June 2, 2014

To: Paul C. Lynch

From: Lab Group D

Subject: Gating Systems and Fluidity (Lab #3)

Dear Paul:

The casting process depends on the ability of molten metal to flow into the mold cavity. Fluidity, the correct size and location of the sprue, runners, gates and other components of the gating system are all of major importance in a casting process. The ultimate goal of the gating system is to control the rate of the metal entering the mold. There are different uses for each system, whether they differ in sprue location, choke location, or gate size. However, an effective gating system will steadily fill the mold cavity, while minimizing turbulence and erosion of the mold. The fluidity, which measures the ability of the metal to flow, is largely influential on the final casting as well.

The objectives of this lab were to compare the flow of molten aluminum through gating systems of variable cross sectional area and to determine the influence of the pouring temperature on the fluidity of aluminium in green sand molds.

To observe the effects of different gating systems, two different molds were created. The molds were created using the same technique, with the exception of the location of the sprue. The time it took to empty the pouring basin, and then the aluminum after it was casted were observed to analyze the effects of the two gating systems. To test for fluidity, two spiral molds were poured. They were poured at two different temperatures so that after solidification, the length of the spirals depicted the fluidity.

Casting Yield:

Yield Percentage= [(Σ weight of flow)/(Σ weight of flow)+(weight of gates+runner)]*100
Mold 1 yield percentage= [(289+260+293+291)/(289+260+293+291+425)]*100=72.7%
Mold 2 yield percentage= [(329+316+330+335)/(329+316+330+335+426)]*100=75.5%
Mold 3 yield percentage= [(281+181+292+336)/(281+181+292+336+320)]*100=77.3%
Mold 4 yield percentage= [(527+375+262+213)/(527+375+262+213+264)]*100=83.9%

Mold number	1				2			
Gate number	1	2	3	4	1	2	3	4
Initial flow gates	3	4	2	1	3	4	2	1
Weight of flow	442	277	174	162	215	129	251	394
Weight of Gates + Runner (g)	268 g.				304 g.			
Casting Yield (Calculate)	79.74%				76.49%			
Pouring temperature (°F)	1400				1400			
Pouring time (s)	5.65				5.66			
Sprue diameter	0.75"				0.75"			
Runner area	0.5in.^{2}				0.5in.^{2}			
Gate Area (in^2)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sprue location (end, center)	E	E	E	E	C	C	C	C
Type of flow (un/pressurized)	**U**	**U**	**U**	**U**	**U**	**U**	**U**	**U**
Gating Ratios (Calculate)								
Casting Pictures								
Runner and Gate Pictures **Weight of Flow Pictures**								

Table 1: Data for Gating

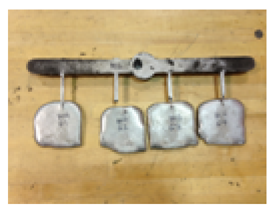
Mold number	3				4			
Gate number	1	2	3	4	1	2	3	4
Initial flow gates	2	3	4	1	1	3	2	4
Weight of flow (g)	253	245	227	231	189	191	225	220
Weight of Gates + Runner (g)	444 g.				452 g.			
Casting Yield (Calculate)	68.28%				64.61%			
Pouring temperature (°F)	1400				1400			
Pouring time (s)	4.03				4.62			
Sprue diameter	0.75"				0.75"			
Runner area	0.5in.^{2}				0.5in.^{2}			
Gate Area (in^2)	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
Sprue location (end, center)	E	E	E	E	C	C	C	C
Type of flow (un/pressurized)	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Gating Ratios (Calculate)								
Casting Pictures								
Runner and Gate Pictures **Weight of Flow Pictures**								

Table 2: Data for Gating (mold 3 & 4)

Gating Ratio:

For ½ in. gate width:

