

The influence of filter type and gating system design on the machinability of vertically parted grey iron castings

Introduction

This report describes the effects that well established different filter types and running system designs have on the machinability of vertically parted moulded castings. Foundries with vertically parted moulding lines normally want to avoid applying filters because their use can, in some cases, lead to extended cycle times. Consequently, the use of filters has been relatively modest. Recently, however, increasing quality demands has led to a renewed interest from foundries.

This paper will deal with grey iron castings such as brake discs, brake drums and clutch plates. The results were obtained from studies, theoretical expertise and foundry field trials. The paper aims to demonstrate that problematic issues regarding filter use on vertically parted moulds can be overcome whilst simultaneously improving the properties of the castings.

Filter location options on vertically parted moulds

If the pattern plate has two or more levels, there is often no option other than to locate the filter in the upper part of the mould. A filter in this position provides a mechanism for slag retention, but much of the flow modification benefits will be lost due to uncontrolled flow of the metal after the filter.

If the filter is located in the bottom of the mould, the increased ferrostatic pressure can result in higher metal velocity through the filter. This increases the risk of slag being forced through the filter and into the casting cavity.

With these problems in mind, the design of pouring systems for vertically parted moulds was revised. The following modifications were found to be helpful in ensuring that moulds fill in a non-turbulent manner.

Runner system design options for vertically parted moulds including filters

Basics

For bottom gated mould cavities, the system choke should be located in the downsprue after the filter. The cross-sectional areas of the runners and ingates should then be increased to reduce the velocity of the metal as it enters the mould cavity. For side-gated moulds, the choke can again be located in the downsprue. The ingate cross-sectional area should then be increased to reduce the velocity of the metal. If the casting is top gated, the choke

must be located at the ingates otherwise the runner system cannot completely fill especially during the early stages of the pour.

Sprue cross-over

A cross-over describes a design in which the downsprue "crosses over" from the swing plate side to the ram plate side before the filter. The advantage is that the liquid metal does not impinge directly on the filter and a slag chamber can be located directly in front of it. This is a technique that is routinely used on horizontally parted moulds. Another advantage of this technique is that the runner fills more quickly and reduces the likelihood of gas entrainment.

Inclined downsprue

A technique to reduce the velocity of the metal is to use inclined downsprues with an inclination of about 10 to 15°. This technique will significantly reduce the velocity of the liquid metal (figures 1 and 2).



Figure 1 Standard gating system



Figure 2 Gating system with cross-over and inclined downsprue

The effects on the mould filling can be dramatic, especially during the critical first few seconds when liquid metal enters the mould cavity (figures 3 and 4).

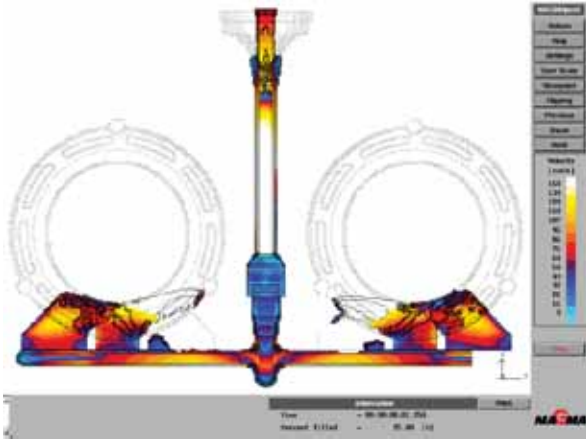


Figure 3 The metal hits directly against the mould cod

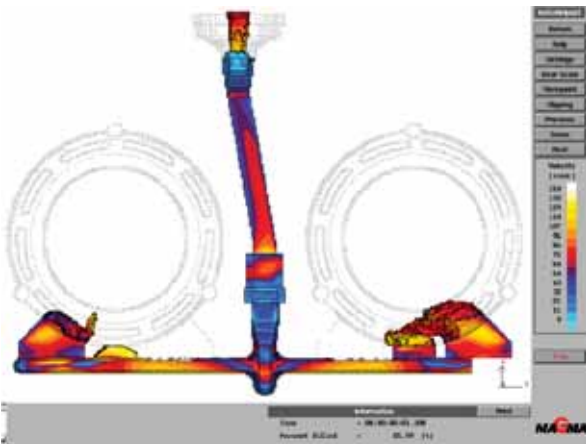


Figure 4 The metal enters the mould cavity at slower speed and does not hit the mould cod directly

Design of the ingates

Castings such as brake discs and drums are almost exclusively bottom-gated and the behaviour of the metal as it enters the mould cavity is critical. Back pressure will not be present at this point and the metal can enter the mould cavity as a “fountain”. This can cause defects due to re-oxidation and sand erosion. To minimise this effect, the flow direction of the metal can be interrupted by the incorporation of an ingate with a 45° angle (figures 5 and 6).

