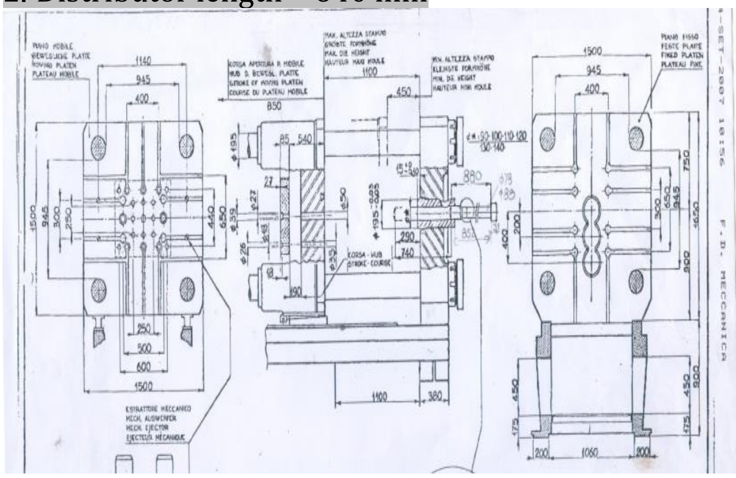
Runner projected area = Total part projected area * .3
= 335.08 * .30
= 100.52 cm2

Total projected area = (Total part projection area + Runner projection area)
= 335.60 + 100.52
= 435.60 cm2

Machine Tonnage = Total projection area * casting pressure
= 435.60 * 800
=348480 kg
= 348.48 Ton (Clamping force)
= 348.48 * 1.2
= 418.17 Ton (Opening force)

Note : - As information available customer using 1100 ton machine, due to die mold design.

2. Distributor length = 640 mm



3. **Shot weight = (Cavity weight + Runner weight + Biscuit weight)**

= (1431 + 1431 * .3 + Biscuit weight)

= 1431 + 429.3 + ((Pie * d * d) / 4 * h)

= 1860.3 + (Pie * d * d * h)……………………………………………………………………(1)

Where h is biscuit thickness.

Shot sleeve filling ratio = (Shot volume) / (Shot sleeve volume)

Shot volume = Shot sleeve volume * filling ratio

Put shot volume value from eqn (1)

689 + ((Pie * d * d) / 4 * h) = (Pie * d * d) / 4 * distributor length * .40 (@40% filling ratio)………(2)

4. **Cavity filling time**

Cavity filling time = K * T * (Ti - Tf + S * Z) / (Tf - Td)

Where,

K = Empirical constant = .034 Sec / mm

T = Casting minimum thickness = 5 mm

Ti = Temperature of molted metal as it enters the die = 680 degree centigrade.

Tf = Minimum flow temperature = 630 degree centigrade.

Td = Temperature of die cavity surface = 180 degree centigrade.

S = Allowable percent solid fraction, it's depends upon casting minimum thickness for 5 mm = 30 %

Z = Unit conversion factor = 4.8

t = (.034 * 5 * (680 - 630 + (30 * 4.8)) / (630 - 180)

= .07 sec

5. **Gate area**

Gate area = (Weight after gate) /(Filling time) * (Density) * (Gate velocity)

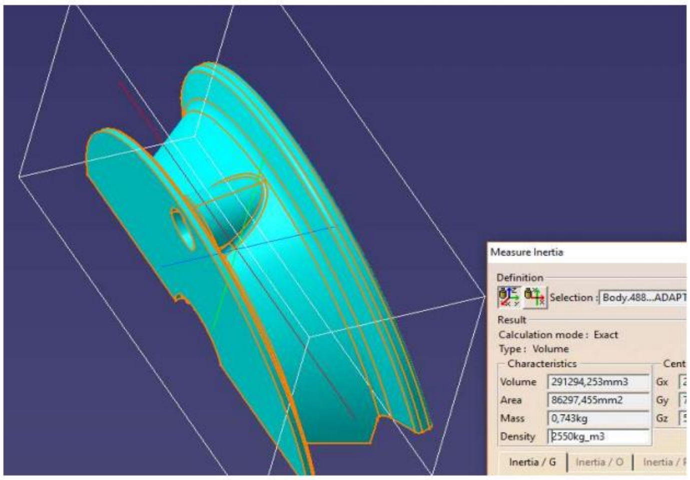
= 1645.65 / (.07 * 2.55 * 4000)

