Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Progressive Evaluation Method for Aluminium Alloys filtration process

Marek Brůna[1], Dana Bolibruchová[1], Augustín Sládek[1]
[1]University of Žilina, Department of Technological Engineering, Univerzitná 1, 01026 Žilina. Slovak Republic, E-mail: rapture.marko@gmail.com

Submitted work is focusing on the filtration of aluminum alloys with aim on filling time, flow turbulence and melt velocity in close vicinity to ceramic filters. These parameter are considered as the most important parameters during melt filtration and therefore needs to be analyzed in real conditions, but also by using modern simulation systems. Supported by numerical simulation software ProCAST, we were able to understand and observe the actions taking place in the close vicinity of filters, which cannot be analyzed by direct methods.

Keywords: *Filtration, simulation, aluminium alloys*

1. First stage of the experiment

In the first stage of the experiment, three different filters were chosen (with direct channels and with conical channels). Figure 1 shows the proposed gating system. Simple cuboid was chosen as the casting.

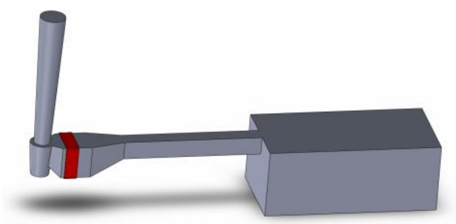

Fig. 1 Gating system with the filter location

We used an alternative (more complex) approach instead of the standard function to analyze the melt flow. Individual filters were imported to the simulation software including the precise channel geometry (based on the CAD files). This fact has a significant impact on the complexity of the entire process, especially on the creation of a 2D and 3D mesh. Input data were set as a model situation, constant for all three variants, which enabled their mutual comparison. To perform simulation was chosen AlSi7Mg0.3 alloy poured at 720 °C by flow rate 1 kg/s into green sand mold (room temperature 20 °C). Figure 2 shows the turbulence intensity at cross-section of the gating system for variant A (channels with equal cross-sections). The color scale expresses the melt turbulent energy level, where purple means zero kinetic turbulent energy and with graduated shades it passes to red, which represents 350 $cm^2.s^{-2}$. Larger turbulence occurs on the outflow side of the filter in the lower part than in the upper part. However, we will be able to draw specific conclusions in terms of turbulence intensity only upon comparison with the other variants.

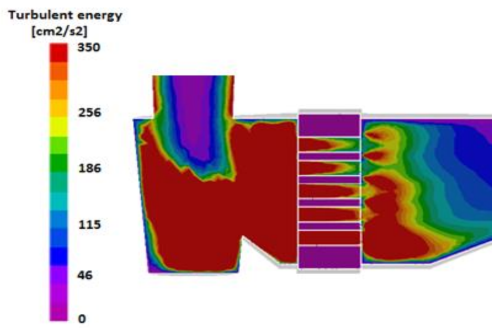

Fig. 2 Turbulence intensity – Variant A, time 0.6 sec.

The filling in Variant B is of a different nature compared to variant A (channels with conical cross-sections - fig. 3). Turbulence on the outflow side of the filter is significantly smaller. Results comparison will be described later on.

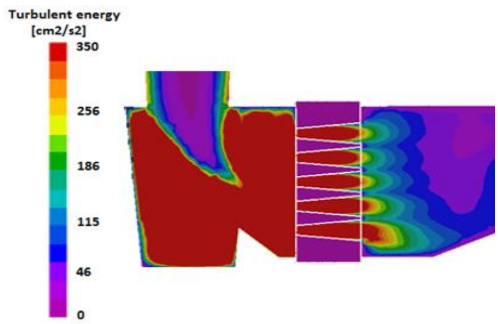

Fig. 3 Turbulence intensity – Variant B, time 0.6 sec.

Variant B1 shows the largest turbulence intensity on the outflow side compared to the other variants (fig. 4, the largest share of red). In terms of flow optimization and the associated turbulences, variant B can be considered as the optimal alternative based on the results criterions.

