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Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS



THERMAL SPRAYING WITH SUSPENSIONS

Hardware components for industrial use

Overview

The use of suspensions as spray additives allows the production of particularly high-quality, finely-structured thermally sprayed coatings. Instead of coating powders with particle sizes of 5 to 50 μm , spraying with suspensions involves the use of sub-micron-sized and nano-sized powders.

Besides the low surface roughnesses, the production of coatings with thicknesses in the range of 10 to 50 μm is one of the most important specific advantages. In terms of hardware, spraying with suspensions requires a suspension feeder and a suitable suspension injector.

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Suspensions can be used as spray additives both in atmospheric plasma spraying (APS) and in high velocity oxygen-fuel spraying (HVOF). For industrial use, high process stability and reliability are crucial criteria. They are largely determined by the properties of the suspensions.





Three pressurized vessels suspension feeder

Fraunhofer IWS has developed an industrial-suitable suspension feeder with three pressurized vessels for coatings in continuous operation, as well as for the generation of multi-layer coatings or composite coatings (Fig. 2). The use of pressurized vessels allows precise, constant, durable and pulse-free feeding.

The vessel sizes can be adapted upon customer request. Two vessels contain the desired suspensions; the third contains a cleaning liquid. In the process, the integrated stirrers ensure stable storage of the suspensions and prevent sedimentation in the vessels.

Functionality

The feeder system offers advantages particularly for continuous coatings production without process interruption. While the suspension is being fed from a vessel in the spray process, the second vessel can be filled. Additionally, two different suspensions can be used for coating deposition.

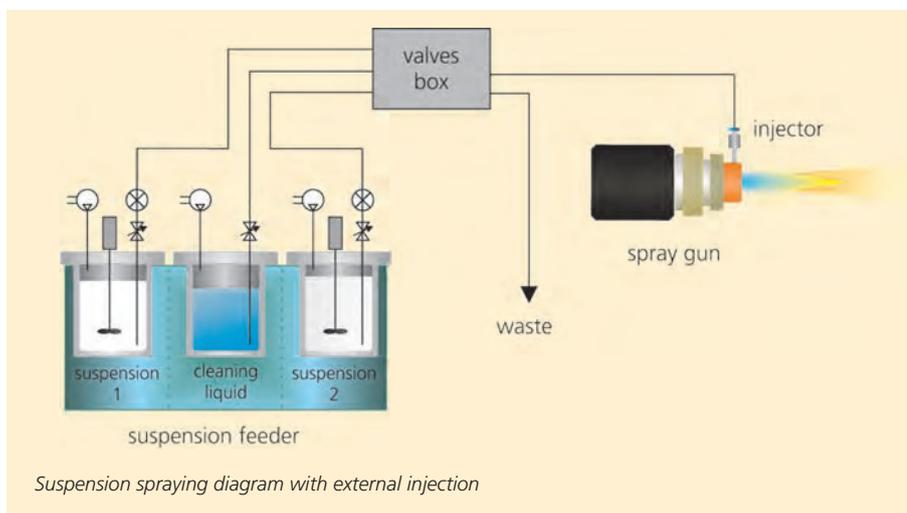
Thanks to pressurized feeding and the implemented control, a wide variety of suspensions can be exactly dosed and precisely fed. In addition, the innovative modular cleaning cycles prevent the formation of sediment. Thus, operating times are increased and lifetime is extended.

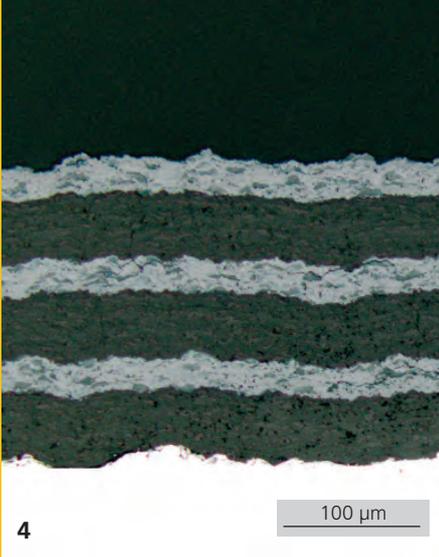
The separate valves box, in which the shift valves are controlled, forms the link between the suspension feeder and the injector. The valve box is directly attached to the burner in order to reduce the response time to the media (Fig. 3). This leads to an increased coating efficiency. The system technology is suitable for a wide range of suspensions and can thus be easily integrated into any spraying process.