= 2.30 cm2

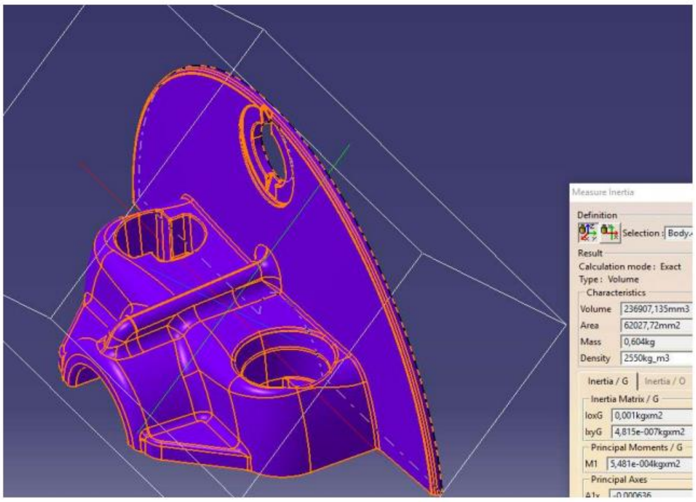
= 230 mm2

As we know that part total volume divided into two part

Part 1 volume = 743 / 2.55 = 291.37 gm / cm3



Part 2 volume = 604 / 2.55 = 236.86 gm /cm3



Ratio of part 1 volume to part 2 volume

Part 1 volume / Part 2 volume = 291.37 / 236.86 = 1.23

Part 1 gate area / Part 2 gate area = 1.23

Part 1 gate area = 1.23 * part 2 gate area………………………………………………………………(3)

Total gate area = part 1 gate area + part 2 gate area

230 = 1.23 * part 2 gate area + part 2 gate area = part 2 gate area * (1.23 + 1)

Part 2 gate area = 230 /2.23 = 103.13 mm2

Part 1 gate area from equation …….(3)

Part 1 gate area = 1.23 * 103.13 = 126.86 mm2

Note: We select gate thickness2 mm for atomize flow.

6. Check for atomize flow :-

Vg^1.71 * Tg * p >= 400

Where,

Vg = gate velocity (Inch / Sec)

Tg = Gate thickness (Inch)

P = density of metal (lb / inch^2)

J = The atomization factor

(1574.8)^1.71 * .078 * .092 = 2104 > 400

So, 2 mm gate thickness will give us atomize flow, which is great.

Table -1: Sample Table format

7. Runner design

We already calculated runner weight without biscuit = 429.3 grm

Runner vol. = 429.3 / 2.7 = 159 cm3 = 159000 mm3

We have to select two runner for two gates.

Gate -1 = 126.86 mm2 = G1

Gate -2 = 103.13 mm2 = G2

As we select gate thickness 2mm, which is suitable for atomize flow.

So,

G1 = w, * t, = 126.86 mm2

w1 = 126.86 / 2 = 63.43 mm

G2 = w2 * t2 = 103.13 mm2

w2 = 103.13 / 2 = 51.56 mm

Where,

w1 and w2 are gate 1 and gate 2 width respectively.

With the help of given data we know that G1 fill 60% of part and G2 fill 40 % of part.so, runner volume divided as ; -

For G1 = Runner vol. = 159000 * .60 = 95400 mm3

For G2, Runner vol. = 159000 * .40 = 63600 mm3

We also know that total runner projected area = 10000 mm2

For G1 projection area = 10000 * .6 0= 6000 mm2

For G2 projection area = 10000 *.40 = 4000 mm2

Runner length for G1 = w1 * L1 = 6000 mm2

L1 = 6000 / 63.43 = 94.59 mm

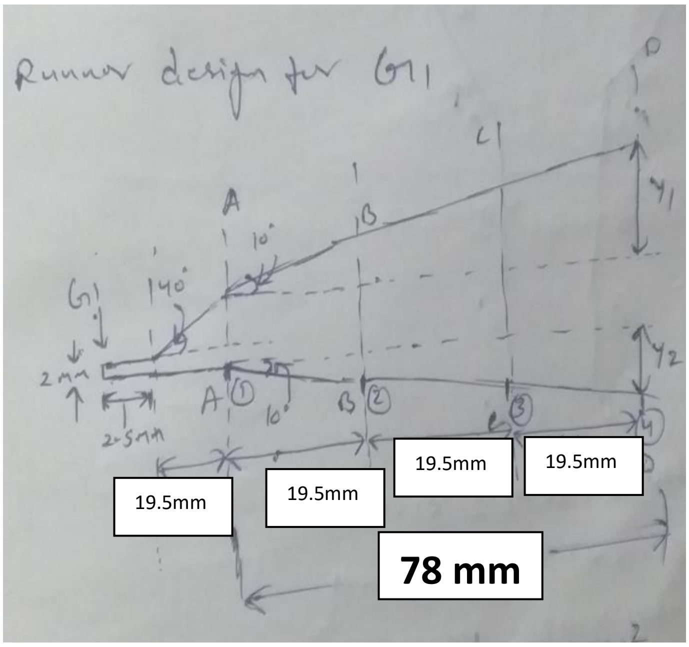
Runner length for G2 = w2 * L2 = 4000 mm2

