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EFFECT OF SAND QUALITY ON GAS EVOLUTION DURING DIPPING INTO LIQUID ALUMINUM

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The amount of evolved gas was examined during decomposition of cold-box binder in this study. Spherical core samples were used for the COGAS tests with different binder content and basic sand. The volume and rate of gas evolution were increasing both by the ratio of fine and separated black (used) sand in the mixture. The gas evolution rate was higher by 60% in case of separated black sand than at reclaimed sand. The measurement results were use in the simulation of the filling process.

Keywords: sand core, cold-box, spherical sample, COGAS test, evolving gas

INTRODUCTION

The knowledge of the core properties and sand mixtures is important for designing and manufacturing the molding process. The binders start to decompose and evolve to gas when the sand cores are in contact with the liquid metal. This gas can cause casting defects.

Measurements of the evolved gas were performed on cold-box samples with the COGAS measuring equipment. Considering the results of gas evolution rate can be drawn valuable conclusion in order to ensure good mould filling.

1. EVOLVING GAS FROM THE RESIN BONDED SAND MIXTURES

The quantity and pressure of evolved gas have influence on the quality of castings. The adsorbed moisture is evaporated by heat load at lower temperature. The binder degradation processes and partial decomposition of bonding bridges start at further increasing of temperature. The dry distillation and complete decomposition of binder components start at 700 °C [1]. The quantity of evolved gas from the resin bonded sand mixtures is influenced by the type and quantity of binder, granulometry properties of sand, geometry, type of coating used, core storage time and molten metal temperature [1–3].

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2. EXPERIMENTAL METHODS

The tool insert made for a multi-step series of measurements. This study was the first phases enter. The shape of the test piece is relevant in later phases. Green sand (fine and medium grain size) mixtures, reclaimed sand mixtures (fine and medium grain size) and sand mixtures with black sand were examined *(Table 1)*. The samples were blown by core blowing machine. Cylindrical specimen core box was completed with a removable tool insert in one cavity *(Figures 1–3)*. Uniform and stabile measurement conditions were provided by the use of spherical core samples. Spherical cold-box core samples (d = 32 mm) were dipped into liquid aluminum. Cold-box resin and activator addition were modified in order to prepare the core samples. *Table 2* contains the information of examined sand mixtures.

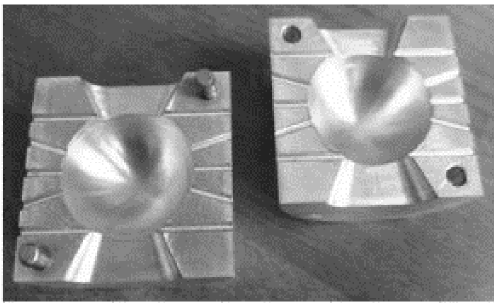

Figure 1
Used tool insert for the core shooting

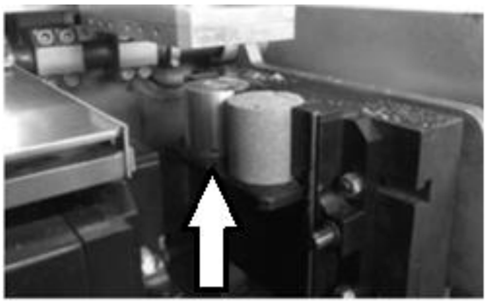

Figure 2
Cylindrical specimen core box with a removable tool insert in one cavity

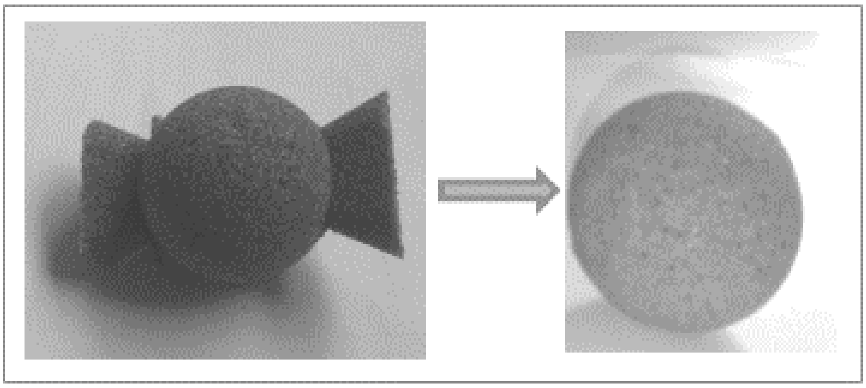

Figure 3
Rough-and prepared specimen

Table 1

Examined sands

Identification	
SH32	Green sand - Medium grain size silica sand (Šajdíkove Humence)
F35	Green sand - Fine grain size silica sand (Frechen)
RM	Medium grain size silica sand (thermal reclaimed sand in the foundry)
RF	Fine grain size silica sand (thermal reclaimed sand in the foundry)
B	Separated black silica sand (only mechanically reclaimed sand)

The company have thermal sand reclamation system. There are 3 possible sand conditions for core making: green sand, thermal reclaimed sand and only mechanically reclaimed sand.

