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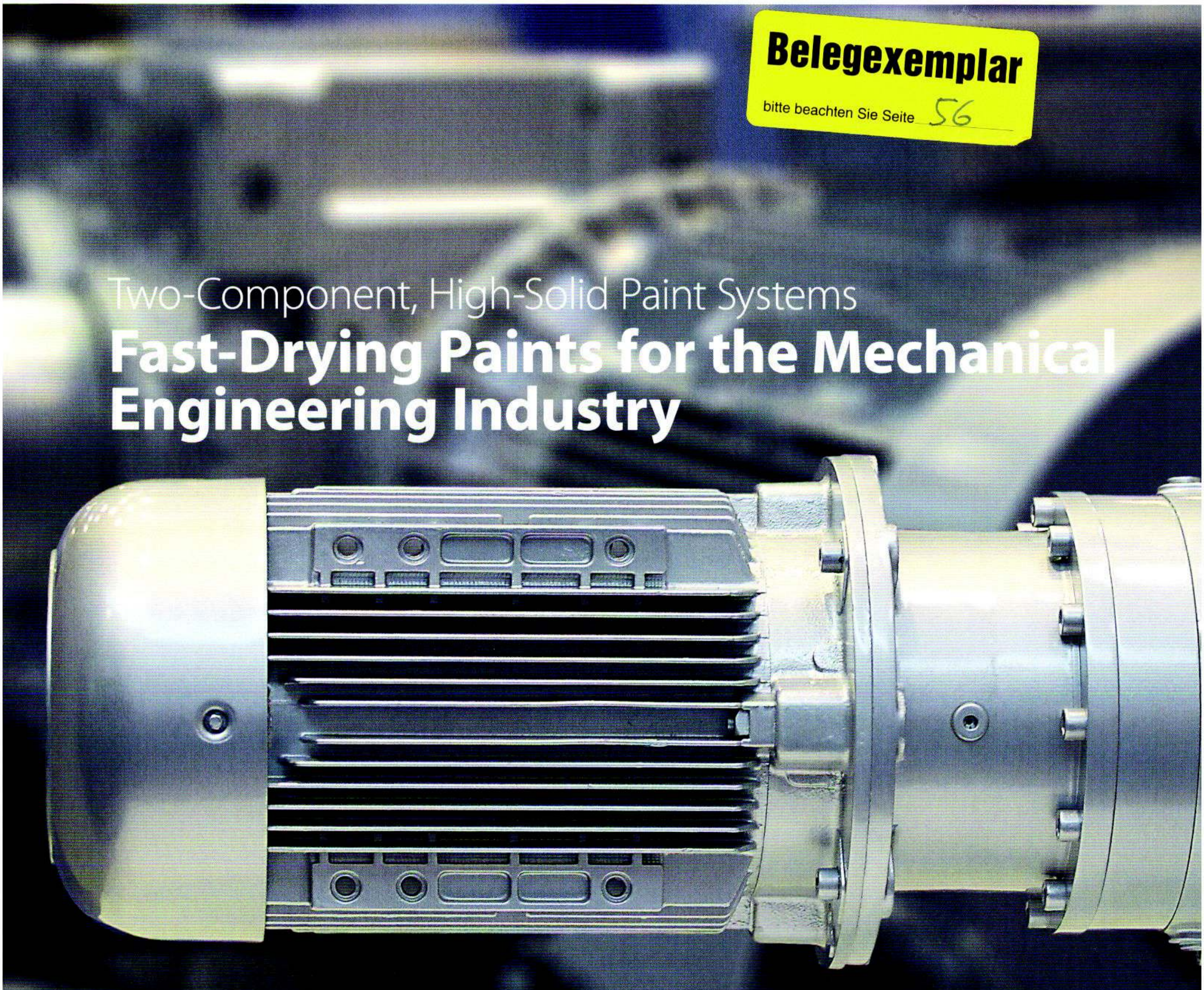
Smart Paint Shops
Improving Flexibility, Quality and Efficiency

Colour change systems
Ultra-Fast Colour Changes in Only 60 Seconds

Condensation Drying
Brilliant Drying Results for Bulk Parts



Two-Component, High-Solid Paint Systems

Fast-Drying Paints for the Mechanical Engineering Industry

Reliable Detection of Faults in the Spray Pattern

As part of efforts to meet high quality standards and accommodate growing volumes of products, manufacturers are increasingly turning their attention to the atomising process. Until now, quality assurance has often simply involved the optical assessment of the spray pattern, but new measurement methods are now helping paint shops to constantly monitor the spraying process and to quantify the results.

