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Fast firing strategy to obtain ceramic membranes shaped by centrifugal casting

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Abstract

In ceramic manufacture, the sintering step generally constitutes the highest thermal energy consumptive step. For this reason, several approaches have been proposed to reduce energy consumption by tailoring sintering conditions without compromising the properties of the final product. Here, an interesting alternative constitutes fast firing, which allows the use of conventional furnaces to carry out the thermal treatment at high heating rates (>500 °C·min^{-1}) and short holding times (≥10 min) [3]. Thus, in this work tubular ceramic membranes were manufactured using fast firing as the sintering technique, and their properties were compared with those of membranes thermally treated using conventional sintering at similar holding temperatures [1, 4].

Initially, an α-alumina aqueous slurry containing 25 vol.% of alumina was prepared and shaped by centrifugal casting following the methodology given in [2]. The slurry was poured into a metallic mold and rotated at 4297.18 rpm for 10 min. After removing the remaining liquid phase and subsequent drying, the green tubes were extracted from the mold and sintered at 1300°C for 10 min. Subsequently, the samples were characterized to determine their shrinkage and their apparent porosity by the Archimedes method. The analyses were performed in triplicate, and the results were compared with data from samples also shaped by centrifugal casting under similar conditions but consolidated by conventional sintering. A schematic diagram comparing the fast sintering cycle proposed in this work, hereon named FF, and the conventional sintering cycles established in the literature, named as CS1 [4] and CS2 [1], can be found in Fig. 1.

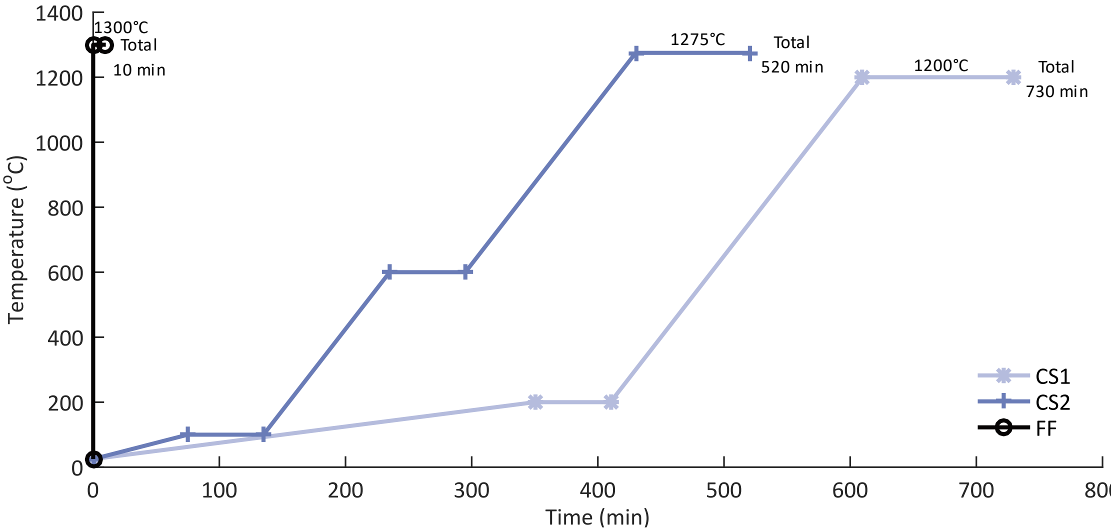

Fig. 1. Comparison of sintering cycles.

The characterization results are summarized in Fig. 2. In Fig. 2(a) it can be observed that the fast fired samples experienced less shrinkage than the conventionally sintered ones, but the results still are in the same order of magnitude. Additionally, the apparent porosity results can be found in Fig. 2(b). Even though the apparent porosity of the fast fired samples are different from CS1, which experienced sintering at a lower temperature for the longest period of time, they are also quite similar to the porosities of the CS2 samples sintered at a more proximate temperature.

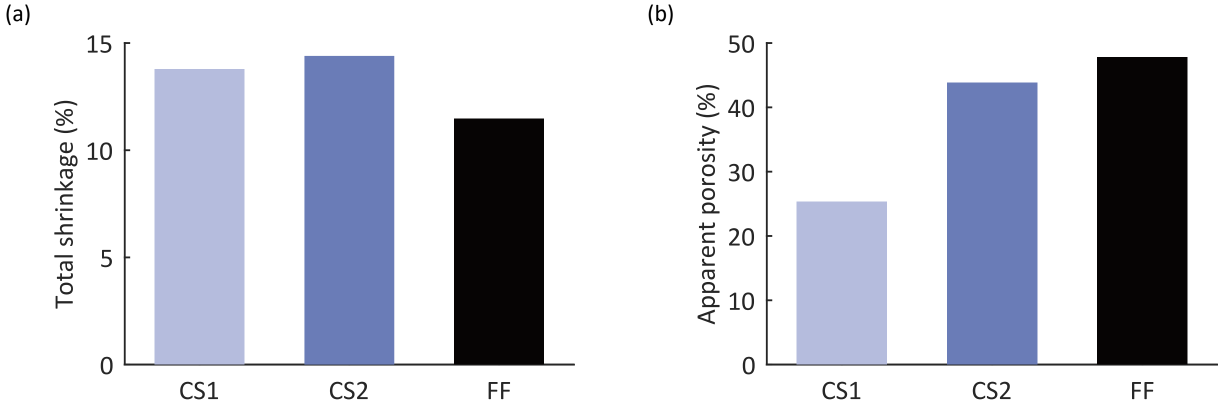

Fig. 2. Characterization results from (a) shrinkage determination and (b) apparent porosity determination in comparison with results from the literature.

A first attempt has been performed to evaluate the membrane performance in terms of the hydraulic permeance. For this purpose, deionized water was used and the concentrate flux was defined as $1 L \cdot min^{-1}$. The test was carried out from 3 to 0.5 bar and the compared results are given in Fig. 3. Here, the hydraulic permeance obtained for the fast fired sample is also similar but higher than the CS2 sample, which can indicate the presence of more interconnected pores.

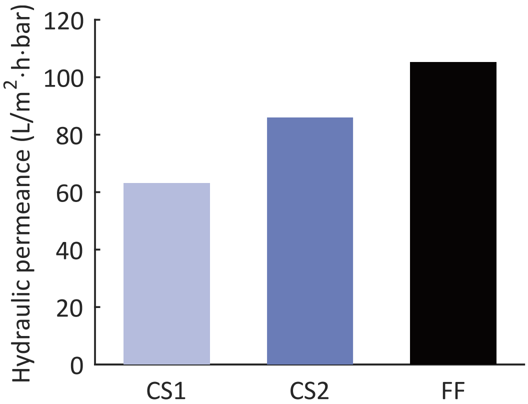

Fig. 3. Hydraulic permeance results comparison with results from the literature.

So, these preliminary results from the fast fired tubes have shown a good agreement with results from the literature, especially with the CS2 samples. This can allow us to infer that the material which underwent fast firing has a potential to be used as a membrane. Further experiments will be carried out to evaluate the ceramic tubes membrane performance.

References

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