TITLE

Analysis of the performance change by inclusion of Basalt fibres in Ceramic Elements

DOCUMENT NUMBER

CCII - 00116

VERSION

V1.0

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DATE CREATED

16 August 2017

CERAMICX CENTRE FOR
INFRARED INNOVATION

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Introduction

This report investigates the performance change in Ceramicx FTE 1000W and FFEH 800W elements due to the inclusion of igneous fibres in the casting mixture. Performance is measured by evaluating the radiative energy emanating from the surface in a grid in-front of the element

Materials

The elements of interest have 5 wt% igneous rock fibres dispersed in the face of the element. The fibres are cylindrical in shape with a length of 3mm and diameter of 15µm. These were mixed into Ceramicx standard ceramic mixture and processed identically to Ceramicx standard FTE element. The elements were glazed in both white and black using the standard procedure.

Method

The test was carried out using the Herschel heat flux mapping apparatus. This automated system guides a heat flux sensor around a 500 x 500 grid in 25mm increments using a robotic arm as shown in Figure 1. The measurements are repeated at separations ranging from 100mm to 500mm. The sensor is a Schmidt-Boelter type sensor with a maximum response level of 2.3 W/cm^2 in the waveband of 0.4 – 10µm.

Elements were allowed to heat for 20 minutes prior to the heat flux mapping routine occurring to ensure that the whole heater was at steady-state operational temperature.

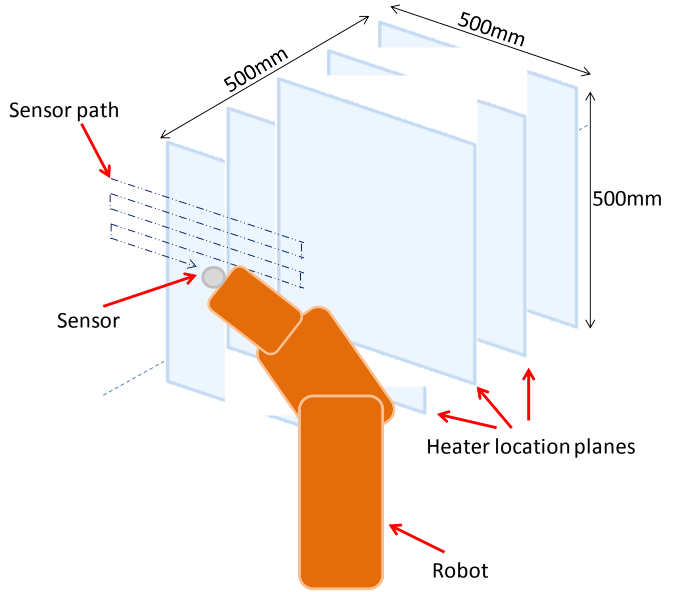


Figure 1: Schematic of measuring grid showing sensor path and planes of heater emitter location

4 Ceramic elements with basalt included were manufactured and compared with two random standard FTE elements. Each element was analysed three times with the average heat flux for each taken.

Results

Standard FTE 1000W

Table 1 shows the average radiative output from three individual measurements of a random FTE samples with serial numbers as shown. The peak heat flux, which is the maximum reading recorded, is also shown in this table.

Table 1: Percentage energy returned as radiative energy

Peak heat flux	
Distance (mm)	**FTE 0517409982**
100	51.55 ± 0.204
200	39.84 ± 0.19
300	28.88 ± 0.18
400	21.13 ± 0.15
500	15.91 ± 0.10

Basalt FTE – white glaze

Four individual FTE elements with basalt included were analysed. The average percentage heat flux recorded at 100mm from the element surface for these samples is shown in Table 2, below

Table 2: Percentage heat flux from white FTE with igneous rock inclusions

Element	Percentage heat flux ± Error
Basalt 1	51.23 ± 0.29
Basalt 2	50.13 ± 0.41
Basalt 3	51.22 ± 0.25
Basalt 4	51.53 ± 0.22

Basalt FTE – black glaze

Four further FTE elements with basalt included, but glazed in black were also analysed. This showed, as expected that these elements are more efficient; returning more of the consumed energy as heat flux.