Table 2

Information from the examined sand mixtures

Type of sand		Identification	Resin content, %	Mean grain size, mm	Loss on ignition, %
Green sand	SH32	SH32	0.55	0.524	1.09
	F35	F35	0.55	0.22	0.85
Reclaimed sand	Medium	RM 0.4	0.4	0.477	0.67
		RM 0.55	0.55		0.85
		RM 0.7	0.7		1.12
	Fine	RF 0.55	0.55	0.239	0.84
		RF 0.7	0.7		1.11
Mixed sand	B = 25% RM = 75%	25B–75RM	0.55	0.475	1.17
	B = 50% RM = 50%	50B–50RM	0.55	0.465	1.27
Black sand	Separated black sand	B	0.55	0.453	1.75
Moisture is under 0.1% except of separated black sand					

The cores were dipped into the melt during the COGAS tests. The gas flow is evolving from the sample due to the heat load and it was registered and recorded during 180 seconds. The gas passes the core through a thin metal pipe which is fit onto the surface of core. The gas is going through a cooled condensate trap. The chemicals with low boiling point are condensated and the rest part of the gas going to the gas collector. The amount of core gas was determined by the amount of water displaced in gas collector [4].

Figure 4 shows the COGAS equipment.

The measurements were made with COGAS measuring equipment at the Nemak Győr Ltd. The temperatures of liquid metal were 690 ^{0}C or 720 ^{0}C during the tests.

The samples had same size, but the weight were different, because of different grain size. We defined values of specific amount of gas to compare these sand mixtures. The specific amount of gas is the quantity of evolved gas during 180 seconds divided by the mass of specimen (ml/g).

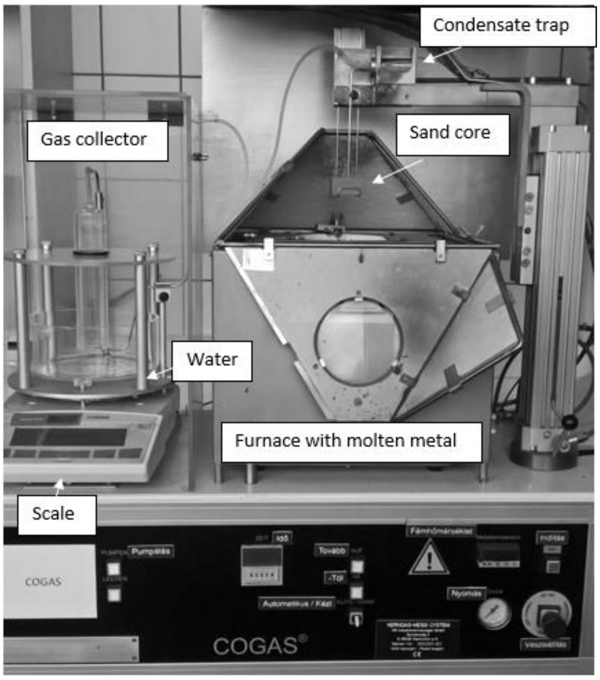

Figure 4
The COGAS equipment

3. EVALUATION OF RESULTS

3.1. The effect of basic sand quality

We examined the influence of the quality of basic sand to the amount of evolved gas. We compared sand mixtures with different grain size (fine and medium) but the same ratio of binder. The specific amount of gas was bigger at fine sand as medium sand. We found the specific amount of gas was bigger at fine sand as at reclaimed and green sand. The difference was same at 690 and 720 ^{0}C too.

The effect of reclamation is an important factor. In case of SH32 sand the value of specific amount of gas is bigger than at reclaimed medium sand. This can be explained by a higher loss on ignition of green sand (organic impurities). It contains more organic material, but we didn’t find this relation between reclaimed medium and fine sand.

