Experience with Automated Development and Spray Application of Coatings

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Abstract

High Throughput Experimentation (HTE) has meanwhile found its way into the coatings industry. More than two years after the first implementation of an automated system for development of coating materials we are able to report about the benefits of this method.
Design of Experiment (DoE) was used for selecting the parameter space for the development of a new recipe for a water-based clear coat. Formulations were produced and applied to test panels by use of an automated HT-system.
The influence of two different additives, two solvents and two binders on the coating properties were investigated. A matrix of over 200 samples was tested within a few days.

Experimental Set-Up

Containers for Sample Preparation

For preparing the formulations and for applying these to test panels the Bosch-syringe was used. In the following sketch (fig. 1) the function of the syringe is shown.

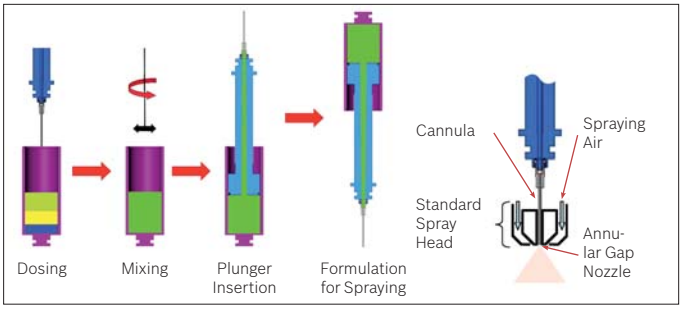

Fig. 1: Formulation of coating material in the Bosch-syringe

Fig. 2: Application of coating using the Bosch-syringe[2]

The HTF-System

The HTF system (see fig. 3) includes the following functionalities[1]:

- Storage of liquid and powder raw materials including sedimenting liquids (fig. 4)
- Gravimetric dosing of liquids from Bosch-syringes and volumetric dosing by use of a line dispenser
- Gravimetric dosing of powders
- Mixing of formulations with an overhead mixer
- Spraying of coating materials on test-panels
- Flash-off and curing of coated panels at elevated temperature

A handling robot is used for transporting syringes with raw materials, powder containers, and cylinders with formulations. Coated and uncoated substrates, are handled independently by a second robot (fig. 5).

Fig. 3: HTF-System with Stäubli handling robot

Fig. 4: Storage of sedimenting raw materials (syringes continuously rotated)

Automated Spray Application

Completed formulations are applied to test panels using a conventional spray head that is modified to allow insertion of the syringe-cannula[2] (see fig. 2). Therefore the flow of spraying and controlling air are identical to a standard spray head.
Constant coating material flow is ensured by forced ejection of material from the syringe. Coated samples are cured in an oven at up to 150°C after flash-off at elevated temperature (see fig. 6).

Fig. 5: Handling robot with test panel

Fig. 6: Curing oven with racks

Results and Discussion

Fig. 7 shows the effect that two different additives have on the DOI 30µm. In the diagram on the right side a negative effect is seen for additive '1' above a certain concentration, while for additive '2' the DOI constantly increases with concentration. The sandardised pareto chart (Fig. 7 left side) shows, that adding both ('AB') to the formulation results in a positive effect, that is larger than one would expect[3].

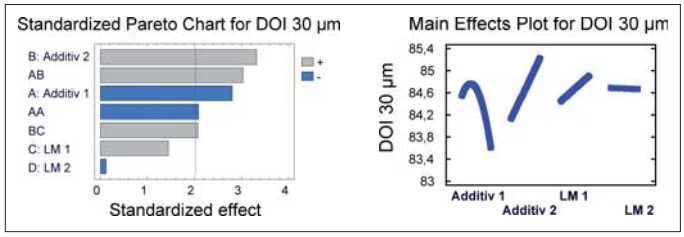

Fig. 7: Non-Linear behaviour of two different additives

Effect of Rheo-Additives

The effect of different rheology modules on the DOI was also investigated. Figure 8 shows DOI values for an established rheo-module in comparison with a new one. The long-wave values reached in practical application are increased by 10 points.
That means by changing the additive the usability (composition area where the formulation shows a stable behaviour) of the formulation is drastically increased

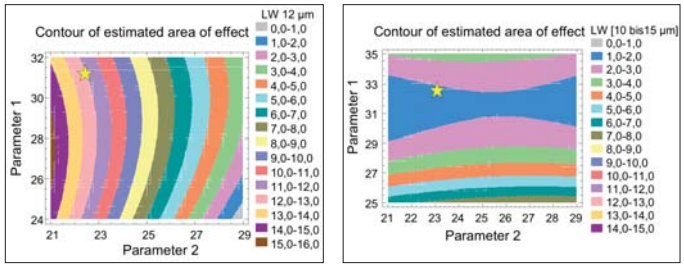

Fig. 8: Effect of rheology modules (left: standard module; right: new module)

Conclusions

The results of our experiments clearly show that systematic optimisation of a coating can be carried out much easier and quicker by utilizing DoE and lab automation. By utilizing high throughput technology it is possible to perform a large number of experiments and thus speed up development of new formulations.
We found that there is a non-linear relationship between the effects of the two additives tested. Using conventional lab work this behaviour would likely not have been detected. Lab automation can therefore reveal yet unknown options for developing new formulations.

References

1) T. Burk, T. Brinz, H. Schmid, Farbe und Lack 10/2005, 44–47
2) J. Ortmeier, S. Ansorge, H. Kost, Farbe und Lack 02/2007, 35–40
3) T. Brinz, T. Burk, R. Emmerich, Farbe und Lack 12/2009, 32–35

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