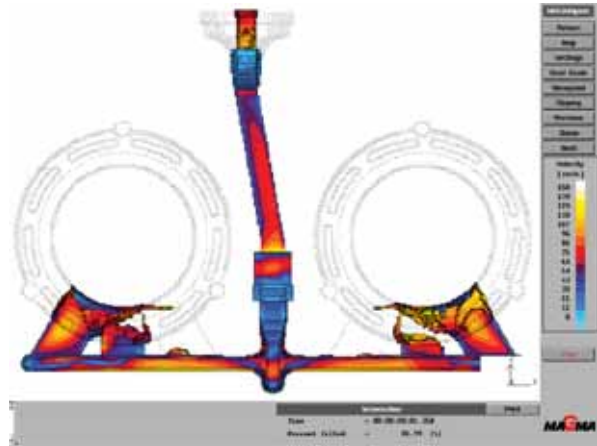


Figure 5 Inclined ingates

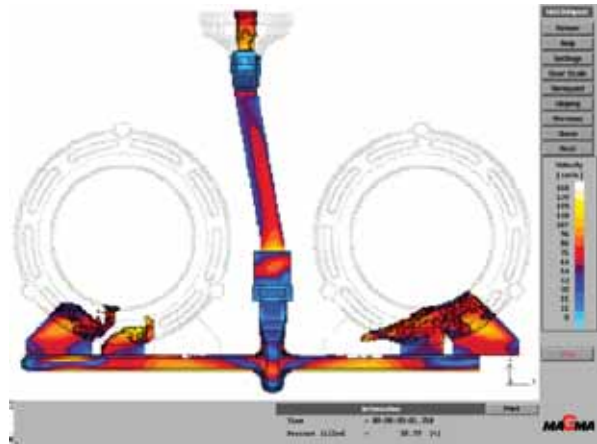


Figure 6 Ingates with 45° angle

Machinability trials

To test some of the above theories, a machinability study was conducted in co-operation with one of the leading European DISA Foundries and a US university. Machinability is related to many factors and the effects may vary from foundry to foundry, and as such, this study can only provide a rough overview on the various factors that may have an influence.

An unventilated brake disk was chosen for the trials. This was done in order to avoid effects related to the positioning of cores.

Trial details

Trials were conducted using a pressed device with a hole diameter of 1.5mm, extruded device in 300 csi, and 30ppi SEDEX* filters. All filters were 50x50x15mm.

The following pouring systems were tested. These were designed to test the concepts discussed earlier.

1. Running system without a filter. Ingate controlled with slag trap. The pattern layout for these trials was provided by the foundry
2. The same system as 1, but without slag trap
3. Filter positioned in the **upper part** of the mould, downsprue controlled (figure 7)
 - a) Pressed device with 1.5mm hole diameter
 - b) Extruded device 300 csi
 - c) SEDEX 30 ppi filter
4. Filter positioned at the **bottom** of the mould, downsprue controlled (figure 8)
 - a) Pressed device with 1.5mm hole diameter
 - b) Extruded device 300 csi
 - c) SEDEX 30 ppi filter
5. Filter positioned at the **bottom** of the mould with additional cross-over, downsprue controlled (figure 9)
 - a) Pressed device with 1.5mm hole diameter
 - b) Extruded device 300 csi
 - c) SEDEX 30 ppi filter

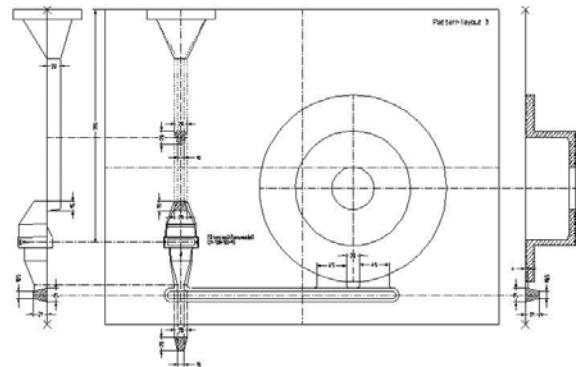


Figure 9 Gating system with filter at the bottom of the mould and cross-over

All trials were conducted during a single morning to ensure conditions were as consistent as possible. With each layout approximately 100 castings were made and, after finishing, the surface defects were counted. The average amount of surface defects on the castings was then calculated.

