

KALPUR direct pouring systems

Investing in your bottom line

Various methods are available today to produce a ductile iron casting. The choices include melting practices, rigging or rigging methods and molding equipment along with other operations. The ultimate goal is to combine the choices to produce the lowest cost casting that meets or exceeds the customer's requirements.

It is sometimes hard to completely account for the effect that all of the possible choices will have on the profitability of producing a ductile iron casting. Some choices are clearly detrimental to profitability, such as 100% inspection to identify preventable scrap. Other choices are clearly beneficial to profitability, such as removing an unnecessary handling stage. Some choices require closer profitability examination because they may add cost at one stage but reduce cost by a greater amount at another stage. An area that fits the last condition is the use of consumable products, such as KALPUR direct pouring systems, CELTEX filters or SEDEX filters, to increase mold yield and remove inclusion-related scrap.

To study the effect on profitability of using feeding aids and filters, a theoretical ductile iron casting was examined. The casting - figure 1 - was designed by the AFS Iron Gating and Riser Committee (5M) for a panel presentation on rigging techniques at the 100th Casting Congress. This casting is well suited to be produced with and without the use of consumable products to enhance yield. The casting was not poured with either system but was examined with a computer simulation program for acceptable fluid flow and casting soundness. By examining the costs of two practices that maximized yield, the complete effect on profitability can be determined.

The Rigging method

The ductile iron hub casting was rigged using standard techniques. For the runner system, the AFS formula for choke area and the law of continuity were used. For the riser system, the modulus method modified for ductile iron and Foseco's FEEDERCALC program were utilized.



Figure 1: Computer simulation of the ductile iron casting

The Base system

The runner design for the Base system was calculated using the AFS formula for choke area:

The choke areas for each of the four casting and riser segments were joined to the down sprue. The Law of Continuity, $Q = V_1A_1 = V_2A_2$, was used to ensure that adequate iron flow was provided for both the upper and lower levels.

The riser system was designed by first calculating the modulus of casting sections. The modulus of each section - figure 2 and figure 3 - was examined to determine if a feed path from the riser to the last section to solidify existed. After an addition of a pad to the inner bore of the casting, a direct feed path to the riser was shown by using a conservative 85% modulus feed-through rule for ductile iron.

The riser size was selected by using the FEEDERCALC program. The printout - figure 4 - for the casting contains the input information in the top section and the calculated sand riser in the bottom portion.

$$A = \frac{W}{T D C (2GH)^{1/2}}$$

A = choke area

W = weight of casting and riser

T = pouring time

D = density of ductile iron

C = friction factor

G = acceleration of gravity

H = effective head height

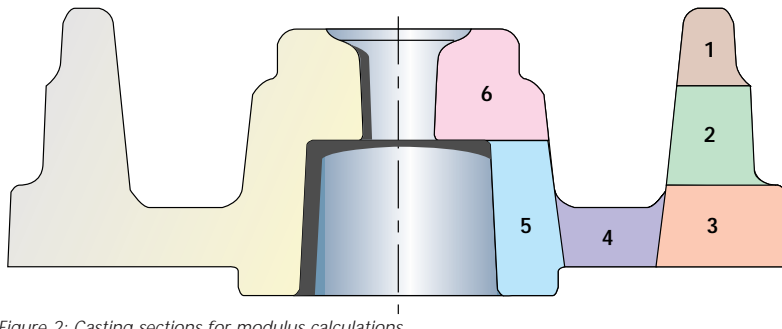


Figure 2: Casting sections for modulus calculations

The KALPUR direct pouring system

The modulus calculations from the Base system were used to evaluate the riser size for the KALPUR direct pouring system. Since both systems utilized riser contacts that were on the rim of the casting, the feed paths found acceptable in the Base System would be correct for the KALPUR system.