The separated black sand that haven’t been reclaimed and it have a high content of residual organic material. Remains of different type of binders (binders of cold-box and hot-box methods used in the foundry) are on the surface of the black sand grains. Knowing that the different binder systems burn out differently from the sand cores. Therefore the value of evolved gas is different too [5]. The amount of evolved gas is grown thus the heat transport intensifies by increasing the ratio of separated black sand.

The value of specific amount of gas is bigger by more than 1 ml/g in case of separated black sand mixture than the reclaimed at 720 ^{0}C *(Figure 5)*.

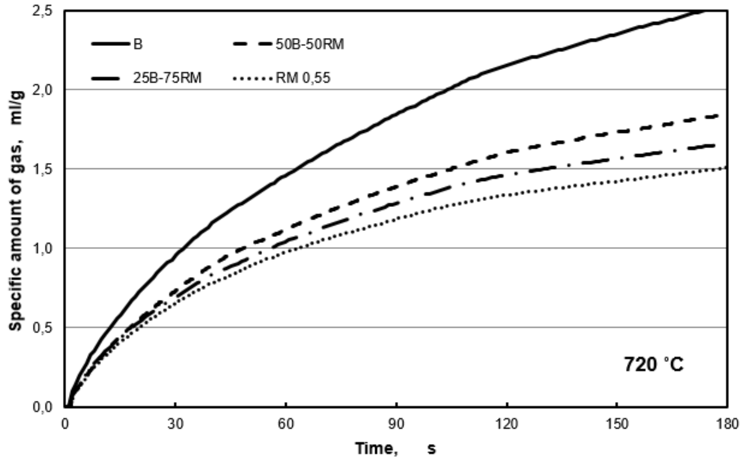

Figure 5
Effect of ratio of separated black sand

3.2. Effect of binder system

The amount of evolving gas increases in case of fine and medium grain sized sand (contained the same quantity of resin) by increasing the resin content. The specific amount of gas increases more than 15% by increasing the resin content *(Figure 6* and *7)*.

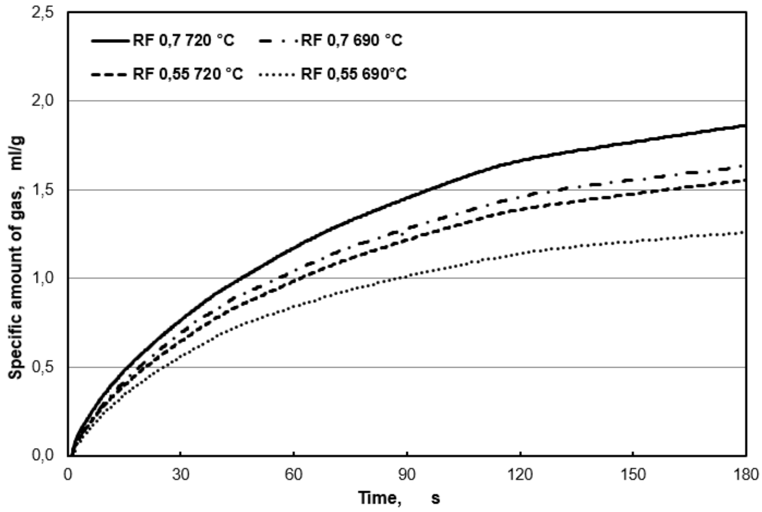

Figure 6
Effect of binder content at different temperatures in case of fine grain size sand and different resin content

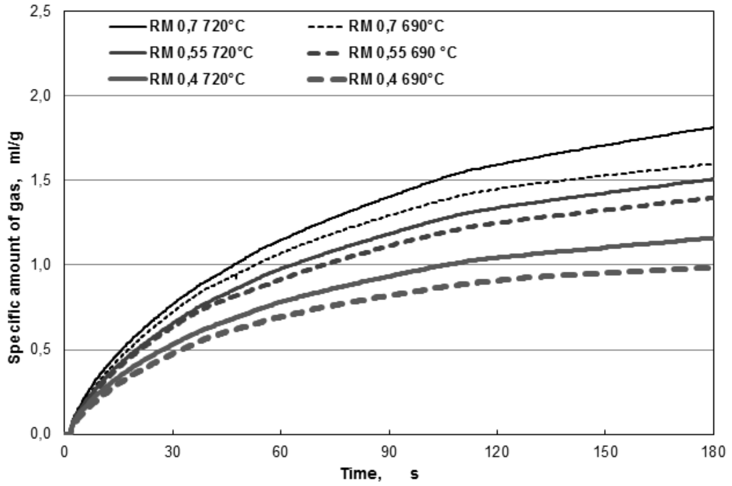

Figure 7
Effect of binder content at different temperatures in case of medium grain size sand and different resin content

3.3. The relative amount of condensate

The amount of condensate is different in each mixture. It is influenced by the temperature of liquid metal and the binder content. Higher binder content causes bigger amount of condensate. The separated black sand content in the mixture increases the amount of condensate too.