Sprue A_S: $\pi\left(\frac{.75}{2}\right)^2 \rightarrow .442\ in.^2$
Runner A_R: $1 * .5 \rightarrow .5\ in.^2$
Gates A_G: A 1 gate → .25 in. ^{2} $\sum 4\ gates = 1 in.^2$

A_S:A_R:A_G $\frac{.442}{.442}$: $\frac{.50}{.442}$: $\frac{1}{.442}$ → 1: 1.1312: 2.262

For ¼ in. gate width:
Sprue A_S: $\pi\left(\frac{.75}{2}\right)^2 \rightarrow .442\ in.^2$
Runner A_R: $1 * .5 \rightarrow .5\ in.^2$
Gates A_G: A 1 gate → .0625 in. ^{2} $\sum 4\ gates = .25 in.^2$

A_S:A_R:A_G $\frac{.442}{.442}$: $\frac{.50}{.442}$: $\frac{.25}{.442}$ → 1: 1.1312: .566

Evaluation questions:
1. As seen in Table II, as temperature increased from 1200 to 1400 degrees Fahrenheit, the fluidity number increased from 11 to 22. Increasing the temperature decreases the surface tension of the metal, which decreases the viscosity. In addition to increasing the temperature, fluidity is also increased by adding a eutectic alloy to the metal or choosing a metal with a higher heat of fusion. Having a higher heat of fusion means it requires more energy to solidify and therefore takes longer, increasing the fluidity. [1] [2]

2. The gating ratio is the ratio of the sprue area, total runner area to the sum of total gating area. In general, the ratio will look like, As: Ar: Ag, the areas of the sprue, runner, and gates respectively. While analyzing the picture of the flows in the ½ in. gate, the outlier was gate 2, it was the last gate to receive initial flow and had a the least weight of 181 compared to gates 1,3,4 with 281, 292, and 336 respectively. Lastly, comparing the weight of flow for each gate width sizes ½ in. and ¼ in. The range in the weights of flow in .0625 in^2 gate was an average of 26g, less than the average range for the .25 $in.^2$ gates of 234.5g.

3. Un-pressurized gating systems produce runners that are not completely filled and provide a gentle flow of the metal into the mold cavity, while pressurized systems fill the gating system completely, and the metal squirts into the mold cavity, creating turbulence. The two systems also differ in the location of the choke, which is the minimum cross sectional area in the gating system. The base of the sprue is the choke of an un-pressurized system, while the gate is the choke in a pressurized system. Molds 1 and 2 have a gating ratio of 1:1.312:0.566 (As:Ar:Ag), which indicates that the choke is the gate and these gating systems are pressurized. Molds 3 and 4 have a gating ratio of 1:1.1512:2.262 (As:Ar:Ag), indicating that the base of the sprue is the coke and therefore these gating systems are unpressurized. Unpressurized systems take longer than pressurized systems to fill. Table 1 shows that the pressurized systems took

7.03s and 8.94s to fill while table 3 shows that the unpressurized systems took 9.35s and 13.06s to fill. Factors that determine which type of gating system to use include the casting process, the size and shape of the casting, quality requirements, and the type of metal being poured. Unpressurized systems are good for aluminium, while pressurized systems are more ideal for materials that don’t pick up oxides.

4. The order in which the mold cavities are filled vary as the sprue position changes. The sprue was positioned in the center for molds 1 and 3, and at the end in molds 2 and 4 (table 3). As molten metal was poured into mold 1, gate 4 filled first, followed by gates 1, 3 and 2, respectively. Whereas, in mold 2, gate 4 filled first, followed by gates 3,1 and 2, respectively. The order of flow in molds 3 and 4 were similar, only differing in gates 2 and 3. The order of flow in mold 3 filled gate 4 first, followed by gates 1,3 and 2, respectively. Whereas, in mold 4, the flow started with gate 4, followed by gates 1,2 and 3, respectively. The overall flow of the metal was better when the sprue position was at the end of the mold; this is depicted through the yield percentages for molds 2 and 4, which are 75.5% and 83.9%, respectively. These yields are relatively better than those of molds 1 and 3, which are 72.7% and 77.3%, respectively.

