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THERMAL AND ENVIRONMENTAL EFFECTS ON CERAMIC FIBRES

S. KARLSSON, R. LUNDBERG and R. CARLSSON

Swedish Institute for Silicate Research, Box 5403, S-402 29 Gothenburg, Sweden

Résumé - On a étudié l'utilisation d'isolants fibreux dans des fours d'industrie céramique. Les principales phases cristallines des fibres comportant Al₂O₃ et SiO₂ sont la cristobalite et la mullite. La proportion de phases cristallisées dépend de la composition chimique et de la température de traitement. La condensation de vapeurs de ZnO provenant des émaux et la formation de ZnAl₂O₄ ont été observées sur des fibres Saffil à 930 °C.

Abstract - Fibre insulations in kilns in the ceramic industry were investigated. Cristobalite and mullite are the main crystalline phases found in Al₂O₃-SiO₂ fibres. The amount of the crystalline phases formed depends on the chemical composition and firing temperature. Condensation of ZnO-vapours from the glaze and formation of ZnAl₂O₄ were found in a Saffil fibre at a temperature of 930 °C.

I- INTRODUCTION

Ceramic fibres have been used as thermal insulation in kilns for several years. A number of investigations about crystallization, sintering, and shrinkage of heat-treated fibres have been presented /1-6/. The influence of atmosphere has to some extent been studied.

Heat-treatment of Al₂O₃-SiO₂ fibres gives mullite and cristobalite as the main crystalline phases. The amount of the crystalline phases formed depends on fibre composition, temperature, and atmosphere. The crystallization speed decreases after the first 10-20 hours of heat-treatment.

This paper presents investigations of ceramic fibres collected from different types of kilns used in ceramic industry in Sweden. The age of the fibres as well as the firing conditions in the kilns varies. The results presented are the first part of a project where the fibre properties will be examined by the collection of samples at fixed intervals.

II- EXPERIMENTAL METHODS

Information about the periodical kilns where fibre samples were taken are summarized in table 1. Two of the kilns, GSS 1 and GSS 3, are of the Shelley type where the fibres are protected from the kiln atmosphere by a sillimanite tile. In these kilns a cylindrical sample was taken from the hot face through the insulation to the steel shield. The other kilns in table 1 are shuttle kilns of various manufacture. The fibres were taken from the hot face of the insulation. Some fibre samples taken from packings in a tunnel kiln were also examined. Chemical composition and maximum temperature of continuous use of the investigated fibres are given in table 2.
Table 1 - Firing conditions of investigated kilns.

<table>
<thead>
<tr>
<th>Kiln</th>
<th>Fuel</th>
<th>Max. temp. (°C)</th>
<th>Type</th>
<th>Insulation</th>
<th>Age (cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSS 1</td>
<td>electricity</td>
<td>1200</td>
<td>biscuit</td>
<td>Cerachrome *</td>
<td>50mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cerafiber *</td>
<td>63mm</td>
</tr>
<tr>
<td>GSS 3</td>
<td>electricity</td>
<td>1200</td>
<td>biscuit</td>
<td>Fiberfrax H **</td>
<td>50mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fiberfrax **</td>
<td>63mm</td>
</tr>
<tr>
<td>RK 1</td>
<td>propane</td>
<td>25</td>
<td>1400</td>
<td>glaze</td>
<td>Saffil ***</td>
</tr>
<tr>
<td></td>
<td>butane</td>
<td>75</td>
<td>1060</td>
<td>glaze</td>
<td></td>
</tr>
<tr>
<td>RK 2</td>
<td>electricity</td>
<td>1250</td>
<td>glaze</td>
<td>Saffil ***</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>propane</td>
<td>95</td>
<td>1400</td>
<td>glaze</td>
<td>Fiberfrax H **</td>
</tr>
<tr>
<td>HB</td>
<td>propane</td>
<td>95</td>
<td>1150</td>
<td>biscuit</td>
<td>Cerafiber *</td>
</tr>
</tbody>
</table>

Table 2 - Properties of investigated fibres.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Al2O3</th>
<th>SiO2</th>
<th>Cr2O3 (wt%)</th>
<th>Max. temp. continu. use (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerafiber*</td>
<td>47</td>
<td>52.7</td>
<td>-</td>
<td>1260</td>
</tr>
<tr>
<td>Cerachrome*</td>
<td>43.5</td>
<td>53.5</td>
<td>2.75</td>
<td>1425</td>
</tr>
<tr>
<td>Fiberfrax**</td>
<td>48</td>
<td>51.6</td>
<td>-</td>
<td>1260</td>
</tr>
<tr>
<td>Fiberfrax H**</td>
<td>62</td>
<td>38</td>
<td>-</td>
<td>1425</td>
</tr>
<tr>
<td>Saffil ***</td>
<td>96-97</td>
<td>3-4</td>
<td>-</td>
<td>1600</td>
</tr>
</tbody>
</table>

The fibres have been examined by scanning electron microscopy (SEM) and X-ray diffraction (XRD) and in some cases by X-ray fluorescence (XRF).

