**Mikael Beving**, Becker Acroma and **Anne Virden**, Malvern Instruments, describe waterborne coating formulation characterisation and how to use droplet size and behaviour information

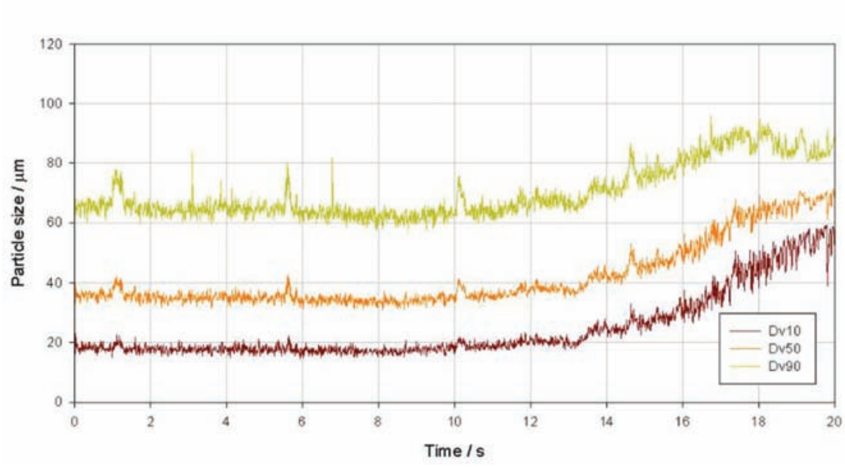
# Smooth coatings for finer furniture

Malvern Instruments' Spraytec measures full particle size distributions at rates as high as 10kHz

The finish on a piece of furniture has enormous importance not only in terms of product durability but also on its consumer appeal. So for manufacturers, selecting the right coating material and the correct application method is a matter both of aesthetics and practicality, with implications for quality, production cost and market price, which must all be balanced. Taking steps to optimise the coating process makes an important contribution, shortening drying time, for example, or significantly reducing the need for costly re-sprays. Careful choice of coatings and achieving real control over the spraying process also works to minimise the environmental impact of these activities.

Matching the coating to the application method is critically important and understanding the behaviour of a coating under different spray conditions informs this process. Particle size is a determining factor. Here the real-time characterisation of a waterborne furniture coating formulation dispersed from an airless spray nozzle is described, together with an examination of how to use the resulting highly detailed information about droplet size and behaviour. Airless spraying is used increasingly for furniture surfaces because of its ability to increase transfer efficiency, production speed and paint output, while reducing overspray and lowering maintenance costs.

Fig 1. Vertical traverse of nozzle 1 across the laser beam




## CRITICAL PARAMETERS

Spray application is used for a variety of surface coatings, from automotive paints through to wood preservatives and polishes. It offers many advantages in terms of the shapes that can be coated and the speed and ease of application. However, these advantages and also the quality of the final product depend greatly on certain parameters that are influenced by the droplet size of the sprayed coating, namely: transfer efficiency (TE), coating uniformity, coating levelling and the risk of environmental exposure. TE is particularly critical, especially for large-scale spraying processes. A high TE enables cost reductions by minimising wastage, reducing pollution (both vapour and solid) and improving operator safety. Since all these factors depend on droplet size, the ability to characterise sprays accurately and precisely is clearly valuable.

The waterborne coatings widely used today not only provide similar finishes to solvent-based coatings but also deliver significant health and environmental benefits. However, particle size must be strictly optimised and maintained to ensure the surface coating quality.

## DROPLET SIZING WITH LASER DIFFRACTION

Laser diffraction is a particle sizing technique that is widely used for measuring sprays. Droplets illuminated in a collimated laser beam scatter light over a range of angles. Larger droplets generate a high scattering intensity at relatively narrow angles to the incident beam, while smaller droplets produce a lower intensity signal but at much wider angles. Laser diffraction systems record the pattern of scattered light and calculate droplet size distribution from these data using an appropriate model of light behaviour.

With laser diffraction, droplet size measurement is fast. Modern systems such as the one used in this work (Spraytec; Malvern Instruments) measure full particle size distributions at rates as high as 10kHz. They can therefore track changes in droplet size in real time, during a spray event. There are also a number of practical features to be considered when characterising sprays, including:

- Having an adjustable distance between the transmitter and receiver so that sprays of different geometries can be accommodated and a large working distance for measuring wide spray fans;
- Air purging to prevent spray deposition on the optical components;
- Compensation for multiple scattering to ensure the accurate measurement of high concentration sprays.

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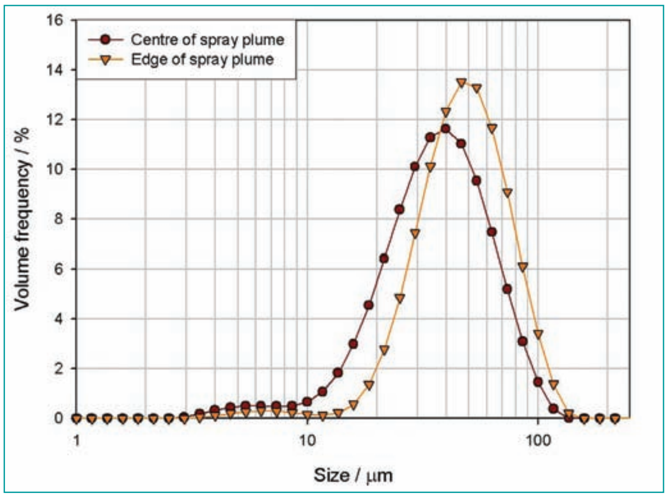


