Microtomographic analysis at the tip of a used AS781 cored wire using the PETRA-III beamline P07 (HEMS)

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In today's manufacturing industry surface coating techniques play a key role since the main body of a part can be made of materials with low costs plus good machinability, while its machined functional surfaces can be coated with materials exhibiting mechanical properties which are different from the bulk material. The aim of such a manufacturing route is that the coating provides a barrier layer to protect the surface from deterioration which is due to mechanical, corrosive or other kinds of loadings.
Thermal spraying techniques are widely used to deposit coatings because of their outstanding characteristics: In particular, they offer the possibility to design composites which exhibit tailored mechanical, chemical and thermal properties by combining several materials. A field of application for these techniques is for example the coating of functional surfaces of large forming tools for deep drawing in order to improve their wear resistance. Among all thermal spraying techniques the twin wire arc spraying (TWAS) is favoured due to the lowest equipment and running costs and the highest deposition rate and mobility. A further advantage of the TWAS technique lies in the large attainable layer thickness range from few microns up to several millimeters.
In the TWAS technique the spraying material is in the form of two conductive wires between which a DC electric arc is ignited. Due to the heat generation in the arc the wire tips are melted. Compressed air or other gases atomize the molten spray material into fine droplets and propel them towards the prepared surface. During the impingement of these in-flight particles upon the substrate surface, they flatten and deform. Finally, these particles solidify and adhere [1].

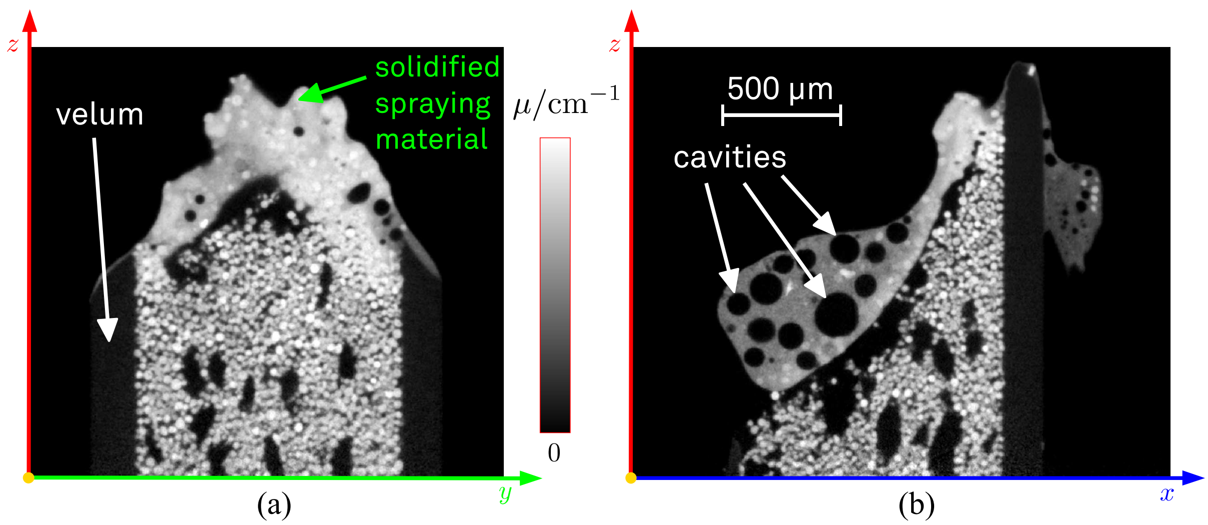

Figure 1: Longitudinal sections through the 3D tomogram showing the solidified spraying material at the wire tip: (a) yz slice and (b) xz slice

