Efficient Painting Processes via Self-Learning Behavior Models

The future of the painting process is the subject of a current joint research project. The goal: to reduce error rates and downtimes, reduce paint consumption and shorten the start-up time for new paints. The project partners involved were able to successfully implement the continuous networking of process and quality data in a demonstrator.

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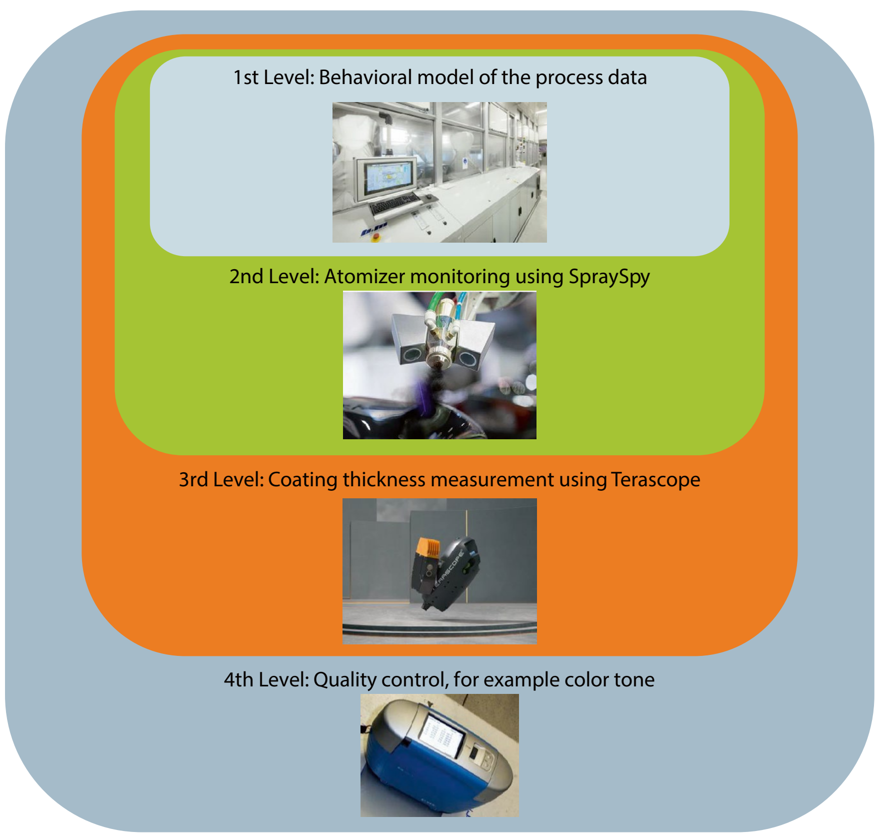
Painting is still considered to be a process sequence that cannot be controlled consistently. Users have to reckon with system failures, rejects and rework because, for example, they cannot maintain the specified paint layer thickness everywhere. In order to make the process more efficient, the Fraunhofer IPA, together with the three companies B+M Surface Systems, Helmut Fischer and AOM-Systems, is researching the optimization of the painting process of plastic parts in automotive and commercial vehicle construction with the help of artificial intelligence (AI). Intelligent algorithms evaluate all the data generated during the painting process and warn of errors at an early stage.

