Analysis of Change of Cast Macrostructure under Influence of Structural Adjustments of Ingate and its Impact upon Mechanical Properties

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***Abstract* – Correlation of macrostructure and of mechanical properties of the cast is a relation which the final quality depends on. The submitted paper analyses the macrostructures of the casts being cast during diverse structural adjustments of the ingate and their influence upon the mechanical properties. On the basis of the results of the performed tests the conclusions were made describing the mutual relation between macrostructures and mechanical properties of the cast with the precautions to be taken and implemented directly in the practice during production.**

***Keywords* – Homogeneity, mechanical properties, structure.**

1. Introduction

Porosity and homogeneity are closely connected with the strength characteristics therefore to acquire the best mechanical properties it is inevitable to eliminate internal defects of the cast. [1] Appropriate method of affecting the homogeneity rests in designing of the gating system so that possible imperfections are recorded and excluded already in designing and development phase. The ingate appears to have the most significant influence upon the cast homogeneity. In the ingate the modulation and speed increase of the melt jet occur. Right the mode of the mould cavity loading and speed of the melt jet determine the character of the final properties of the cast [2, 3].

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2. Experimental material

Macrostructural changes were examined with the particular cast of the electric motor flange which was produced from the alloy of EN AC 47100-AlSi12Cu (Fe). Five testing series of casts were assessed and each series was cast with the constant technological parameters of the casting cycle which are presented in Table 1.

Table 1. Basic technological parameters of the casting cycle

Basic technological parameters of the casting cycle	
Parameters	**Values**
Alloy temperature	708 °C
Temperature of form	220 °C
Plunger pressing velocity	2.9 $m.s^{-1}$
Increase pressure	25 MPa

The casts were cast using the die casting machine Müller Weingarten 600. The macroscopic structure of the samples was assessed by microscope OLYMPUS GX51 with a hundredfold magnification and processed by the ImageJ software. The static compression test was performed with the device TIRAtest 28200 and the ball thrust test was performed with the measuring machine HPO 250 in accordance with the STN EN 6506-1 standard. The variable parameter on the basis of which the macrostructure and mechanical properties were assessed was the ingate height. The boundary values of the ingate height were determined by means of the simulation program NovaFlow&Solid with application of the NovaShot modulus. The assessed values of the ingate heights and the related cast series are presented in Table 2. [4]

Table 2. Ingate heights as per series

Series number	1.	2.	3.	4.	5.
Ingate height [mm]	b_1=1.25	b_2=1.03	b_3=0.92	b_4=0.82	b_5=0.75

3. Analysis of macrostructure

The objective of the macroscopic analysis of the cast was examination of non-homogeneity occurring in the cast volume. The cast homogeneity was assessed in the area which was from the point of view of function of the cast considered to be critical (Fig. 1). It is the case of structural hole of the flange by means of which the flange shall be connected with the body of the electric motor. The selection represented an appropriate alternative to detect mutual correlation of the cast homogeneity and of the mechanical properties. The homogeneity was assessed by the X-ray pictures of the individual samples and by the scratch patterns. [4]

