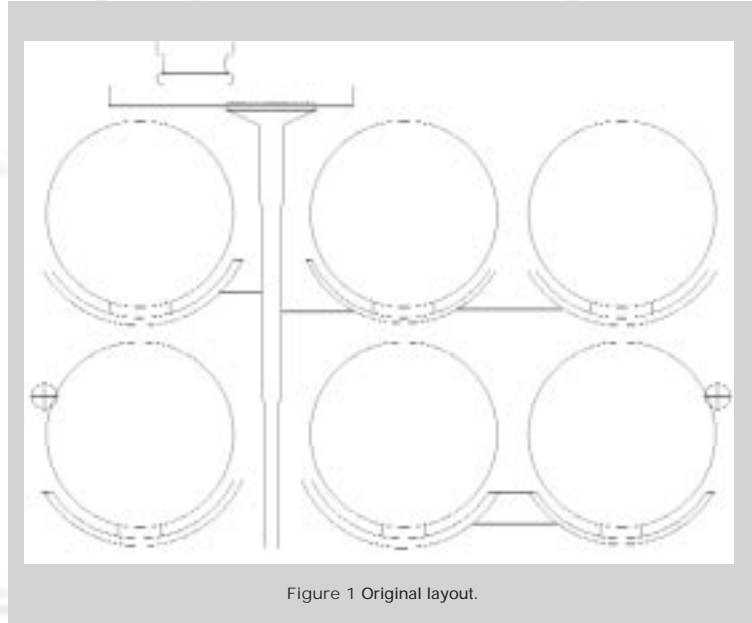


# The role of filtration in the design of concept gating systems for vertically parted moulds

## Introduction

The Demisaş Foundry located close to Bilecik in the northwest of Turkey, has been producing iron castings since the 1980's, the production capacity has grown steadily and now reached 80,000 tonnes per year.

These problems were particularly noticeable on a solid brake disc that was being produced with six cavities on a pattern plate; the original layout is illustrated in Figure 1. The lower three cavities suffered from surface defects such as slag, sand inclusions, and penetration for the reasons outlined above. Also many of the castings showed small areas of micro porosity.



The casting production results were:

- ❑ Foundry scrap rate: 6 to 7% (slag, sand inclusions and penetration were the main causes).
- ❑ Customer returns: 2,2 to 2,5% (majority of these were gas blowholes and micro porosity).

The production programme includes; compressors, brake discs, flywheels, brake calipers and brackets, all these castings are produced in vertically parted green sand moulds on three different types of **Disamatic** moulding machines.

One of these is a 2070 type, a large machine that can give rise to some specific problems such as high metal velocity during pouring, the height of the metal fall associated with the larger mould dimensions (700 mm x 950 mm) can cause sand erosion, whilst the high ferro-static pressure following completion of mould filling can contribute to metal-mould penetration and dilation.

How practical production solutions were devised to overcome these problems is the theme of this paper. Demisaş approached FOSECO and requested its support in this work.

## Casting production parameters

### 1. Chemical analysis (wt %):

- C 3,40 to 3,50
- Si 2,10 to 2,20
- Mn 0,50 to 0,55
- P 0,05 max.
- S 0,10 max.
- Cr 0,10 max.
- Cu 0,40 to 0,50
- Sn 0,04 to 0,08
- Ti 0,02 max.
- CE 4,10 to 4,30

### 2. Pouring:

- Inoculation stream: 0,1% max (inoculant containing Mn-Zr).
- Pouring temperature range: 1410°C to 1430°C
- Weight of the spray: 39 Kgs.
- Pouring time: 9 to 11 seconds.

### 3. Sand properties:

- AFS grain size: 70 to 90
- Compactability: 35 to 39
- Green compression strength: 2100 g/cm<sup>2</sup>
- Wet tensile strength: 0,35 psi min.
- Permeability: 50% min.
- Volatile: 3,0% to 3,1%
- Active clay: 8% to 10%
- Fines: 4,5% to 6,5%

## The concept gating study

The original gating system was a traditional Disamatic design with the choke (flow control) at the runner. This resulted in high ingate velocity erosion and mould fill turbulence.