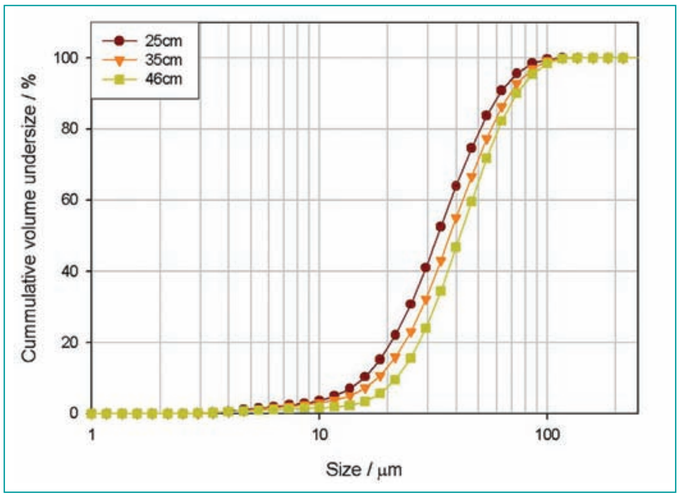




Fig 2. PSD at centre and edge of fan

Fig 3. Far right: Cumulative size as a function of distance

## INVESTIGATING SURFACE COATING SPRAYS

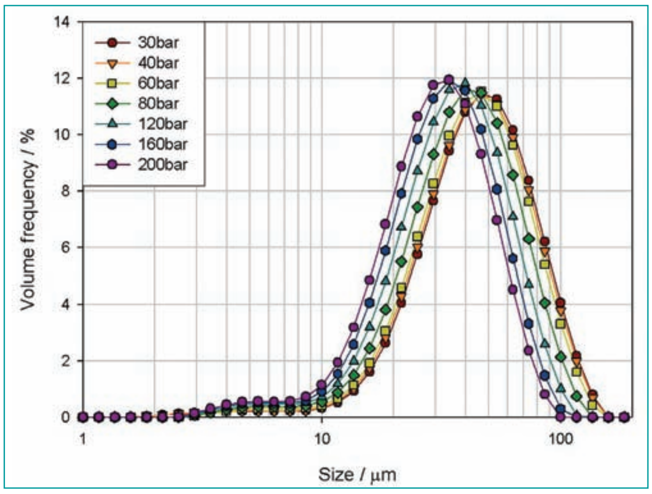
Controlling droplet size during spray coating requires manipulation of those parameters that can be varied easily to achieve a good finish. Typically these include the distance between the spray nozzle and the substrate, and the fluid pressure. To investigate the impact of these parameters, laser diffraction was used to characterise a waterborne coating dispersed from an airless spray nozzle.

Spray coating systems have wide spray geometries for quick and even coverage. Therefore the first measurements were to investigate the consistency of droplet size across the spray fan. Results gathered during a vertical traverse of the spray fan, starting from its centre, are shown in **figure 1**. As the time axis translates into distance from the fan's centre, the measurements indicate that droplet size increases towards the edges.

**Figure 2** shows a comparison of particle size distributions (PSD) measured at the centre and edge of the fan. The median droplet size in the centre is 34µm, while at the edge it is 44µm. The variation in size distribution, particularly in the level of fines, may have a significant impact on the nature of the applied coating film. A common solution is to move the spray nozzle back and forth across the work surface so that each area is coated with droplets of a similar size.

## HOW DOES DROPLET SIZE VARY WHEN THE DISTANCE BETWEEN NOZZLE AND TARGET IS CHANGED?

Fig 4. Particle size distribution as a function of pressure




Increasing the distance between the work item and the spray nozzle provides another means of ensuring a distribution of droplet sizes reaches each part of the coated surface, yielding a uniform coating thickness. Furthermore, sprayed coatings are generally applied with the nozzle positioned at an angle to the substrate, meaning that the droplets travel varying distances before hitting the target. To study the effect of distance, the average droplet size distribution at the centre of the fan was measured at a distance of 25cm, 35cm and 46cm. The results, presented in **figure 3**, show an increase in the median droplet size from 33µm to 41µm as the nozzle is moved further away from the measurement zone. Droplet coalescence within the spray fan is the most likely cause of the observed size increase.

## HOW DOES NOZZLE PRESSURE INFLUENCE DROPLET SIZE?

The droplet size produced by a given nozzle will be a function of the physical properties of the coating or paint, the nozzle geometry and the pressure applied to force the liquid through the nozzle. Adjusting this pressure allows the droplet size distribution to be optimised for a given application. **Figure 4** shows the average PSDs obtained from the centre of the fan for this test system, operated at pressures in the range 30 to 200 bar. These data show that droplet size decreases significantly with increasing pressure. For this particular coating and nozzle, the median size at 30 bar is 42µm, reducing to 28µm at 200 bar.

## CONCLUSION

The quality of sprayed coatings and paints applied to furniture and other products, minimising production costs and stepping up health and environmental benefits, all rely on being able to control the main parameters affecting droplet size distribution. While smaller droplets are generally preferred when it comes to improving levelling, if droplet size is too small there may be insufficient mass transfer of paint and an increased risk of environmental pollution. Conversely, droplets that are too large can cause insufficient levelling.

A laser diffraction technique was used to investigate the variation in droplet size distribution for a waterborne paint dispersed by airless spraying. Real-time changes in droplet size were measured across the entire spray fan, at varying distances between the nozzle and target, and at a range of liquid pressures. The results show that this measurement method generates highly detailed droplet size data that can be used for the fine adjustment of spray parameters such as pressure and distance. By this method, droplet size can be tailored to achieve optimal nozzle and paint performance for any given coating application.