Application note: 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.

The aim of this application note is to reach a better understanding of the reasons behind such different behaviour. This will be achieved using experimental data from mercury porosimetry and by modelling the porous structure of the samples 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%).

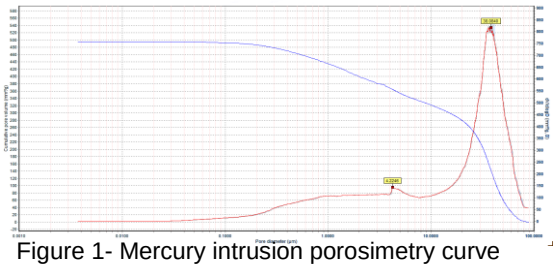

Figure 1- Mercury intrusion porosimetry curve (blue) and its first derivative (red) for sample A.

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.

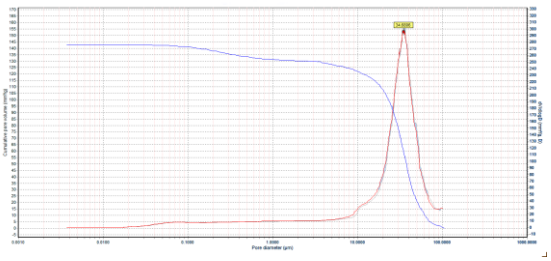

Figure.2 - Mercury intrusion porosimetry curve (blue) and its first derivative (red) for sample B.

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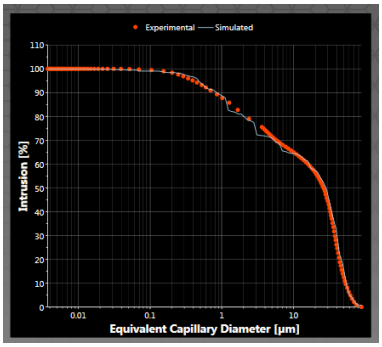
The major difference between the 2 samples is their value of porosity, while the pore size distribution is relatively similar, with the majority of the pore volume in the 10 to 100 µm range.

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.



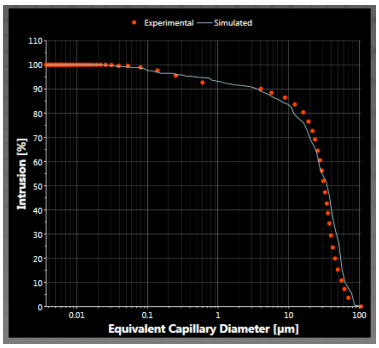


Figure 3A & 3B – Where 3A represents PoreXpert fitting of sample A and 3B represents PoreXpert fitting of sample B.

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.

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. Once again, PoreXpert was able to identify 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 showed a very uniform wetting of the unit cell. Sample B on the other hand, because of the different (vertically banded) structure, showed 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.

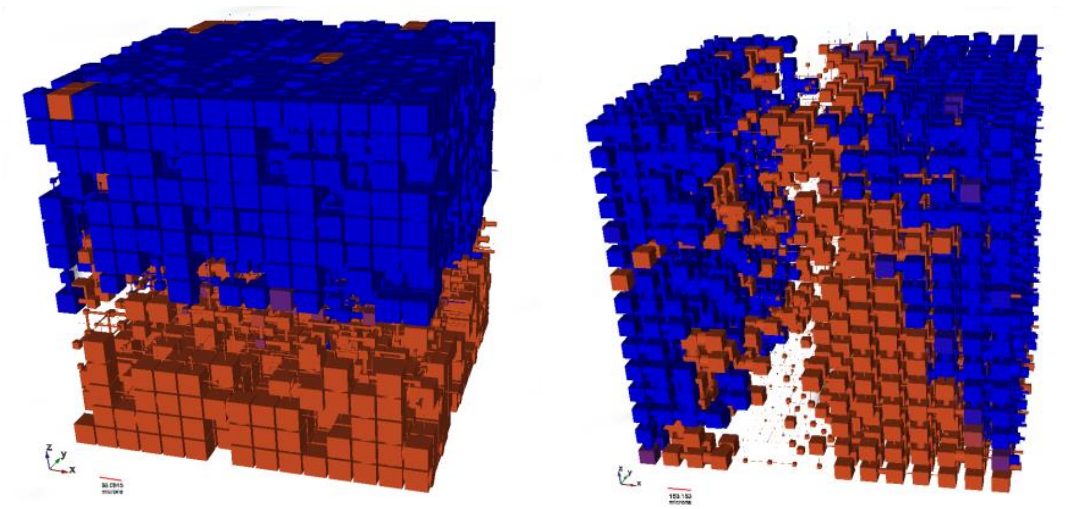


Figure 4A & 4B – Where 4A shows the wetting simulation after 10 ms for sample A. The wetting fluid is shown blue. 4B demonstrates the wetting simulation after 10 ms for sample B.

Conclusion

PoreXpert modelling was able to identify major structural differences in 2 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 was able to show 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, and it could be used to modify the ceramic powders' manufacturing process, so that the appearance of imperfection in the pigment application process could be reduced or entirely removed.

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