Figure 1. Sampling spot to assess the macrostructure of cast

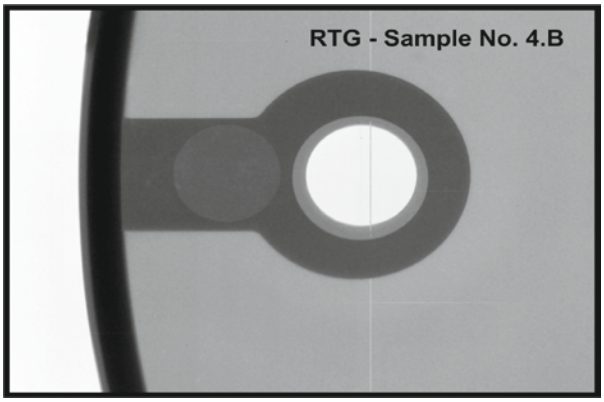

Figure 2. X-ray picture with the lowest ration of the cavities

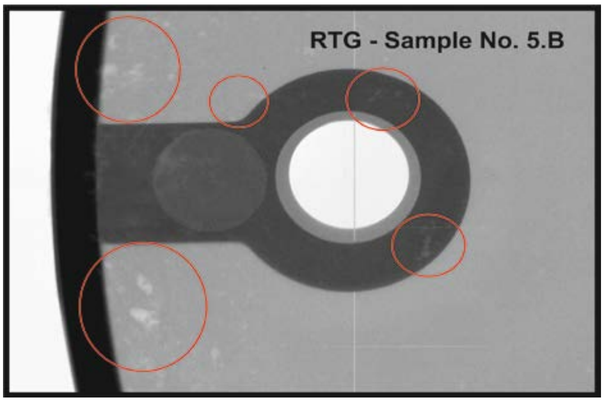

Figure 3. X-ray picture with the highest ration of the cavities

4. Analysis of X-Ray Pictures

Each sample employed in determination of the permanent deformation was submitted to the X-ray picture analysis. Fig. 2 presents the sample with the lowest ratio of the cavities in the cast body and Fig. 3 shows the sample with the highest content of the cavities.

5. Analysis of porosity

The values of porosity *f* were acquired by the ImageJ software on the basis of scratch patterns in the critical cast spot. The measured porosity values *f* are presented in Table 3. Plotting of relation between porosity and ingate height is shown in Fig. 4. [4, 5]

Table 3. Measured porosity values

Porosity values *f* of samples in the critical spot of the cast			
Sample designation	**Ingate height [mm]**	**Ingate width [mm]**	**Porosity [%]**
1.B	1.25	60.968	0.89
2.C	1.03		0.87
3.B	0.92		0.85
4.B	0.82		0.18
5.A	0.75		1.27

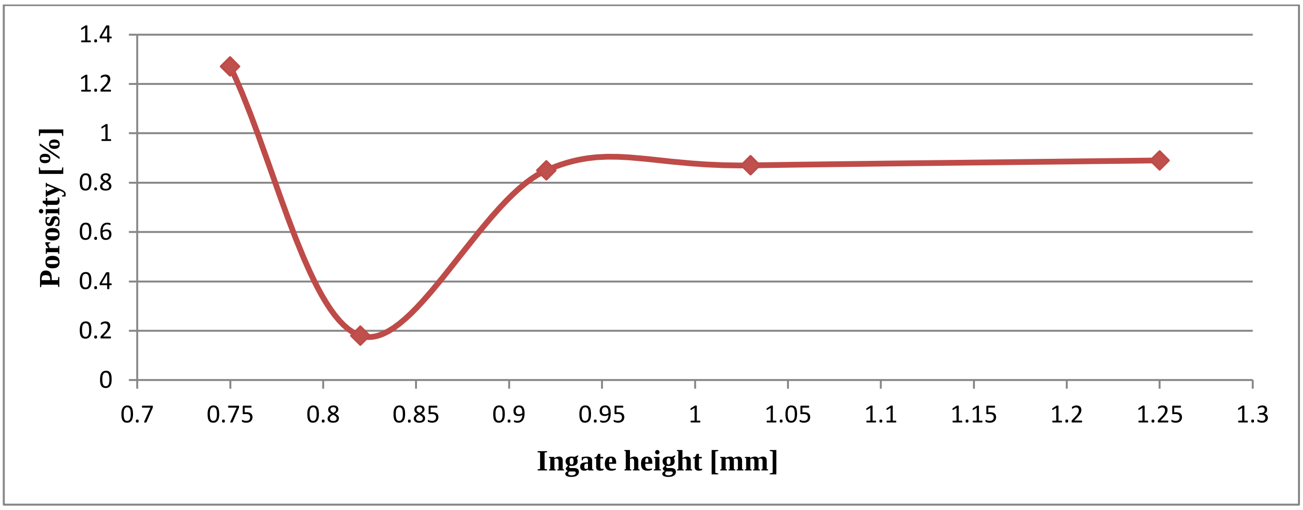

Figure 4. Dependence of porosity f on the ingate height change

6. Analysis of permanent deformation

Deformation was examined in the critical spot of the cast according to Fig. 1. The measurement was performed in accordance with GME 06 007 and GME 60 156 standards. [6] Table 4 presents the measured values of permanent deformation in relation to ingate height change and Fig. 5 shows plotting of dependence of the average values of permanent deformation on the ingate height change.