L2 = 4000 / 51.56 = 77.57 mm

Note; Both runner distance from diffuser should be equal as shorter one.

So both runner length = 77.57 mm

Add “ Y “ section = 94.59 - 77.57 = 17 mm



From above figure :-

T(AA) = 19.5 * tan20 = 6.63 mm

T (BB) = 39 * tan20 = 13.26 mm

T (CC) = 58.5 * tan20 = 19.89 mm

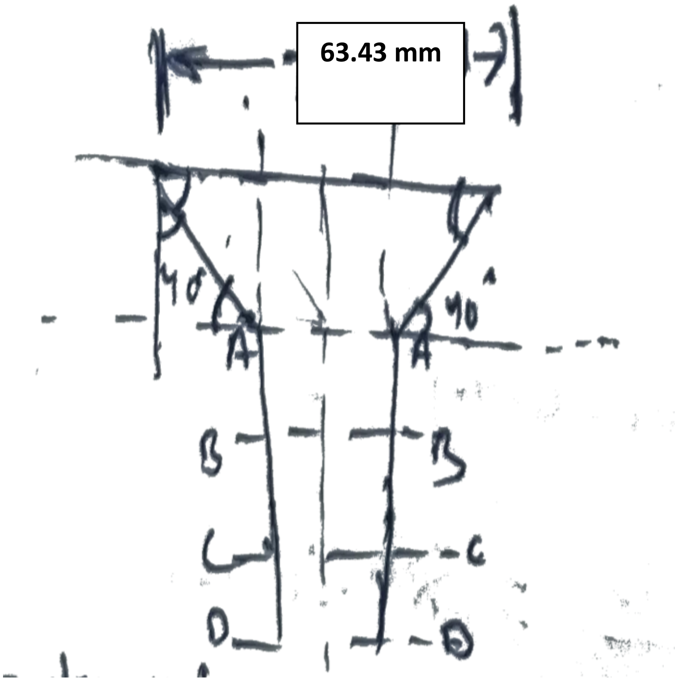
T (DD) = 78 * tan20 = 26.52 mm

Where,

T (AA), T (BB), T (CC), and T (DD) are runner thickness at AA , BB, CC, and DD cross section.

Important Note; Same you can calculate for G2

Runner width calculation for G1



W (AA) = 63.43 * tan40 = 53.22 mm

W (BB) = 53.22 * .97 = 51.62 mm

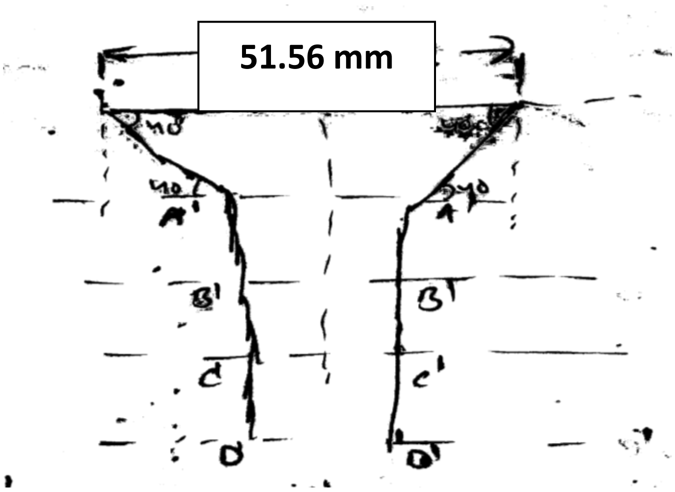
W (CC) = 51.62 *.97 = 50.07 mm

W (DD) = 50.07 * .97 = 48.57 mm

Where,

W (AA), W (BB), W (CC) and W (DD) are runner width at AA, BB, CC and DD cross section area.

