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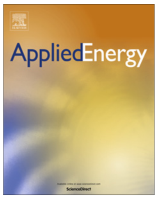

Thermal analysis of a stoneware panel covering radiators

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HIGHLIGHTS

- We study the thermal performance of water radiators covered with a stoneware plate.
- Thermocouples, IR thermal images and CFD analysis were used.
- CFD analysis reproduces the thermal performance of the radiator.
- The stoneware does not significantly improve the energy properties of the water radiator.

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ABSTRACT

The utility of a stoneware panel covering radiators to improve their energy performance is analysed. These types of panels are normally used for aesthetic purposes, although manufactures argue that they also have a practical use due to retaining heat which is emitted when the radiator is turned off.

A theoretical–experimental study was thus conducted to verify this claim. The temperatures of four pairs of water radiators were simulated using CFD analysis, one of each pair being covered with a stoneware panel during heating and cooling. These temperatures were compared with those measured using infrared thermography and thermocouples located on the surface of the radiators and stoneware panels.

Both the experimental and theoretical methods confirm that the temperature of the stoneware panel during cooling is slightly higher than the corresponding temperature of the aluminium surface of the radiator. This difference tends to disappear, however, and is of less than 2 °C only 50 min after cooling has started.

1. Introduction

Water radiators are among the most widely used heating systems. A radiator's performance is affected by several factors, crucial among which are water temperature, water flow and design. As regards the last factor, the use of finned radiators makes it possible to increase the heat emitting surface. However, this type of radiator is more expensive and difficult to manufacture than single panel radiators. It is also more difficult to clean and hence more exposed to failure due to fouling. Novel designs have been proposed to increase the heat transfer from a radiator into the surroundings: the use of one or two high emissivity sheets placed between the interior surfaces of a double radiator [1], the use of metallic foils as radiation barriers [2], or the use of surfaces with high emissivity and roughness attached to the wall behind the radiators [3]. Moreover, metallic paint finishes have been shown to reduce radiant heat output by up to 10% [4]. Some other designs have been patented that claim to improve the performance of heating radiators: mounting the heating system sandwiched between ceramic elements [5], or inside an agglomeration of inert stone waste [6]. Some radiator manufacturers use stoneware panels to cover their radiators, basically for aesthetic reasons (see Fig. 1).

They claim that the panels also improve the thermal energy properties of these radiators. The attachment of a stoneware panel to the heating element has thus been put forward as a thermal energy accumulator and radiator [7]. In this case, it has been claimed that, once heated to the working temperature, the stoneware panel maintains this temperature and radiates heat for a longer time after the heater has switched off. Not only

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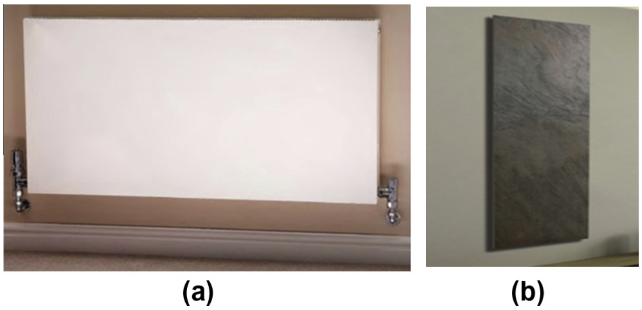

Fig. 1. Horizontal (a) and vertical (b) stoneware covering radiators.

performance, but also production and maintenance costs need to be taken into account. For instance, the heat output from a finned radiator can drop up to 20% in four months due to fouling [1].

The objectives of this paper are to study the dynamic behaviour of water radiators during heating and cooling and assess the influence of a stoneware panel attached to them. The paper also aims to show the capability of Computational Fluid Dynamics (CFD) simulations to investigate this dynamic behaviour in the radiator-stoneware system. The temperature distribution over the surface of the radiators and over the surface of the stoneware panels was analysed, as well as the dependence of the surface temperature on time. Thermal infrared (IR) imaging was used for this purpose. Thermal IR imaging has proved to be a powerful technique for studying radiator faults [8], as well as the dynamic behaviour of panel radiators [9] and of thermal radiators [10].