Aaron Oberthür

AOM-Systems has collaborated with a well-known supplier to the automotive industry to investigate pneumatic atomisers and high-speed rotary atomisers using the SpraySpy optical spray measurement system. In this article, we describe how even small changes in the operating parameters of the atomisers can be identified by measuring the spray parameters.

Those changes made in the operating parameters simulate typical faults in the production process which can have a wide range of causes, including human error, positioning mistakes, variations in the paint composition and the environmental parameters or wear in the spray nozzles.

The inline, ATEX-compliant SpraySpy model: SS20V125A measurement system used in this case allows the droplet size, speed and number (number of droplets in the measurement volume per unit of time) in the spray to be recorded at the same time.

Measurements with the pneumatic atomiser

The spray of a white base coat from the pneumatic atomiser was measured in the atomising direction at a distance of 10 cm from the nozzle outlet (*Figure 2*).

The atomising air flow, air fan flow and paint flow rate were varied in increments of 5% from a reference point similar to the production parameters, as shown in *Table 1*.

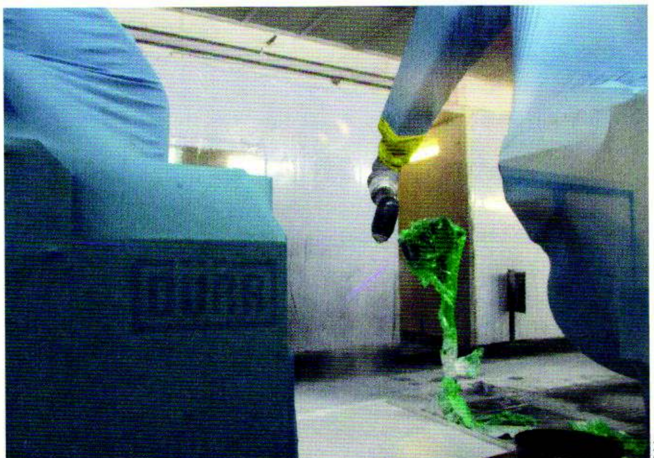


Figure 1 > Tests with a high-speed rotary atomiser using an optical spray measurement system.

Figure 2 > Measurements with a pneumatic atomiser (left).

Operating parameters \ Deviation	-10 %	-5 %	Ref. point	5 %	10 %
Paint flow rate [mL/min]	270	285	300	315	330
Atomising air flow [NL/min]	180	190	200	210	220
Air fan flow [NL/min]	270	285	300	315	330

Table 1 > Operating parameters of pneumatic atomisers.

Operating parameters \ Deviation	-5 %	Ref. point	5 %
Paint flow rate [mL/min]	285	300	315
Shaping air flow 1 [NL/min]	285	300	315
Shaping air flow 2 [NL/min]	285	300	315
Bell rotation speed [krpm]	23	25	27

Table 2 > Operating parameters of high-speed rotary atomisers.

The droplet size and speed varied only slightly when the paint flow rate and atomising air flow were modified. However, the modification in the paint flow rate resulted in a change in the number of droplets that was represented by a parabolic curve with a minimum of 285 mL/min (*Figure 3* left).

In contrast, the increase in the atomising air flow produced an almost linear change in the number of droplets (*Figure 3* right). An increase of 5% resulted in a rise in the number of droplets of around 926 droplets/s. The direct relationship between the number of droplets and the atomising air flow, which was accompanied by only a slight increase in the droplet speed (by around 0.3 m/s) and droplet size (by around 0.5 µm), indicates that the original point in the spray where the measurements were made had shifted. The spray at this point then contained a higher number of droplets and the spray cone had become narrower.

Changes in the air fan flow resulted in significant variations in all three parameters. As expected, the droplet size and droplet speed were in inverse proportion to one another (*Figure 4* left). However, despite a constant volume of paint the number of droplets fell (*Figure 4* right). This behaviour, which at first seemed contradictory, became easier to understand when we took into consideration that the air fan flow has a strong influence on the shape of the spray. As the amount of air fan grew, the spray became increasingly compressed into one plane. At the same time, the spray angle increased in the second plane. As a result, there were fewer droplets at the measuring point.