Simple operation

The feeder is intuitively operated by means of a 10.4" touchscreen. With the in-built SIEMENS SPS, the feeder possesses a compact, robust and multi-functional control. Via the different levels of operation, it is possible to adapt the feeder to new requirements, to precisely supervise and to document each process step. The modularly-structured programs can be composed according to requirements. The process data are presented functionally and in diagrams.

The main menu shows only the parameters required for the chosen program. Parameter entries are thus simplified and process reliability is increased. The individual process data and process steps are presented in a compact and clear manner.





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100 µm



5

The title blocks show the pressure and flow curve diagrams, which can be tailored to customer requirements. The operational principle of the feeding system allows the precise monitoring of the individual process steps. In addition to the process data, the operational principle indicates the route taken by the fluids in the process by means of colored indicators. Additionally, the valves can be manually operated via touchscreen. This allows a full process control.

Adapted injectors

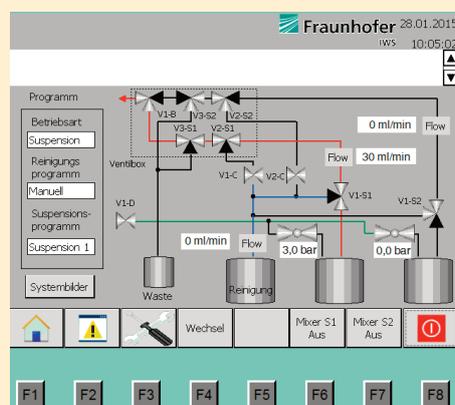
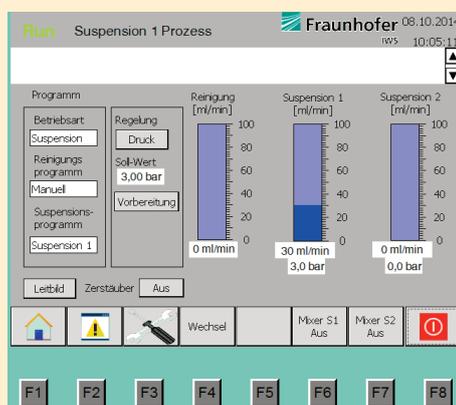
In addition to the suspension feeder, injectors for APS and HVOF spraying were developed at Fraunhofer IWS Dresden (Fig. 5). The injectors have inner diameters of 0.2 and 0.3 mm and inject the suspension as a compact fine stream.

The feeding rates are between 20 to 100 ml·min⁻¹. In APS spraying, the suspension is externally injected into the plasma. In HVOF process, the suspension is directly injected into the combustion chamber. Optimized gun parts are available for this process in order to adjust a conventional HVOF spray gun for suspension spraying.

Spraying with suspensions was adapted to the plasma spraying systems F6 and Delta available at Fraunhofer IWS, as well as to a TopGun HVOF system and was extensively tested with Al₂O₃, Cr₂O₃, TiO₂ and YSZ suspensions. In combination with the suspension feeder, complete conversion kits can now be offered for suspension spraying. This allows for the integration of this technology into existing spray systems.

