BUSINESS FIELD PVD VACUUM COATING TECHNOLOGY


1

NEW COATING SOLUTIONS FOR MASSIVE FORMING TOOLS

THE TASK

The term “massive forming” designates a group of modern manufacturing processes in metal forming. It is characteristic for such processes that substantial amounts of material are displaced or accumulated during forming, which typically requires substantial mechanical forces. Typical products of massive forming processes are powertrain elements such as toothed shafts, connection rods or screws as well as numerous types of semi-finished products and preforms.

Massive forming tools are exposed to substantial mechanical loads especially in surface near regions. High contact pressures are combined with relative motions, which is challenging for the tool surfaces. Abrasive wear is the limiting factor for tool life. An additional challenge is often the high process temperature.

Such tools are made from highly temperature resistant materials to achieve a long tool life while making quality products. The associated material costs are very high. Surface modifications are sought to further improve the tool longevity by reducing friction and wear under extreme loads. Under ideal circumstances it should also be possible to use less costly bulk tool materials in combination with high performance surface treatments.

A cooperation project was performed to investigate the possibilities to reduce wear and friction in forming processes.

OUR SOLUTION

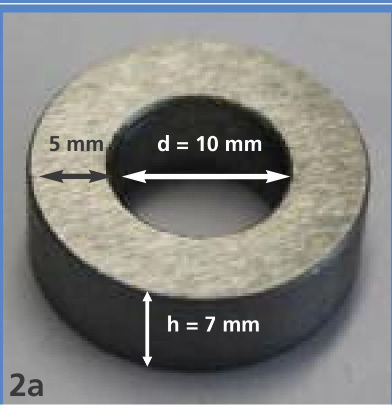
The project work performed at the Fraunhofer IWS Dresden focused on development and testing of suitable high temperature resistant coatings. The following requirements were defined:

- high hardness and abrasion resistance under high contact pressures
- low friction versus steel surfaces in lubricated tribosystem
- avoidance of cold welding
- avoidance of crack formation and provision of excellent coating adhesion to substrate

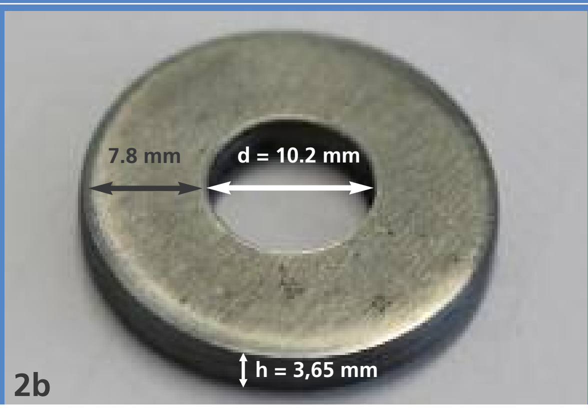
Experiments were performed to identify and characterize suitable coating systems. The applied coating process was an industrial arc technology, which is a standard technology for the coating of tools.

The tribological behavior of the coated surfaces was tested in a tribometer with ball-disk setup. The coated test specimen is placed in contact with a steel ball, which moves back and forth across the sample under lubricated conditions with defined contact pressure. Outputs of this experiment are the coefficient of friction and the wear rate.

Additional ring compression experiments were performed to more closely represent application conditions. A steel ring is mounted between two compression plates and then compressed to half of its original height. This represents conditions which are typical for many forming tools that are shaped in the form of round blanks.



2a



2b

RESULTS

The tribometer tests yielded varying degrees of wear for the different samples. Uncoated steel samples showed substantial wear. On the other hand there was almost no wear detectable on samples coated with AlCrSiN or AlCrTiN. This is in particular impressive since the test was performed with very high contact pressures for the coated samples (> 2000 MPa compared to 1750 MPa for uncoated samples).

Uncoated and coated round steel blanks were used as compression plates for the ring compression tests (Fig. 2). In the case of uncoated blanks the material was the more expensive steel type 1.2379. The coated blanks were made from lower alloyed C45 steel. Fig. 3 shows the development of wear patterns of uncoated and coated round blanks.

Uncoated (top row) compression plates and coated compression plates (bottom row)

uncoated pressure plates (1.2379)		
after 10 sprains	after 30 sprains	after 50 sprains
		
coated pressure plates (AlCrN on C45)		
after 10 sprains	after 30 sprains	after 50 sprains
		

3

Even after 50 compressions there is no wear detectable on coated blanks (bottom right).

These results show the impressive potential of such coatings for forming tools. Wear reduction was demonstrated even on a lower alloyed steel being used as the tool material.

The Fraunhofer IWS is grateful to the Fraunhofer IWU in Chemnitz for performing and analyzing the forming tests.

1 Coated demonstrator tool (extrusion press stamp)

2 Ring for ring compression test, a) prior to compression and b) post compression (photo IWU)

CONTACT

Dr. Otmar Zimmer
phone +49 351 83391-3257
otmar.zimmer@iws.fraunhofer.de