To find the solution to the problems described above it was decided to radically redesign the gating system by:

- a. Introducing more changes of direction in order to reduce metal velocity and artificially increase friction losses in the gating system.
- b. Thermally separate the castings from the gating system much more quickly.

Today, filtration is widely used in modern foundries mainly for slag and sand retention. Given that this is one of the main functions of a conventional gating system and that this role can be fulfilled by the use of a filter it becomes possible to design systems which are more casting production friendly. This option was fully used in this case and the results suggest that such gating systems could be applied more widely for casting production on large vertically parted moulds.

The first concept gating system incorporated a SEDEX\* foam ceramic filter, 50 x 50 x 15mm with 20 ppi porosity. Based on the filter retaining the greater part of the slag it was possible to make major unconventional changes to the gating system design:

- a. The system was "opened" substantially to reduce velocity (with the ratios of 1:1,3:1,7).
- b. The falling velocity was reduced by use of a downsprue crossover from one side of the mould half to the other, just above the filter.
- c. Broad thin connections between the downsprue and runner bar were used in order to drastically reduce the solidification time at this point.

The resulting gating system design and dimensions are illustrated in Figures 2 and 3.

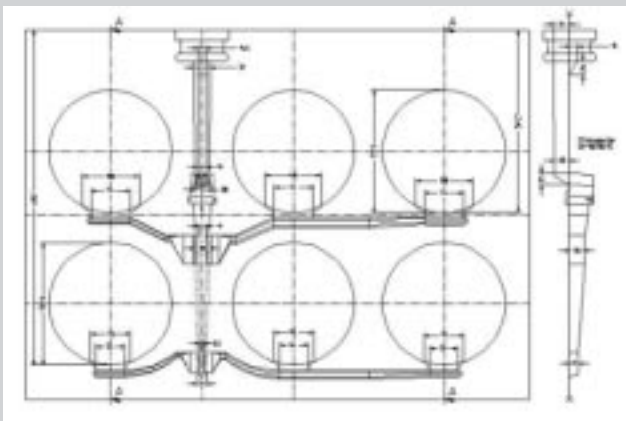


Figure 2 Dimensioned diagram of the modified system



Figure 3 Pattern plate with the first gating system concept

Taken from the mould fill simulation sequence Figure 4 shows the gating system has completely filled just one second into the pouring cycle, no metal having entered any of the cavities at this point. Figure 5 shows the situation 3.6 seconds into the pour, all six cavities are seen to be filling smoothly and evenly. Also, the pale blue colour in the gating system indicates low velocity, that also indicates minimum filling turbulence, the first of the key objectives of this project - namely to avoid erosion. The foundry man is in complete control of his pouring operation!

Figure 6 shows the beginning of the solidification process immediately after filling - all the areas in red are above 1160°C. The pale blue areas at the runner bar junction are already very close to the eutectic temperature, this indicated that the gating system and mould cavities have separated thermally from each other very quickly and means that the cavities are no longer subjected to high ferro-static pressure. This helps to fulfil the second objective of the project - the avoidance of penetration. Furthermore Figure 7 shows the solidification condition after three minutes have elapsed and indicated some possible hot spots, which it was considered, could be the probable location of the sporadic micro porosity problem.

