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by Hakam Muzaki

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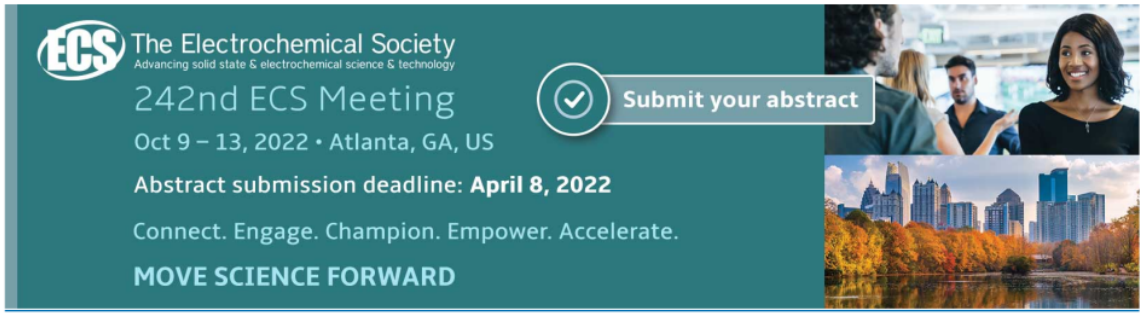


Gating System Measuring of Sandcasting

H Muzakki, I Millaily, & H Winandar

Department of Mechanical Engineering, Universitas Trunojoyo Madura, Indonesia

Abstract. Sandcasting is the oldest casting method and valuable however it has still some problems. This study discussed a mathematical approach in the gating system design. A gating system of a Connecting Road from cast iron was used as an object this study. This study measured fluid flow, a gating position in a mold, pouring, spur basin, pouring time, and riser. Solidification time affect volume and surface area, so in this study we adjusted the height of riser based of 1.2 up to 2 as riser diameter. Results of mathematic analysis show that pouring time was 3 sec, dimension of runner as 1.2 cm as High, 1.2 cm of Large, 2.06 of Pressure. The other dimensions were 2.9 cm of High spur, 5.5 cm of Pouring basin, 3.15 cm^2 of large of spur with 7.56 cm^3 as volume total, and weight total of gating system and riser 0.285 kg. The metal fluid was poured in a molding at 2.83 sec. Dimensions of gating were gotten the 0.42 cm2 from the first in gate and 0.63 cm2 for second in gate.

Keywords: Gating System, Measuring, Sandcasting

1. Introduction

The oldest casting method is sandcasting and this method is also valuable[1]. Santosh Reddy Sama et al developed a Sprue design for metal casting using 3D sand-Printing[2]. On the other hand design and control from greensand mold press casting based on estimation of estimation of metal filling behavior[3]. San molding can used to produce a component with complex shape, various size required or specification need. the getting system is still problem in this method[4]. Sandcasting method still has problem and many researchers have developed this method.

Optimization of Sand Casting Process for aluminum has studied by Mekonnen Liben Nekere and Ajit Pal Singh. They used Taguchi's Robust Design method to optimize the seven of casting parameter that affect to quality of product feature[5]. Optimization of characteristic of 3D sand printing processing was studied by Philip Hackney, Richard Wooldridge for producing a traditional Fouran mold tool[6]. Optimization of Design from Gating and feeding system based on Simulation technique had been studied by Sachin L. Nimbulkara and Rajendra S. Dalu[7]. Process parameters of sand casting affected to quality of casting result.

Core shifts was monitored when was processing of metal casted by a wireless sensing[8, 9]. Datau S.G. et al studied the effect of sand casting process parameter to mechanical properties of casting results. They stated that casting parameters significantly influence to casting result such as an effect of runner size to mold cavity[10]. Mohammed Viquar Mohiuddin et al has experimental studied the sand mold process parameter of aluminum alloy sand casting. The sand mold parameters were used grand size, clay content, molding hardness. They had used sand size, clay content, moisture content, and number of ramming[4]. K.K.Pathak et al studied the influence of gating geometry on casting based

computer simulation. They state that shrinkage porosity, filling time, solidification time and velocity were critically parameters in experiment[11].
Hodbe and Shinde stated that in the traditional casting process redesign of the feeder, getting system, etc to improve the quality of casting product and prevent the defect casting[12]. This study discussed measuring of gating system of Sandcasting.