Table 3: Percentage heat flux from black FTE with igneous rock inclusions

Element	Percentage heat flux ± Error
Basalt 1	52.78 ± 0.23
Basalt 2	53.49 ± 0.04
Basalt 3	53.44 ± 0.10
Basalt 4	53.11 ± 0.06

The average radiant heat flux for black glazed elements with igneous rock inclusions is 4% higher than that of the equivalent white elements

Peak heat-flux

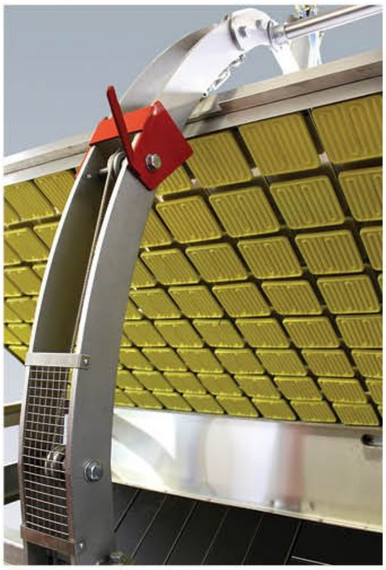
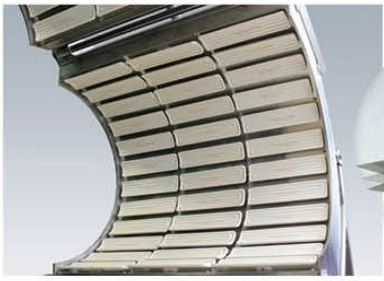
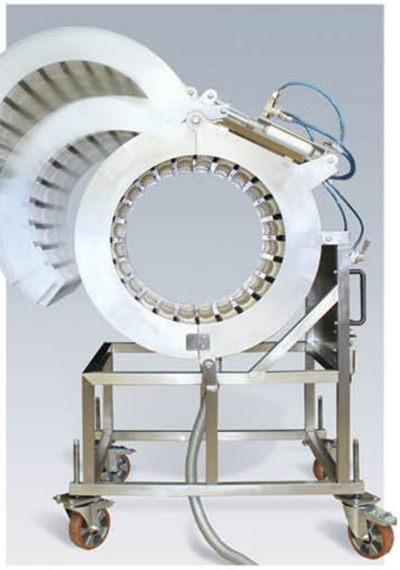
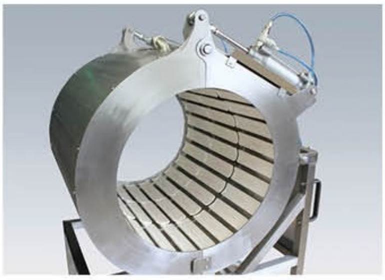
The peak heat-flux measurements follow the same pattern as the percentage heat flux. While the values varied, the broad trend shows that peak heat flux for black glazed elements is higher than that of white glazed elements.

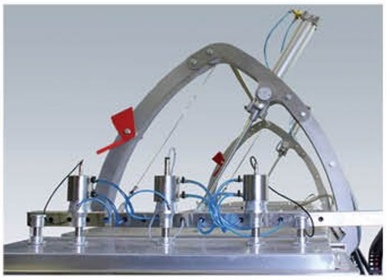
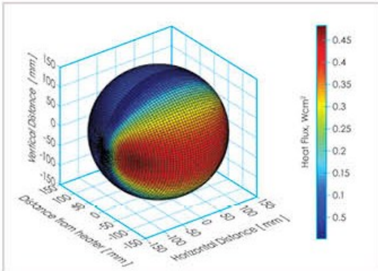
Analysis

A one-way ANOVA was conducted on the heat flux results at 100mm from the surface and on the peak heat flux. This shows that at the 95% confidence interval, there is no discernible difference between the standard white element and that of element, glazed in white, with igneous rock inclusions.
As expected, there is a statistical difference between the white and black glazed elements with igneous rock inclusions which follows previous research conducted by Ceramicx on the effect of black glaze on element efficiency
The same statistical method was applied to the peak heat-flux values and the trend in the P-Values was similar. A statistical difference, as demonstrated for the efficiency of the elements, is seen between the black and white glazed elements, but not between the two white glaze elements.

Conclusion

This analysis shows that adaptation of Ceramicx's ceramic mixture to include igneous rock fibres does not alter the efficiency of the elements. Of more influence is the colour of the glaze, which can lead to a 4% increase in the radiant heat flux output for a 1000W heater. Consistent with previous research carried out and published by Ceramicx, the black glaze remains the most efficient heat flux increase method.



Vertical Distance [mm]
Distance from heater [mm]
Horizontal Distance [mm]
Heat Flux, Wcm²
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.5