INFLUENCE OF SURFACE AREA IN THE FLOWABILITY BEHAVIOUR OF SELF-FLOW REFRATORY CASTABLES

D. G. Pinto¹,², A. P. Silva¹,², A. M. Segadães¹,², T. C. Devezas¹,²
¹Department of Electromechanical Engineering, University of Beira Interior, Covilhã, Portugal
²Department of Ceramic and Glass Engineering, University of Aveiro, Aveiro, Portugal

Abstract: Aluminium oxide (alumina) exhibits a high melting point (2050°C), high hardness and excellent abrasion resistance, what makes it one of the most common raw materials for self flow refractory castables (SFRC) for monolithic linings. However, besides the properties of its ingredients, the success of the refractory lining depends on its easy installation (good flowability). The objective of this work was to evaluate the dependence between the flowability index (FI) of the fresh concrete and the specific surface area (SSA) of its particles. The castable mixtures were formed by three different size classes of commercial tabular alumina (aggregate) ([0.2-0.6mm], [0.5-1.1mm] and [1-3mm]), added to an optimized constant alumina matrix of three fine size classes (“<230” and “<500” mesh) tabular alumina, and CT3000S6 reactive alumina). The proportion of matrix to aggregate was varied (eight different mixtures, table1), controlled by the SSA value.

MOTIVATION:
SFRC shared allow:
- High flowability
- High temperature
- Easy application
- Low water contents
- High mechanical resistance

LEGEND:
1 - The comercial tabular alumina;
2 - Wet sieves;
3 - Suspension of class of “<500” mesh;
4 - Mortar mixer;
5 - Casting the paste in the slump flow;
6 - Dispersal paste;
7 - Metallic moulds and the test pieces;
8 - Test pieces in sintering process.

The evolution of the (FI) is shown in the Figure 1. The results demonstrate that there is a clearly dependence between the FI and the SSA. This relation can be described, with great accuracy (elevated value of R²=0.9839) by the quadratic polynomial equation (Eq.1).

\[ FI = 276.74 \times (SSA)^2 + 1486.6 \times (SSA) - 1855.1 \]  \hspace{1cm} (Eq.1)

Table 1: Properties of the analysed mixtures

<table>
<thead>
<tr>
<th>Mixtures</th>
<th>Matrix [wt%]</th>
<th>Aggregate [wt%]</th>
<th>SSA [m²/g]</th>
<th>IF [%]</th>
<th>Relative Error [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>38.5</td>
<td>61.5</td>
<td>1.983</td>
<td>94.99</td>
<td>0.099</td>
</tr>
<tr>
<td>M2</td>
<td>40.0</td>
<td>60.0</td>
<td>2.060</td>
<td>93.90</td>
<td>0.201</td>
</tr>
<tr>
<td>M3</td>
<td>42.0</td>
<td>58.0</td>
<td>2.163</td>
<td>92.64</td>
<td>0.081</td>
</tr>
<tr>
<td>M4</td>
<td>42.5</td>
<td>57.5</td>
<td>2.186</td>
<td>92.60</td>
<td>0.082</td>
</tr>
<tr>
<td>M5</td>
<td>45.0</td>
<td>55.0</td>
<td>2.317</td>
<td>91.92</td>
<td>0.091</td>
</tr>
<tr>
<td>M6</td>
<td>46.0</td>
<td>54.0</td>
<td>2.368</td>
<td>91.46</td>
<td>0.074</td>
</tr>
<tr>
<td>M7</td>
<td>47.5</td>
<td>52.5</td>
<td>2.445</td>
<td>91.33</td>
<td>0.026</td>
</tr>
<tr>
<td>M8</td>
<td>50.0</td>
<td>50.0</td>
<td>2.573</td>
<td>94.96</td>
<td>0.021</td>
</tr>
</tbody>
</table>

CONCLUSIONS:
- The FI increases with the increase of fine particles content (larger SSA), but for SSA values higher than 2,4m²/g, it requires a higher increment in SSA, to get a small increase in FI, with the consequent increase in castable cost.
- To guarantee the FI corresponding to a self-flow behaviour (FI> 80%), it is necessary that the refractory castable has a SSA higher than 2,215 m²/g, as given by the equation (1), and this corresponds to (table 1) a minimum 45 (wt%) of matrix in the mixture.
- In this research it was possible to estimate the value of the flowability index (FI) in function of the specific area (SSA) of the eight mixtures analysed.

These results are very important to optimize the composition of the self-flow alumina refractory castable for monolithic applications.

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