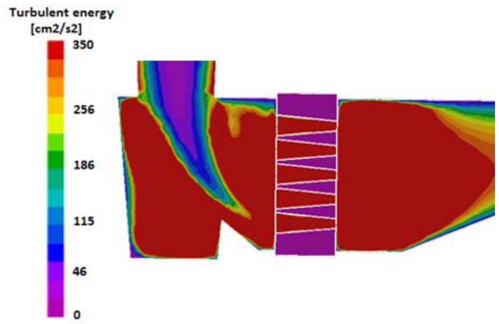

Fig. 4 Turbulence intensity – Variant B1, time 0.6 sec.

Variant B1 features the highest velocity on the outflow side, uneven flow and large turbulences. These turbulences are probably caused by nozzle-like shape of channels, which supports increase of velocity on the outflow side. This phenomena can be evaluated as negative effect leading to higher reoxidation and porosity nucleation during solidification [1].

2. Second stage of the experiment

During the second stage of the experiment were used 4 different ceramic filters (tab. 1). The objective of the second stage was to evaluate turbulence activity and velocity of the melt in the filter close vicinity (while flow area is changing due to amount of channels and their diameter).

Table 1 Parameters of the filters

	Filter 0810	**Filter 0812**	**Filter 0735**	**Filter 0825**
Channel diameter [mm]	Ø 3,2	Ø 2,3	Ø 2	Ø 2
Flow area [mm^2]	1351	1495	1348	1223

Filter impact on the melt velocity in the section plane leading through the middle of the gating system (Fig. 5) was investigated. The greatest deceleration of the melt occurs by introducing a 0810 filter. Comparison of the 0735 and 0825 filter simulations, clearly shows that melt velocity is affected also by the size of the flow area. Flow area affects the size of metallostatic pressure in the way that the larger the flow area, the more easily depressurization occurs. At the same time the melt velocity on the outflow side of the filter is also influenced to a great extent by the primary shock wave on the filter [1].

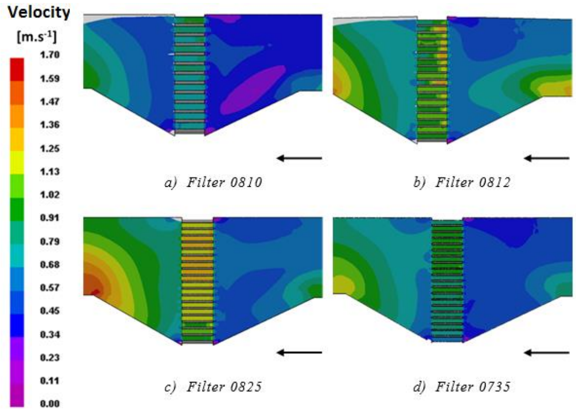

Fig. 5 Melt velocity – time 0.65 sec.

When evaluating turbulence, optimal results were achieved by a 0812 filter, which exhibits on the outflow side the lowest level of turbulent flow (Figure 6b). Although it has been proved that flowing through narrower filter channels accelerates the melt movement, the channel hydraulic diameter is so small that the Reynolds number reaches lower values than those for a 0810 filter having the largest channel diameter.

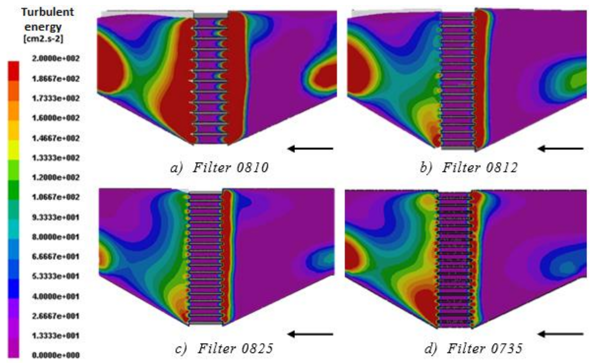

Fig. 6 Melt turbulence – time 0.65 sec.

3. Conclusion

The objective of this paper was to utilise numerical simulation for analysis of important parameters when casting aluminium alloys through ceramic filters. Partial objectives following the individual stages of experiments have confirmed that simulation is a useful tool even for this field of foundry industry.

References

[1] PASTIRČÁK, R. (2014). Effect of low pressure application during solidification on microstructure of AlSi alloys. In: Manufacturing technology. ISSN 1213-2489. Vol. 14, no. 3. pp. 397-402.