2. Material and Method

Each metal has difference mechanical properties[13, 14], not only mechanical properties but also difference thermal and physic properties. Thermal and Physic properties were sound in table 1.

Table 1. Thermal and Physic properties

Property	Value
Melting Temperature	1150 - 1250 ℃
Service Temperature	-100 - 400 ℃
Density	7.1 - 7.3 g/cm^3
Young's Modulus, E	167 - 170 GPa
Compressive Strength, σ_c	-
Yield Strength, σ_y	250 MPa
Tensile Strength, σ_{ts}	400 MPa
Poisson's Ratio	0.21 - 0.26
Vickers Hardness	
Shear Modulus, G	
Fracture Toughness, K_{IC} (plane-strain)	22 - 54 MPa/√m
Thermal Conductivity, λ	25 - 42 W/m.K
Thermal Expansion, α	10 - 11.5 E-6/C
Production Energy	16.4 - 18.2 MJ/kg
CO_2 Emission	1 - 1.1 kg/kg

2.1. Fluid Flow

The metal fluid flows in the gating system or rising, the metal fluid through each cavity and in the casting. When metals liquid flew in the casting affected some energy such as potential energy, kinetics energy, pressure and friction. The energy rises because of gravitation and friction to wall of casting[15]. Effected from every energy could be represented with formulation

$$WZ + WPv + \frac{W^2}{2g} + WF = k$$

W = Sum of flow fluid weight (kg)
Z = High of fluid metal flow (mm)
P = Pressure of fluid statics (kg/mm^2)
v = Specific volume (mm^3/kg)
V = flow fluid speed (mm/s)
g = gravitation (mm/s^2)
F = Friction loss

2.2. Gating System

The Gating system mathematic analysis used Bernoulli Law. Value or Number of flow speed from fluid when come in and come out in a vertical gat which has difference height, based on the Continuities law that debit of fluid volume in 1 region same with 2 region. This illustration of this law was represented by figure. 1.
Q = A.V constant, so A_1x V_1 = A_2x V_2

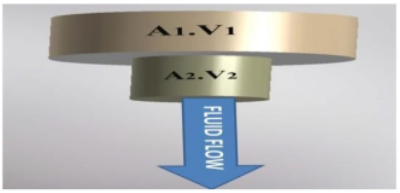


Figure 1. Fluid flow

A_1 = Cross-sectional area 1 (mm^2)
V_1 = Fluid speed on cross-sectional 1 (mm/s)
A_2 = Cross-sectional area 2 (mm^2)
V_2 = Fluid speed on cross-sectional 2 (mm/s)

A gating position in a mold has three types

Top Gating was shown in figure 2.

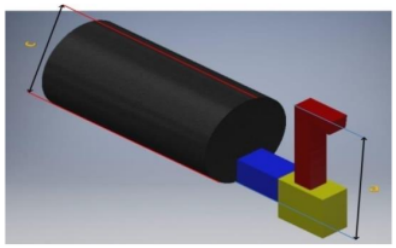


Figure 2. Top gateing

Where is

$$hm = a - \frac{c}{2}$$

Middle Gating was shown in figure 3.

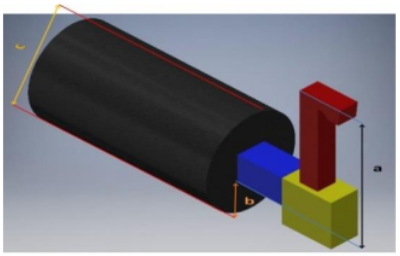


Figure 3. Middle gating

Where

$$hm = \frac{2ac\ b^2}{2c}$$

Bottom gating was shown in figure 4.

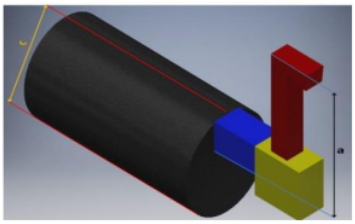


Figure 4. Middle gating

Where

$$hm = a$$

2.3. Pouring

Pouring is a place where metals fluid was put in a cast molding. Effect pouring from the metal fluid rise a turbulence flow so to reduce effect of turbulence of the metal fluid, a pouring place was shaped cup or basin. Pouring cup and basin were presented by figure 5.

