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Development of a Gating System for the "H" Process of Metal Casting

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by
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Introduction

Statement of the Problem

The "H" Process of metal casting uses a unique gating system that controls the flow of molten metal during the casting process. A feeder/runner bar serving each casting is the vital element in the "H" Process. Available information on the "H" Process is not very specific about the runner system configuration. This study will develop a gating system for use with the "H" Process using the available information and principles of conventional gating practice.

Importance of the Study

The country's economy demands that modern industries find ways to increase productivity while lowering energy costs. The "H" Process uses less labor and energy per casting than conventional metal casting techniques. This is accomplished with the use of a feeder/runner bar system. (Miller and Company, 1982, note 1) This system reduces energy remelt costs and increases casting yield with lower scrap and finishing costs. The "H" Process is an important and viable casting method for the economic times.

Assumptions

For the purpose of this study, the melting and pouring procedures are assumed to be properly monitored to ensure consistently good metal flow during casting. Any casting defects should be directly attributable to the gating system, not the melting and pouring procedures.

Limitations

This study is limited by the amount of technical information available. The process is patented with licensing agents in the United States. The licensing agent was contacted and provided helpful basic information, but understandably, specific technical information could not be provided without threatening the license.

Definition of Terms

Directional Solidification - Refers to the solidification pattern where the metal solidifies at the point furthest from the gate of the gating system and progresses toward the gate. (Sylvia, 1972, page 312)

Gate -- The point at which molten metal enters the mold cavity. (Sylvia, 1972, page 316)

Hot Spot -- An area in the mold that is hotter than the surrounding mold material due to small volumes of sand in relation to high volumes of metal.

Laminar Flow -- A flow of liquid that is free of turbulence characterized by a straight line motion.

Riser -- Reservoir of molten metal attached to the casting to compensate for internal contraction of the casting during solidification. (Sylvia, 1972, page 325)

Runner -- The portion of the gating system that connects the down sprue and gate at the casting. (Sylvia, 1972, page 326)

Runnersphere -- A spherical shape in a core used to conduct metal to a casting cavity in a controlled manner. After the mold is filled the runnersphere serves as a riser. (Hoult, 1979, page 237)

Turbulence -- A flow in a liquid characterized by a churning or swirling motion.

Weir -- A dam in the runner system to control the flow direction and velocity.

Chapter 2
Review of Literature

"The Principle! The "H" Process is vertical pouring with horizontal controlled flow casting. A feeder/runner bar serving each casting is the vital element in the "H" process." (Miller and Company, 1982, note 1)

This process was developed and put into practice in 1975 at Rotherham, England by W. H. Booth & Co., Ltd. with Miller and Company of Chicago, Illinois as the United States sub-licensing agents. Continued development of this casting system is an ongoing process.

The "H" process uses rigid sand molds that incorporate all the factors that contribute to the production of quality castings. The factors are:

1) A rigid sand mold capable of repetitive, economical production.
2) Contained within the mold must be a runner system that enables controlled pouring of the metal into the mold, smoothly and without agitation or turbulence.
3) During the pouring of the liquid metal, the mold must retain its shape, must resist any erosion, breakage or washing away of sand on the face of the mold. After metal has been poured, the mold must have a means whereby liquid and solid contraction can take place. Liquid metal must be available to feed all parts of the casting that require feeding, both at the point where it is required and for as long as it is required.
4) After the metal has solidified, forming the casting, the mold must collapse, or break down, allowing the contraction of the casting.
5) It must be possible to remove the gating and risering systems with a minimum of effort and without destroying any of the required casting shape. (Miller and Company, 1982, note 1)

The use of rigid molds and the horizontal casting method has several advantages over vertical casting methods.

> The "H" Process achieves the lowest possible ferrostatic casting pressure, so strain of mold joints is reduced to a minimum. Rigidity of molds, increased by horizontal clamping, results in the final castings being precise dimensionally, with minimal finning at the mold joints. These factors result in little or no cleaning being required. (Miller and Company, 1982, note 1)

The molds produced with the shell mold process are stacked vertically while they are hot. This allows the molds to be positively located and minimizes warpage. The mold strings are clamped hand-tight. As the metal is poured into the mold string, the heat expands the sand tightening the mold joints. Mold strings may be stored vertically, saving floor space.

There are no minimum or maximum casting weights with the "H" Process. The physical limitations of the mold blower and casting string handling equipment set the practical limits for the process. The molten metal available at the pour is not too critical due to the controlled flow. If insufficient metal is available for pouring a mold string, only one cavity is lost and the balance of the unpoured molds can be restacked and poured.

The "H" Process is compatible with most core making processes. The sand-to-metal ratio will vary between the different types of core processes. A typical sand-to-metal ratio for double-sided shell molds is 1:1 for light to medium weight castings. Average sand-to-metal ratios for Isocure, CO_2, Furan, and SO_2 molds are 2: 1. Lightener pockets in the pattern equipment could be used to lower the sand-to-metal ratio.

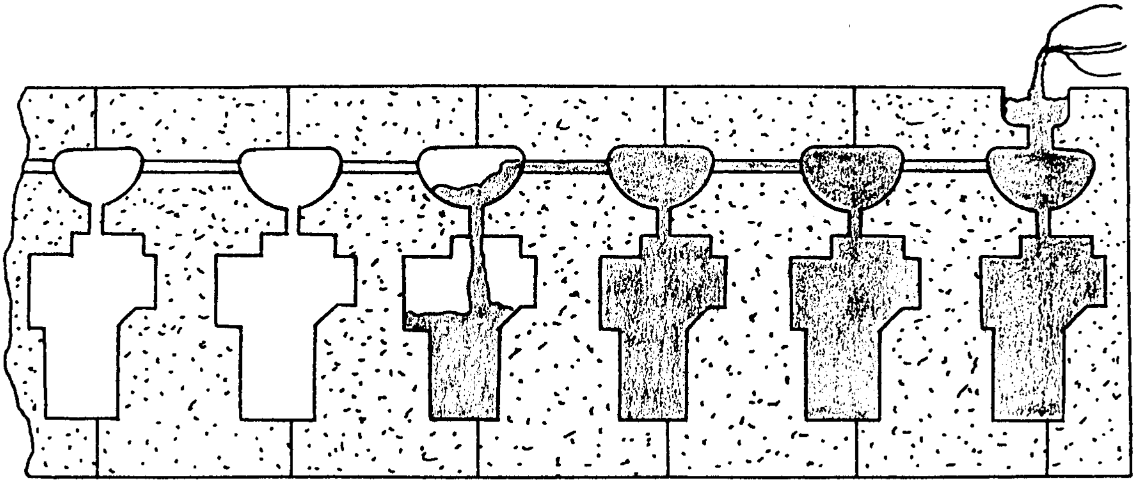
The "H" Process is versatile with different types of ferrous and non-ferrous metals. Below is an analysis for metals that have been successfully poured using the "H" Process:

Typical Metal Analysis (Percent):

1) Stainless Steel= C .08 max., Si 1.5 max., Cr 17.0-21.0,
Ni 8.5, Mo 1.0 max., P .04, S .04
2) Aluminum = Cu 0.1, Mn 0.1, Fe 0.6, Ni 0.1, Zn 0.1,
Pb 0.1, Sn 0.05, Ti 0.2, Balance Al
3) Ferritic Ductile Iron = C 3.75, Si 2.50, Mn .04,
S .006, P .02, Mg .035
4) Bronze (Gunmetal) = Cu 85.0, Sn 5.0, Zn 5.0, Pb 5.0
5) Malleable Iron = C 2.50, Si 1.45, Mn .50, Cr .035,
S .10, P .05 (Eberhardt, 1980, page 18)

The "H" Process has several distinct advantages over conventional molding and casting processes. Controlled pouring is one. Due to the runner/gating system configuration, the molten metal flows into the first casting completely filling the mold cavity before the second mold is filled (see Figure 1).

Figure 1
Horizontal Controlled Flow Casting



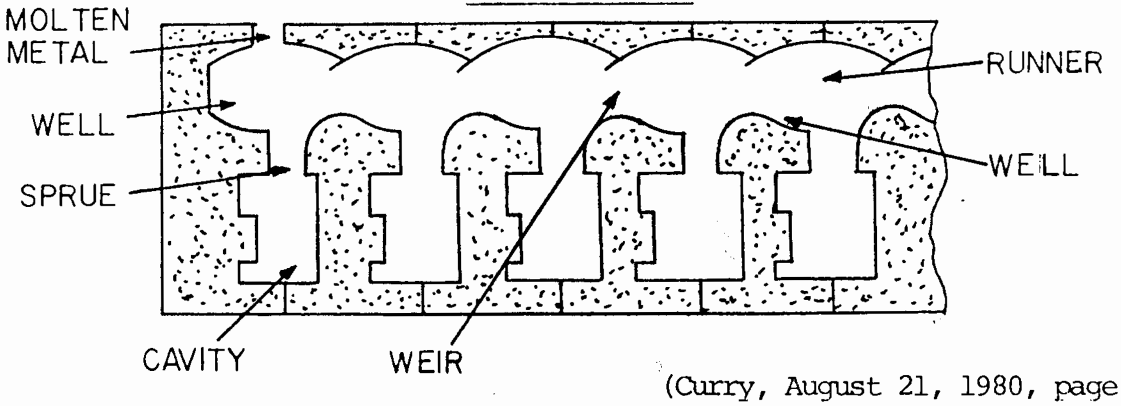
(Miller and Company, 1982, note 1)

This controlled pour continues for the full length of the string of molds being poured. The cores are positioned so that the castings are poured vertically to fully utilized the advantage of directional solidification.

This runner system used in the "H" Process is called a runnersphere due to its shape. The runnersphere controls the metal flow by the use of a weir.

> The process requires only a single runner that is shaped to form a weir at the sprue of each mold. When metal is poured, it flows into a well and then into the mold cavity. Metal continues to fill the well until it flows over a weir and into the next well. This process continues until all wells have been filled. Thus, forward velocity of the molten metal is checked, allowing metal to enter each cavity with minimum turbulence. The technique prevents solidification of the sprues to each cavity because the wells are continuously fed with molten metal. (see Figure 2) (Curry, August 21, 1980 page 113)

Figure 2
Mold Cut-away



(Curry, August 21, 1980, page 113)

The ideal pouring sequence is when one casting cannot be poured until its adjacent casting has been completely filled.

A second advantage of the "H" Process is flow feeding to the castings. As molten metal cools, it undergoes liquid and solid contraction known as shrinkage. To ensure that a casting is the correct size, during liquid contraction the runner system must provide molten metal to refill the mold cavity. In conventional casting, risers are attached to the gating system to feed the castings during this phase of solidification. In the "H" Process the runnerspheres are the risers. The continuous flow of metal through runnerspheres of castings already poured ensures maximum temperature of metal being maintained as each casting cavity is filled. This ensures that the casting will be fed during liquid contraction providing a sound quality casting.

A riser cannot feed a casting if the ingate has frozen off. In the "H" Process the gate is formed between the bottom of the runnersphere and the top of the casting resulting in a hot spot around the gate. This keeps the gate from freezing off allowing the feeding of the casting during contraction. Because of the hot spot around the gate, the gate can be made smaller providing an advantage during knockoff of the castings from the runnerspheres.

A third advantage is maximum mold yield. "A mold with nominal thickness for maximum curing, in conjunction with patterns spaced closely as possible, will produce castings with a maximum mold yield. Ductile iron mold yield for light to medium weight castings poured at Booth Foundry is between 70.0% and 80.0%." (Eberhardt, 1980, page 5)

Table 1 lists seven foundries that are currently using or testing the "H" Process list their increase in yield. The names of the foundries using the new process are confidential. A 27% increase in yield for ductile iron was the average for these foundries.

> Significant Yield Improvement -- The benefits of the process are many, but the one that stimulates the most interest is the significant increase of salable, quality castings that can be produced from a ton of metal poured. A case in point is ductile iron: with conventional molding and gating practice, 1000 lbs. of castings are produced in the mold for every ton of iron poured, based on a 50.0% mold yield. With the "H" Process, 1500 lbs. of castings can be produced for each ton of ductile iron poured, with a 75.0% mold yield. (Miller and Company, 1982, note 1)

This advantage alone makes the "H" Process an attractive alternative to conventional casting processes.

Table 1
Yield Increases for Seven Foundries

FOUNDRY	CASTING WT.	TYPE MOLD "H" PROCESS	% YIELD CONV. MOLD	% YIELD "H" MOLD	INCREASE IN % YIELD
1	3.34	SHELL	45.2	71.3	26.1 *
2	3.30	ISOCURE	48.0	75.0	27.0 *
3	6.00	ISOCURE	46.0	80.0	34.0 *
4	1.90	SHELL	44.0	74.0	30.0 *
5	4.20	ISOCURE	53.0	78.0	25.0
6	4.20	ISOCURE	50.0	68.0	18.0 *
7	4.20	ISOCURE	53.0	78.0	25.0

*DUCTILE IRON

DUCTILE IRON AVERAGE 27.0

(Miller and Company, 1982, note 1)

The runnersphere system's shape which has a high point above each gate traps slag and other contaminates as they float on top of the molten iron. This decreases the amount of slag defects in the castings made with this process.

The use of rigid core molds yields a good as-cast surface which requires very little shot blasting. Very little grinding is required on the castings due to the small ingates.