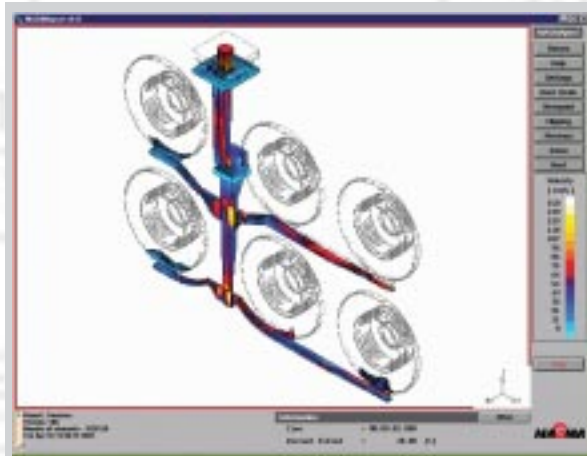


Figure 4 Filling simulation-1 after 1.0 second of pouring

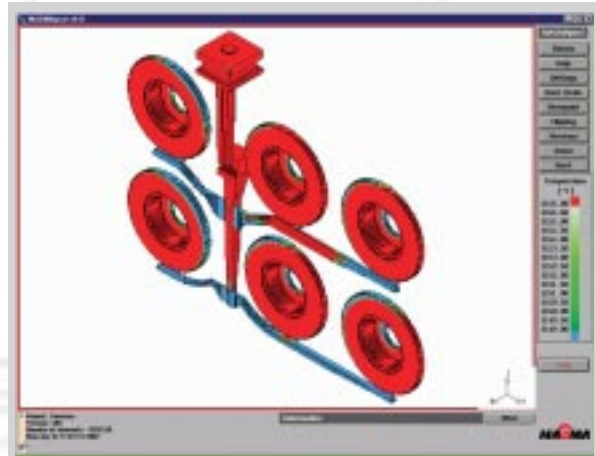


Figure 6 Solidification condition immediately after completion of pouring

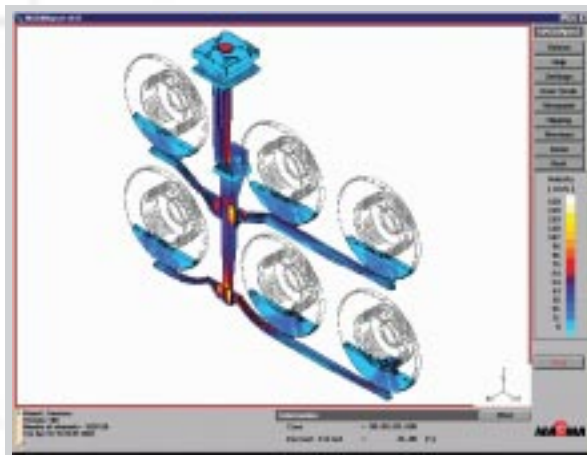


Figure 5 Filling simulation-1 after 3.6 seconds of pouring

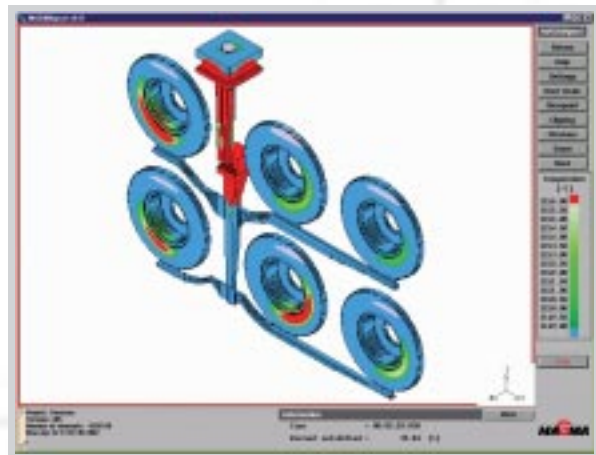


Figure 7 Solidification condition 3 minutes after completion of pouring

## Results

**The results of trials 1 and 2:** the results of these two trials were similar to each other with scrap rates up to 40%. The main cause was sand inclusions resulting from some erosion and poor filter placement technique. It was decided to amend the system to increase the level of friction in the gating system further in order to slow down the flow of metal even more. This amended gating system design is shown in Figure 8, whilst Figures 9a and 9b show the modified pattern plate.

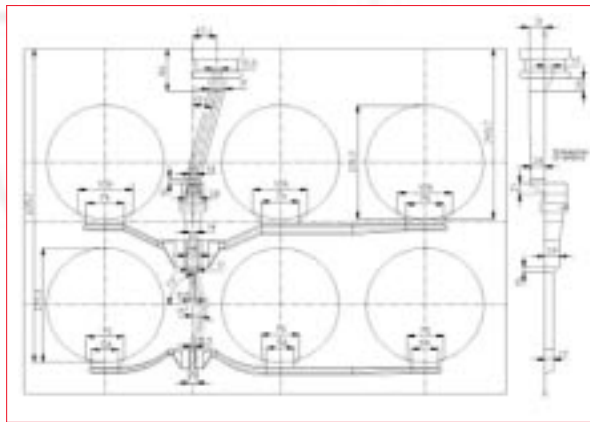


Figure 8 Dimensioned diagram of the modified system with the upper part of the downsprue inclined and a "dogleg" bend added to the lower downsprue.

