PoreXpert modelling of pigment application onto ceramic powders

Introduction

This application note shows how PoreXpert can be used to simulate the application of a pigment onto ceramic powders using wetting simulations.

The application of pigment to ceramic powder used in the manufacturing of tiles is carried out using water as a medium for the transport of the pigment within the porous space of the powder.
Sample A showed very good uniform pigmentation, while the results of the application of pigment to sample B were bad, with a less uniform pigmentation.

This application note shows how to better understand the difference in behaviour, by using experimental data from mercury porosimetry and by modelling the wetting of the porous structures with PoreXpert.

Mercury porosimetry

A preliminary observation and comparison of the mercury intrusion curves showed that there were major differences in the overall value of porosity, with sample A showing value of accessible porosity (45.47%) much higher than sample B (21.20%).

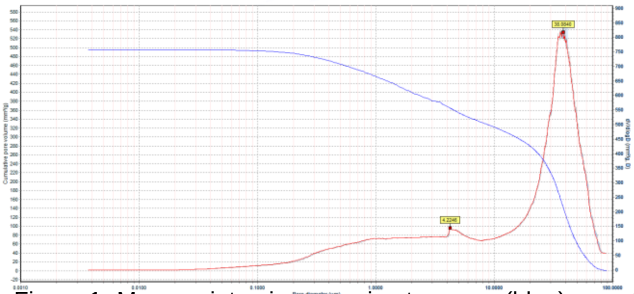


Figure 1- Mercury intrusion porosimetry curve (blue) and its first derivative (red) for sample A.

A traditional interpretation of the mercury porosimetry intrusion curve, which takes the first derivative of the curve (shown in red in Figures 1 and 2) and models the porous material as a bundle of capillaries, cannot fully explain how the differences in the pore size distribution and the value of porosity between samples would affect the application of pigment to the powder.

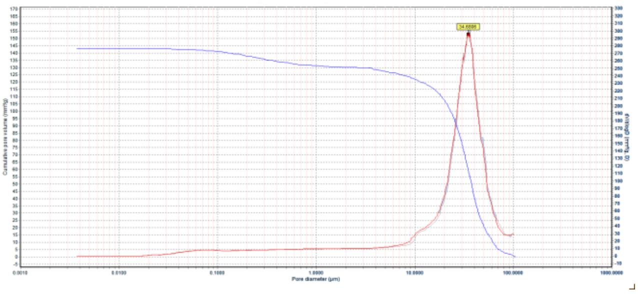


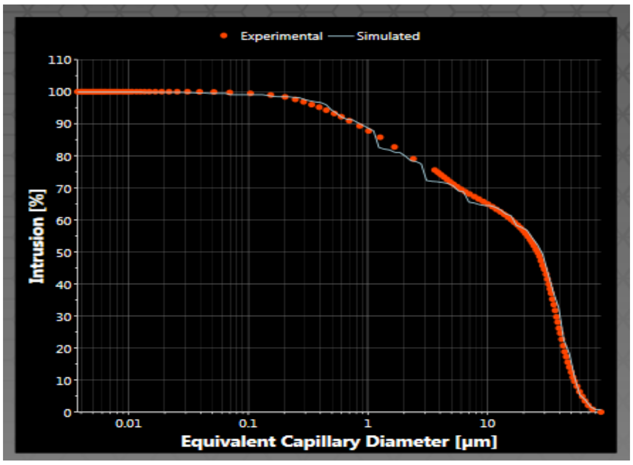
Figure.2 - Mercury intrusion porosimetry curve (blue) and its first derivative (red) for sample B.

The major difference between the two samples is their porosity, while the pore size distributions are more similar, covering the range 100 nm (0.1 µm) to 100 µm .

Modelling with PoreXpert

When modelling a series of samples using PoreXpert, we usually recommend that the user should select one ‘structure type’ (throat-size short-range auto-correlation function) and model all the samples using the same structure type. However, in this case the mercury intrusion curves were so widely different that PoreXpert was allowed to test all structure types and find which structure type would yield the closest match to the experimental intrusion curve, and whether any meaningful trends emerged.

Sample A was modelled using a horizontally banded structure with large-to-small throats arrangement, while sample B was modelled by PoreXpert using a vertically banded structure, Figure 3.