The finishing operations are reduced as discussed by Eberhardt and Jenkins: (1930)

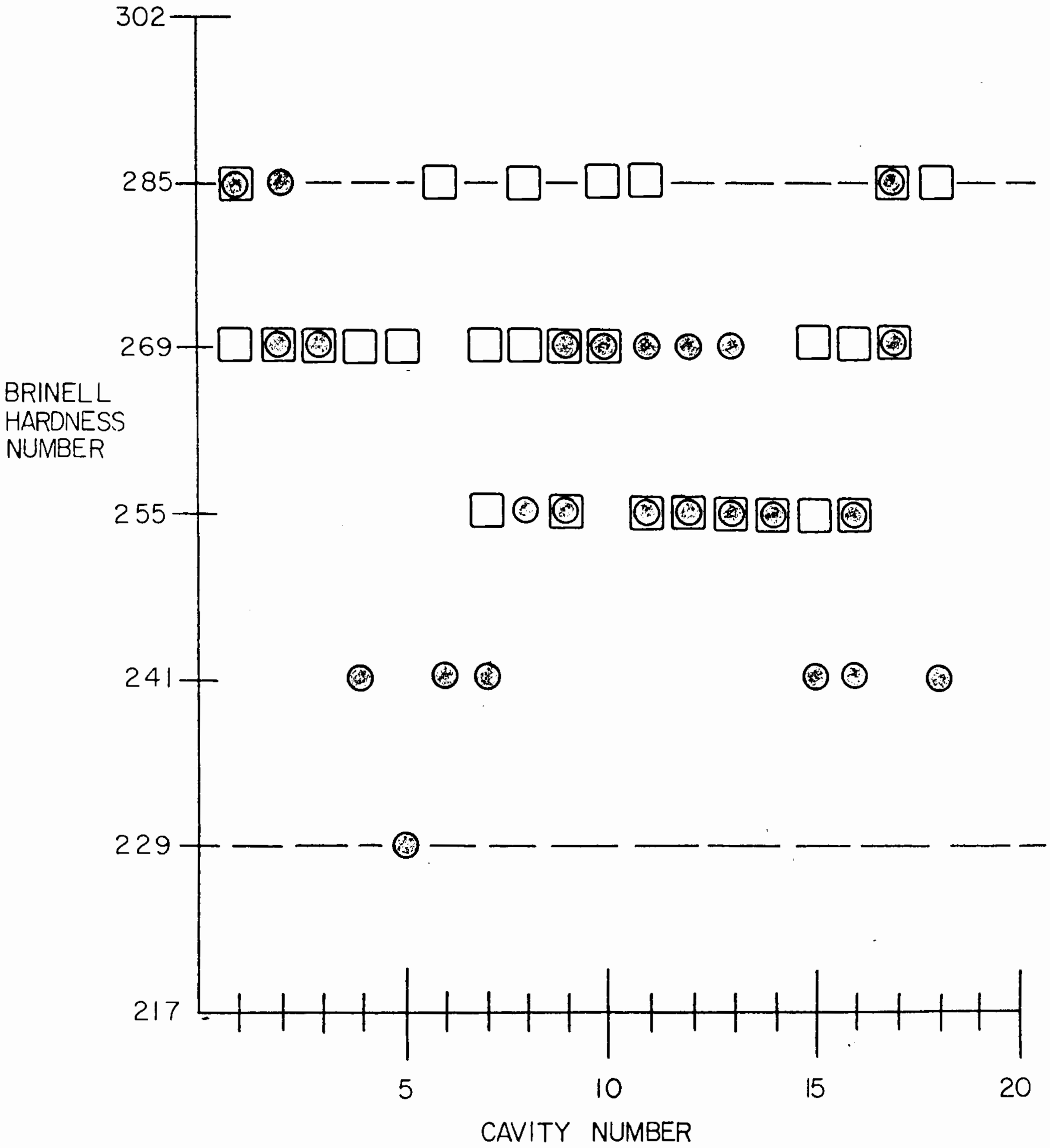
> Reduced Finishing Operation -- The small ingate size, minimal parting fins, and improved as-cast surface as compared to green sand molded castings, results in less grinding, cleaning, and other salvage operations in the finishing department. In many cases, fins experienced from cores set in green sand molds can be eliminated by making the cored area an integral part of the "H" Process mold, and thus eliminate the cost of a core plus a grinding operation."

Another advantage of the "H" Process is the control of hardness and microstructure formations. Due to the alignment of the molds, side by side, uniform cooling is achieved with only the ends cooling at a different rate. In Figure 3, 52 hardness readings were taken on two strings of castings. Pearlitic Ductile Iron was used for a hardness specification of BHN 229-285. All of the castings fell within the acceptable limits with most castings from the middle of the string grouped around BHN 255-269.

A similar test of 40 hardness readings from two strings of castings using Ferritic Ductile Iron was plotted in Figure 4. The Specifications required a hardness range of BHN 156-217. Both strings fell

Figure 3

Pearlitic Ductile Iron -- Hardness Test



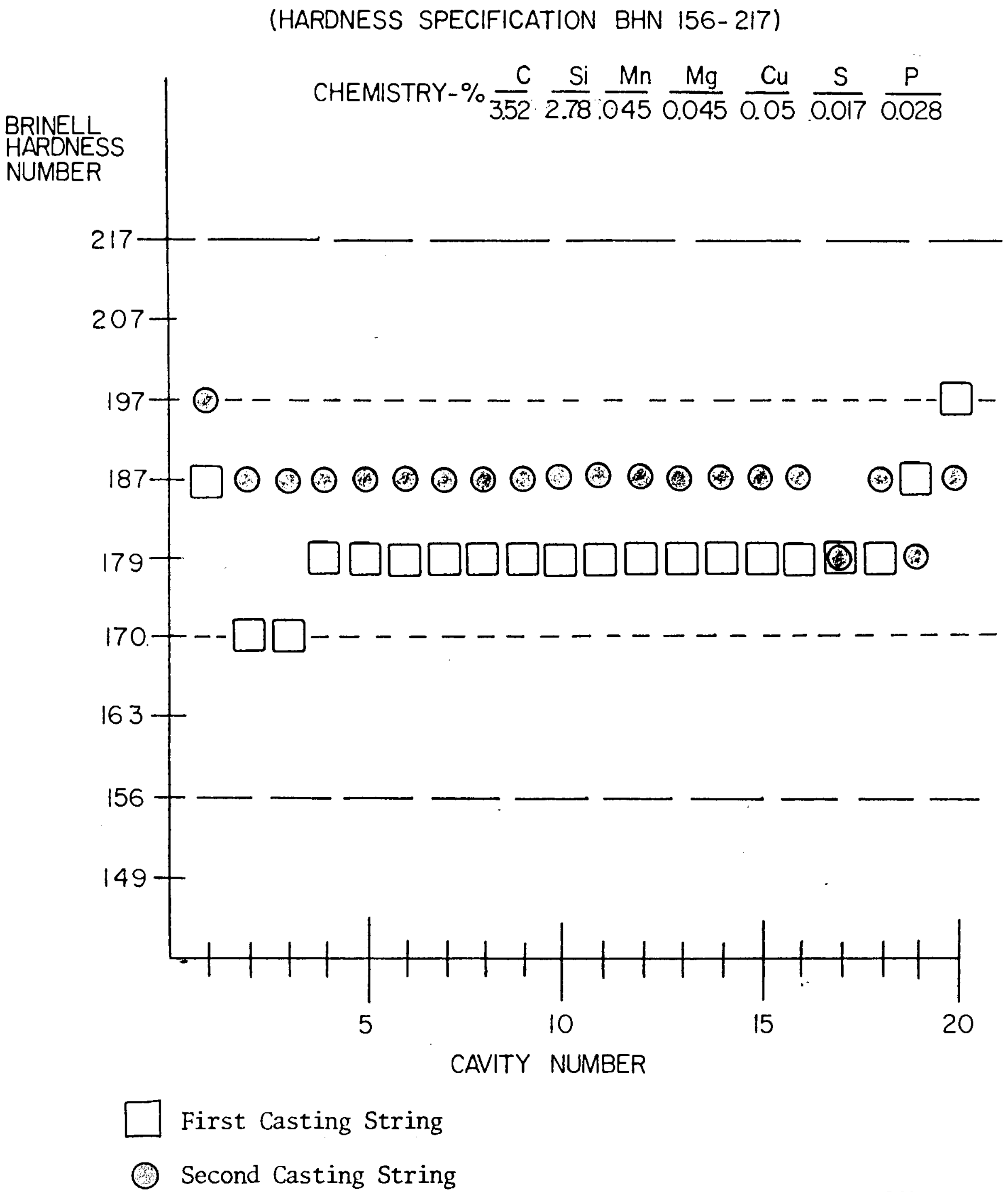
CHEMISTRY-%	C	Si	Mn	Mg	Cu	S	P
	3.60	2.67	0.27	0.48	0.65	0.008	0.007

□ First Casting String

○ Second Casting String

(Eberhardt, 1980, page 27)

Figure 4
Ferritic Ductile Iron — Hardness Test

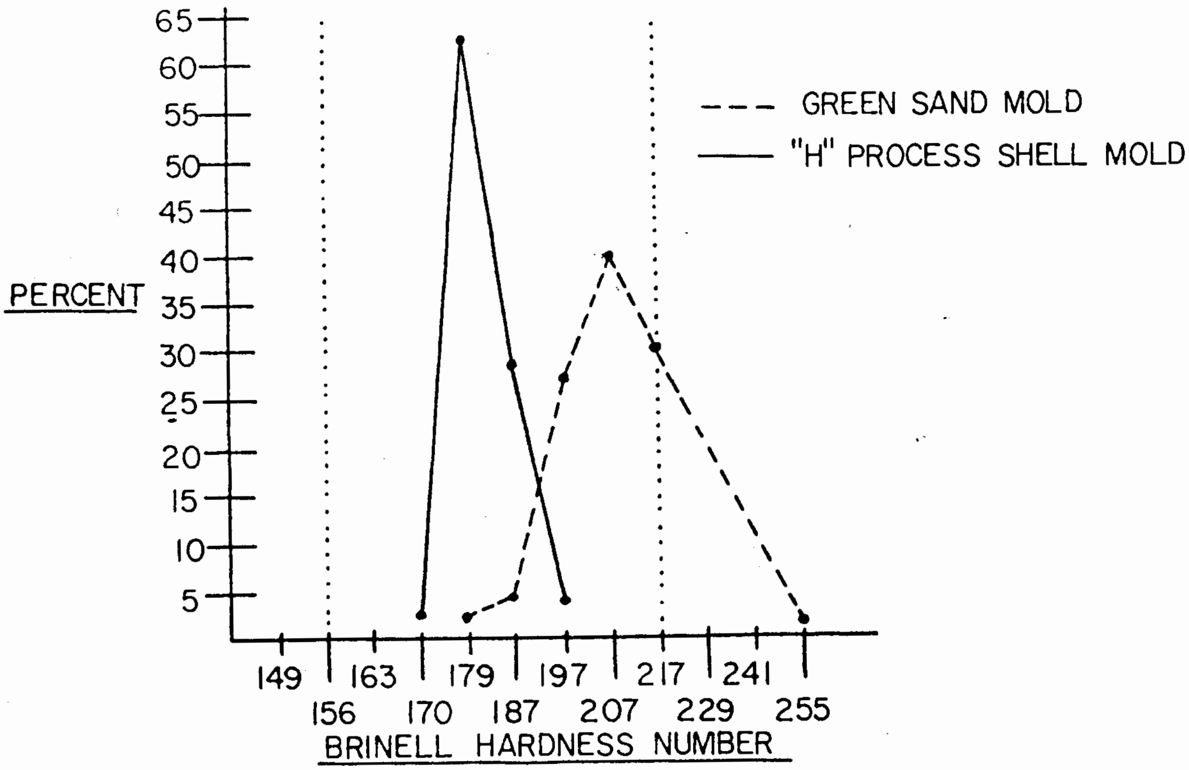


(Eberhardt, 1980, page 28)

well into the middle of the range throughout the length of the strings. The castings weighed 3.34 lbs. and used double-sided shell molds 2 1/4 inches thick. The weight of pour was 93.8 lbs. with a 1.25: 1 sand-to-metal ratio. These two examples are typical of what can be expected with the "H" Process with respect to hardness control.

Miller and Company has done comparative hardness tests between green sand molding and "H" Process methods for similar castings. One hundred readings were taken from both processes using Ferritic Ductile Iron. The results are shown in Figure 5. The "H" Process castings all fell within the acceptable limits, whereas, 1% of the green sand castings fell outside the limits.

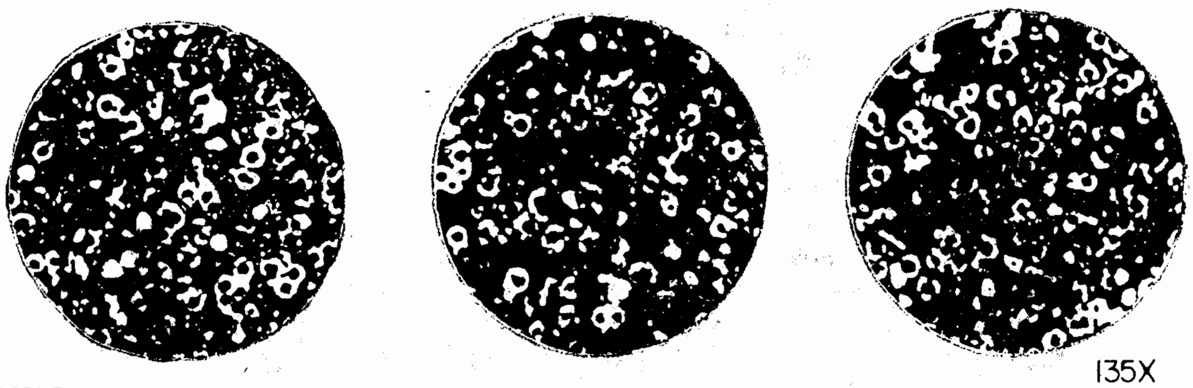
Figure 5
Ferritic Ductile Iron Casting Hardness Comparison



(Miller & Company, 1982, note 1)

Microstructure sections taken from 3/16 inch sections of the first, middle, and last castings of a 18 mold string of pearlitic ductile iron are shown in Figure 6. The hardnesses yielded were BHN 285, 277, and 285 respectively. All three sections exhibit uniform microstructure control throughout the casting string.