Figure 5. Puring

2.4. Sprue

Sprue is a part of a gating system which is to reduce a turbulence effect when the metal fluid is falling down before an in gate part. The shape of spur was presented by figure 6.

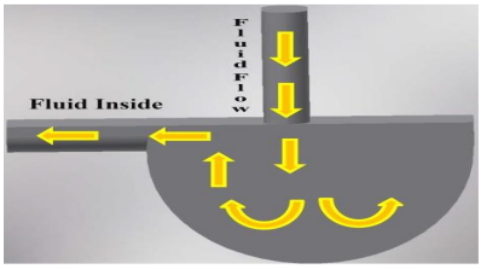


Figure 6a. Circle

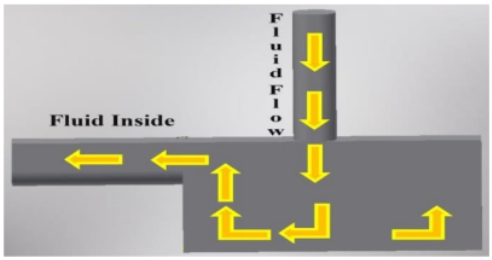


Figure 6b. Right angle

2.5. Total of In Gate area large

Debit of Fluid flow through in the mold based on total of in gate area large. The gate area large total could be counted with:

$$A_1 = \frac{22.6\ X\ W_t}{\rho\ X\ t_p\ X\ f\ X\ \sqrt{hm}}$$

A_1 = Total of In gate area large
W_t = Pouring Weight Total
t_p = Pouring time
hm = Effective High
f = velocity Factor
ρ = density

2.6. Pouring Time

Pouring time is the need of time to pour the metal liquid or fluid to mold up to completely. The mathematic model to calculate pouring time presented by

$$(t_p) = K\left[1.4 + \frac{T_c}{1.5}\right]\sqrt{W_t}$$

t_p = Pouring time (Sec)
T_c = Casting Thickness (cm)
W_t= Casting Wight (kg)
K =Fluidities Factor (based on Factor composition of Chemist composition)

2.7. Riser

Metal casting process has effected to reducing volume when solidification so riser was need to add liquid or metal fluid at around riser. The height of riser can be adjusted based on diameter such as 1.2 up to 2 from diameter of riser.

3. Result and discussion

Solidification time of the casting process was also effected volume and surface area.
Given :

Wc = 0.172 x 2 = 0.344 kg
Wg = 0.16 kg (planed)
Wt = Wc + Wg
= 0.344 + 0.16
= 0.504
Tc = 1.6 cm
k = 2.5

Pouring time

$$\begin{aligned} Tp &= k\left(1.4 + \frac{Tc}{1.5}\right)\sqrt{Wt} \\ &= 2.5\left(1.4 + \frac{1.6}{1.5}\right)\sqrt{0.504} \\ &= 2.5\ (1.49)0.71 \\ &= 2.645\ s \end{aligned}$$