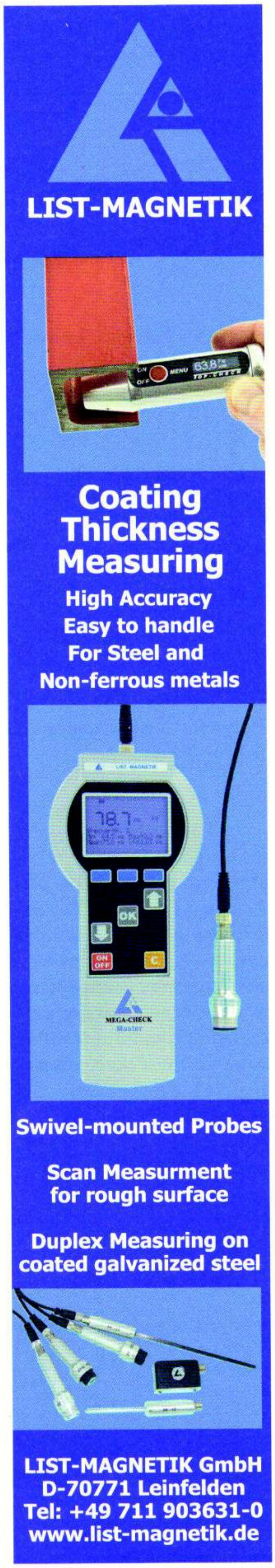
Measurements with the high-speed rotary atomiser

As in the previous test series, with the high-speed rotary atomiser (*Figure 1*) the paint flow rate (white base coat), atomising air flow 1, atomising air flow 2 and rotation speed of the bell were varied in 5% increments (*Table 2*). In this case, the measuring point was moved from the atomiser axis to a distance of 7 cm from the edge of the bell.

As expected, there was an almost linear increase in the number of droplets and their diameter as the paint flow rate was raised (*Figure 5* left). In contrast, the diameter fell and the number of droplets increased as the rotation speed changed (*Figure 5* right). The droplet speed remained almost constant when the paint flow rate rose by 0.1 m/s per 5% increment.

However, as the rotation speed grew, the droplet speed fell slightly by -0.2 m/s per 5% increment. The explanation for this phenomenon is that the droplets reduced in size at the same time and smaller droplets slow down to a greater extent than larger droplets because of their lower inertia.

The increase in shaping air flow 1 resulted in a linear fall in the number of



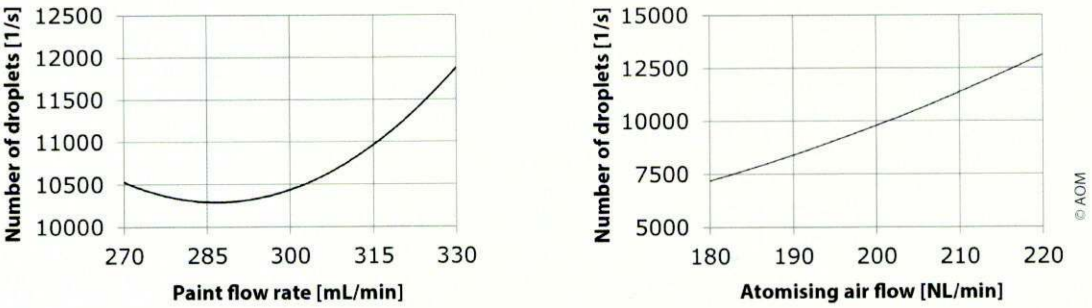


Figure 3 > Pneumatic atomiser: Number of droplets in relation to the paint flow rate (left) and the atomising air flow (right).

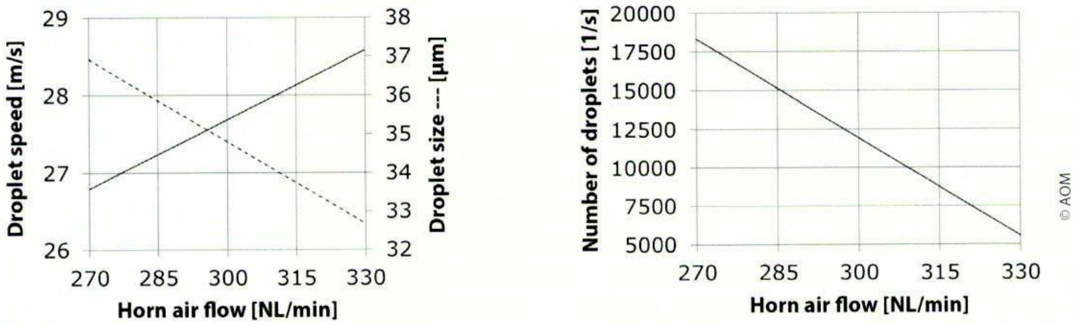


Figure 4 > Pneumatic atomiser: Droplet speed and size (dotted line) in relation to the air fan flow (left) and the number of droplets (right).

droplets, while the size of the droplets increased (*Figure 6*). The dynamic forces involved in creating the droplets (centrifugal force, surface tension of the liquid and aerodynamic forces produced by the two shaping air flows) are in a constantly changing equilibrium with one another, however those forces were not further analysed in this project.