Figure 6
Microstructure Sections -- Pearlitic Ductile Iron



MOLD LOCATION 1 9 18

CHEMISTRY - %	C	Si	Mn	Mg	Cu	S	P
	3.62	2.66	0.32	0.049	0.67	0.007	0.007

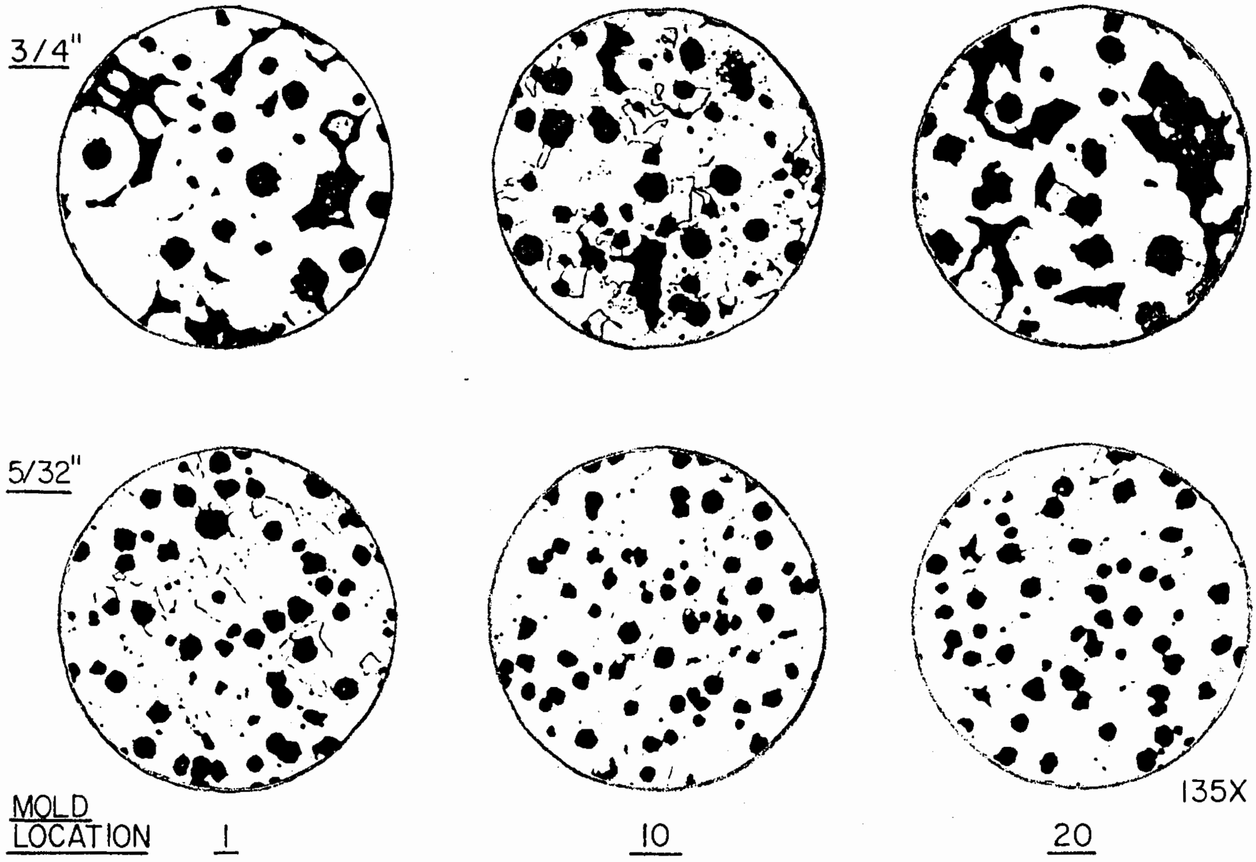
2.0% NITAL

(Eberhardt, 1980, page 30)

Similar tests were run on ferritic ductile iron castings of 3/4 inch and 5/32 inch sections. The hardnesses measured were BHN 197, 187, and 187 respectively. Photomicrographs of these sections appear in Figure 7.

Figure 7

Microstructure Sections -- Ferritic Ductile Iron



CHEMISTRY- %	C	Si	Mn	Mg	Cu	S	P
	3.52	2.78	0.25	0.045	0.05	0.017	0.028

2.0% NITAL

(Eberhardt, 1980, page 31)

A slight increase in the amount of pearlite is shown in sections 1 and 20. This is due to the faster cooling rate at the ends of the casting string. This condition may be controlled by the use of insulating material or boards to the end of the clamping fixture.

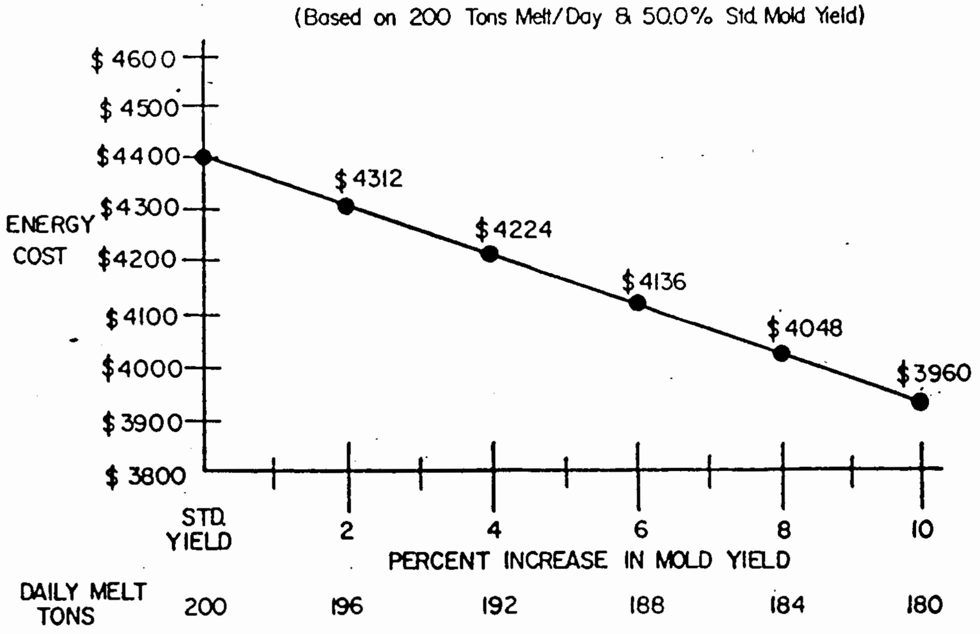
The "H" Process yields a significant dividend in energy conservation as illustrated by Eberhardt and Jenkins: (1980)

> Significant Energy Savings -- With the increase casting yields that are realized from this process, less remelt is generated with commensurate melting energy savings. With current and future escalating costs for energy, these savings can be quite dramatic for foundries. For example, the cost to melt cupola iron with coke at $ .08 per lb. amounts to $22.00 per ton of melt, assuming a figure of 275 lbs. of coke to melt a ton of iron -- a 7.3:1 metal-to-coke ratio. This does not include the cost for hot blast gas, blower, or electric furnace duplexing power, oxygen, fluxes, and other related melting costs.

The savings are illustrated in Figure 8 for cupola melting. A melt for a standard yield pour would require $4,400.00 in energy costs. A pour with a 10% mold increase requires $3,960.00 in energy costs. This is a $440.00 ($4,400.00 - $3,960.00) savings on coke per day or a $105,600.00 annual (240 days) energy savings.

Figure 8

Energy Cost Reduction With Increase in Mold Yield -- Cupola



(Eberhardt, 1980, page 24)

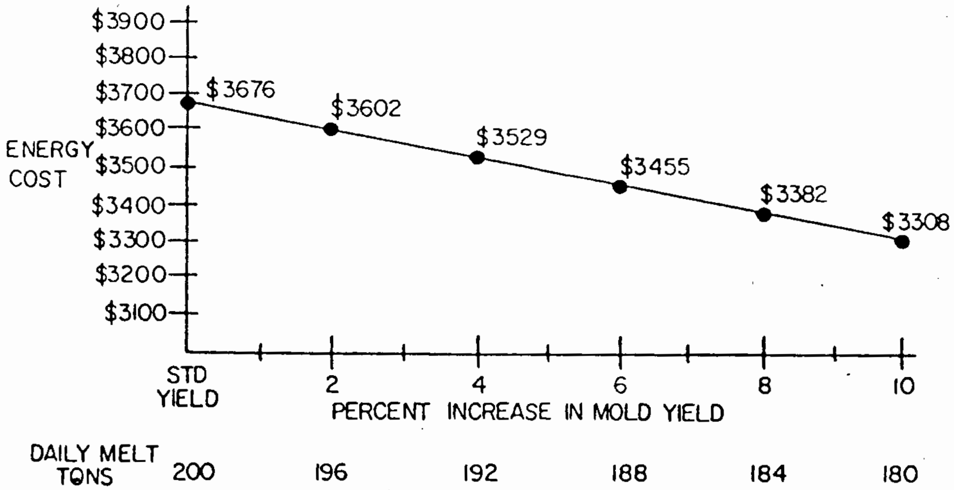
Eberhardt and Jenkins (1980) go on to say:

> Similarly, the electrical energy to melt a ton of iron in a coreless induction furnace is $18.38, based on a requirement of 525 KWH per ton of melt at a cost of $ .035 per KWH. Again, preheater gas, refractory costs, etc., are not considered in this calculation.

Figure 9 illustrates the savings realized by a 10% increase in mold yield for induction melting. Standard yield energy costs are $3,676.00. A 10% yield increase would require $3,308.00 for energy costs. This is a daily savings of $368.00 ($3,676.00 - $3,308.00) or $88,320.00 annually.

Figure 9
Energy Cost Reduction with Increase in Mold Yield
Coreless Induction Furnace

(Based on 200 Tons Melt /Day & 50.0% Std. Mold Yield)



(Eberhardt, 1980, page 25)

The "H" Process is a relatively new method of metal casting with many attractive advantages for the future. It is a process whose full potential has not been realized.

Chapter 3
Procedures

A basic working knowledge of the "H" Process was acquired from various sources. Letters to Miller and Company and American Foundrymen's Society Technical Library were written (See Appendix page 42-50) with the information requested provided by these companies. Other sources of information were identified through computer assisted literature searches of the following data bases: Compendex, ISMEC - Mechanical Engineering File 14, BRS - TYMNET - NTIS, and BRS - TYMNET - Conference Papers Index. (See Appendix page 51) The Library of Congress - National Referral Center Data Base in Washington, D. C. was contacted for a search of government documents. These sources identified the same papers on the "H" Process.

A gating system should do the following:

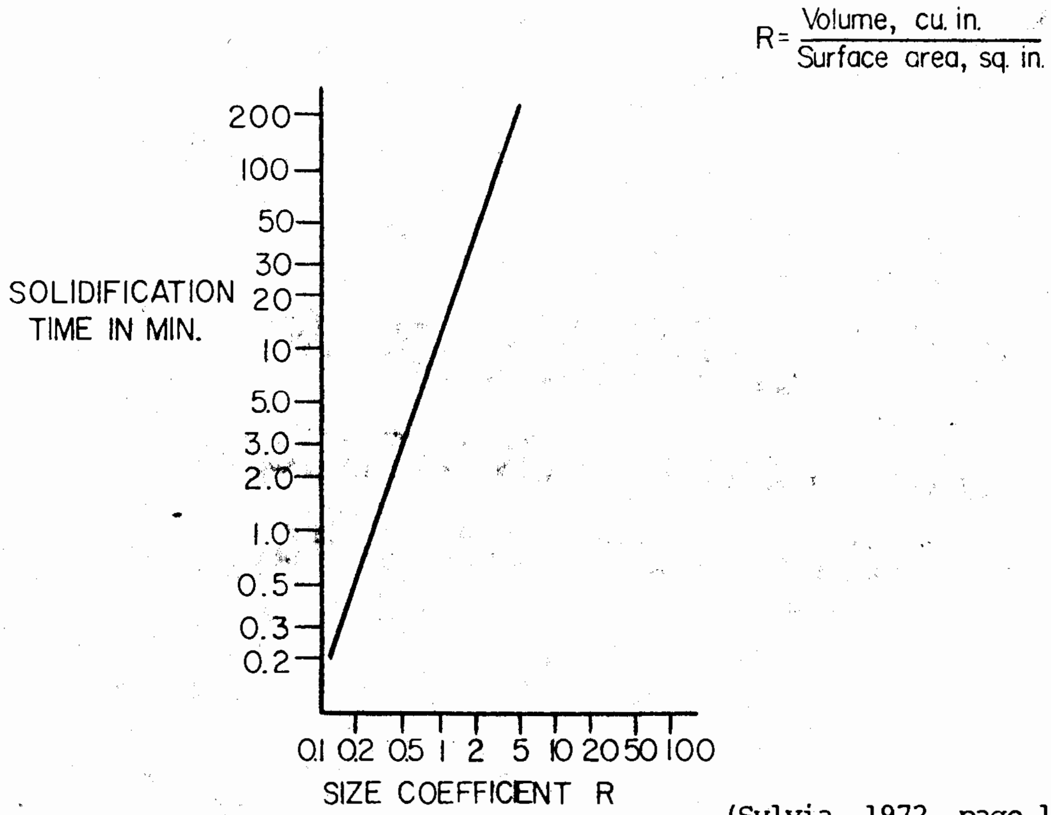
1) Provide metal to the mold.
2) Limit turbulence in the molten metal during pouring.
3) Feed the casting during the solidification process.
4) Provide a clean metal flow.