3.4. Relative amount of gas in various intervals

Table 3
Relative amount of gas in different intervals, Resin content 0.55%, test temperature 690 °C

690 ºC	**Relative amount of gas, %**			
Mixture/ Interval	**1st period**	**2nd period**	**3rd period**	**4th period**
	0–30 s	**30–60 s**	**60–120 s**	**120–180 s**
SH32	49.14	20.21	23.32	7.34
F35	44.47	23.06	26.78	5.69
RM 0.55	45.95	22.47	23.73	7.85
RF 0.55	45.38	22.19	23.35	9.08
25B–75RM	44.62	21.89	23.86	9.62
50B–50RM	43.65	22.07	27.15	7.13
B	40.4	21.24	25.31	13.05

The test time was divided into periods. We observed that the gas formed in different amounts *(Table 3* and *4)*.

40–50% of the gases evolve during the first period after dipping the samples into liquid metal. During the next 30 s this amount is halved. It's the same quantity of the evolving gas forming during the second minute. The remaining quantity (7–13%) evolves during the third minute.

At lower temperature (690 °C) during the first 30 s more gas evolve higher in percent than at 720 °C.

Table 4

Relative amount of gas in different intervals,
Resin content 0.55%, test temperature 720 °C

720 °C	**Relative amount of gas, %**			
Mixture/ Interval	**1st period**	**2nd period**	**3rd period**	**4th period**
	0–30 s	**30–60 s**	**60–120 s**	**120–180 s**
SH32	46.37	20.22	22.58	10.83
F35	42.88	20.8	25.07	11.25
RM 0.55	48.6	21.73	22.39	7.27
RF 0.55	41.77	21.67	25.89	10.67
25B–75RM	41.49	20.89	25.54	12.08
50B–50RM	39.91	20.67	26.46	12.95
B	38.31	19.88	26.79	15.02

3.5. Gas evolution rate

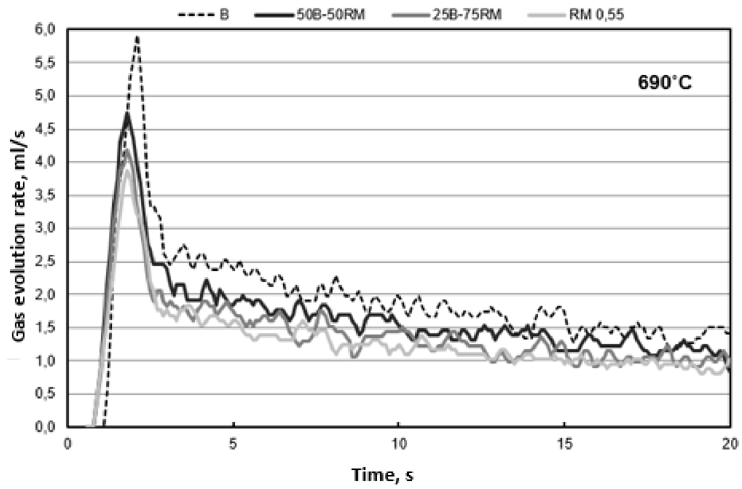

Figure 8

Gas evolution rate in case of sand mixtures contained black sand

The gas evolution rate was different at different test temperatures. The gas evolution rate was directly proportional to the amount of resin in case of same basic sand. The biggest intensity measured right after dipping the samples into the melt. Thereafter the intensity decreased gradually. Pressure increase can be observed during the first seconds. The reason of this observation is the suddenly evolved gas amount caused by the warming of trapped air in the pore and the presence of large temperature gradient on the mould wall. It fills the pores and the gas evolution starts [6].

The gas evolution rate increases by increasing the ratio of black sand in case of mixtures contained black sand *(Figure 8)*.

CONCLUSIONS

The aim of this study is the statement of factors that have an influence on the amount and intensity of evolved gas from the sand core mixtures. Uniform and stabile measurement conditions are provided by the use of spherical core samples. Thus the results were comparable for evaluation.

The results can be used in the simulation of filling process.

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