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Phase change materials integrated into glass scraps-based tiles for ventilated façades applications: a laboratory scale-up case study

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Abstract:

Ceramic foams represent an interesting class of materials for insulation applications, thanks to the their low flammability, which make them a safer alternative to polymeric insulation products. Ceramic foams are characterized by peculiar microstructures, with a porous texture which formation can be induced by the introduction of an expanding agent. Its activation within the ceramic batch is achieved during the firing process. The integration of Phase Change Materials (PCM) within the pores of the ceramic matrix represents a very challenging goal to importantly improve the thermal insulating performances and comfort of buildings. The possibility to embody PCM into porous fired tiles is strictly related to the size and amount of pores formed during the process. For this purpose, the capability to control and predict the bloating phenomena as a function of the tiles size is a key point to define the thermal performances of the final device. Starting from a typical porcelain stoneware tiles formulation, silicon carbide (SiC) powder was added as an expanding agent. Furthermore, the bulk composition was optimized by addition of glass scraps. The presence of glass reduces the carbide stability leading to observe bloating phenomena in a temperature range typical of the industrial ceramic tiles production. To evaluate how the tiles size can influence the microstructures, in terms of pores amount, shape and size, a laboratory scale up process was carried out. The scale up process was done passing from 30 mm of diameter specimen to a 150x150 mm demonstrator device. The samples were characterized by bulk density, linear expansion, water absorption and pores distribution. The effects of the firing process parameters on the specimens' physical properties were studied. The increase of temperature leads to an initial decrease of the bulk density, given by gas formation due to SiC oxidation, followed by a progressive densification regardless the increased expansion potential. The pores amount size and shape showed to be dependent both on the efficiency of SiC decomposition and glass viscosity. The changes in terms of density are matched to the amount of pores, affecting the potential amount of PCM that could be incorporated. Linear bloating and pores size showed an evident relationship to the specimens size, emphasized by the reduction of the heating rate.