Modulus calculation			
Section	V	SA	M
1	8.02	40.12	0.20
2	17.47	47.88	0.36
3	19.78	52.71	0.38
4	9.52	32.83	0.29
5	6.07	23.39	0.26
6	6.21	22.55	0.30

Figure 3: Modulus of casting sections

Casting section weight	16.7 lb (1)		
Inscribed sphere diameter	1.13 in		
Mold Density	2	0.260 lb/cu. in	
	Ingate 4	Blind side riser	Safety C
	C.E.	4.51 %	
	Temp.	2600 F	
	Shrinkage	3.58%	
Sand riser	3.0 in. dia.	4.6 in. high	Weight 7.99 lb
	Feeding yield 61% (65)%		
— or —			
Sand riser	2.8 in. dia.	5.7 in. high	Weight 8.77 lb
	Feeding yield 60% (63)%		
Approximate riser base weight	2.00 lb	Minimum neck modulus	0.30 in
Iron	C 3.65%	Si 2.55%	P 0.02%
Foseco	FEEDERCALC		

Figure 4: Base system FEEDERCALC program printout

Casting section weight	33.4 lb (2)		
Inscribed sphere diameter	1.13 in		
Mold Density	2	0.260 lb/cu. in	
	Ingate 1	Open side riser	Safety C
	C.E.	4.51 %	
	Temp.	2600 F	
	Shrinkage	3.58%	
KALPUR for iron	7.0 cm. dia.	10.0 cm. high	Weight 4.22 lb
Add 2 oz. FERRUX 746	Feeding yield 84% (87)%		
— or —			
KALPUR for iron	2.0 in. dia.	6.0 in. high	Weight 5.20 lb
Add 2 oz. FERRUX 746	Feeding yield 78% (81)%		
Safety level A+			
Approximate riser base weight	2.29 lb	Minimum neck modulus	0.30 in
Iron	C 3.65%	Si 2.55%	P 0.02%
Foseco	FEEDERCALC		

Figure 5: KALPUR system FEEDERCALC program printout

The FEEDERCALC program was used to select the correct KALPUR unit size. The Base system inputs were used as a starting point for the program's calculations. Modifications were made to more closely represent the direct pouring of the castings. These changes included resetting the weight input and the castings per riser input, in order to take into account the two castings that each KALPUR unit would be required to feed. The riser type was changed from "blind" to "open" riser. In addition, the relationship between the ingate and the riser was changed from "not adjacent to riser" to "pour down riser." The printout - figure 5 - encompasses these changes and shows the computer selected KALPUR 7/10 unit.

The runner system is very simple. It is made from two KALPUR units, the riser bases, riser necks and a small interconnection runner. The runner was calculated using the law of continuity to provide iron to fill the four castings simultaneously.

The casting results

The layout of the pattern plate for the Base system - figure 6 - is very full. The castings are clean because a CELTEX 2.60 x 2.60/100 Filter is used with a nonpressurized runner system. The castings are sound because an adequate sand riser is provided for each casting.

The layout of the pattern plate for the KALPUR system - figure 7 - is more open. The castings are clean due to the integral SEDEX 50 dia. x 22/10 ppi Filter. The castings are sound because of the feed metal provided by the insulating properties of the KALPUR unit.

The MagmaSoft® printout - figure 8 - at 40% mold fill confirms that the castings will fill simultaneously with little turbulence. Note the high velocities in the KALPUR units but low velocities in the casting cavity.

The MagmaSoft printout - figure 9 - just at complete filling confirms the temperature is higher in the riser than in the castings. This temperature gradient, produced by the KALPUR unit and direct pouring, will ensure that the riser can provide adequate feed metal.

The mold yield for the KALPUR direct pouring system is 81.3%. The mold yield for the Base system is 54.2%. Therefore, the KALPUR system contains 41 lbs. less iron than the Base system. The mold yield is tabulated in figure 10.

The financial results

The KALPUR system and the Base system were designed using the same rules for choosing a riser system and runner system. The risers and runners were calculated for both systems to meet the minimum requirements for the casting with the same safety factor. Therefore, the costs of each system can be compared.

The KALPUR system and the Base system contain filters to remove slag in the metal. The riser sizes for both systems were chosen to produce sound castings. Therefore, it is assumed that in production, the scrap rate for both systems will be equal.

The pouring times for both systems are approximately equal due to design of the ingates. The application of a CELTEX filter or a KALPUR unit will require a core setting operation. Therefore, the production times are assumed to be equal for the two methods.

The major differences between the two systems are the mold yield, the casting cleaning and finishing, and the consumable products that are used. Therefore, these areas can be used to compare the profitability of the KALPUR system and the Base system.

The costs used for the profit/loss calculations are listed in figure 11. The metal conversion cost contains all of the costs to melt and handle one pound of iron. Included are costs for electricity, refractories, additions, labor, and testing that can be directly attributed to melting and handling the iron. To confirm that the conversion costs were realistic, foundries were asked for their input. The range of conversion costs given was \$0.06 to \$0.12 per pound so the \$0.08 per pound that was calculated is fairly conservative.