Runner width calculation for G2



W (A'A') = 51.56 * tan40 = 43.26 mm

W (B'B') = 43.26 * .97 = 41.96 mm

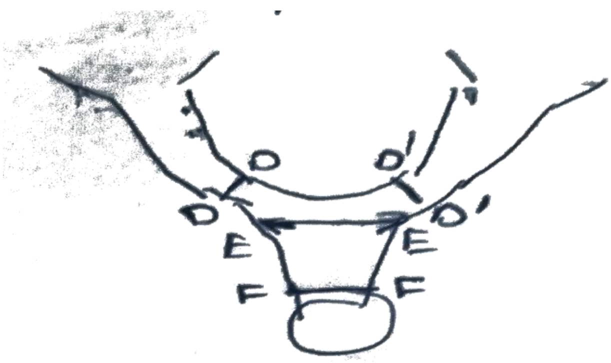
W (C'C') = 41.96 * .97 = 40.70 mm

W (D'D') = 40.70 * .97 = 39.48 mm

Where,

W (A'A'), W (B'B'), W (C'C') and W (D'D') are runner width at A'A', B'B', C'C' and D'D' cross section area.

Calculation for ' Y ' section



W (DD) = 48.57 mm

W (D'D') = 39.48 mm

Than,

W (EE) = 1.4 * (48.57 + 39.48) = 88 mm

W (FF) = 1.3 * W (AA) = 1.3 * 53.22 = 69 mm

Here W (AA) consider because maximum runner width at starting.

And,

T (FF) = (G1 runner length + Y section length) * tan20

= (78 + 17) * .34 = 95 *.34 = 32 mm

8. Biscuit Thickness

1. Biscuit Thickness = T (FF) * 1.25 = 40 mm

Now from equation .....(1)

Shot volume = 689 + (3.14 * d * d * 4) / 4

= 689 + 3.14 * d *d ……………………………………………………………………(4)

Put shot volume value in equation ...(2) from equation...(4)

689 +(3.14 * d * d) / 4 * 4 = (3.14 *d * d * 64 * .40) / 4

(3.14 * d * d) / 4 * (25.6 - 4) = 689

d * d = 40.76 cm2

d = 6.3 cm

d = 63 mm (Plunger Diameter)

Selected plunger diameter = 70 mm

9. High speed length

High speed length = Volume ahead gate / Plunger area

= ((Part weight + overflow weight) / 2.55) / (3.14 * 3.5 * 3.5)

= ((1431 + (1431 * .15)) / 2.55) / 38.46

= 645.09 / 38.46

= 167 mm

10. Intensification phase length

Intensification phase length = (Biscuit thickness + mechanical delay + electrical delay)

= 40 + 10 + 10

= 60 mm

11. First phase length

First phase length = (Distributor length - (High speed length + Intensification phase length)

= (640 - (167 + 60) = 413 mm

12. First phase speed

First phase speed = (22.8 * (100 - filling ratio %) / 100) * plunger diameter^1/2

= (22.8 * (100 - 40) / 100) * 70^1/2

= 13.68 * 8.3 = 114.45 mm / s

v1 = .11 m / s

13. Fast shot speed

Fast shot speed = (Vol (part + overflow) / plunger area) / (filling time)

= 167 / .07 = 2385.71 mm /s

v2 = 2.38 m/ s

14. Gate velocity

Gate velocity = (plunger area * fast shot speed) / (gate area)

= (38.46 * 2.38) / 2.3

Vg = 39.79 m/s (Perfect)

15. Intensification pressure

Intensification pressure = Casting pressure * (Plunger diameter / Injection piston diameter)^2

= Cp * (dp / Dip)^2

= 800 * (7 / 15.5)^2

= 800 * .20

= 162.94 kg / cm2

3. CONCLUSIONS

Yes, we have design die parameter and hpdc machine parameter as we desired casting quality. Yes, we need to take some minor correction during machine parameter validation. We have validated first phase length and speed on machine for minimum air entrapment. We need to increase intensification pressure from 160 kg/cm2 to 200 kg/cm2 for shrinkage free casting. We also use SDS process validation tool to validate our process parameter and we have done also pq2 analysis with the help of SDS pq2 analysis tool. we don't need to any changes in die . We get the desire quality in T0 trial.

We give satisfactory time during die design. We are more focused towards feeding system during die design we ensure there will be no breakup in between solidification due to uneven volume to surface area ratio. We select filling time for desired quality surface. I mean we analyze each and every parameter which is responsible to get desired casting quality, so that we can get reult without hit and trial.

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BIOGRAPHIES

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