2. Experimental procedure

In order to compare the behaviour of a radiator covered or not with a stoneware panel, two identical aluminium radiators were connected in parallel to ensure that the water flow rate and water temperature were the same for both. The front of one of the radiators was covered with a stoneware panel using adhesive glue (see Fig. 2).

The experiment was carried out for radiators with 12, 10 and 6 elements. The recirculation pump provides a suitable water flow and the valves in the experimental setup are used to avoid water recirculating from one radiator to the other during heating and cooling. Pipes are covered with mineral wool to minimize heat losses.

Table 1
Dimensions of the four types of radiators analysed.

Case	Number of elements in the radiator	Radiator size (width × height) (cm)	Stoneware plate size (width × height) (cm)
I	6	44 × 44	46 × 46
II	6	48 × 78	50 × 80
III	10	80 × 44	82 × 46
IV	12	100 × 50	102 × 52

The temperature of the water flowing into the radiators was measured using a thermocouple attached to the water inlet (point T1 in Fig. 2); the temperatures of the radiator and the stoneware panel were measured using two thermocouples attached to the mid-point of the radiator and the stoneware panel, respectively (points T2 and T3 in Fig. 2). These temperatures were used to obtain the thermodynamic temperature from the IR images.

The experiment was carried out as follows. First, the water heater was turned on and hot water was pumped into the two radiator system for about 60 min to ensure that the water, radiators and stoneware panel reached a steady-state temperature. The steady-state temperature of the water was fixed. This constituted the heating phase of the experiment. The heater was then turned off and non-heated water was allowed to circulate through the radiator for another 60 min. This constituted the cooling phase of the experiment. The whole experiment was carried out for three hot water steady-state temperatures as measured at T1: 50, 60 and 70 °C. The valves in Fig. 2 were closed during cooling in order to prevent water backflow.

Four cases were studied. The type of radiator, its size and the size of the stoneware panels used in each case are given in Table 1.

Thermal IR images were obtained using an Agema Thermovision 470 system which includes a video camera that allows continuous recording of data over time. Thermal IR data from −20 °C to 1500 °C can be recorded with a sensitivity of 0.1 °C at a distance of 1 m and a precision of 2% at 30 °C. Data were collected using an RS170 (CCIR/PAL) video output with 140 lines per image. The lens of the thermal camera was placed 10 m from the radiators so that the front surface of both radiators could be viewed simultaneously on each IR image. Temperatures at T1, T2 and T3 and front-view IR images of both radiators were taken simultaneously. Moisture was neglected, as it is not relevant given the experimental conditions.

The temperature of an object obtained from the as-recorded IR image depends on the distance from the camera, the lens used, the

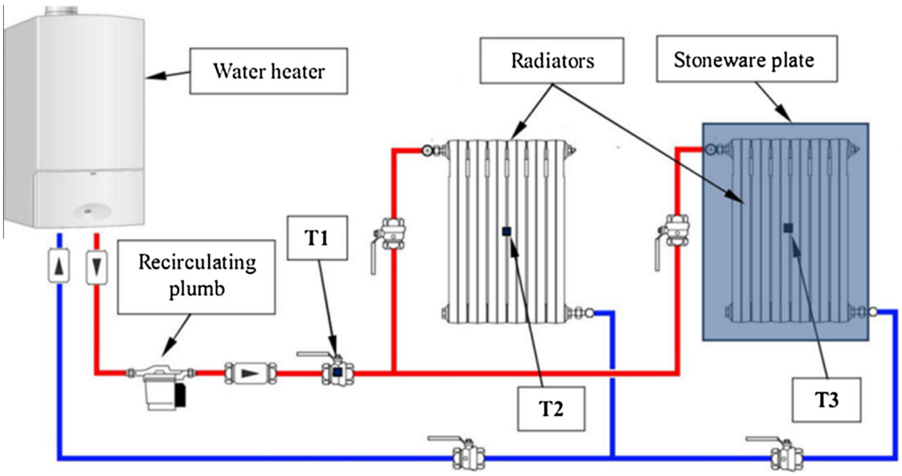

Fig. 2. Experimental set up with identical radiators of 6 elements connected in parallel. Points T1, T2 and T3 show the location of the thermocouples.