Thin layer coating on porous substrate vs. dense, smooth substrate

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In the context of membrane making it is important to coat a thin selective layer on top of a porous substrate. To realize this provides technical challenges compared to coating a thin layer on top of a dense smooth surface; a porous substrate absorbs part of the coating which results in a < 100% thickness retention. This makes it difficult to make a defect free thin coating layer product. Several methods were tested to get the thinnest possible defect-free coating layer on top of a porous substrate. Methods like smooth roller coating, gravure coating reverse & forward, kiss coating & direct mode, slot die coating, pre-wetting were applied.

Important subject in this investigation was to determine at first the critical operation window of the tested coating methods. Main testing was done using a smooth dense substrate (like PET), to see the capability of the used materials and conditions. Once this was established, the same but limiting tests were done using porous substrate.

In Fig. 1 displays the experimental data of PET substrate together with literature model data (Carvalho) plotted in a commonly used critical operation window graph Ca = f(Gap/Wet thickness). It shows that the experimental data do not match with the Carvalho model data[1], which was also found by a study of L. Wengeler[2]. Other models[3,4] have been verified whether they show a better fit.
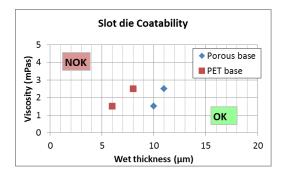

Fig. 1. Critical operation window.

Fig. 2 Coatability window porous substrate.

The match to the Carvalho model will become even worse in case a porous substrate is used. Fig. 2 shows the critical operation window difference between a dense smooth (PET) - and a porous substrate, which is quite large. The solution is very quickly absorbed by the substrate. This fast absorption probably influences the Gap/Wet thickness ratio, in fact the ratio becomes higher. According to Fig. 1 this will decrease the critical operation window.

Last but not least is the impact on defect level when a porous substrate is used. The required coating thickness is < 1 μm, but Fig. 3 shows clearly that a defect-free product could not be made. It seems that other methods should be tested to reach the requirements.
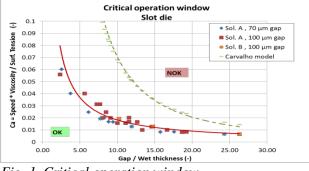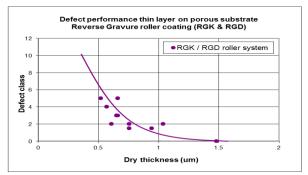

Fig. 3. Defect performance thin layer on porous substrate

Limited investigations have been done on this subject: *coating a defect-free, very thin layer on top of a porous substrate*. Different approaches are required in comparison to a dense smooth substrate. For better understanding what is really happening more investigations and modelling will be required.

References

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