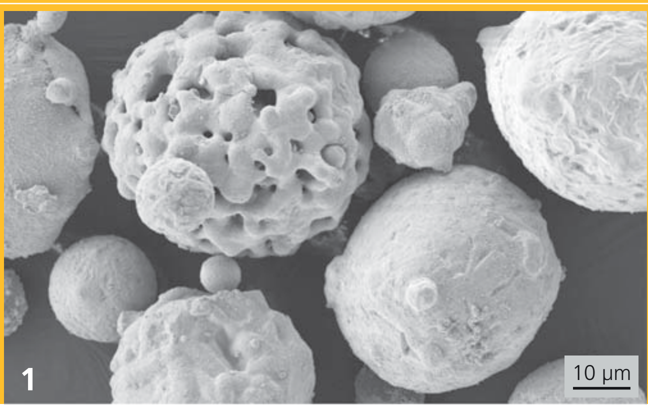

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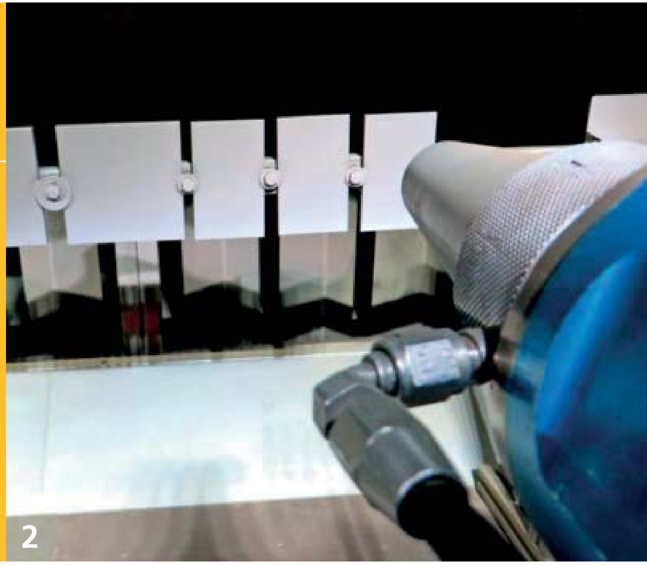
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EFFICIENT HARD MEDAL DEPOSITION FOR HIGH TEMPERATURE APPLICATIONS

THE TASK

Protection against wear is one of the most important applications of thermal spray hard metal coatings. Hard metal coatings based on WC and Cr_3C_2 with various binders (Co, Ni or NiCr) are state-of-the-art. Such coatings are predominantly deposited using high velocity oxygen fuel spray processes (HVOF). An issue in industrial use is the low deposition efficiency of only 35 to 40 percent for HVOF systems using liquid fuel. HVOF guns of the third generation use gaseous fuel and can reach a deposition efficiency of about 60 percent, however at reduced powder feeding rates. One of the reasons for the low deposition efficiency is the non-uniform heating of the powder particles in the flame jet. Moreover, high deposition efficiencies do not automatically lead to high quality coatings.

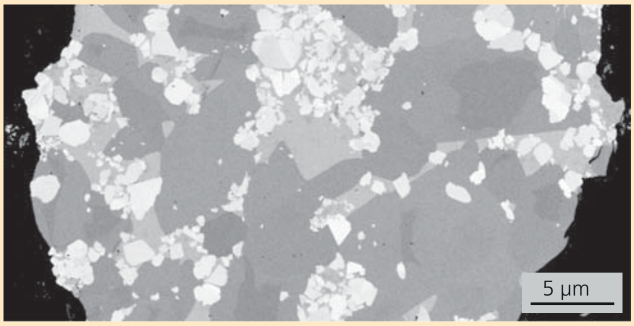
The development of new applications typically faces technical as well as economic challenges. An example is the need to improve the coating quality at high temperatures while, at the same time, to reduce the coating costs, for instance by increasing the coating efficiency. Furthermore, the correlation between powder properties, spraying process parameters and the resulting tribological properties of the coatings is only partially known.

To address these questions we systematically studied the effects of various feedstock powders on the properties of the resulting coatings and on the deposition efficiency during high velocity oxygen fuel thermal spraying. The studied feedstock powder materials were Cr_3C_2-NiCr and Cr_3C_2-WC-Ni. In addition to the economic parameters the study focused on the wear performance of the coatings at temperatures up to 800 °C.

OUR SOLUTION

After spray drying of the Cr_3C_2-NiCr powders (C1 to C5), they were consolidated by sintering or plasma densification. Due to different manufacturing processes, the powders vary in terms of morphology, porosity and carbide corn size. The Cr_3C_2-WC-Ni powders (W1 and W2) contain Cr_3C_2 carbides but also very fine WC carbides. The binder phase consists mostly of nickel (Fig. 3).