- In gate ⟶ Bottom Getting

Hm = a ρ : 7.250 gr/cm^3

Hm : 55 mm = 5.5 cm f : 0.6

$A_I = \frac{22.6.wt}{\rho.tp.f.\sqrt{hm}}$

$= \frac{22.6\ .\ 0.504}{7.250\ .2.645\ .0.6\ .\ \sqrt{5.5}}$

$= \frac{11.4}{27}$

$= 0.42\ cm^2$

A_{I_1} = ½. A_I

= ½.0,42

= 0,21 cm^2

- Dimensi in gate

  h_I : 0.6 cm

  l_I : 1.2 cm

  p_I : 2.061 cm

- Runner

Ar = $3.A_I$

= 3. 0.42 cm^2

= 1.26 cm^2

Ar_1 = ½.Ar

= ½.1.26

=0.63 cm

- Dimensi runner

  Hr : 1.2 cm

  Lr : 1.2 cm

  Pr : 2.061 cm

- Sprue

As = 1.5 . A_I

= 1.5 . 0.42

= 0.63 cm^2

$Ds = \frac{\sqrt{4\ .\ 0.63}}{3.14}$

= 0.89 cm

Hs = 29 mm ⟶ 2.9cm

- Pouring Basin

X = 2.31

Dp = (2 . 2.31) + Ds

= 4.62 + 0.89

= 5.51 cm

- Sprue Basin
  - Large of sprue basin(Asb) = 5 . AS

    = 5 . 0.63

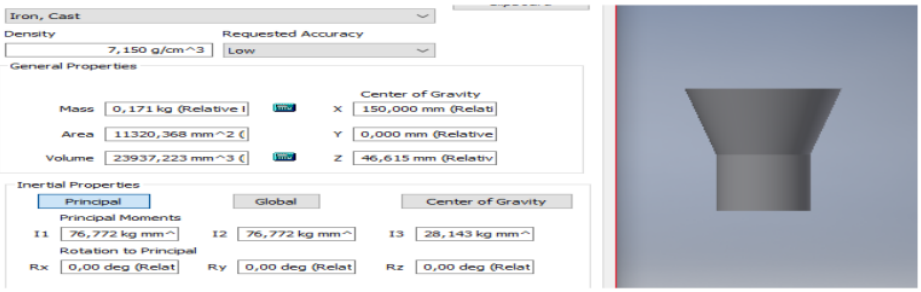
    = 3.15 cm^2
  - Diameter (d) $= \frac{\sqrt{4\ .\ Asb}}{\pi}$

$$= \frac{\sqrt{4 \,.\, 3.15}}{3.14}$$
$$= 2.0 \text{ cm}$$

- Height of sprue basin = 2 . hr
- $= 2 \,.\, 1.2$
  $= 2.4$ cm

- Weight gatting system
- Volume in gate $= AI_1 \,.\, p_1$
  $= 0.21 \,.\, 2.061$
  $= 0.43281 \text{ cm}^3$
- Volume runner $= Ar_1 \,.\, Pr$
  $= 0.63 \,.\, 2.061$
  $= 1.3 \text{ cm}^3$
- Volume sprue basin $= As \,.\, hs$
  $= 0.63 \,.\, 2.9$
  $= 1.827 \text{ cm}^3$
- Volume pouring basin $= 23.9 \text{ cm}^3$
- Volume sprue basin $= Asb \,.\, hsb$
  $= 3.15 \,.\, 2.4$
  $= 7.56 \text{ cm}^3$
- Weight gatting system
  $$= \frac{(2\,V1) + (2Vr) + Vs + Vps + Vsb) \,.\, \rho}{1000}$$
  $$= \frac{(2\,(0.21) + 2\,(0.63) + 4.41 + 23.9 + 7.56) \,.\, 7.20}{1000}$$
  $= 0.27$ kg
- Weight total gatting system and riser
  = weight riser + weight gatting system
  $= 0.015 + 0.27$
  $= 0.285$

. Calculation based on CAD represented with figure 7.



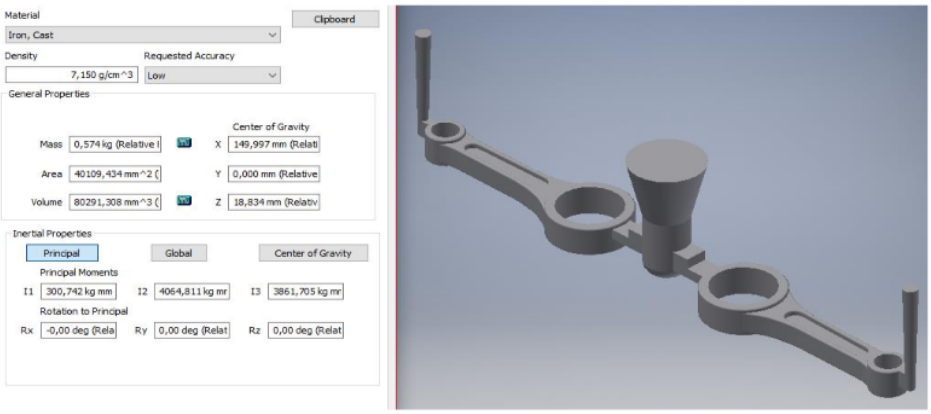


Figure 7. The results of calculation based on software

4. Conclusion

Some mathematic models could be used to calculate a gating system in a sand casting mold. This study counted the size of some gating system elements. The metal fluid was poured in a molding at 2.83 sec. Dimensions of gating were gotten the 0.42 cm^2 from the first in gate and 0.63 cm^2 for second in gate.

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