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Gas Emissivity of a Modified Cellulose Mix at the Temperature of 900°C

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Abstract

This paper presents the findings of a study of gas emissivity and the volumetric gas flow rate from a patented modified cellulose mix used in production of disposable sand casting moulds. The modified cellulose mix with such additives as expanded perlite, expanded vermiculite and microspheres was used as the study material. The results for gas emissivity and the gas flow rate for the modified cellulose mix were compared with the gas emissivity of the commercial material used in gating systems in disposable sand casting moulds. The results have shown that the modified cellulose mix is characterized by a lower gas emissivity by as much as 50% and lower gas flow rate per unit mass during the process of thermal degradation at the temperature of 900°C, compared to the commercial mix. It was also noted that the amount of microspheres considerably affected the amount of gas produced.

Keywords: Cellulose mix, Gas emissivity, Gating system

1. Introduction

Foundry engineering is a part of heavy industry which uses materials and semi-finished products from highly diverse groups of materials, from metals through minerals to chemical products [1-8]. Pouring metal into a disposable sand mould is one of the methods of obtaining a finished cast. Degradation at high temperatures of mould materials used to produce such disposable moulds is a consequence of the whole process of casting metals and their alloys. When molten metal is poured into a mould, the materials used to make it undergo natural thermal degradation. The process inherently involves emission of gas from places exposed to contact with liquid metal, where temperatures are very high. Gas emitted from mould materials during cast production is usually a result of the presence of organic compounds, such as resins and binding agents used to bind moulding sand in elements of the gating systems or protective coats [9-15].

Excessive production of gas per weight unit of moulding materials that are in contact with liquid metals results in formation of casting defects on the surface which are difficult to remove. A number of authors have investigated the processes which may result in formation of casting defects, such as the presence of gas bubbles close to the surface [16-18]. There are a number of potential factors during the process of cast production which may contribute to formation of such defects. The gating system which is the first to come into contact with liquid metal in a mould is one of such factors.

2. Methodology and plan of study

A Gasdurchmessgerat Type PGD device manufactured by Georg Fischer was used to measure the gas emissivity per unit mass and the volumetric flow rate. The device diagram is shown in Fig. 1.

Gas emissivity was measured at the temperature of 900°C +/- 2°C. The test samples were placed inside a preparation chamber (16) at the room temperature and subsequently the whole measurement chamber (9) was blown through with nitrogen for 120 seconds. After neutral nitrogen atmosphere was obtained, the vent valves and inflow valves were shut (18, 19). After the system was closed, the mechanism (17) was released for shooting the sample (previously weighed on a laboratory balance) into the measurement chamber with the test temperature of 900°C +/- 2 °C. The gas emissivity was shown on the screen (6) and expressed in cm³. The volumetric flow rate was measured simultaneously.

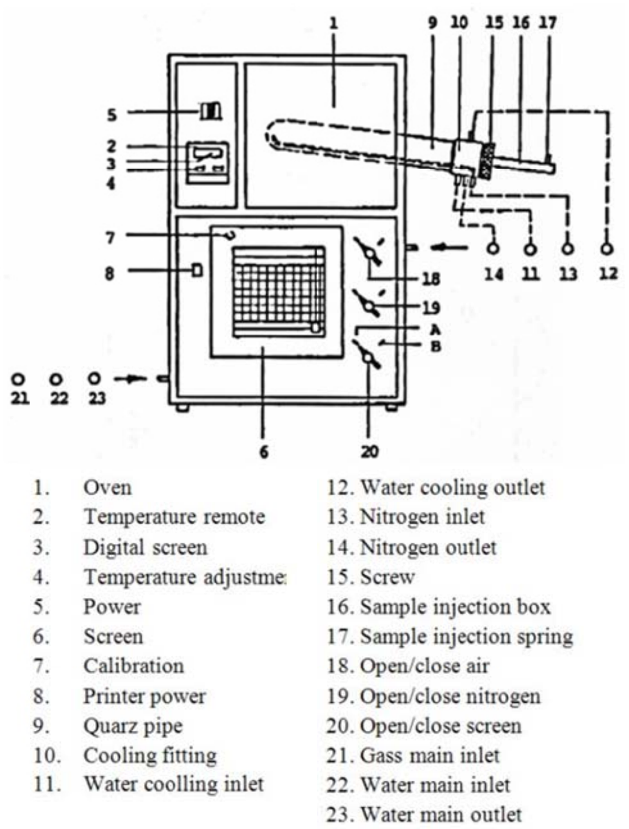

Fig. 1. A diagram of the Gasdurchmessgerat Type PGD device for measuring gas emissivity

The gas emissivity and the volumetric flow rate of the gas generated in the process was determined from three trials done with a commercial profile used in elements of gating systems and 3 samples from a patented material composition [19]. The composition of own patented mixes used in the experiment is shown in Table 1.

