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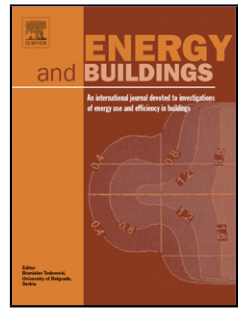

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Evaluation of VIPs after mild artificial aging during 10 years: focus on the core behavior

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Abstract:

The prediction of the long term performance of VIPs remains challenging. To improve the forecast, the evaluation of VIPs aged for very long periods can help significantly. This study reports the characterization method which was implemented on VIPs after an artificial aging of 10 years in the laboratory, at room temperature in two different relative humidities: quite low and high (23 °C at 33 and 80 %RH). The aim is to evaluate the aging of the fumed silica core thanks to the detailed study of the hygrothermal and structural evolutions of the core material. The evaluation reveals that the silica core has been partly aged at high relative humidity (80 %RH), as highlighted by: (i) the moisture content at equilibrium which is not so high as the moisture content that could be reached by short-term additional aging of the sole silica at high humidity levels, (ii) the evolution of the specific area (decrease of only several percents). For the VIP aged at relatively high humidity, the water sorption isotherm indicates that the moisture content inside the VIP corresponds to a humidity level of 44 %: in comparison with the permeation at the beginning of the accelerated aging, the WVTR decreased approximately by a factor 2 (humidity gradient from 80 to 44 %). Furthermore, thanks to the follow-up on the weight and internal pressure of the VIPs, the permeances of the barrier laminate to water vapor and air are also estimated.

Keywords: VIP, Long term aging, Performance, Characterization, Silica core, Sorption isotherms, Drying tests, Thermal conductivity, Pressure, Weight gain

Introduction

The prediction of the long term performance of VIPs remains challenging. It is important that the thermal conductivity of VIPs after a long aging in laboratory or in service is not underestimated for their increasing application in buildings. There are many reasons for the deviation towards too low predicted values: e.g. the relevance of the model used or the accuracy of the data. According to the most commonly used models, the degradation of the thermal performance (conductivity increase) is due firstly to the increase of the internal pressure (main contribution: dry air), that leads to the increase of the gaseous contribution to the thermal conductivity and secondly to the increase of the solid conduction [1]. This increase of the solid conduction is due (i) to the physisorbed water on the silica skeleton and (ii) to the smoothing and coalescence of the primary particles of silica, both resulting in enhanced connection between the particles. Indeed, as it was extensively studied by Zhuravlev [2] and first observed by Transmission Electron Microscopy (TEM) by Morel for pyrogenic silica [3] [4], the silica skeleton undergoes surface modifications during aging at 80 %RH (20 to 60 °C). TEM examinations show that the surface of the aged material appears smoothened and a coalescence of the primary particles is evidenced without any modification of the aggregates architecture [3] [5] (Figure 1). This is linked to the decrease of the measured specific surface area and suggests an enhancement of the structural contribution to the thermal conductivity.
Aging models developed a decade ago to predict the evolution of the centre-of-panel thermal conductivity do not take into consideration the aging of the core itself. Recently, difference between prediction and measurements has been pointed out by Brunner [6] whose measurements on monitored VIPs installed on a roof for about 8 years have shown an underestimation by the model by an amount of 1.1 to 1.4 mW/(m.K) in their centre-of-panel thermal conductivity [6]. The authors presume that aging of the core is the more likely explanation: a redistribution of Si and O atoms around the neck of SiO_2 particles enhances the structural heat transfer trough the SiO_2 skeleton.