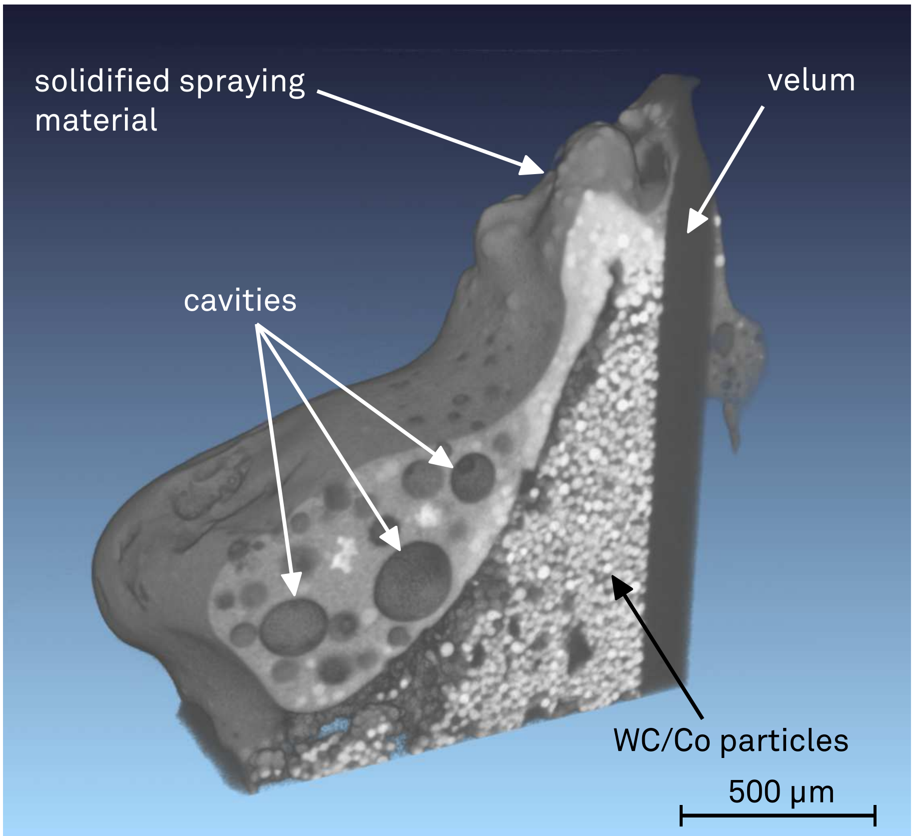

Figure 2: Virtually cut 3D tomogram of the cored wire tip which permits insight into the wire and the melted and re-solidified spraying material

Although TWAS is widely used, many of its underlying processes are not yet fundamentally understood. Therefore, in order to study the melting behaviour the tip of a cored wire after usage was investigated by µCT:
The cored wire AS781 (1.6 mm in diameter) consists of a Ni velum which is filled with spherical WC/Co particles exhibiting diameters in the range 25 - 45 µm. The experiments were carried out at the PETRA-III beamline P07 (HEMS) using monochromatic photons of the energy $E = 120$ keV which were selected with a double-crystal monochromator.
In Fig. 1 longitudinal sections through the generated 3D tomogram of the tip of a used cored wire are depicted. The velum and the spherical particles can clearly be recognized in the lower areas of these sections. As these particles are arbitrarily sectioned the circular intersection areas can be seen between the velum walls. Both subfigures 1 suggest that the spraying material was in the molten state during the spraying process since a large contiguous region at the most outer end of the cored wire (upper area of these sections) are visible which look like a cap of the cored wire. This spraying material mass which has solidified after stopping the thermal spraying process is interspersed with spherical discontinuities, namely smaller high-attenuating WC/Co particles (bright spots in Fig. 1(a)) and larger low-attenuating spherical cavities (dark circular areas in Fig. 1(b).
The arrangement of these cavities as well as of the high-attenuating irregular- and globular-shaped flaws in the re-solidified spraying material can be seen in the virtually cut 3D tomogram (cf. Fig. 2).

References

[1] W. Tillmann, J. Nellesen and M. Abdulgader, J. Therm. Spray Technol. 21, 514–521 (2012).