Using these as the objectives to be obtained for the "H" Process gating system along with information obtained in the review of literature, a gating system was designed.

A casting of a one inch cube was chosen as the standard shape. A cube can be measured easily, inspected for defects, and will exhibit shrinkage due to its thick section very readily. Aluminum was chosen as the metal to be cast due to the ease of controlling melt and pouring conditions. The core box was constructed using the proper shrinkage allowances for aluminum.

The runnersphere which serves as a riser was calculated using the conventional risering formula. The riser must solidify after the casting being poured, in order to feed the shrinkage properly. N. W. Chvorinov developed a logarithmic curve giving solidification time of castings of various sizes (See Figure 10).

Figure 10
Logarithmic Curve For Solidification Time



(Sylvia, 1972, page 155)

The size coefficient $R = \frac{\text{Volume, cu. in.}}{\text{Surface area, sq. in.}}$. (Sylvia, 1972, page 155)

A riser can be considered as a casting differing only in shape from the casting it feeds. This allows the solidification rate of a casting to be dependent on the relation between surface area and volume of the casting and riser.

$$R_{\text{casting}} = \frac{\text{Volume, cu. in.}}{\text{Surface Area, sq. in.}}$$
$$= \frac{1 \text{ in.}^3}{6 \text{ in.}^2}$$
$$= 0.16666$$

Solidification time for the casting is .3 minutes from Figure 10.

$$R_{\text{Riser}} = \frac{\text{Volume, cu. in.}}{\text{Surface Area, sq. in.}}$$

Volume of a sphere $= \frac{4 \pi r^3}{3}$

$= 4.1888 r^3$

Surface Area of a Sphere $= 4 \pi r^2$

$$R_{\text{Riser}} = \frac{4.1888 r^3}{4 \pi r^2}$$

Assume the Riser to have a volume of 1 in.^{3}

$$1 \text{ in.}^3 = 4.1888 r^3$$
$$\frac{1 \text{ in.}^3}{4.1888} = r^3$$
$$.2387318 \text{ in.}^3 = r^3$$
$$\sqrt[3]{.2387318 \text{ in.}^3} = r$$
$$r = .62 \text{ in.}$$

Area of sphere $= 4 \pi r^2$

$= (4)\ (3.14)\ (.62 \text{ in.})^2$

$= 4.828 \text{ in.}^2$

$$R_{\text{Riser}} = \frac{1 \text{ in.}^3}{4.828 \text{ in.}^2}$$
$$= .20712$$

Solidification time for the Riser is .6 minutes from Figure 10. The solidification time for the casting was .3 minutes and the time for solidification of the riser was .6 minutes, therefore, the riser will feed the casting during solidification. The radius of the runnersphere used was .62 inches.

If the riser is to feed the casting, the gate must not solidify before the casting. The "H" Process creates a hot spot between the riser and the casting which keeps the gate from freezing. The maximum length of the gate should be the riser diameter divided by two.

$$\text{Maximum Length of Gate} = \frac{\text{Diameter of riser}}{2} \quad \text{(see Figure 11)}$$

$$= \frac{1.24\ \text{in.}}{2}$$

$$\text{Maximum Length of Gate} = .62\ \text{in.}$$

A gate length of .25 in. was chosen.

The diameter of the gate equals the length of the gate plus two tenths of the diameter of the riser.

$$\text{Diameter of gate} = L\text{gate} + 0.2\ \text{Diameter of Riser} \quad \text{(See Figure 11)}$$

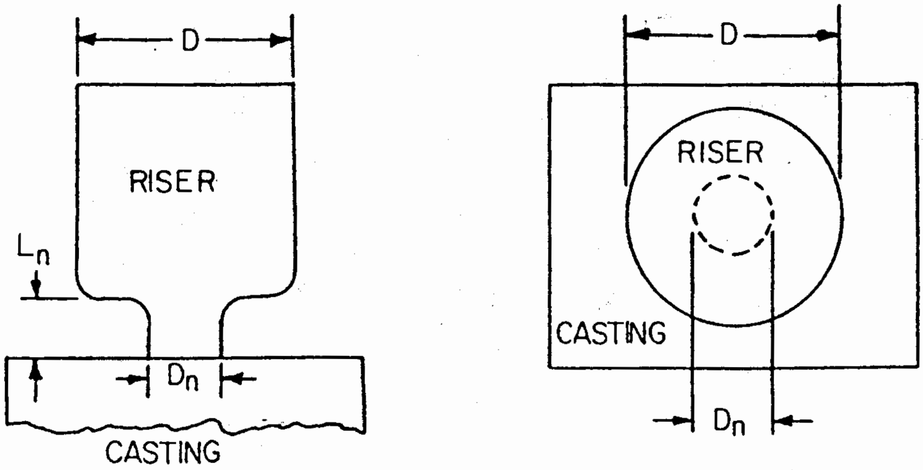
$$= .25\ \text{in.} + (0.2)\ (1.24\ \text{in.})$$

$$= .25\ \text{in.} + .248\ \text{in.}$$

$$= .498\ \text{in.}$$

A weir or dam to control the metal's forward velocity must be incorporated between each of the runnerspheres. These weirs ensure that the mold being poured is completely filled before the metal flows over the weir to the next mold. It was placed on the upper one-half of the runnersphere with its lower edge on the centerline of the sphere.

Figure 11
Riser-neck Dimensions — Top Riser



L_n Maximum of D/2

$D_n = L_n + 0.2D$

(Sylvia, 1972, page 164)

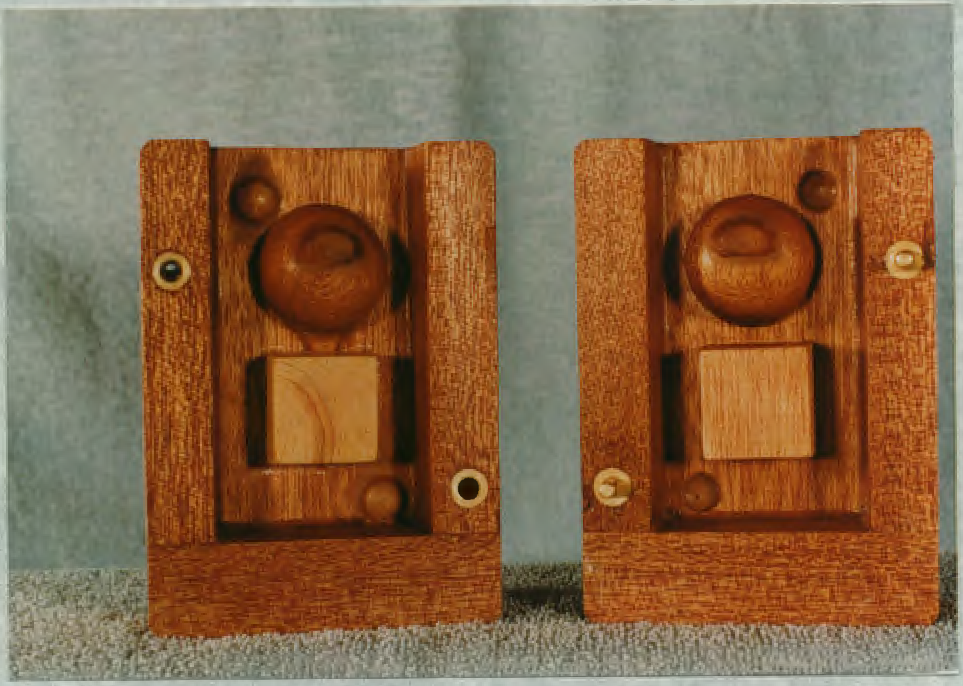
It blends uniformly from the shape of the runnersphere to an oval shape with a cross-sectional area approximately equal to .125 square inches. Using the dimensions listed above, a core box that produced a double sided core was produced (See Figure 12).

A matchplate to cast eight one inch cubes was made to compare the conventional green sand casting process to the "H" Process. The calculations for the size of the gating system can be found on page 55 of the Appendix.

Eight clear plastic cores were made using a clear casting resin and the "H" Process core box. (see figure 12) The plastic cores were assembled as if they were sand cores in preparation for casting. The first core had a down sprue drilled into the runnersphere to allow colored water to enter the gating system. Each casting cavity had a small hole drilled through the plastic to allow the air to escape. This would not be done on a sand mold. Due to the porosity of the sand, the mold gases escape through the sand.

Red colored water was poured into the mold string filling the first four full casting cavities. Blue water was then poured in the same manner with the mixing action of the flow pattern being recorded by a camera.

Figure 12
"H" Process Core Box



Chapter 4
Results

The "H" Process core box in this study has a total volume of 2.03 cubic inches per core. The runnersphere volume is 1.03 cubic inches per core. This is a 49% yield for this core box. The weight of the castings and runnerspheres is 1.59 pounds.

The matchplate using conventional gating practice has a volume of 16.51 cubic inches which includes the eight cubes to be cast. (see figures 13 and 14) The gating system, including risers, has a volume of 8.51 cubic inches for a 48% yield. The weight of the castings and gating system is 1.6 pounds.

Figure 13
Matchplate -- Cope

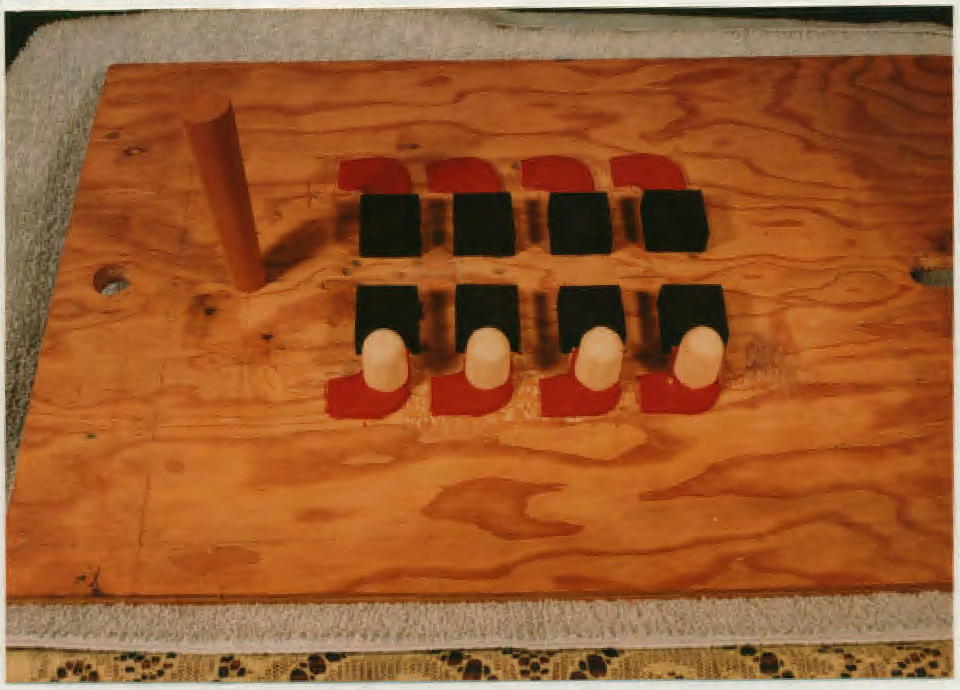
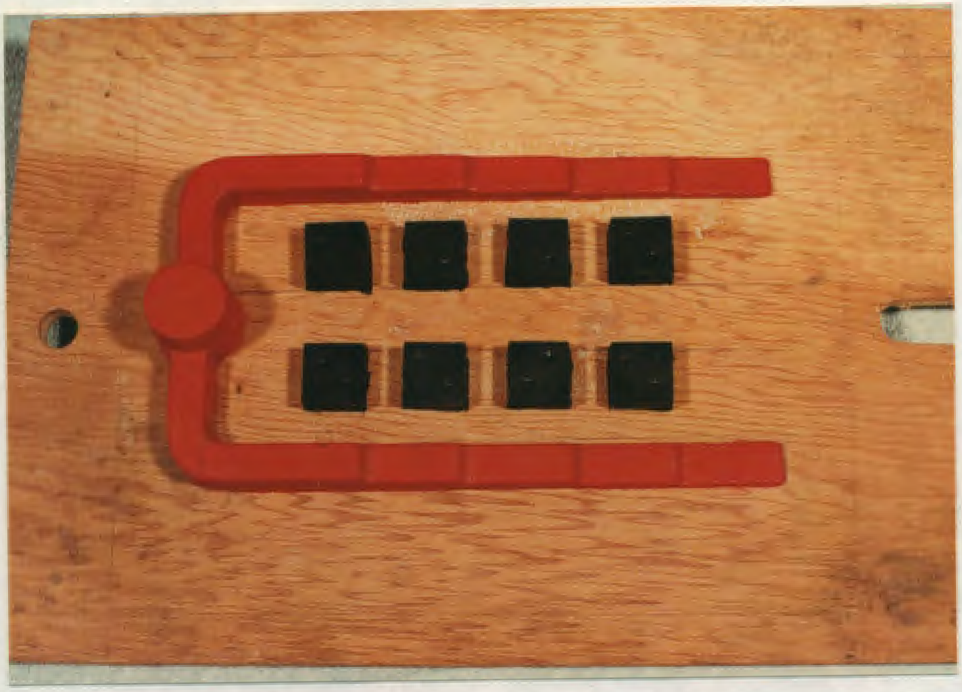