III - RESULTS

The fibre insulations which have been studied seem in general to be very little affected by the temperature and the atmosphere in the kilns. The surface of the fibre blankets or blocks is soft and except the Saffil fibres of unchanged colour. The Saffil fibres in kilns RR 1 and RK 2 have a light pink colour. In the two kilns GSS 1 and GSS 3 the fibre insulation is protected against the kiln atmosphere by a sillimanite tile. Therefore only minor influence from the kiln atmosphere on the ageing and crystallization behaviour of the fibres is expected.

Table 3 summarizes the crystalline phases which have been found in Al2O3-SiO2 fibres. The table shows that cristobalite and mullite are the main phases. Mullite is formed at a lower temperature than cristobalite. The fibres which have been closer to the tile in kiln GSS 1 are completely crystallized. No remaining glass phase is found, but the fibres still have a glassy appearance. Compared to non-crystallized fibres they are slightly more deformed and bent, figure 1. The crystalline phases formed depend on the chemical composition of the fibres. This is clearly seen in kilns GSS 1 and GSS 3. The higher Al2O3 content in the Fiberfrax H fibre causes formation of mullite as the main phase. In both the kilns, the cristobalite content has a maximum about 25 mm from the hot face. This has also been found in other kilns not presented here.

The firing conditions of kiln RP differs from the one in the kiln GSS 3. Examination of a fibre sample shows, however, that the crystallization behaviour seems to be almost unaffected by the different firing conditions. The relative amounts of the crystalline phases formed as well as the microstructure are similar. Kiln HB is a shuttle kiln with a reducing atmosphere between 1050 and 1150 °C, followed by oxidizing atmosphere during the cooling period. SEM and XRD did not reveal any specific influence of the reducing atmosphere.

* Johns Manville
** Carborundum
*** ICI
Table 3 - Crystalline phases in heat-treated Al2O3-SiO2 fibres.

Fig. 1 - Cerachrome fibres from kiln GSS 1. a) hot face, b) hot face, c) as received.
Fig. 2 - Saffil fibres. a) kiln RR 1, 290 cycles, b) kiln RK 2, 1000-1100 cycles, c) as received.

Figures 2a-c show two samples of Saffil fibres used for different numbers of firing cycles as well as Saffil fibres as received. It is clearly seen how the number of firings influence the crystallization course and how the crystals grow larger and larger. The crystallite size in Saffil fibres as received is about 0.5 μm /7/. Figure 2a shows crystallite sizes of more than 3 μm. The light pink colour of the fibres has not been explained.

Fig. 3 - Saffil fibres from a tunnel kiln. a) with ZnAl2O4 at 950°C, b) no ZnAl2O4 at 1070°C.
Saffil fibres were used as packings in a tile insulated tunnel kiln. Near the inlet opening of the kiln, at a temperature of 930°C, vapours from the glaze condensed on the fibres and formed ZnAl2O4. These fibres have a different microstructure compared to Saffil fibres used at higher temperatures. Traces of ZnAl2O4 was also found at a temperature of 1010 °C but nothing at 1070°C. Figure 3a shows fibres with ZnAl2O4 at 930°C and figure 3b fibres at 1070°C.

IV - CONCLUSIONS

Heat-treatment of Al2O3-SiO2 fibres gives cristobalite and mullite as the main crystalline phases. The amount of the two phases depends on fibre composition and temperature. The influence of the kiln atmosphere is not so obvious and further tests are needed to investigate its influence. In polycrystalline Saffil fibres heat-treatment influences the crystal growth and microstructure. Cristallite sizes larger than 3 μm have been found. ZnO-vapours from the glaze condensed and reacted with Saffil fibres and formed ZnAl2O4 at a temperature of about 930 °C in a tunnel kiln. At higher temperatures it was absent.

The results, which have been presented here, will be followed up by collection and examination of new fibre samples from the kilns in about a year. This is done in order to study the ageing and the influence of firing conditions on the fibres. After fibre samples have been examined over a period of a couple of years it will be easier to draw conclusions about the influence of the firing conditions.

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REFERENCES

/2/ Hiraikuski et al., Taikabutsu 25 (1973) 491.
/6/ XXIVth International Colloquium on Refractories, Aachen 1981.