The cleaning and finishing cost was obtained from recent articles on cleaning department costs. These costs were based on actual financial data from foundries and have been confirmed.

The financial comparison - figure 12 - contains the costs for specific processes or products. For the conversion cost to remelt the runner systems and riser systems, the weight of each system was multiplied by \$0.08 per pound. For the consumable products costs, the number of products in each mold were multiplied by the unit cost. For the cleaning and finishing cost, it was assumed that it took one minute to handle and grind one contact on the KALPUR unit casting and it took 1.5 minutes to handle and grind the two contacts on the Base castings. These times were multiplied by the \$0.25/minute to obtain the total mold cleaning cost.

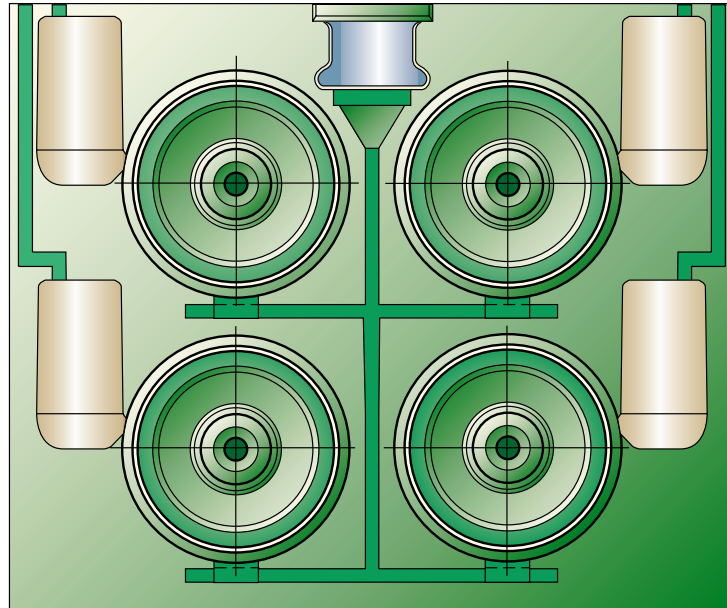


Figure 6: Base system layout

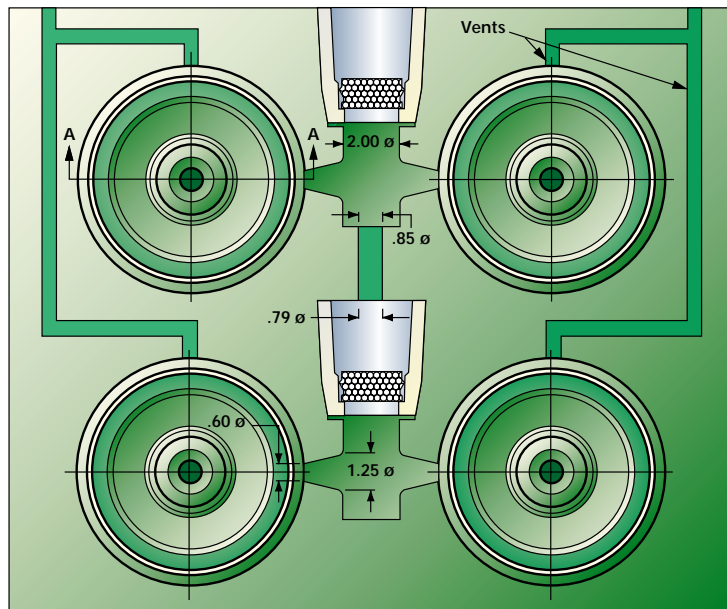


Figure 7: KALPUR direct pouring system layout

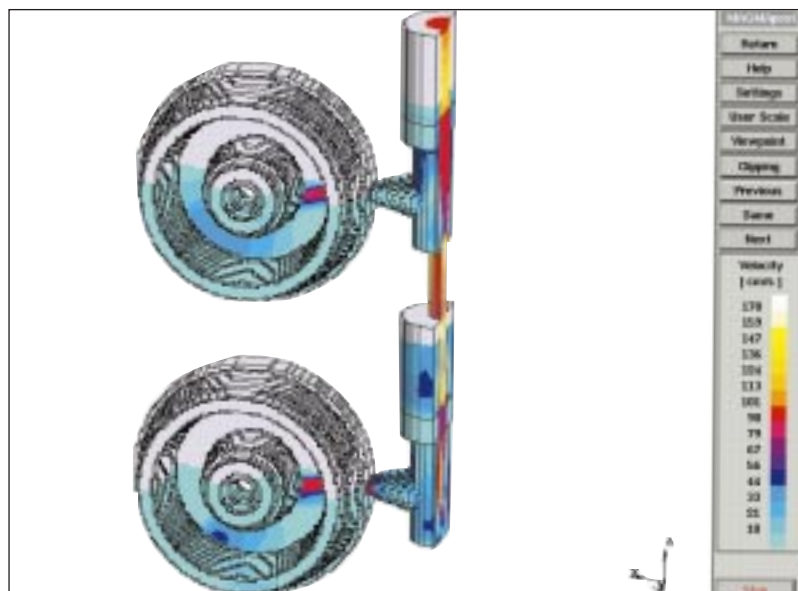


Figure 8: MagmaSoft velocity printout of KALPUR system

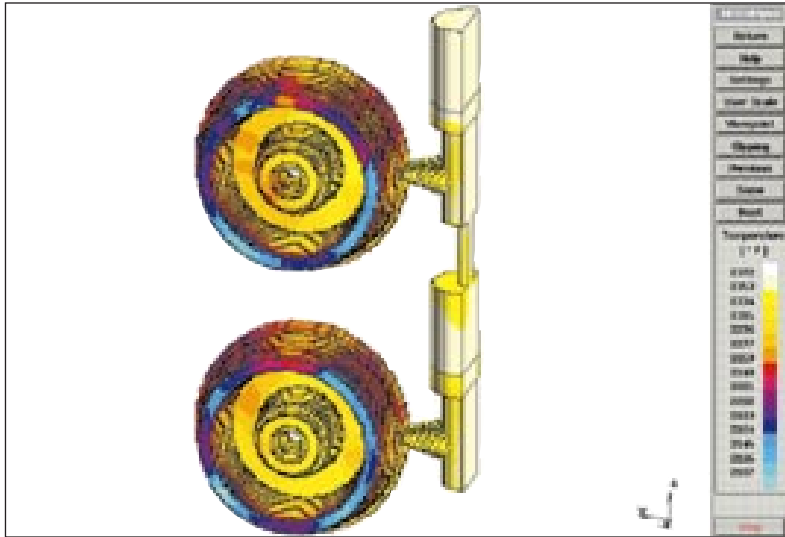


Figure 9: MagmaSoft temperature printout of KALPUR system

We would like to thank the personnel from Magma for their help in producing this article. KALPUR direct pouring systems

The KALPUR direct pouring system saves \$1.08 per mold over the Base system. This savings includes all costs that are equal to both systems and the consumable product cost for both systems.

Conclusion

