CALCIUM ALUMINATE CEMENTS FOR HIGH-TECH CASTABLES

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1 Introduction

Refractory castable technology has developed significantly over recent years. Using special grain size distributions and new combinations of fine powders within the binder system, ULCC, LCC, and MCC castables are available today which show superior performance in comparison to traditional concrete and brick linings. For example, monolithic castables are now used in secondary steel ladles or special sections in Portland cement furnaces. The major part of the improvement is related to the optimisation of the binder system, which includes fillers, additives, and the calcium aluminate cement.

This paper will show that the calcium aluminate cements (CAC) SECAR® 71 and SECAR® 80 play a key role to achieve high-tech castables with high consistent performance. Furthermore, the paper will focus on additional parameters that need to be taken into account when applying modern castables. The mixing energy is one of the key parameter to achieve optimal placing performance.

2 Refractory castable systems

A large number of different refractory castable systems are on the market today. Figure I shows a generalised view of the different cement bonded refractory mixes.

To realise all these different mixes, a calcium aluminate cement, SECAR® 71, is available and allows a high flexibility regarding this diversification of castable types. Three essential raw materials in the castable system play a key role: the fillers like microsilica and reactive alumina, the additive system (deflocculator, retarder, accelerator) and the calcium aluminate cement. All three together build up the binder phase and are interdependent in the sense that their interactions are all linked.

2.1 The fillers

Microsilica or Fume silica and reactive alumina, which are used in modern high-tech castables, have high specific surface areas. They require the use of deflocculating additives to disperse them with water whilst maintaining a low water/binder ratio. These fillers together with the additives can influence the chemical behaviour of the binder system due to the fact, that they for example can have an influence on the pH-value and on the level of soluble alkalis. These parameters influence the function of the CAC.

2.2 Additive systems

Several different fillers are in use in deflocculated ultra low, low and medium cement castables. These different fillers require adapted additive systems to optimise the water demand, flow and setting properties. Therefore, it is essential that calcium aluminate cements be used, which can be applied with all types of filler as well as the different additive systems. Especially SECAR® 71, which is in use on a global basis, is the calcium aluminate cement for all types of deflocculated systems. It is approved for use in combination with several additive systems (figure II). How effective these special additives are, is first of all dependent upon the type of the fillers. Furthermore, these additives, even if they...
have at 20°C very similar behaviour, can show quite different properties at low and high temperatures. Their efficiency is enhanced with SECAR, which possesses unrivalled regularity.

**Figure II. Example for additive systems of deflocculated refractory castables**

### 2.3 The type of calcium aluminate cement

Very small amounts of additives are put into refractory castables to deflocculate the high quantity, in surface area terms, of filler. The additives together with the filler dominate the chemical behaviour of such systems in ultra low and low cement castables. Therefore special care needs to be taken regarding the right choice of calcium aluminate cement, to make sure, that the working and setting time as well as the strength formation will take place in a proper and reproducible way. Highly consistent calcium aluminate cements such as SECAR® 71 and SECAR® 80 ensure that all type of modern high technology castables are able to achieve the targeted working time, set and strength development at the right time. Depending on requirements, these two calcium aluminate cements allow either a formulation simplicity in case of SECAR® 80, which is a pre-formulated binder, or formulation flexibility with SECAR® 71. SECAR® 71 is pure calcium aluminate cement based on the mineral phases CA and CA2. It is CA, which is the phase with the highest hydraulic potential that creates after mixing with water the strength in the castable.

In combination with the CA2, alumina fillers, and appropriate aggregates, SECAR® 71 allows application temperature of up to 1800°C, in case of SECAR® 80 up to 2000°C.

As SECAR® 71 does not contain other additives, it easily can be used in combination with several deflocculation systems as described above. This is summarised in table 1.

**Table I. The conception of the calcium aluminate cements**

<table>
<thead>
<tr>
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<th>SECAR® 71</th>
<th>SECAR® 80</th>
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<tbody>
<tr>
<td>Mineralogy</td>
<td>CA</td>
<td>CA, CA2</td>
</tr>
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<td></td>
<td>xxx</td>
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<td>Concepts</td>
<td>Pure cement, no additives</td>
<td>Formulated cement</td>
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<td>Refractory applications</td>
<td>Formulation flexibility</td>
<td>Formulation simplicity</td>
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The resulting performance of modern high-tech ULC- and LC-castables is superior compared to conventional castables (figure III), providing that they are mixed and installed under proper and defined conditions.

### 3 The quality perception of refractory castables

The quality perception of refractory castables
Figure III. Performance of castable systems and installation sensitivity

The LCC, ULCC systems are more sensitive with respect to the installation conditions. This is due to the fact that the 3 parts of the binder, the fillers, the additives and the calcium aluminate cement play an interactive role between each other. To achieve an optimal performance, multiple parameters need to be taken into account (figure IV). In addition to the use of highly consistent raw materials and an optimised formulation the conditions during the installation play a key role.

The most important criteria which need to be strictly controlled and monitored when installing a deflocculated castable are: the proper amount of mixing water in relation to the flow properties, the mixing procedure itself and the temperature.

The lower the cement content, the more sensitive the castable will become against these parameters. Therefore, the lower the cement content is, the higher the demand for consistent raw materials, and controlled and stable process parameter will be.

3.1. Mixing energy

The mixing energy is one key parameter which needs to be controlled in order to ensure a correct deflocculation of the system deflocculation, which in turns defines the castable flow, working time and hardening kinetic with low mixing water. For deflocculated ULCC, LCC, MCC and self-flow castables it is absolutely imperative, to use high intensity mixers.

Figure V shows for example, that a difference of 5 minutes in mixing time for a low cement castable could...
result in a reduction of the setting time of about 2 hours, which corresponds with the time when the heat evolution in the castable occurs.

For that reason it is important to use a calcium aluminate cement such as SECAR® 71 in a deflocculated system which allow the application at low medium and high temperatures.

Furthermore a system with SECAR® 71 remains adaptable with retarders like citric acid and accelerators like lithium carbonate in case of very special and extreme temperature conditions.

4 Summary

Modern high-tech refractory castables are very complex systems. The three interdependent participants in the bond system dominate their behaviour: the filler, the additives and the calcium aluminate cement. With SECAR® 80, formulation simplicity can be achieved whilst SECAR® 71 offers a high degree of flexibility to formulate all types of refractory mixes in the diversified world of castable with one single calcium aluminate cement. Beside the use of these highly regular calcium aluminate cements in combination with controlled fillers and additives, one key element especially for ULC and LC castables is the installation technique. Special attention needs to be taken regarding the mixing equipment, the mixing time, and the conditions during installation. These parameters need to be controlled carefully as they have a superior influence onto the performance of high-tech castables.