Table 1 shows the results:

System	Pouring Temp [°C]	Pouring Time [s]	Number of Castings	Surface Defects Side 1	Surface Defects Side 2	Defects TOTAL	Average Defects per Casting
1	1410	10	80	278	178	456	5.7
2	1405	7.5	90	583	636	1219	13.5
3a	1410	6.0	86	215	303	518	6.0
3b	1417	5.4	72	177	245	422	5.9
3c	1408	5.4	92	285	341	626	6.8
4a	1403	5.0	79	56	49	105	1.3
4b	1402	5.2	85	33	24	57	0.7
4c	1411	5.4	82	22	26	48	0.6
5a	1406	5.6	83	46	79	125	1.5
5b	1404	5.6	85	19	11	30	0.4
5c	1404	5.2	85	13	10	23	0.3

Table 1

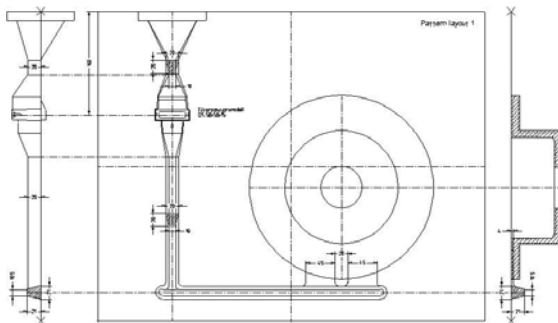


Figure 7 Gating system with filter in the upper part of the mould

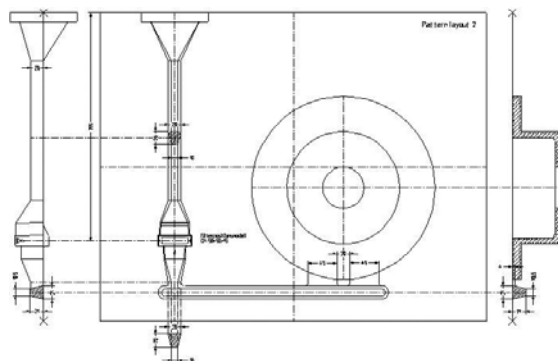


Figure 8 Gating system with filter at the bottom of the mould

Trial observations

- ❑ The redesigned gating (incorporating a filter) significantly reduced the pouring time
- ❑ The design and the connection to the slag chamber in trial 1, does not allow faster pouring times without sustainable quality losses
- ❑ The position of the filter greatly influences the average amount of surface defects per casting. This could be a reason why many foundries do not notice any scrap reduction when filters are placed in an ineffective position. Additionally, the possibility of reducing pouring times is often not considered
- ❑ The best result was achieved with cross-over and the SEDEX foam filter.

After the evaluation, the machinability of the castings was tested. Because of the considerable high costs involved only 4 systems out of 11 were machined. They were then compared to the castings made by pouring systems without a filter and slag trap.

For the machinability study metal tools were used. Surface speed was constant at 1500 SFM (7.62m/s).

Machining procedure:

- ❑ The remains of the ingates were removed and these areas were machined
- ❑ The brake disc was then mounted on the CNC machine and machined from the inside to the outside as described below:
 - 2 slices of 0.5mm each were machined off. These slices will hereafter be referred to as "SKIN". After each cut the wear of the tools was measured and recorded
 - 4 slices of 0.5mm each were machined off. These slices will hereafter be referred to as "BULK". Again, the wear of the tools was again measured and recorded.

This was repeated until a maximum tool wear of 0.025 inch was attained for "SKIN" and for "BULK". Three tools were applied per batch (figure 10).

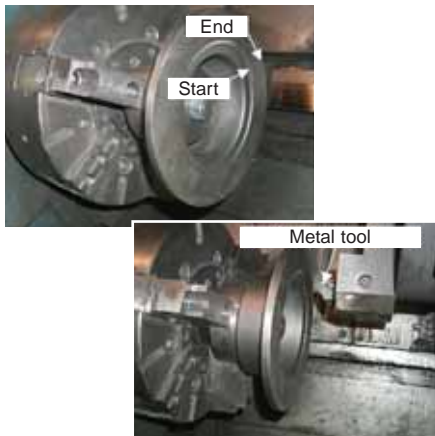


Figure 10 CNC device with tool

The machinability index is defined as tool wear in inches (in.) for a certain amount of cut metal in cubic inches (in³).