Figure 14

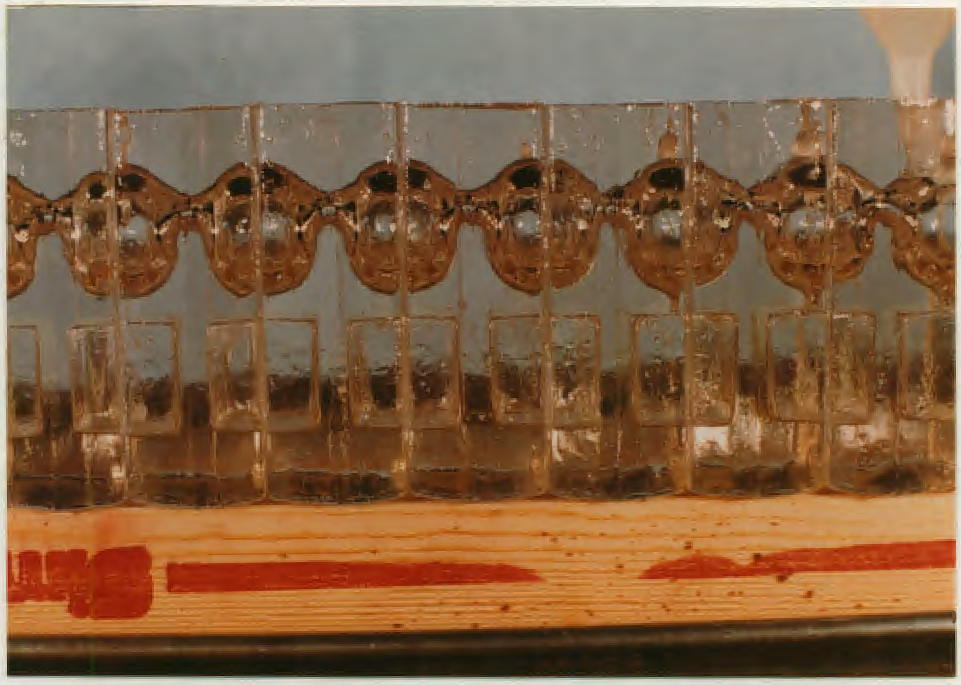
Matchplate -- Drag



The flow test was recorded in a series of pictures. Figure 15 shows the core string prior to the flow test.

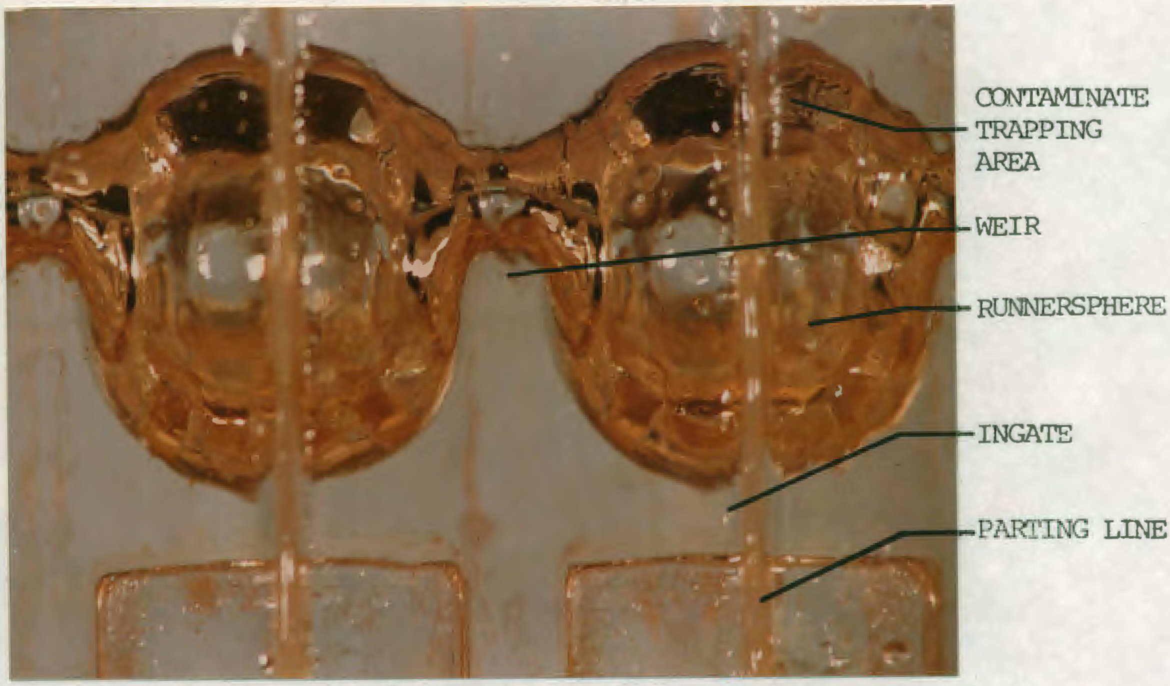
Figure 15

Flow Test -- Set Up



In Figure 16, a close view of the runnerspheres, the weir or dam is evident between each sphere. The portion of the sphere above the weir is to trap floating contaminates in the metal. The ingate is obscured by the parting line between the cores.

Figure 16
Flow Test -- Runnersphere Identification



Each core is locked with a mating half of the next core by locating pins as seen in Figure 17. The red colored water was introduced into the mold string filling the first four cavities as shown in Figures 18 through 21. Note the forward velocity is controlled by the weirs.

Figure 17
Core Locating Pins

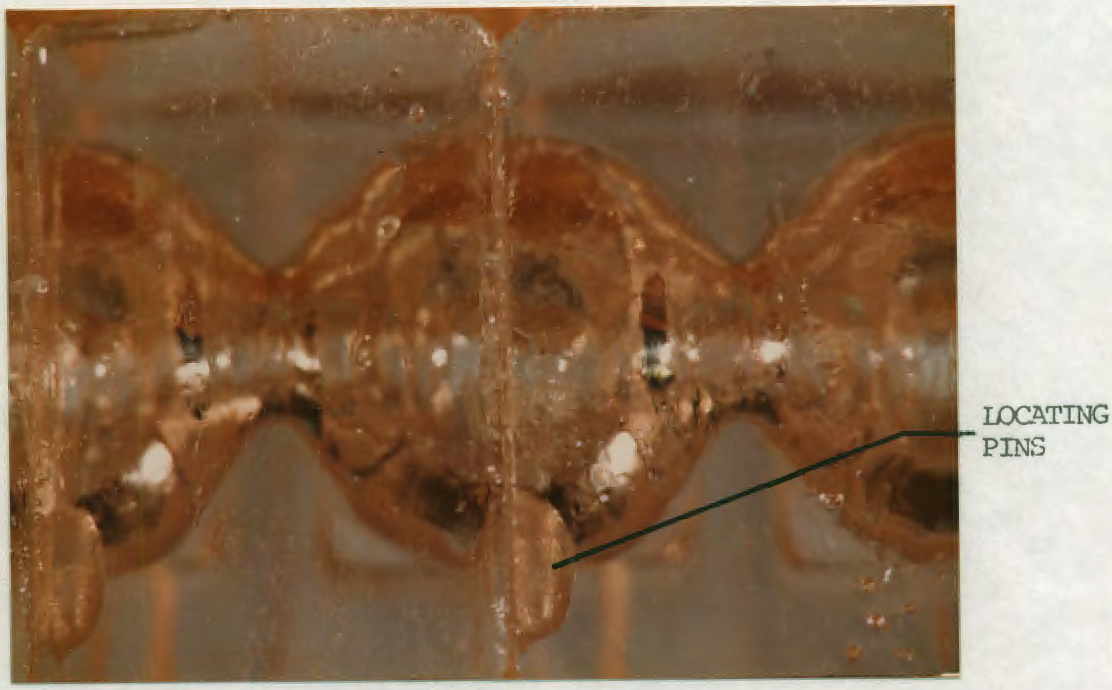


Figure 18
Flow Test -- Cavity One

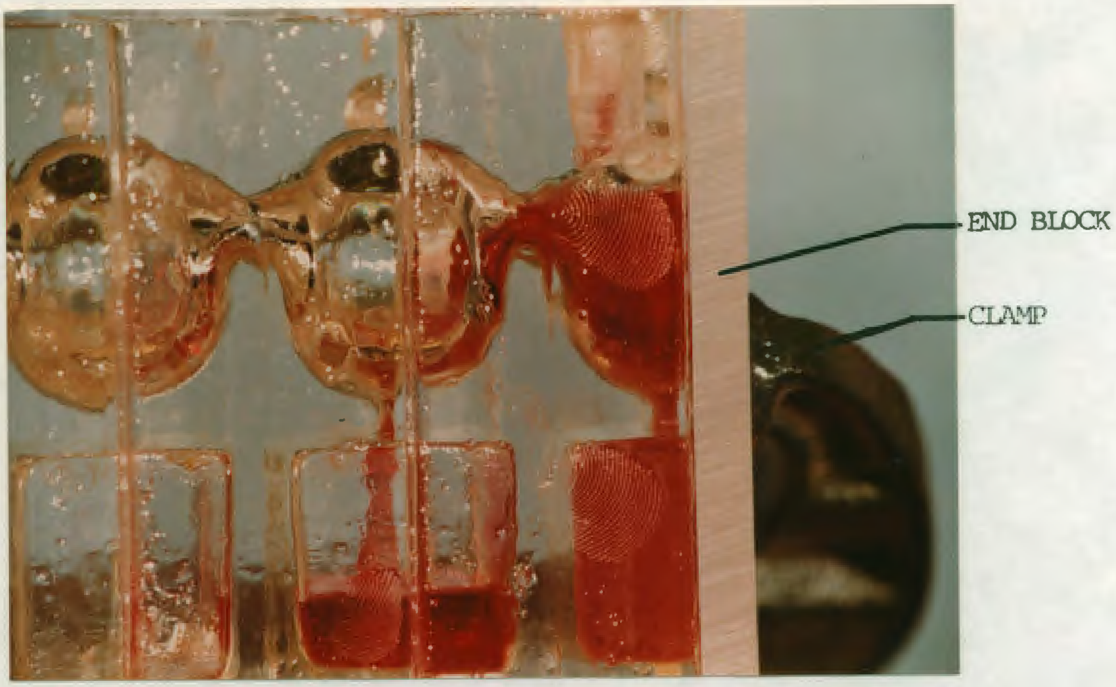


Figure 19
Flow Test -- Cavity One

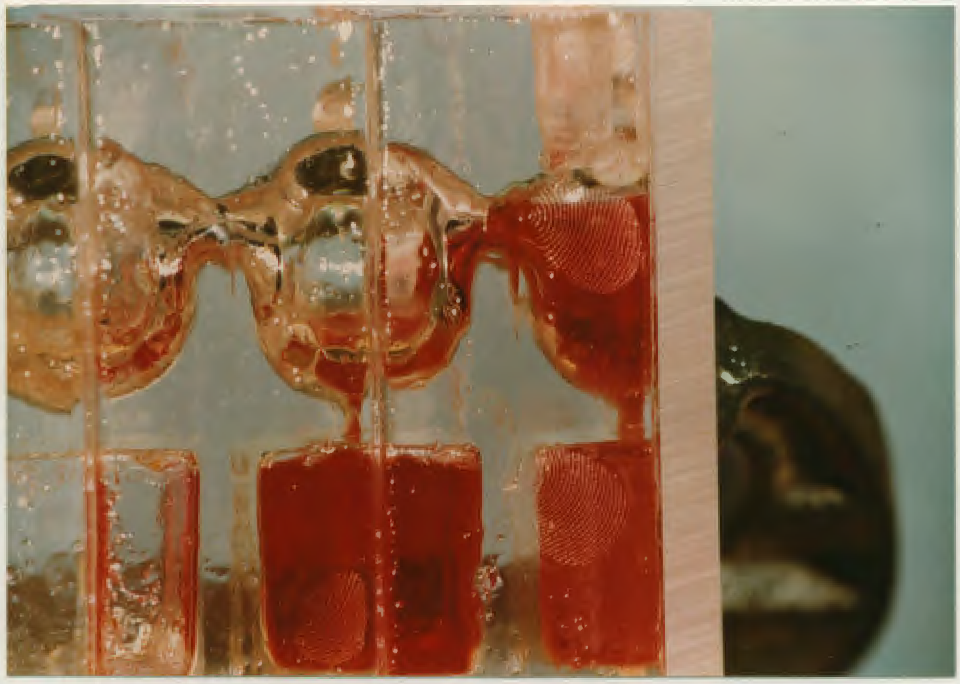
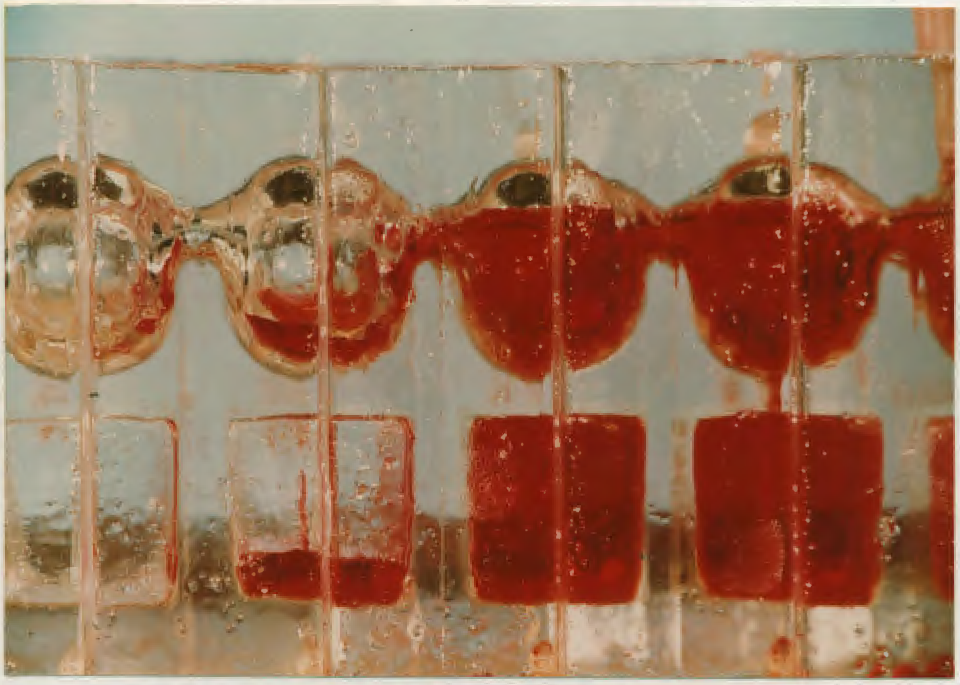