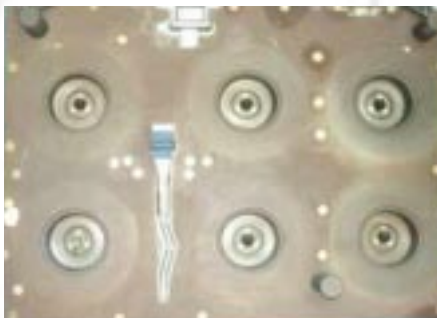
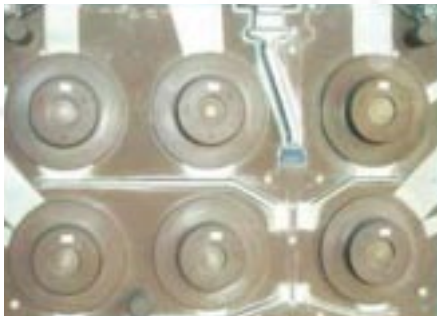


Figure 9a and 9b Photo of final pattern plate

**The results of trials 3, 4 and 5:** The results from trial 3, using the modified system were much better, there was no erosion and no penetration and the level of inclusions remained acceptable.

For the first three trials the Sedex filter was placed in the open mould by hand, for the trials 4 and 5 the filter was placed using the Disamatic Core Setter system. Trial 4 results: based on 100 moulds, out of 600 castings only four castings were scrapped. Small gas defects were noted in some of the two lower cavities. So that for trial 5 the venting system was improved, 630 castings were produced out of which only three were scrapped and no gas defects were found.

**The results of production runs-1 and 2:** Using the second modified system production run 1 was carried out; the results are summarised in Table 1.

Scrap type	Amount	Percentage, %
Slag	21	0.9
Blowhole	4	0.2
Broken	2	0.1
External shrinkage	10	0.4
<b>Total</b>	<b>37</b>	
<b>Good castings</b>	<b>2219</b>	
<b>Scrap rate, %</b>		<b>1.6</b>

Table 1 Scrap level of production run 1

Following this success a larger production run of 13,000 castings was made with even better results, no erosion and no penetration, summarised in Table 2 (run 2).

Scrap type	Amount	Percentage, %
Slag	74	0.6
Blowhole	23	0.2
Other	23	0.2
<b>Total</b>	<b>120</b>	
<b>Good castings</b>	<b>12960</b>	
<b>Scrap rate, %</b>		<b>0.9</b>

Table 2 Scrap level of production run 2

## Conclusions

Application of this concept gating system succeeded in solving the two main casting production problems of erosion and penetration, the concept gating system was modified to make it suitable for routine casting production purposes. The original foundry scrap rate of more than 6% was reduced to less than 1%.

Micro porosity was also eliminated; this was a further unexpected benefit, which it is believed resulting from the quick thermal separation of the gating system from freshly poured castings resulting in improved self-feeding.

When pouring large vertical moulds metal velocity is difficult to control. This was achieved in this work by the use of angles and sharp changes in the direction of metal flow.

Whilst simulation was of great help in designing the system, practical foundry trials were still essential in order to finalize the system design and obtain the sought for improved results.

The use of high efficiency, ceramic foam filters to retain slag and sand is absolutely necessary to be able to design and successfully apply this type of unusual and novel gating system.

## Acknowledgments

Mr Ken Taylor would like to thank his co-authors, Mr Nazim Narçin and Mr Osman Karabacak and the Demisaş Foundry for their help in the publication of this paper. Thanks also to Günter Strauch of FOSECO Germany for his patient and creative contribution in preparing the filling and solidification simulations.