Changes can be made in processes and applications to improve the profitability of producing a casting. Whether old technology such as hand-calculated modulus, or new technology such as KALPUR direct pouring systems are used, a complete re-examination of a casting process can increase the return to the financial bottom line.

As has been shown with the use of the KALPUR system, money can be saved in the total cost of producing a casting when consumable products are added to the process. By looking at an accurate accounting of total costs, money spent early in the process is more than returned later in the process. In a financial sense, this compares to investing early to obtain a greater return later.

Mold yield

	KALPUR unit system	Base system	Difference
Casting	66.80	66.80	0.00
Padding	0.64	0.64	0.00
Riser neck	0.84	0.20	-0.64
Riser basin	5.18	7.80	2.62
Riser	8.44	32.00	23.56
Runner system	0.29	15.75	15.46
Total	82.19	123.19	41.00
Yield	81.3%	54.2%	-33.3%

Figure 10: Mold yield comparison

Financial assumptions

Metal conversion costs	\$0.08 per pound
Cost of cleaning and finishing	\$0.25 per minute
Cost of filters	\$0.30 each
Cost of direct pour unit	\$1.50 each

Figure 11: Financial assumptions

Financial comparison

Process/Product	KALPUR unit system	Base system	Savings
Conversion cost of runner & riser system	\$1.23	\$4.51	\$3.28
Filter cost	\$0.00	\$0.30	\$0.30
Direct pouring unit cost	\$3.00	\$0.00	(\$3.00)
Cleaning & finishing cost	\$1.00	\$1.50	\$0.50
Total	\$5.23	\$6.31	\$1.08

Figure 12: Profit/loss comparison