Figure 20
Flow Test -- Runnersphere Close-up

Figure 21
Flow Test — Cavity One through Four



Blue colored water was poured into the gating system to check the flow within the gating system previously filled with red water (See Figures 22 through 29). Note the blue water forces the red ahead of it as it flows through each runnersphere. The metal is completely replaced by fresh or hot liquid. The castings already filled remain red, therefore, the cooler metal remains undisturbed within the casting cavities. The forward velocity is continually checked by each successive weir.

Figure 22
Flow Test -- Introduction of Blue Water

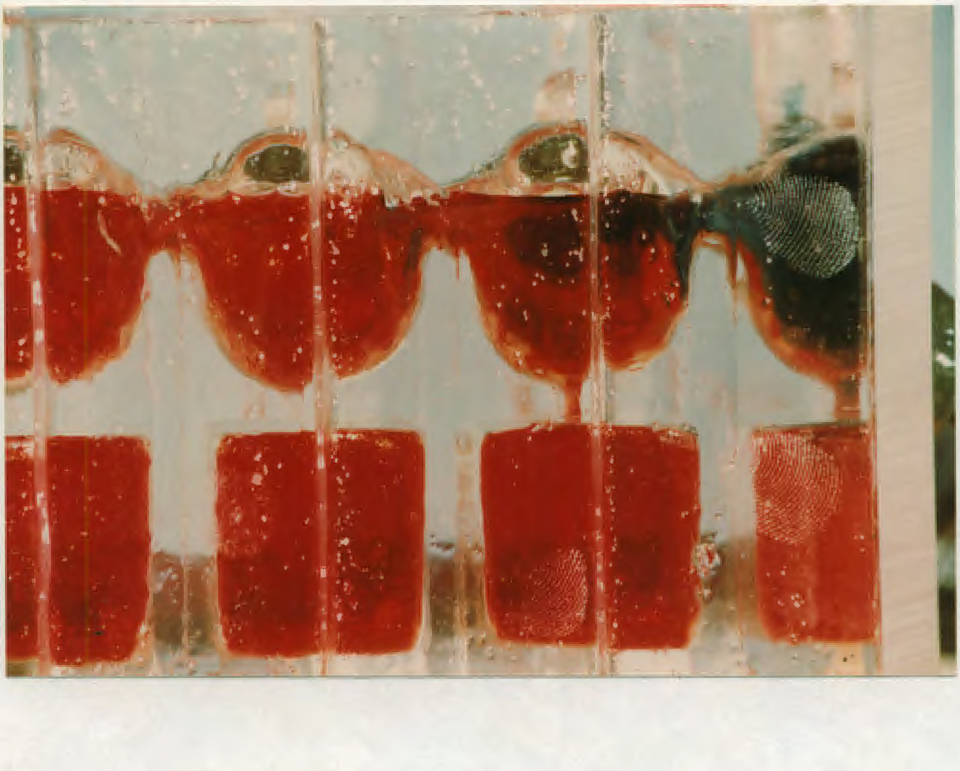


Figure 23
Flow Test — Runnersphere Close-up

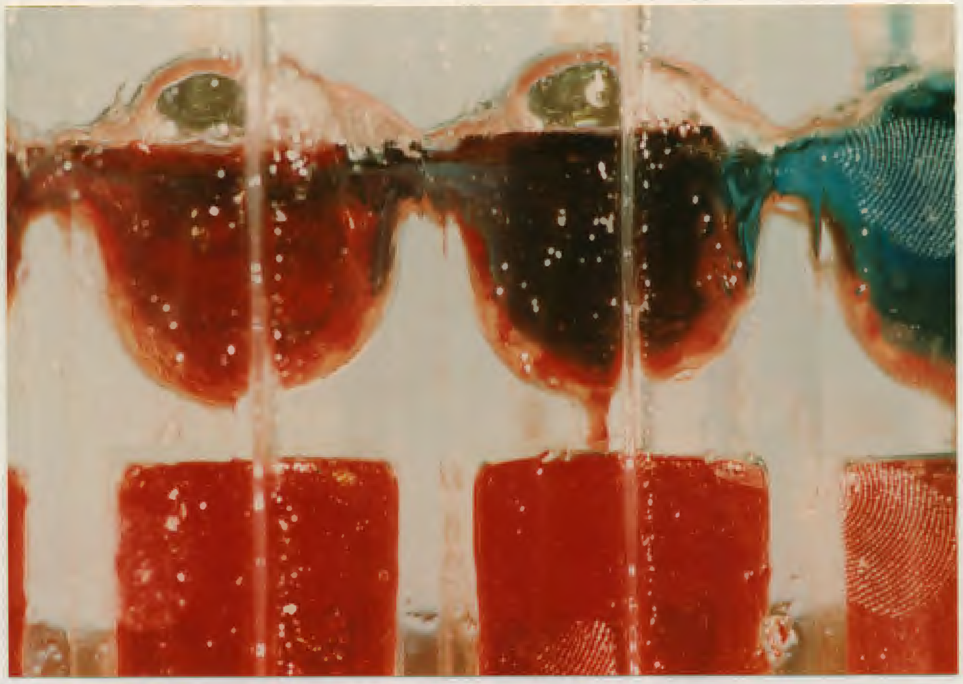


Figure 24
Flow Test

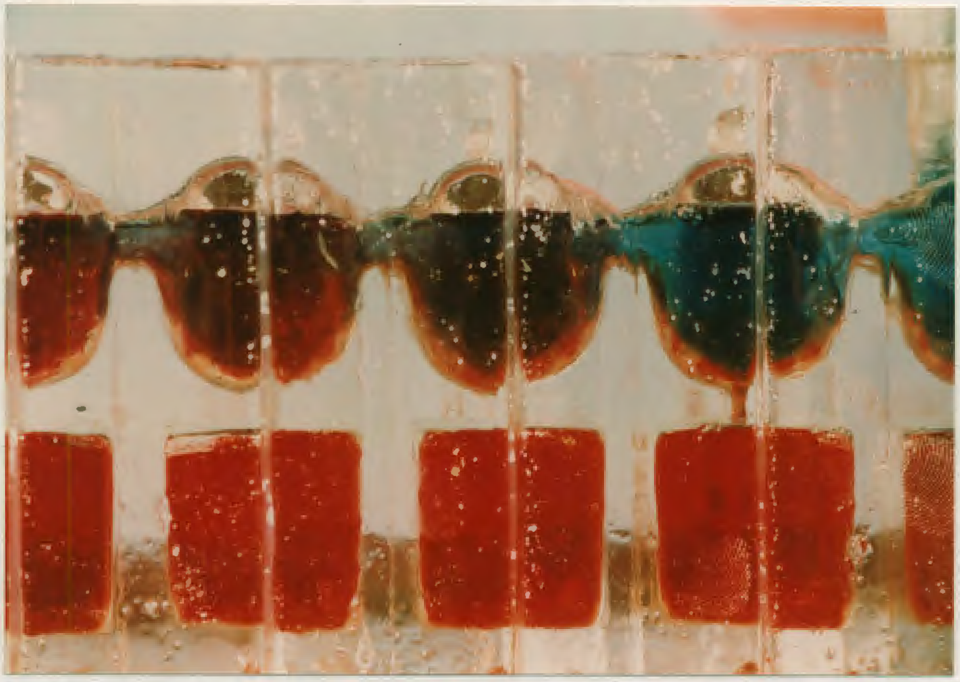


Figure 25
Flow Test

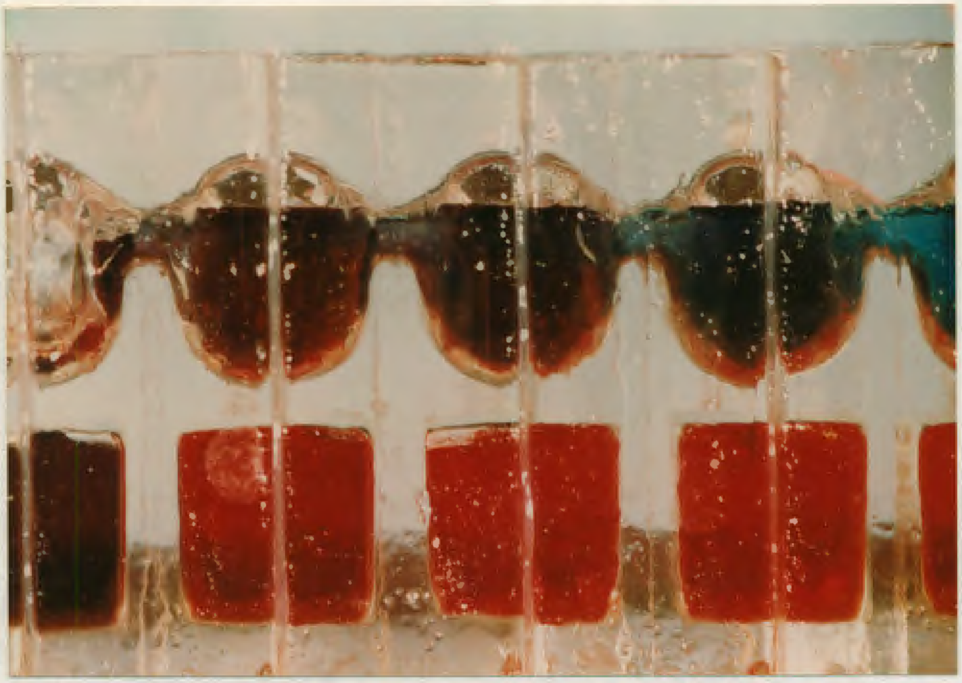