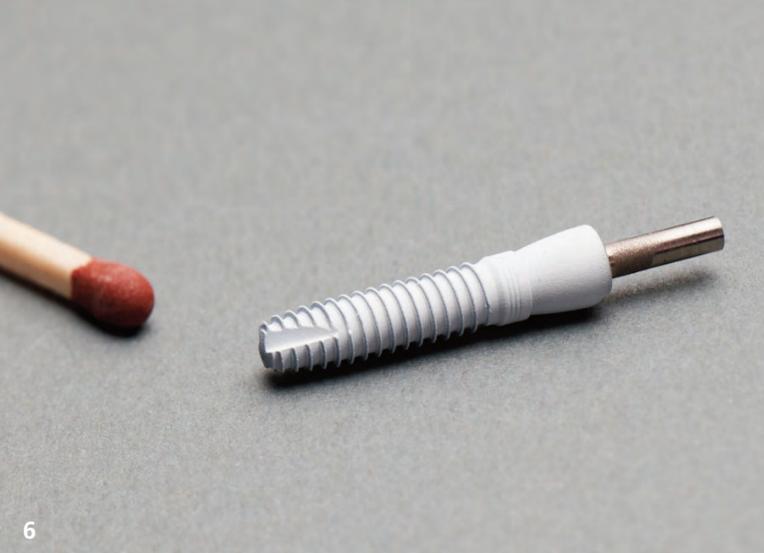
Most important features

- adaptation to existing spray systems thanks to integrative structure
- touchscreen control with modular programs
- pressure flow and throughflow control
- dataLog function
- PID controller optimization for adapting the parameters to new hardware and suspensions
- long-term operation without interruption of the coating process
- production of multi-layer and composite coatings
- level monitoring and emergency stop



Intuitive operation of the suspension feeder via main menu (left) and full control via operational principle (right)

- 1 Aqueous suspensions suitable for thermal spraying
- 2 Three pressurized vessels suspension feeder
- 3 Valves box with HVOF gun
- 4 Polished cross-section microstructure: multi-layer coating made of Al₂O₃ (dark grey) and TiO₂ (light grey) based on aqueous suspensions
- 5 Suspension injectors for HVOF and APS



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Technical data of the suspension feeder

| Dimensions (W x H x D) | |
|------------------------------|--|
| Feeder without control panel | 850 mm x 790 mm x 530 mm |
| Feeder with control panel | 850 mm x 1640 mm x 530 mm |
| Valves box | 105 mm x 166 mm x 280 mm |
| System | |
| Three vessels | vessel 1: cleaning liquid (water) vessels 2 and 3: suspensions |
| Capacity | cleaning liquid 3.1 l (standard) suspension 6.2 l (2 x 3.1 l) |
| Feeding rates | up to approx. 2 l·min ⁻¹ (depending on the injector) |
| Integrated functions | |
| Control programs | manual, pressure control, throughflow control |
| Suspension programs | individual suspension alternating suspension (continuous operations / multi-layer coating) mix suspensions |
| Cleaning programs | small cleaning cycles for individual feeding way complete cleaning cycles for all feeding ways |
| Operation | touchscreen and mechanical |
| Atomising gas | air or inert gas (e.g. Ar) possible |
| Spraying process | HVOF and APS |
| Configuration | directly via touchscreen |
| Other functions | determination of new control parameters datalog system |
| Safety | emergency STOP |
| Level monitoring | manual operation of the valves |
| Supply | |
| Electrical connection | standard safety plug / direct |
| Supply | 230 VAC (50 Hz) 10 A (max.) air pressure (max. 6 bar) |

Our services

Fraunhofer IWS offers comprehensive services for spraying with suspensions:

- development of hardware components and conversion kits for spraying with suspensions
- testing suspensions on behalf of customers as well as the development of suitable suspensions
- development and characterization of tailored coating solutions, from the material to the coated component
- user support in technology implementation and system integration.

6 Coated tooth implant with thin (20 µm) ZrO₂ suspension coating

7 Coated copper plate with suspension-sprayed HVOF Al₂O₃ insulating coating and HVOF-Cu coating for electronic applications

Picture credits:

Title image, Fig. 3, 6: Jürgen Jeibmann;
Fig. 1, 2, 4, 5, 7: Fraunhofer IWS