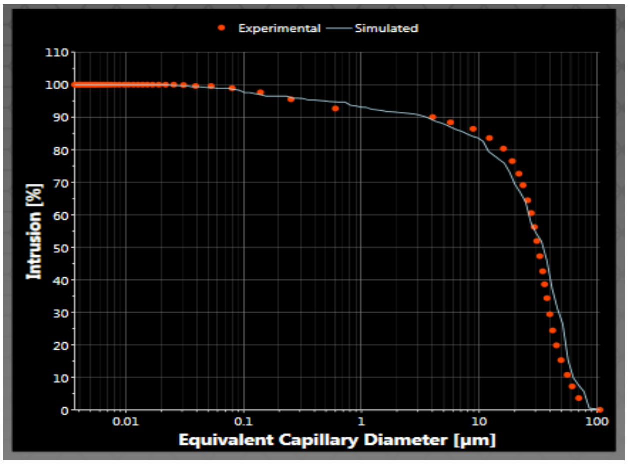


Figure 3. PoreXpert fit to sample A (upper graph) and sample B (lower graph).

In order to simulate the process that delivers the pigment into the ceramic powder, wetting simulations were run for a total time of 10 ms. The wetting simulation is very sophisticated, taking into account both capillarity forces and the inertia of the fluid as it is pulled though the void network. PoreXpert identifies interesting trends in the wetting simulation results, which can be clearly seen in the visual representation of the unit cell after wetting has taken place. Samples A shows a very uniform wetting of the unit cell, Figure 4. Sample B on the other hand, because of the different (vertically banded) structure, shows a completely different pattern in the wetting of the cell, with large areas of the cell showing little or no wetting fluid, which is an indication of the reason why the pigment would not be uniformly applied to this sample. The ‘unit cells’ shown in Figure 4, which connect to replicates of themselves in every direction, are relatively small for clarity- with your own copy of PoreXpert, you can generate unit cells over 4 times larger in volume.

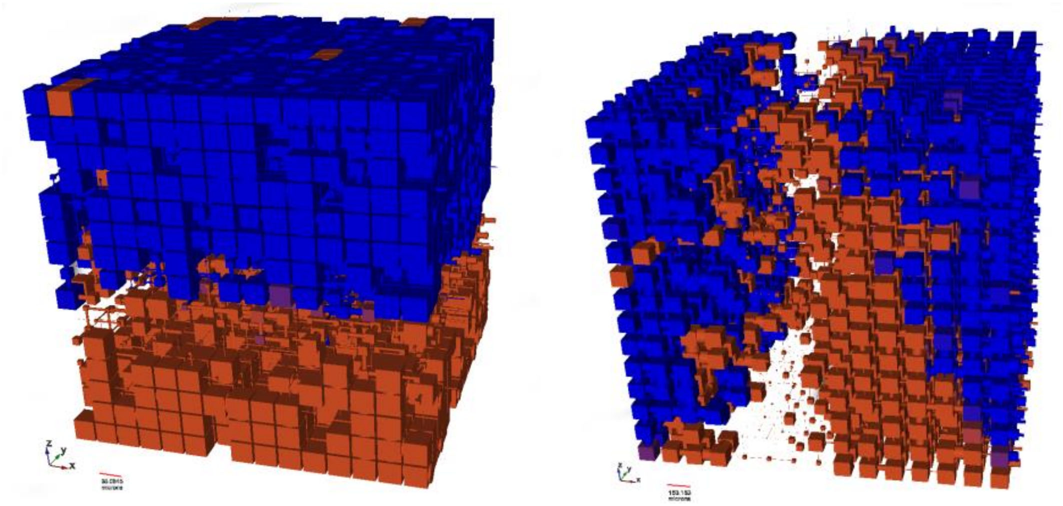


Figure 4. Simulation of 10 ms of wetting with water (shown blue). Left – for sample A, right for sample B.

Conclusion

PoreXpert modelling is able to identify major structural differences in two ceramic samples that showed very different behaviour when they underwent a process of pigment application which used water as the medium for the delivery of the pigment.

The wetting simulation on the modelled void structure shows how the different simulated powders act in a situation similar to that of the application of pigment. This new insight into the structural differences of the void network could not be achieved by mercury intrusion porosimetry alone. Modelling with a larger set of samples could be used to modify the manufacturing process, by analysing production and PoreXpert parameters against quality parameters such as uniformity of pigmentation, by means of Principal Component Analysis.