Figure 26
Flow Test -- Cavity Five

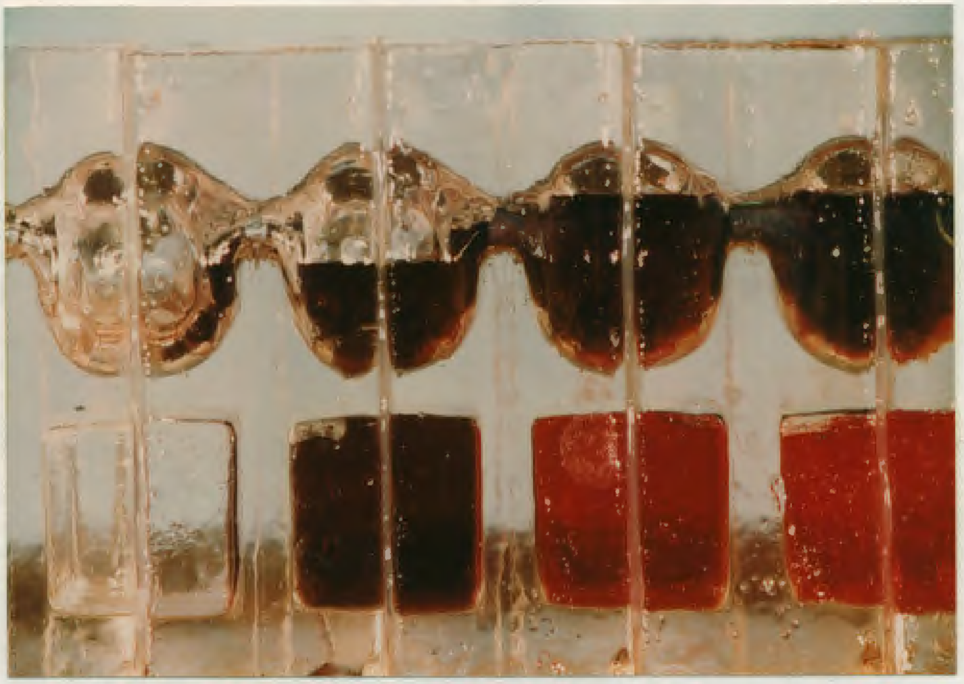


Figure 27
Flow Test -- Cavity Six

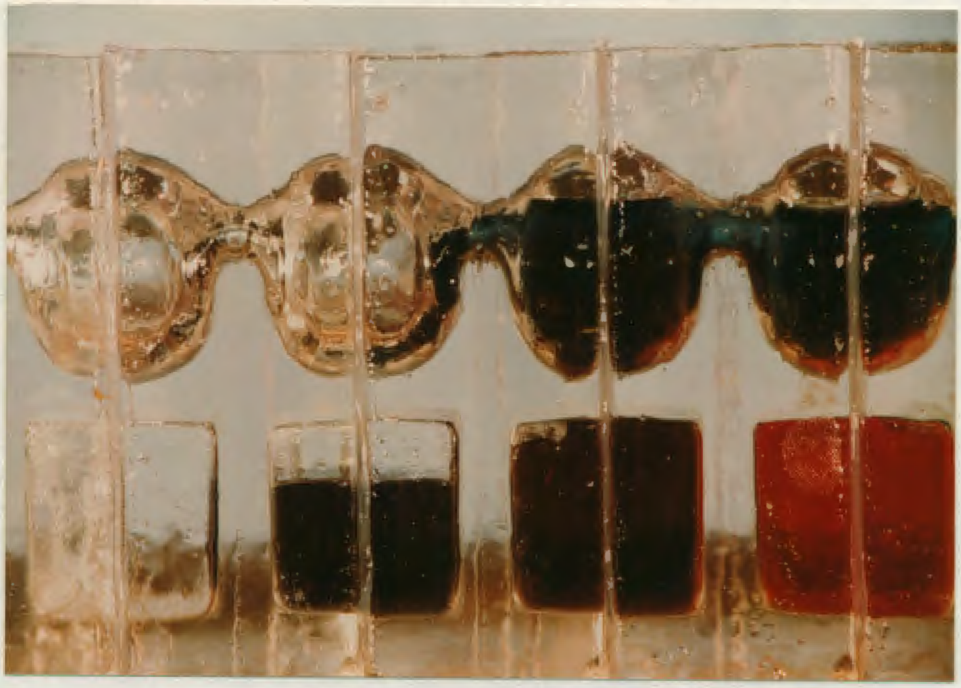


Figure 28
Flow Test -- Riser Filling on Cavity Six

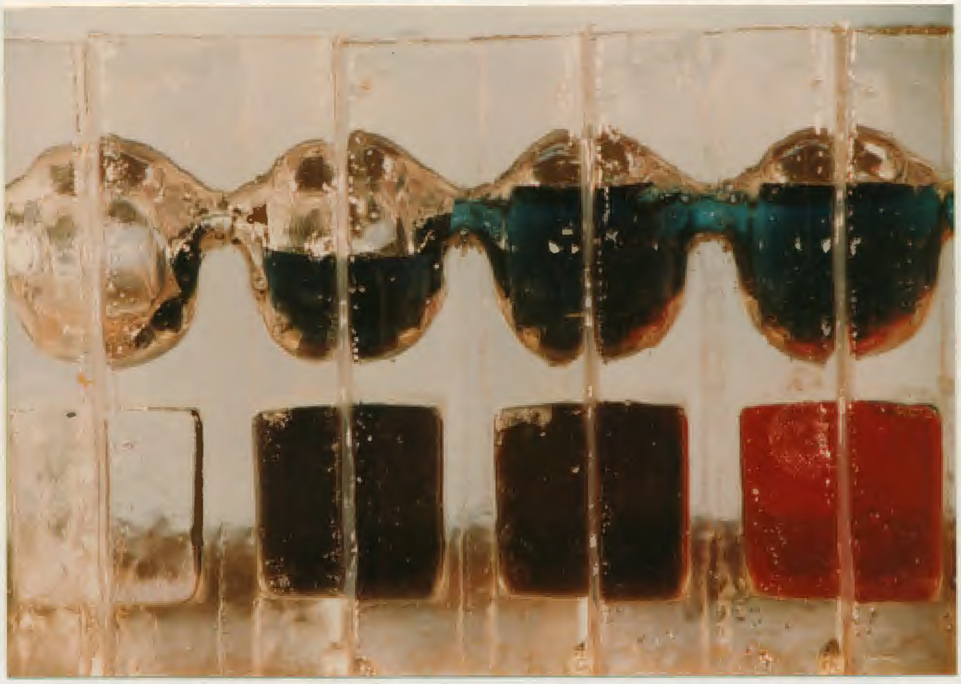
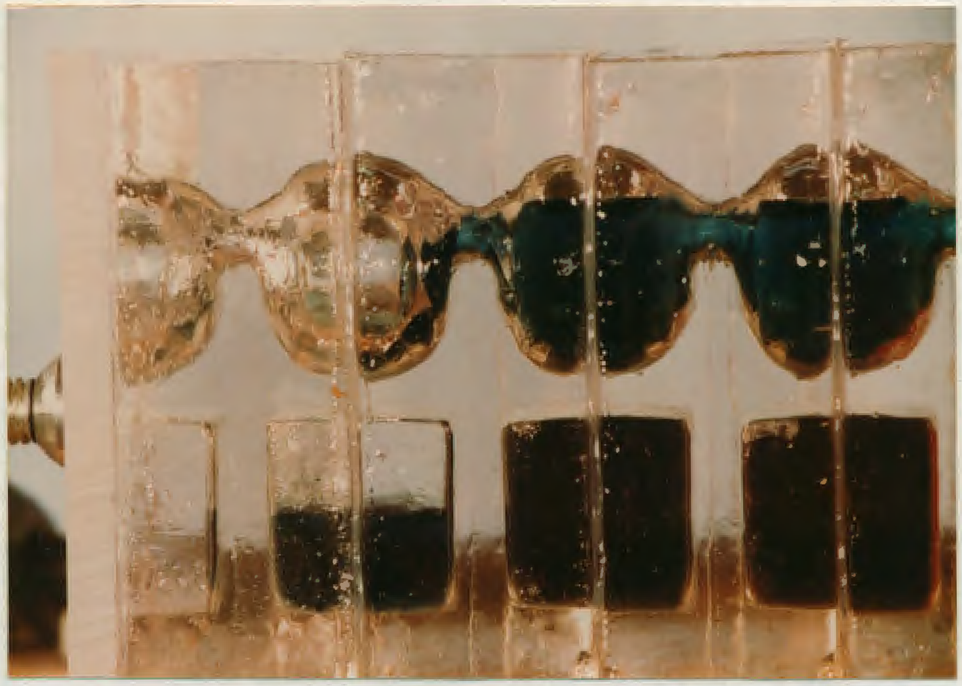


Figure 29
Flow Test -- Cavity Seven



Figures 30 to 32 show the final result of the flow test. Note in Figure 32 the end caps and clamping fixture.

Figure 30
Flow Test -- Filled Molds

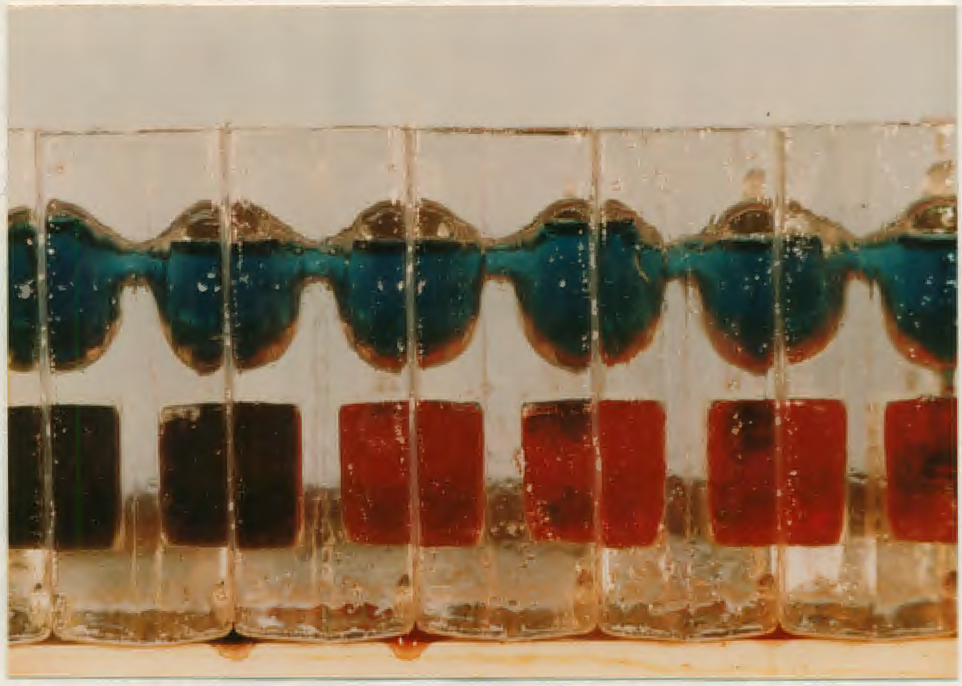


Figure 31
Flow Test -- Completed

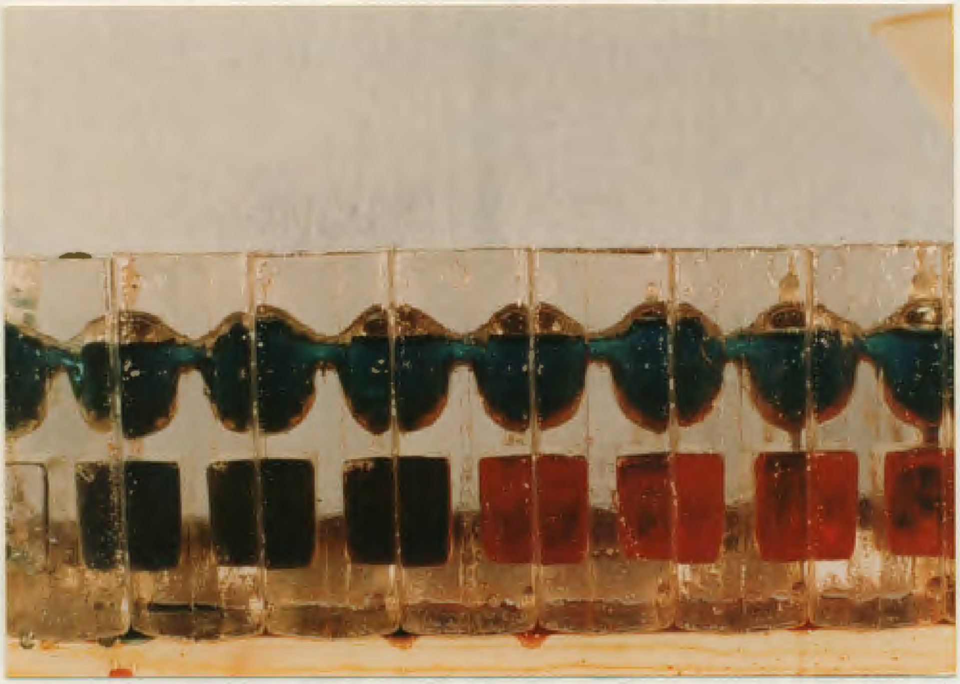
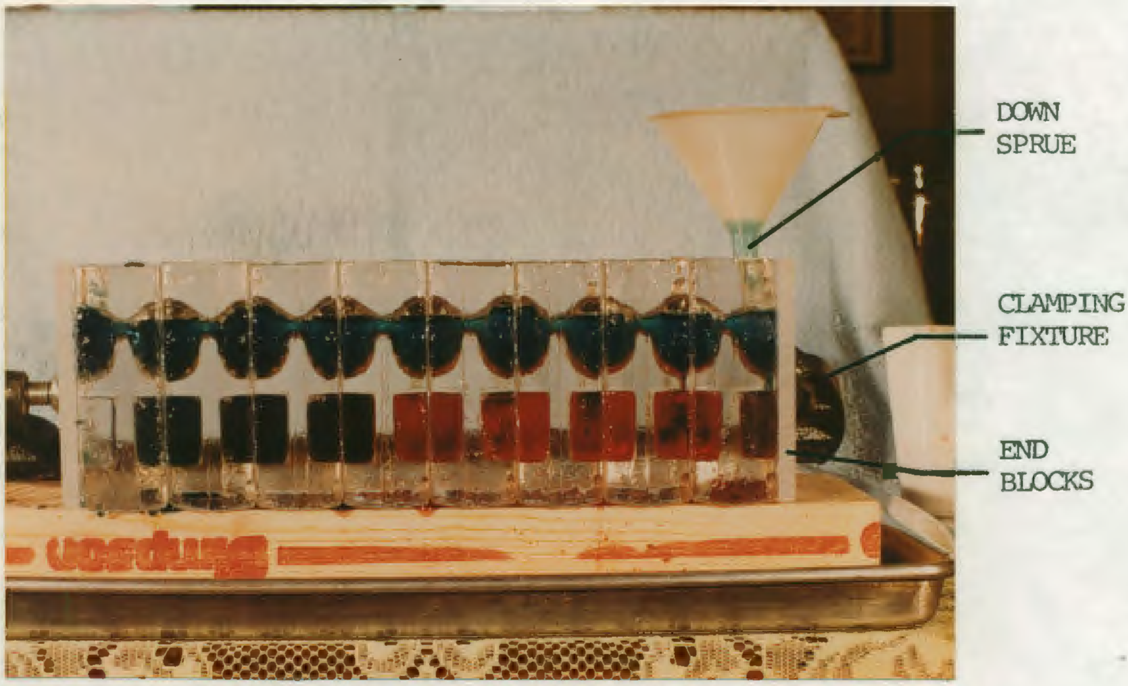


Figure 32
Flow Test -- Final Form



Chapter 5
Discussion and Conclusions

The "H" Process runner system designed in this study was evaluated on the following points:

1) Does the gating system provide metal to the mold?