Table 4. Measured permanent deformation values

Permanent deformation values *s* of samples in the critical spot of the cast					
Sample No.	**Ingate height [mm]**	**Ingate width [mm]**	**Permanent deformation *s* [mm]**		
			Values	**Arithmetic average**	**Dispersion of the values**
1.A	1.25	60.968	0.077	0.068	0.015
1.B			0.065		
1.C			0.062		
2.A	1.03		0.048	0.053	0.009
2.B			0.057		
2.C			0.055		
3.A	0.92		0.041	0.044	0.006
3.B			0.045		

3.C			0.047		
4.A			0.037		
4.B	0.82		0.032	0.033	0.006
4.C			0.031		
5.A			0.057		
5.B	0.75		0.054	0.058	0.008
5.C			0.062		

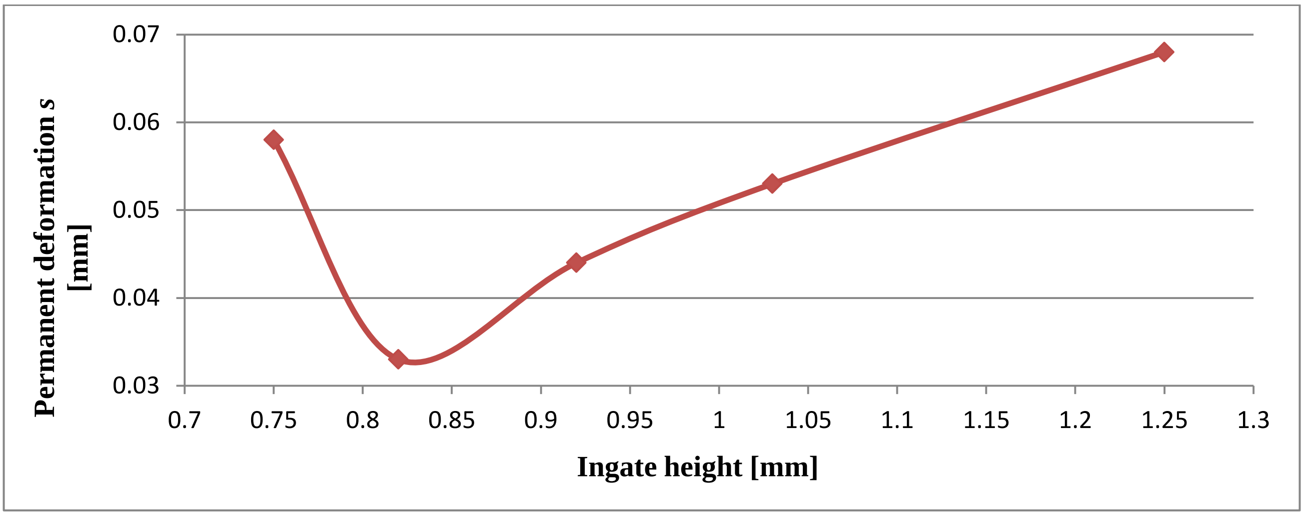

Figure 5. Dependence of permanent deformation s on the ingate height change

7. Assessment of the achieved results

The assessment of the results achieved through the analysis of the individual examined parameters led to the conclusions regarding the influence of the ingate height on the values of permanent deformation and porosity of the individual cast series. The lowest values of permanent deformation and porosity were acquired in the series of casts being cast with the ingate height of 0.82 mm. In case of the assessed scale of the ingate height the examined parameters have increasing tendency. The extreme is represented by the ingate height reaching b_5=0.75 mm in case of which the value of porosity f and of permanent deformation *s* reach the highest values. The situation can be explained by the type of the melt flow in the mould shaping cavity. There exists a presumption that with the given ingate height the value of the melt speed shall reach the point in which the flowing takes on dispersing character by means of which the gases and air shall get closed in the cast volume. Such state shall be demonstrated by increased formation of pores. The analysis of assessment of dimensions, structure and location of the internal defects allowed determination of correlation of mechanical characteristics and of structural parameters. It was proved that the increasing ratio of porosity and cavities in the cast body leads to increase of the value of permanent deformation *s*.

8. Conclusion

Finally, the conclusion can be drawn that the ingate height influences distribution, size and number of pores. The values of porosity *f* are influenced mainly by shaping and by directing of the melt jet into the mould shaping cavity and by change of the melt speed flowing through diverse areas of the ingate by which the mode of the mould shaping cavity loading is changed. That results into different modes of absorption of gases and of formation of pores that shall be demonstrated by mechanical properties of the casts.

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