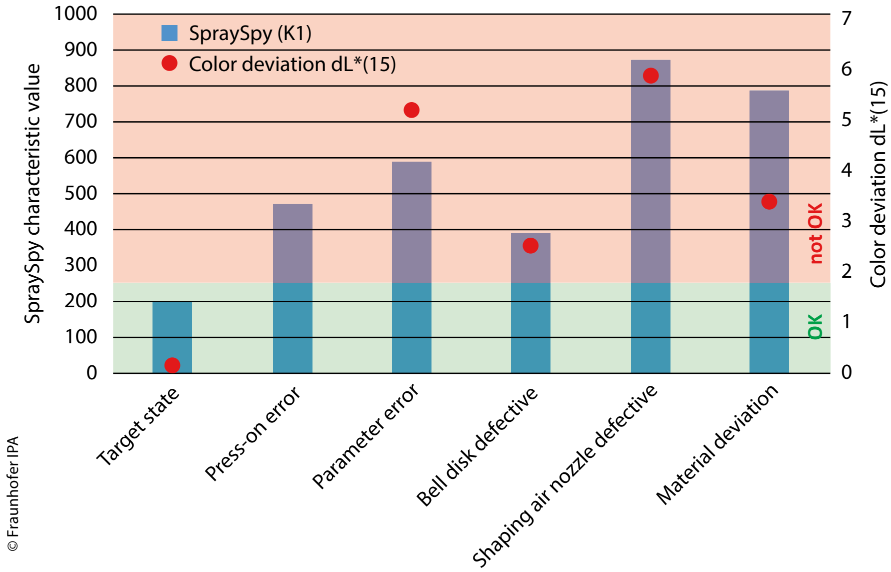
Merge quality and process data

The aim of the research project is to reduce the number of defects by 30 % and downtimes by 20 %. In addition, the optimization should reduce the annual paint consumption and shorten the start-up time for new paints by 10 % in each case. To achieve this, the method combines quality data such as visible coating defects or coating thickness measurements with process data from the system control. The data is then used to create a fine-granular behavior model, which the scientists evaluate using a machine learning method. The algorithms are supposed to detect impending quality deviations at an early stage and also immediately point out their cause.

What is new about the approach is that it also includes the quality of the spray jet in the data evaluation and thus takes into account a factor that is often not yet monitored. Moreover, in addition to the usual process data, the method can also check the quality of the end product by means of terahertz measuring technology



Behavioral model divided into process level and three levels of quality data for painting processes.



Average spray spy characteristic value and color deviation for different defect categories: The different defect patterns are recognizable in the spray and also lead to measurable deviations in the color tone.

as well as color tone measuring equipment. The research project thus forms a bracket over the process data of the plant and the spray jet as well as the quality data of the product.

The project partners are focusing on the painting of bumpers, rear-view mirrors, door handles and other plastic add-on parts in the automotive and commercial vehicle sector. This industry has an enormous product throughput and there is considerable interest in increasing efficiency. In addition, there is a very high level of automation and digitalization in paint shops, which makes the use of AI promising.

Monitoring of the spray jet and the layer thickness

The Spray Spy Process Line PL200 sensor system from AOM-Systems is used to monitor the coating process. This controls the quality of the spray pattern during coating and detects even the smallest deviations from the target value. These can be, for example, changes in the spray jet geometry of the local volume flow or the viscosity of the coating.

With the help of Helmut Fischer's Terascope TDS 5 terahertz measurement technology, the thicknesses of all layers can also be monitored simultaneously and precisely in just one process step. This makes it possible to determine more data in less time and thus increase both machine utilization and inspection frequency.

These two new data sources are essential to predict the coating result and determine the source of error. They allow a reliable behavior model and thus a better prediction quality in the field. This in turn leads to the minimization of errors described above, reduced downtimes and the desired increased resource efficiency.

The demonstrator

A first demonstrator has been set up at the Fraunhofer IPA: This records process data such as the paint pressure in 40-ms cycles. The Spray Spy monitors the spray jet (1st level of quality data) – the scientists can determine the quality of the paint finish in terms of layer thicknesses (2nd level) and color consistency through color measurements (3rd level).

The demonstrator consists of a 6-axis painting robot that applies a metallic base coat by means of a high-rotation atomizer. In the process, those responsible for the project select standard operating parameters from industry and manipulate them in a targeted manner. This allows them to track various defects from their origin to their effect on the painting result or on the resulting quality of the coating. The aim here was to simulate faults that usually occur in production and to obtain characteristic images of the cause in order to train the AI on them. These are:

- Pressing error,
- Parameter deviations,
- Air pockets,
- defective bell discs of the high rotation atomiser and
- Variations in the paint material.

Spray monitoring with the Spray Spy then provides a time series for these scenarios. From these values, the scientists can use statistical methods to generate characteristics to distinguish between the normal (OK) and the defect case (not OK). Based on this data, the AI learns the characteristic error pattern of a defect. In the future, the system is to be further developed so that it not only detects the defect in production, but can also assign it to a defect cause and automatically issue a recommendation for action (for example, clean or replace the bell plate).

By observing the spray with the Spray Spy, users can now detect many of these deviations during the application process and thus identify errors at a very early stage. In this way, they can avoid a high level of rework or costs due to rejects, especially in the case of systematic deviations such as defects in the equipment or batch deviations in the coating material. The next step in this project is to transfer the knowledge gained so far to a series painting line on a trial basis. //

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