2) Is turbulence within the molten metal reduced by the runner system?

3) Is shrinkage controlled?

4) Is clean metal provided to the casting cavities?

The gating system designed consisted of a down sprue, a series of runnerspheres, gates to casting cavities, and a vent hole. The runner system designed provided metal to all casting cavities.

A laminar flow within the molten metal was achieved in the runner system using large radii where possible. This flow characteristic was clearly observed during the flow test of the clear plastic cores. This test would be analagous to the flow of molten metal because of the similarity of behaviors for all liquids concerning their flow properties.

One of the key parts of the runnersphere's success in flow control is the weir between each successive runnersphere. During the flow test, the down sprue was kept full allowing the fastest possible flow within the runner system. The forward velocity was checked by each weir allowing a controlled sequential pour of all molds in the casting string.

Shrinkage control was achieved using this new runnersphere configuration. The riser in a conventional gating system was replaced by the runnersphere which is attached to each casting by an in-gate. Each runnersphere was large enough to feed the casting as solidification occurred. The presence of a continuous supply of molten metal was made possible due to the constant flow of fresh hot metal in the runnerspheres during the casting process. Directional solidification was enhanced by the configuration of the gating system which also aided shrinkage control. The in-gate did not freeze off due to the natural hot spot created between the casting and runnersphere areas around the gate. This allowed the runnersphere to feed the internal shrinkage within the casting. The results of shrinkage control are less scrap and more usable castings which can be translated directly to a lower cost per casting.

Floating contaminates, which are a problem with heavier metals, are taken into account in the design of this runner system. The upper portion of the spheres in the runner system are natural traps for contaminates. If good quality molds are used with properly melted metal, the runner system should trap the floating contaminates which lowers the scrap rate and the cost per casting.

The gating system designed did meet all of the requirements as listed above. The main advantage of the "H" Process is the increase in yield of castings for the amount of metal poured. The increase over the conventional gating system which was designed for this paper was not as great as expected. This may be due to an oversized runnersphere. Formulas for the correct dimensions are protected by license but can be purchased from Miller and Company. Further experimentation may be able to increase the yield rate for this mold.

The "H" Process is a relatively new foundry technique being put into practice in 1975. Today, the cost to produce castings is being investigated constantly in an attempt to find ways to save money. The "H" Process can reduce the cost per casting by utilizing a higher yield rate for the metal poured, better shrinkage control, and better contaminate control. The "H" Process is a unique method of casting metal and is an economically viable solution in an ever changing industry.

Reference Notes

1. Miller and Company. (1982). "H" Process Horizontal Controlled Flow. Unpublished manuscript. (Available from Miller and Company, 55 East Monroe Street, Chicago, Ill. 60603).

References

American Foundrymen's Society. (1967). Basic Principles of Gating. Addison-Wesley Publishing Company.

American Foundrymen's Society. (1968). Basic Principles of Risering. Addison-Wesley Publishing Company.

Curry, D. T. (1980). The Horizontal Process: A New Twist in Casting. Machine Design. Volume 52, Number 19.

Eberhardt, C. M., & Jenkins, L. F. (1980). Update of the "H" Process (Report No. 8005). American Foundrymen's Society Tech Report.

Hoult, F. H. (1979). The H Process of Repetition Casting Manufacture (Preprint No. 79-69, page 237-240). AFS Transactions.

Sylvia, J. G. (1972). Cast Metals Technology. Addison - Wesley Publishing Company.

Appendix A
Letters, Replies, Invoices

Dean A. Boyce

Waterloo, Iowa 50703

Miller & Company
55 East Monroe St.
Chicago, Illinois 60603

Dear Sirs,

I am a graduate student at the University of Northern Iowa, Cedar Falls, Iowa, and am interested in the horizontal process of metal casting. The article "The Horizontal Process: a new twist in Casting" by David T. Curry in the August 21, 1980 issue of Machine Design lists your company as the licensee of the Horizontal process in the United States.

I have been unable to locate much information on this topic. Would you please provide me information about the process, specifically, the runner system, weir, and well.

Postage has been included for your convenience. Your prompt reply will be greatly appreciated.

Sincerely,

Dean A. Boyce

Enc.

Miller and Company
THE TOTAL SERVICE PEOPLE
55 EAST MONROE STREET, CHICAGO, ILLINOIS 60603
TELEPHONE: 312—372-1500

October 27, 1982

Mr. Dean A. Boyce

Waterloo, IA 50703

Dear Dean,

Thank you for your letter asking for information on 'H' Process.

I am enclosing our literature on 'H' Process that we send to prospective licensee foundries.

It isn't possible to give you specific information on the items you mention since these are the basis of the patent for which foundries pay a license fee.

If you could indicate more clearly the reasons for your interest in 'H' Process, together with any industrial connections you may have, we could possibly go into more detail.

Yours truly,

Brian Grice
'H' Process Manager

BG:ml
Encl.

SERVING THE MELTING INDUSTRY SINCE 1919

Dean A. Boyce

Waterloo, Iowa 50703

C. M. Eberhardt
Miller & Company
55 East Monroe St.
Chicago, Illinois 60603

Dear Sir,

I am a graduate student at the University of Northern Iowa, Cedar Falls, Iowa. In October, 1983, I requested information on the "H" Process of Metal Casting. Your company provided a report by L. R. Jenkins and C. M. Eberhardt entitled Update of the "H" Process. The information contained within that paper was used as a source of reference in my Master's research paper.

Quotations were cited using the Fourth edition American Psychology Association format. All the information from charts or graphs used were redrawn and properly cited.

To avoid any copywrite violations I would appreciate a written letter of permission to be included in the appendix of my paper. Enclosed are sample copies of my report for your examination.

My research paper is being written to fulfill the graduate requirements for a Master's Degree in Industrial Technology. It is not intended for any other use, such as publication.

Postage has been included for your reply. Thank you for your time and cooperation.

Sincerely,

Dean A. Boyce

Danville, IL 61832
October 1, 1984

Gordon Gledhill
Miller and Company
Suite 3525
55 East Monroe Street
Chicago, IL 60603

Dear Gordon:

Please find enclosed a request from Dean A. Boyce, graduate student at the University of Iowa, regarding permission to use "H" Process technical publication data for a research paper to fulfill graduate requirements for a masters degree in Induatrial Technology.

This request was forwarded to me by the Chicago Office, but should more appropriately be handled by yourself and Miller and Company.

Best regards,

C. M. Eberhardt
Metallurgical Consultant

CC: D. A. Boise
File

Miller and Company

THE TOTAL SERVICE PEOPLE

55 EAST MONROE STREET CHICAGO, ILLINOIS 60603

TELEPHONE: 312-372-1500

OFFICE OF THE
VICE PRESIDENT CORPORATE SUBSIDIARIES

October 9, 1984

Mr. Dean A. Boyce

Waterloo, Iowa 50703

Dear Mr. Boyce:

Referring to your letter addressed to the attention of Mr. C. M. Eberhardt, we agree to allow the "H" Process data attached to your letter to be included in the appendix of your paper towards a Master's Degree in Industrial Technology.

We appreciate the documented notation regarding your thanks to Miller and Company and take this opportunity to congratulate you ahead of your graduation and wish you well in your future endeavors.

Yours very truly,

A. G. Gledhill

AGG/lmc

cc: C. M. Eberhardt

SERVING THE MELTING INDUSTRY SINCE 1919

Dean Boyce

Waterloo, Iowa

50703

A F S Technical Library
Gulf and Wolf Roads
Des Plaines, Illinois
60016

Dear Sirs,

I am a graduate student at the University of Northern Iowa in Cedar Falls, Iowa. I am currently conducting research on the Horizontal ("H" Process) Process of Metal casting. The process was developed by W. H. Booth and Co. Ltd. with Miller and Co. of Chicago, Illinois as the United States licensee.

I have been able to locate only a few trade journal articles on this topic. I would appreciate any help that your library could provide me.

Thank you,

Dean A. Boyce

DAB: ahb

CA 79-746 FILE: MISCELLANEOUS

THE H PROCESS OF REPETITION CASTING MANUFACTURE
F. H. Hoult
AFS Transactions 1979, p. 237-240
Available as Preprint No. 79-69 ~~$12.00~~ $6.00

The H Process uses rigid, double-sided molds produced by coreblowing machines. Each mold carries a half casting impression on each side, complete with runner bar, feeder head and ingate. Molds, when clamped together horizontally, form a pouring system of a top continuous runner and feeder bar. This runner/feeder bar is at one end opened up to form a pouring basin.

The objective of this paper is to explain the advantages of controlling variables in casting manufacture and show how they can be applied to the production of castings with resultant efficiency, economy of power, and raw materials. The H Process and the special considerations in using this process are described in the paper.

Illustrations are included.

AMERICAN FOUNDRYMEN'S SOCIETY / CURRENT AWARENESS SERVICE

SAND MOLDING

CA 80-279 FILE: CORES

THE "H" PROCESS
F. H. Hoult
British Foundryman. Supplement (June 1979), p. 47,49,51-52, 4 pages $3.40

The "H", or Horizontal Process, consists of the use of a double-sided core capable of being assembled into a horizontal string or clamp. Advantages of the process include controlled pour, flow feed, and ability to store cores and cast when required. Details of the process are illustrated and summarized in this article.

AMERICAN FOUNDRYMEN'S SOCIETY / CURRENT AWARENESS SERVICE

SAND MOLDING H process

CA 81-102 FILE: SAND MOLDING

UPDATE OF THE H-PROCESS
L. R. Jenkins and C. M. Eberhardt
Available as TR 8005 ~~$95.00~~ $16.00

This article describes the basic elements and benefits of the "H" Process (Horizontal controlled flow feed) as utilized by W. H. Booth & Company in England. The process consists of pouring metal into rigid, doublesided sand molds that are clamped together in a block-type, horizontal string assembly. Molds can be made from shell, airset, coldbox or hotbox bonded sands. Higher yields, controlled flow, promotion of directional solidification, low sand/metal ratios and maximum metal temperatures at the mold cavity are items utilized to advantage by the process.

Dean A. Boyce

Waterloo, Iowa
50703

A F S Technical Library
Gulf and Wolf Roads
Des Plaines, Illinois
60016

Dear Ann,

Thank you for the reference information that you sent to me on the "H" process of metal casting. Please send the following materials;

CA 79-746 File: MISCELLANEOUS
THE H PROCESS OF REPETITION CASTING MANUFACTURE
F. H. Hoult
AFS Transactions 1979, p. 237-240
Available as Preprint No. 79-69 cost $5.00

CA 81-102 File: SAND MOLDING
UPDATE OF THE H-PROCESS
L. R. Jenkins and C. M. Eberhardt
Available as TR 8005 cost $16.00

I am enclosing $23.00 for the materials plus postage and handling.

Thank You,

Dean A. Boyce

50'

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INTERNATIONAL HEADQUARTERS: Golf and Wolf Roads, Des Plaines, Illinois 60016-2277

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484 80 ...

10 13

☐ Undergraduate Student ☐ Staff
☒ Graduate Student ☐ Faculty
☐ Other
Department Industrial Technology
Campus Phone
Home Phone 233-3423

SEP/ (engineering & technology)

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THE HORIZONTAL PROCESS OF METAL CASTING - THE PROCESS USES HORIZONTAL DOUBLE-[illegible] MOLDS THAT REQUIRE A SINGLE RUNNER. IT USES A WEIR IN THE RUNNER TO CONTROL THE FLOW OF METAL.

(H-process and [illegible] casting)

[illegible]

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metal castings on horizontal presses

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engineering

metal casting & H-process

[illegible]

[illegible]

cross [illegible] vol not [illegible] db

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Calculation for the Conventional Gating System

A ratio of 1:4:4 for the choke, cross sectional area of runners, and cross sectional area of the gates, respectively, was used for these calculations. The choke was placed at the bottom of the down sprue with a diameter of .56 inch used.

Sprue base -- 5 times the choke CSA

$\pi r^2 = \text{CSA}$

$(3.14)(.28 \text{ in.}^2) = .2463 \text{ in.}^2$

$(.2463)(5) = 1.232 \text{ in.}^2$

$1.232 \text{ in.}^2/\pi = .392 \text{ in.}^2$

$\sqrt{.392} = .626 \text{ in.}$

$(.626)(2) = 1.25 \text{ in.}$

Diameter = 1.25 in.

Depth = 2 x Runner Height

= 1.34 in.

Runner - Two Runner Bars

Choke area = .25 in.^{2}

TCSA of Runners = 4 x .25 in.^{2}

TCSA of Runners = 1 in.^{2}

CSA of 1 Runner = .5 in.^{2}

Runner dimensions = .75 in. x .67 in.

Gates - Eight total

TCSA of Gates = 1 in.^{2}

CSA of 1 Gate = .125 in.^{2}

Gate dimension = .75 in. x .17 in.

(American Foundrymen's Society,
Basic Principles of Gating, 1967)

(American Foundrymen's Society,
Basic Principles of Risering, 1968)