The results were recorded and graphed as described in the graph below (figure 11).

Figure 12 - 15 present the results of various gating and filter types.

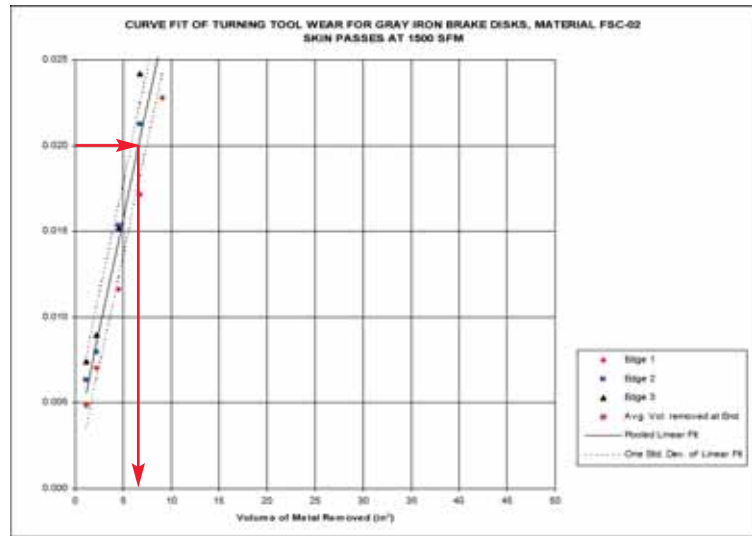


Figure 11

Comments on the graph:

- The x-axis shows the amount of cut metal in cubic inches
- The y-axis shows the tool wear in inches
- As reference point a tool wear of 0.020 inches was set and in comparison the amount of cut metal was identified
- The dotted line shows the variation (standard deviation)
- The steeper the straight line the worse the machinability.