Extension Questions :

1. Pure aluminum is not usually used for structural applications; in order to produce aluminum of adequate strength other elements are added. Adding silicon to aluminum reduces the melting temperature and improves fluidity. Fluidity is a material's ability to flow into and fill a given cavity, as measured by the dimensions of that cavity under specified experimental conditions.Fluidity is the length and relating back to this lab, if silicon was added to the molten aluminum metal it would increase the number of spiral rotations in the fluidity test performed, increasing the total distance length. [3] [4]

2. Pressurized and unpressurized gating systems each have positive and negative effects in metal casting. Pressurized systems generally have a higher casting yield because they have smaller runner systems. This results in less metal being wasted in the runner system. The pressurized system however does cause turbulence which can cause problems in highly intricate parts. An unpressurized system reduces turbulence. Unpressurized systems often require larger molds due to their larger volume runner systems. If high production and casting yield is desired, then a pressurized system is more apt to be used, but an unpressurized system creates less turbulence leading to better mechanical properties. [5]

3. A sprue is typically designed such that the bottom of the sprue has a smaller cross sectional area, compared to the top of the sprue, to minimize aspiration of the metal going into the mold cavity. A tapered sprue will keep it full of molten metal, rather than letting air travel through the metal which would result in more porosity in the final casting. [6]

4. Superheating an alloy leads to better fluidity of the metal, however there are some limitations to superheating an alloy as well. One of the problems of superheating an alloy is that it increases the presence of saturated gases in the metal. The other dilemma faced through superheating, is that it also increases the ability of the molten metal to penetrate into the surface of the mold material. [7]

Sincerely,

Jake Stanko(10), Prithvi Doddanavar(4), Kate Gilland(6), Kaushal Pathak(9)

Casting Lab 3: Gating & Fluidity

Table 1: Data Sheet for Gating

Mold number	1				2			
Gate number	1	2	3	4	1	2	3	4
Initial flow gates	2	4	3	1	3	4	2	1
Weight of flow (g)	289	260	293	291	329	316	330	335
Weight of Gates + Runner (g)	425 g.				426 g.			
Casting Yield (Calculate)								
Pouring temperature (°F)	1360				1360			
Pouring time (s)	7.03				8.94			
Sprue diameter	0.75"				0.75"			
Runner area	0.5in.^{2}				0.5in.^{2}			
Gate Area (in^2)	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
Sprue location (end, center)	C	C	C	C	E	E	E	E
Type of flow (un/pressurized)	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
Gating Ratios (Calculate)								
Casting Pictures								
Runner and Gate Pictures **Weight of Flow Pictures**								

Table 2: Data Sheet for Fluidity

Mold	1	2
Pouring temperature (F)	1200	1400
Pouring height (in.)	4	4
Fluidity number	11	22
Fluidity distance (in.)	22	44

Table 3: Data sheet gating(2)

Mold number	3				4			
Gate number	1	2	3	4	1	2	3	4
Initial flow gates	2	4	3	1	2	3	4	1
Weight of flow	281	181	292	336	527	375	262	213
Weight of Gates + Runner (g)	320 g.				264 g.			
Casting Yield (Calculate)								
Pouring temperature (°F)	1360				1360			
Pouring time (s)	9.35				13.06			
Sprue diameter	0.75”				0.75”			
Runner area	$0.5in.^2$				$0.5in.^2$			
Gate Area (in^2)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sprue location (end, center)	C	C	C	C	E	E	E	E
Type of flow (un/pressurized)	**U**	**U**	**U**	**U**	**U**	**U**	**U**	**U**
Gating Ratios (Calculate)								
Casting Pictures								
Runner and Gate Pictures **Weight of Flow Pictures**								

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