Table 1.
Patented fitting samples composition used for research

	Sample 1, [g]	Sample 2, [g]	Sample 3, [g]
Paper pulp	270	270	270
Expanded perlite	15	15	15
Expanded vermiculite	30	30	30
Microspheres	80	0	160
Aluminosilicate resin	190	151	243

All the components presented in Table. 1 were mixed and, after the test samples were formed, excess water was evaporated at the temperature of 130°C during 40 minutes. The amount of the binder – aluminosilicate resin – accounted for 32.5% of the weight of the other components of own samples.

3. Results of the experiment

The results of measurements of the gas emissivity converted to unit mass are presented in Table 2.

Table 2.
Gas emissivity [cm³/g]

Commercial cellulose sample	411
Sample 1	235
Sample 2	366
Sample 3	187

The distribution of the gas emissivity over time for all the samples under analysis is shown in Fig. 2.

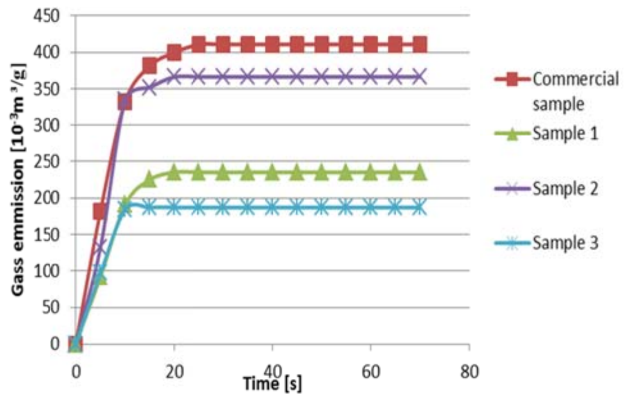

Fig. 2.Gas emissivity over time for all the samples

The results show that the highest gas emissivity (411 cm³/g) was recorded for the commercial sample. It is followed by samples number 1, 2 and 3, with the gas emissivity of 235 cm³/g, 366 cm³/g and 187 cm³/g, respectively.

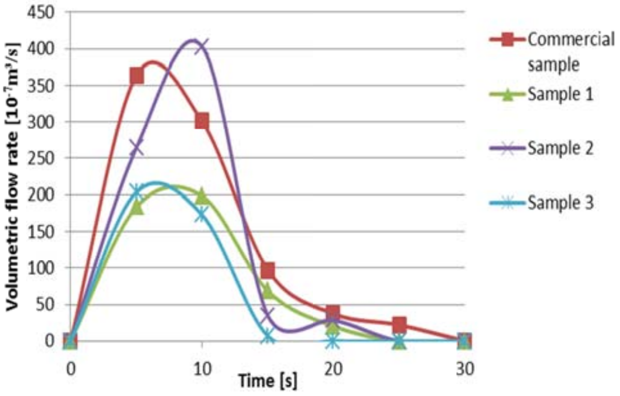

Fig. 3. Volumetric flow rate in nitrogen atmosphere

Fig. 3 shows the results of measurements of the volumetric gas flow rate for gases released during thermal treatment of samples in nitrogen atmosphere. The first to start is the degradation of the commercial sample, which is consistent with the results shown in Fig. 2. The highest volumetric flow rate was recorded for sample 2. Similar curves were obtained for samples 1 and 3.

4. Conclusions

These study results have shown that the highest emissivity per unit mass characterised the commercial cellulose mix used in gating systems. The effects of such high emissivity have been observed earlier [9, 20, 21], although they were not measured as those previous studies had other objectives. The proposed modified cellulose mix [19, 20] with additions of expanded perlite, expanded vermiculite and microspheres as well as aluminosilicate as a binder can be considered as an alternative material for manufacturing gating systems in foundry engineering. Its heat resistance is similar to that of ceramic materials and to commercial cellulose mix, which has been confirmed in previous studies; its emissivity per unit mass is lower than in the commercial mix.

The results have shown that using a different binder in own mixes reduces the amount of gas generated during the high-temperature thermal treatment compared to the compounds used in the commercial mix, i.e. melamine-urea-formaldehyde resins [20, 21].

The results of the experiment also indicate that an increase in the mass of the microspheres in the mix prepared for the experiment reduced the amount of gas generated, which is interesting considering the fact that the commercial mix has also been shown to contain microspheres [21]. Despite that fact, sample 2, without microspheres, has lower emissivity than the commercial sample with microspheres. Further studies are going to focus on quantitative determination of the effect of microspheres, expanded perlite and expanded vermiculite on the amount of gas emitted from a unit mass of the cellulose mix.

The volumetric flow rates shown in Fig. 3 are consistent with the total gas emission in Fig. 2. Such results are important for comparisons of different materials used in gating systems because an increase in the flow rate means that that gas is released more quickly from the materials under study in contact with liquid metal. This may mean that an excessive amount of gas will be released before crystallisation occurs in the layer adjacent to the wall, causing undesired presence of gas in the contact area between the gating system and the cast.

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