BUSINESS UNIT
PVD VACUUM
COATING TECHNOLOGY

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PVD COATINGS TO OPTIMIZE FRICTIONAL POWER TRANSMISSION

THE TASK

Frictionally engaged component connections such as clamp, flange or screw connections are present in nearly all technical applications including mobile powertrains, steel constructions and wind energy systems. Such connections can transmit more power and higher torques if the static friction between the connecting surfaces is increased or if more connection elements (e.g. screws) are installed. Alternatively, higher static friction would be beneficial to maintain power transmission with reduced dimensions of connection elements and thus improved volume efficiencies.

There were approaches to increase static friction in the past. One solution was to attach hard particles to foils and place these between the engaging surfaces. Another solution is based on thermal spray coatings with a metal matrix and embedded ceramic particles, which were deposited on one of the engaging surfaces. In both cases the thickness (in the range of 1/10 of a millimeter) of either the foil or the thermal spray coating has to be considered during the design phase of the component. Thin film hard coatings for tools and components are deposited using PVD processes. These coatings are known for their wear resistance and tendency to not adhere to the counterpart. There are no known solutions to purposely increase the friction of these coatings. However, if this were possible it would offer a space saving solution to reliably increase static friction in diverse environments.

OUR SOLUTION

Arc-PVD process is an industrial standard process to coat tools. A specialty of this process is the emission of microscopic droplets in addition to the coating plasma. These droplets are incorporated into the coating.

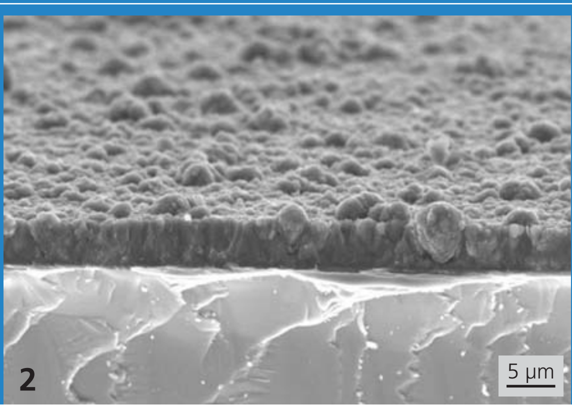
By means of a suitable coating design, IWS engineers were able to use of the droplet-induced roughness to create surfaces with very high static friction. Combined with the high wear resistance and good adhesion to the substrate this system offers an excellent solution to create reliable and long-term stable static friction performance for a given friction couple.

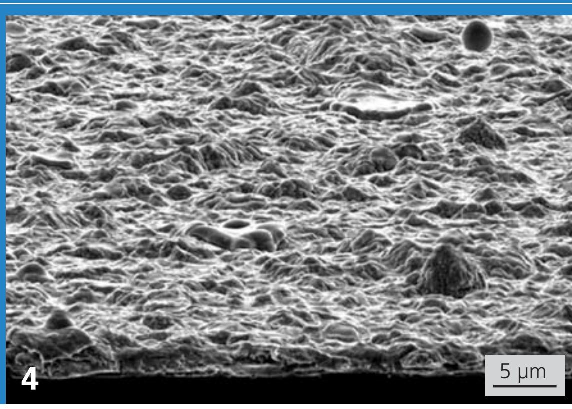
RESULTS

Initial experiments indicate two possible coating systems, which could be suitable to increase the friction coefficient:

- hard amorphous carbon coatings (ta-C)
- Nimonic90- AlTiN

Arc deposition of such coating systems results in pronounced micro roughness. In case of the carbon coating this is the result of hard carbon particles, which form during the evaporation of graphite and incorporate structurally into the coating surface (Fig. 2). The Nimonic90- AlTiN system is built from a Nimonic layer with marked roughness (Fig. 4), which is then coated with a thin AlTiN film to stabilize the surface structure.

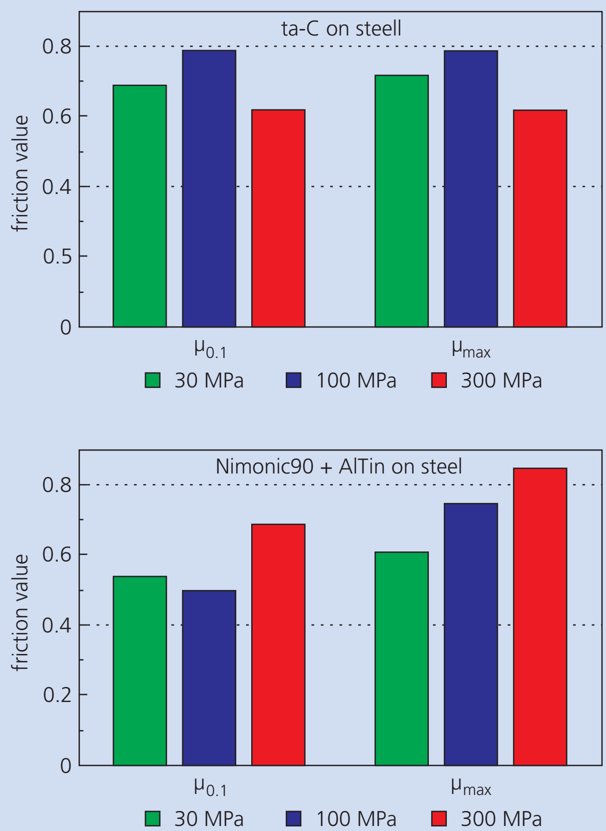




The friction behavior was evaluated in a torsion test stand. The friction couple is pressed together at various pressures and then twisted. The torsional moment is measured as a function of the twist angle. Various friction parameters are derived from the data such as $\mu_{0.1}$ (coefficient of friction at 0.1° torsion) μ_{max} (maximum coefficient of friction).

The torsion tests require special test specimen. One side of each friction couple was coated. The film thickness was for both coatings between 3 and 5 microns. The counter surface remained uncoated.

Friction coefficients $\mu_{0.1}$ and μ_{max} of coated friction couples at pressures of 30 MPa, 100 MPa and 300 MPa.



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The measured friction coefficients are shown in Fig. 3. Both coatings achieve values between 0.5 and 0.8 (depending on experimental conditions). These data represent a substantial increase compared to mechanically processed steel surfaces (friction coefficient of about 0.2).

Additional experiments were performed to study the influence of different environments such as lubricating of the friction surfaces. The results showed only a slight reduction of the friction coefficients of about 10 - 20 %.

Coated surfaces therefore offer a high potential to reduce material and space when optimizing frictionally engaged joints. PVD coatings are especially suitable. The low thickness of the coatings makes it possible to integrate them into mechanical systems without problems.

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1 Flange and shrink fit connections

2/4 Fracture image of arc deposited ta-C (2) and metal (3) coatings for friction increase

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