Dr. Joachim von Seyerl studied chemistry at the Technical University Munich and earned his PhD in 1980 at the University Konstanz. Since then he held various positions in the Chemical Division of SKW Trostberg AG / Degussa AG. He is in charge as Head of New Business Development at Degussa Construction Polymers, Trostberg, Germany.

1 Introduction

The global refractory industry has experienced a decline in consumption to about a third of what it was in 1970. Unshaped monolithic refractories have been increasing over shaped refractories due to various reasons. Besides restructuring, another way to deal with the changes of the markets is to develop new materials, products and application systems. For instance grain size of various raw materials, especially concerning the fine binder matrix of refractory-mix designs effect placing properties and strength [1]. For a successful placing of castables it is important to modify the flow behaviour. This can be achieved by different dispersant additives [2]. However the interaction between dispersant and type and particle size distribution of the fine material also gives different results with respect to flowability, setting time and strength development. The present work focusses on different reactive alumina types in a high-alumina, microsilica-free mix design.

2 Experimental

All tests were carried out using a tabular alumina aggregate mix (see Table 1), 5 % Secar 71, a CAC with 70 % Al₂O₃ content and 17 % reactive alumina. The main difference of the aluminas was in particle size: one multi-modal, two bi-modal and one mono-modal type were used in the evaluations. The products used were provided by Almatis (CL370C; CTC50) and Pechiney (PBR; PFR20).

The dispersing agents tested were selected from the polycarboxylate ether group with modified side-chain length and charge density at the backbone. The dosage was standardised at 0.2 % based on total solids.

The amount of water added was chosen at 4.4 % except when the multi-modal CTC50 was used due to segregation.

All dry ingredients were mixed in a Hobart mixer for 1 min. After water addition mixing was continued for 4 min. Immediately after mixing the prepared castable was placed into a stainless steel cone with a diameter of 100 mm at the bottom, a diameter of 70 cm at the top and 50 mm in height. The cone is lifted 10 min, 30 min, 60 min and 90 min after water addition to allow flowing of the castable for 2 min. Then two perpendicular measurements of the diameter are taken and the average value is reported in centimetres.

A part of the prepared castable was placed in a Dewar. Temperature development over time was electronically monitored with a thermometer.

Another part of the prepared castable was filled into a 4 cm × 4 cm × 16 cm mould for hardening. The cold crushing strength development was recorded after 24 h hardening of the prism with respect to EN 196 using a machine provided by Toni Technik [3].

3 Results

The flow characteristics of all 8 formulations tested look similar. The initial flow is slightly decreasing over time, but workability is still good after 90 min (see Fig. 1). Only Castament FS30 shows a slight delayed plastizising when CL370C is used. In general, Castament FS30 provides a slightly improved flow over Castament FS60. The main difference results from the reactive alumina type used. Bi-modal alumina gives better flow than mono-modal alumina thus suggesting a further possibility for water reduction.

The development of green-body strength shows significant differences depending on the reactive alumina used as well as the dispersant type. Using Castament FS60 as a dispersant all mix designs show good cold crushing strength (CCS) with values well above 20 N/mm².

Using Castament FS30 as a dispersant only the multi-modal and one bi-modal alumina type show values of 26.6 N/mm² and 12.8 N/mm² respectively.

This findings can be explained looking at the measurement of the heat of hydration (see Fig.2). The temperature development over time strong:

Table 1 • LCC refractory mix design

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
<th>Content / %</th>
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<tbody>
<tr>
<td>Tabular alumina</td>
<td>3–6 mm</td>
<td>25</td>
</tr>
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<td></td>
<td>1–3 mm</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1–2 mm</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>0.5–1 mm</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>0.2–0.6 mm</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2 mm</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>&lt;0.45 mm LI</td>
<td>9</td>
</tr>
<tr>
<td>Reactive alumina</td>
<td>variable</td>
<td>17</td>
</tr>
<tr>
<td>Cement</td>
<td>Secar 71</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Dispersant (Castament)</td>
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<tr>
<td>Water</td>
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<td>4.4</td>
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</table>
4 Conclusion

Different reactive alumina grades strongly influence setting time of castables. Setting time increases with multi-modal < bi-modal < monomodal alumina (CTC50 < PBR < CL370 C < PFR20).

The use of different Castament dispersants, in combination with reactive alumina allows to adjust setting times and flow in a wide range.

References


[3] Special thanks to Adolf Färberböck who carried out all trials.

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Fig. 1 • Development of flow and cold crushing strength (CCS), Top: Castament FS60, Bottom Castament FS30

Fig. 2 • Development of hydration heat, Top: Castament FS60, Bottom: Castament FS30

Flow/cm

Temperature / °C

Time / h

Time / h

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