The project "Resource-efficient coating using innovative high-speed rotary atomisers (ESTA)" organised by the automation and process technology committee of the DFO (German Research Association for Surface Treatment) is currently investigating related phenomena.

The droplet speed remained almost constant at between 8.4 m/s and 8.8 m/s during changes to shaping air flow 1, while it showed a slight tendency to rise when shaping air flow 2 was changed. This behaviour is plausible, as shaping air flow 1 is primarily responsible for causing the droplets to separate and disintegrate. Shaping air flow 2 diverts the spray and has only a minor influence on its speed. The added volume of paint did not bring any kinetic energy into the system. On the contrary, because of the additional mass, the motor powering the bell had to provide extra energy in order to keep the speed of the bell constant.

From an overall perspective, minor changes of up to 5% in shaping air flow 2 have only a slight influence on the spray parameters.

Atomiser	Operating parameters	Influence on the droplet dynamics in the spray
Pneumatic atomiser	Paint flow rate	Weak
	Atomising air flow	Moderate
	Air fan flow	Strong
High-speed rotary atomiser	Paint flow rate	Moderate
	Shaping air flow 1	Moderate
	Shaping air flow 2	Weak
	Bell rotation speed	Very strong

Table 3 > Influence of the operating parameters on the droplet dynamics in the spray of a pneumatic atomiser and a high-speed rotary atomiser.

Summary

This short series of tests demonstrated a clear connection for both atomisers between the operating parameters and the measurements of the spray parameters (*Table 3*). In the case of the pneumatic atomiser there was a linear relationship between the atomising air flow and the number of droplets. In addition, there was an obvious correlation between the three spray parameters and the variation

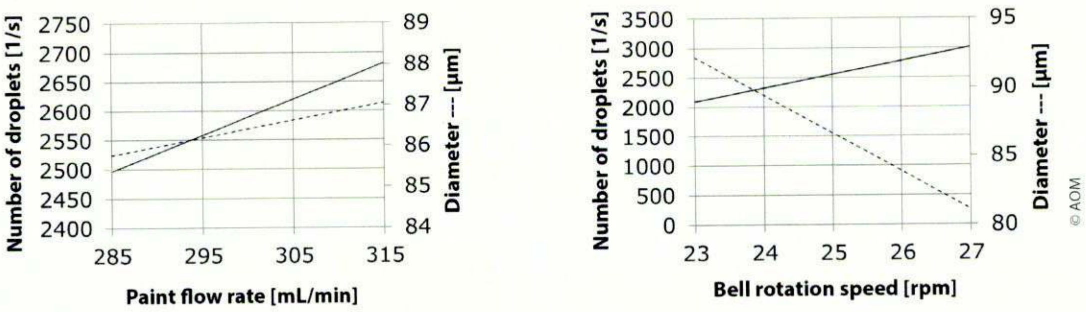


Figure 5 > High-speed rotary atomiser: Number of droplets and size (dotted line) in relation to the paint flow (left) and the bell rotation speed (right).

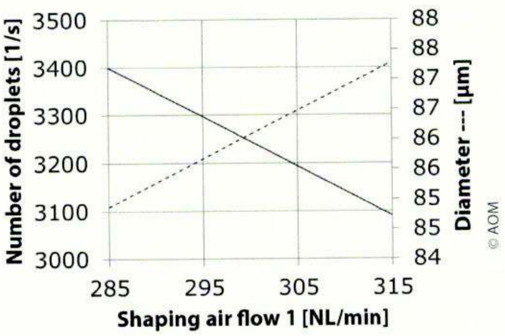


Figure 6 > High-speed rotary atomiser: Number of droplets and size (dotted line) in relation to the shaping air 1.

in the air fan flow. We also demonstrated that the paint flow rate had only a negligible influence on the spray. As expected in the case of the high-speed rotary atomiser, the rotation speed had a strong influence on the droplet parameters. High rotation speeds always reduce the droplet size. In addition, a correlation was identified between the number of droplets, the paint flow rate and shaping air flow 1. The variation in the operating parameters had very little impact on the droplet speed.

The SS20V125A measurement system from AOM-Systems can reliably measure changes in the paint spray caused by variations in the operating parameters of as little as 5%, despite the fact that the manufacturer's figure for the total error rate of the robot is 2.5%, which is not significantly less. The system's high level of sensitivity and ability to record several spray parameters simultaneously allow spray faults to be detected quickly and reliably.

The ATEX-compliant and Electrostatic compatible SpraySpy product range makes it possible for the first time to use a system of this kind for inline quality monitoring and to detect small deviations in the spray. This brings the possibility of a fully automated monitoring and control circuit for paint applications one step closer and represents a significant move towards the development of completely automated and networked smart paint shops. //

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