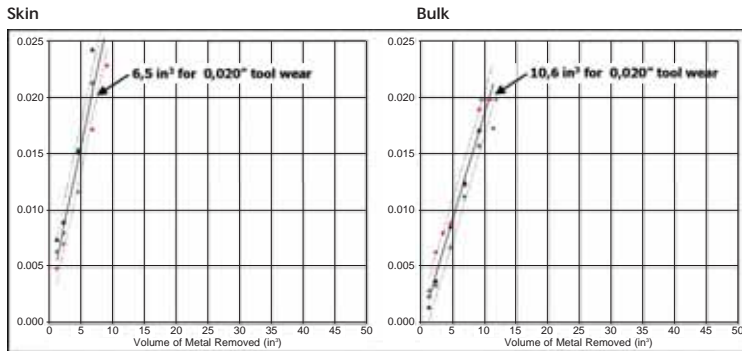


Figure 12 Gating systems without filter and slag trap

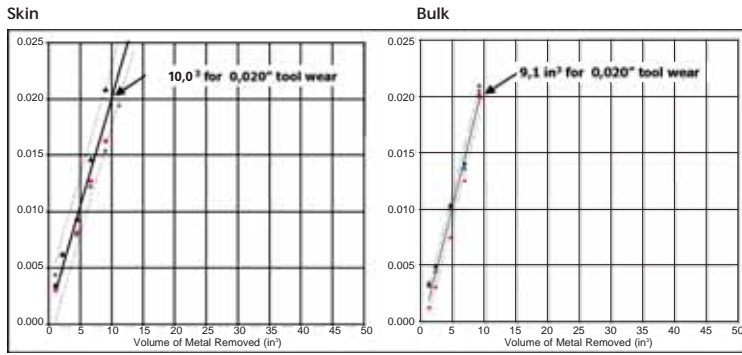


Figure 13 Gating system with pressed device (1.5mm hole diameter) and cross-over

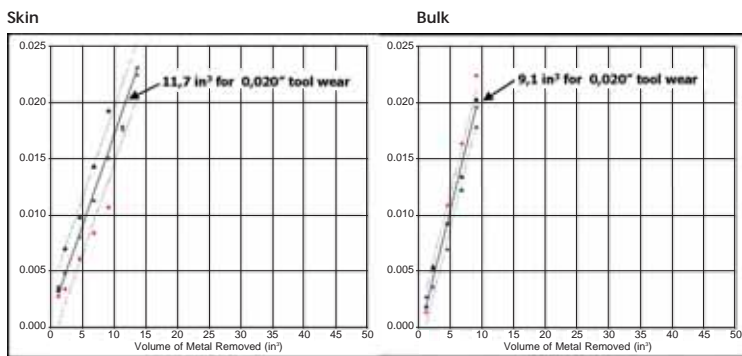


Figure 14 Gating systems with extruded device (300c/s) and cross-over

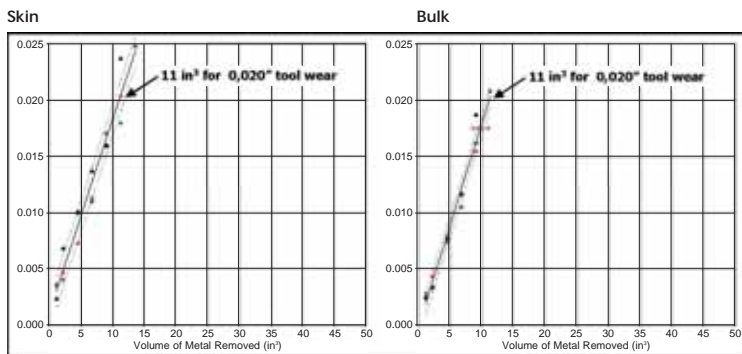


Figure 15 Gating system with SEDEX 50x50x15/30ppi and cross-over

Discussion

- ❑ The castings without a filter and slag trap have more surface defects. The “SKIN” therefore exhibits a much worse machinability than the “BULK”
- ❑ When extruded and pressed filters are used, some improvements are observed. “SKIN” machinability is improved but the results are variable
- ❑ When SEDEX filters are used the machinability of the castings are significantly improved. The values for the “SKIN” and the “BULK” are almost identical. This suggests that very few surface inclusions are present.

In explaining the differences between pressed, extruded and foam filters, it is thought that pressed and extruded filters can quickly create a back pressure, that will prevent dirt from the pouring system from entering the mould cavity. However, these filter types are not as effective as foam filters when it comes to removing inclusions throughout the duration of the pour. This means that over the whole pouring time foam filters will retain more inclusions than their pressed and extruded counterparts.

The results for the machinability of SKIN and BULK were compared to the system without a filter and slag trap. The results are presented in the following graph (figure 16).

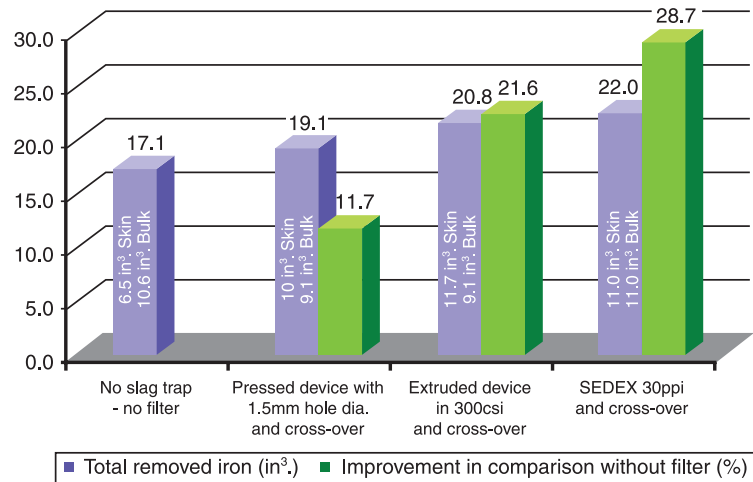


Figure 16 Comparison of the amount of removed metal to a tool wear of 0.020in.

Summary

The graph clearly shows that when using SEDEX filters machinability is improved by 30% compared to castings produced without filters.

The design of the gating systems and the positioning of the filter has a great influence on the casting result.

Additional positive side effects when using filters can be: reduced pouring time, improved productivity and improved yield, since no slag trap is necessary. These points should not be neglected when calculating the overall costs, attributes such as these are commonly overlooked when considering the use of filters.

References

Casting Plant and Technology International, 04/2006
 New possibilities for pouring systems with vertical mould partition
 Andreas Baier and Günter Strauch FOSECO GmbH, Borken