SEM image of Cr_3C_2-WC-Ni (W1) powder particle: WC (white), Cr_3C_2 (dark gray) and binder (light gray)



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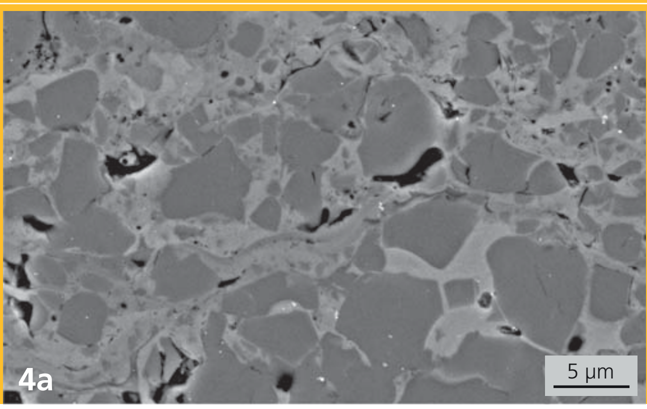
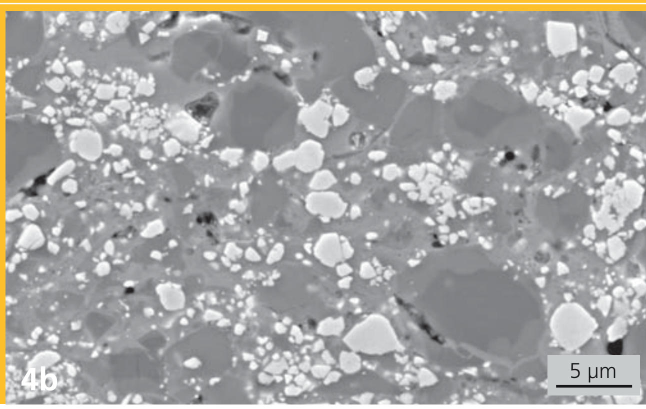
The coatings were produced using two different HVOF processes with liquid (K2) and gaseous fuel (DJ2700), as well as with an HVAF process (M3). Compared to HVOF, the use of the HVAF process is relatively rare, but it has a high potential in terms of the technical performance of the coatings as well as economic considerations. The coating were produced with parameter sets that provide dense coatings and high deposition efficiencies.





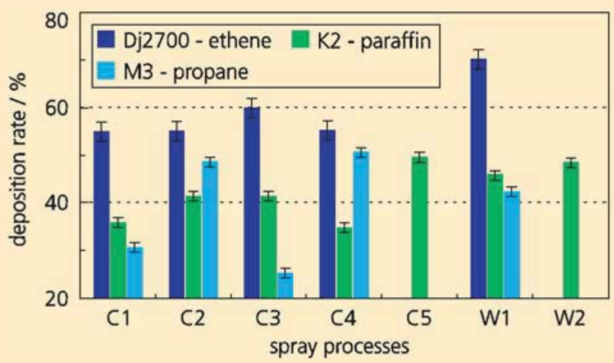
RESULTS

Those sprayed coatings which were deposited using liquid fuels (HVOF K2 and HVAF M3) were much denser than those deposited with gaseous fuel (HVOF DJ2700). The carbides remain mostly intact in the coatings (Fig. 4a and 4b), maintaining the same morphology as in the powder. In Cr_3C_2-NiCr coatings we found Cr_3C_2 and the binder phase. The finer WC carbide grains from the W1 powder are also visible after spraying (Fig. 4b).

Most of the coatings showed hardness values above 1000 HV0.3. This either meets or exceeds the performance of typically used coatings. The Young's moduli ranged from 150 – 200 GPa, which is an excellent result for Cr_3C_2-NiCr coatings. The use of finer carbide grains and WC additives has a positive effect on the coatings.

The liquid fuel HVOF and HVAF processes achieved high deposition rates of up to 4 kg h^{-1}, which implies substantial time savings for coating production. On the other hand, the gaseous fuel HVOF process implies higher deposition efficiencies (Fig. 5). The WC alloyed powder process achieved a deposition efficiency of 70 percent. For liquid fuel HVOF processes the deposition efficiency could be improved to almost 50 percent when using experimental powders Cr_3C_2-(WC)-Ni (C5 and W2).

Deposition efficiency for used coating powder and spray processes



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Abrasive wear test results showed that the wear resistance highly depends on the material. The addition of WC leads to an improved wear resistance for all temperatures. The improvement was about 100 percent compared to pure Cr_3C_2-NiCr coatings. This is especially remarkable for applications at high temperatures and loads since hard metals, which are purely based on WC, typically fail under these conditions. Another important result is the increase of the wear resistance at room temperature after the coatings had been heat treated for 8 h at 800 °C in argon atmosphere. This simple post treatment can significantly broaden the application spectrum of Cr_3C_2-NiCr coatings.

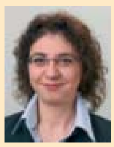
The results presented here were part of a binational Cornet research program. In Germany the IGF project 91EBR was performed in cooperation with Fraunhofer IKTS and it was funded by the Research Association for Welding and Related Processes of the DVS. In Austria the Austrian Society for the Promotion of Research mbH supported the project 839126 at the AC2T GmbH.

1 Cr_3C_2-NiCr powder

2 Equipment to spray hard metal powders

4 SEM image of a Cr_3C_2-NiCr (a) and a WC-Ni coating (b)

CONTACT



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