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IMPROVED CAVITATION WEAR RESISTANCES OF TURBINE MATERIALS

THE TASK

Modern high performance materials in power plant machinery are exposed to high temperatures and wear loadings. For example, the leading edges of steam turbine blades, located in the lower temperature stage of the turbine, face direct erosion from the impact of condensing water droplets, which can reach sound velocity. Special steps for wear protection are required to increase the service life of these blades in addition to selecting appropriate base materials. It is also essential to test the wear resistance of the components under real operating conditions to prove the effect of material and process optimizations.

OUR SOLUTION

At the Fraunhofer IWS various wear protection technologies have been developed for high performance materials as they are used in the energy sector. A suitable tool is the high power diode laser with laser powers in the multi kilowatt range.

In principle there are three technological variants:

- martensitic surface hardening of hardenable steels,
- laser solution annealing of the surface region of precipitation hardening steels with subsequent low temperature precipitation hardening in a furnace without affecting the bulk material,
- laser gas alloying (e. g. of titanium materials) by remelting the surface region in a suitable gas environment.

To implement these technologies, several machine designs have been developed which are based on robot-handling of the processing optics and include optional shield gas chambers, which are designed to fit special parts. With the help of additional axis for turning and swiveling the workpiece, it is possible to generate very flexible 3D processing tracks on the workpiece surface. The process has to be stable and safe to produce quality results. This is supported by performing temperature-controlled treatments using the temperature control unit "LompocPro" and the thermal imaging camera "E-FAqS" to capture the temperature fields. Fraunhofer IWS engineers also adapted a test stand to measure the cavitation wear resistance of the processed materials (Fig. 3). The test conditions are standardized. An ultrasonic sonotrode is applied to erode the surface material. The volume removed per time delivers precise results about the wear performance of the materials.

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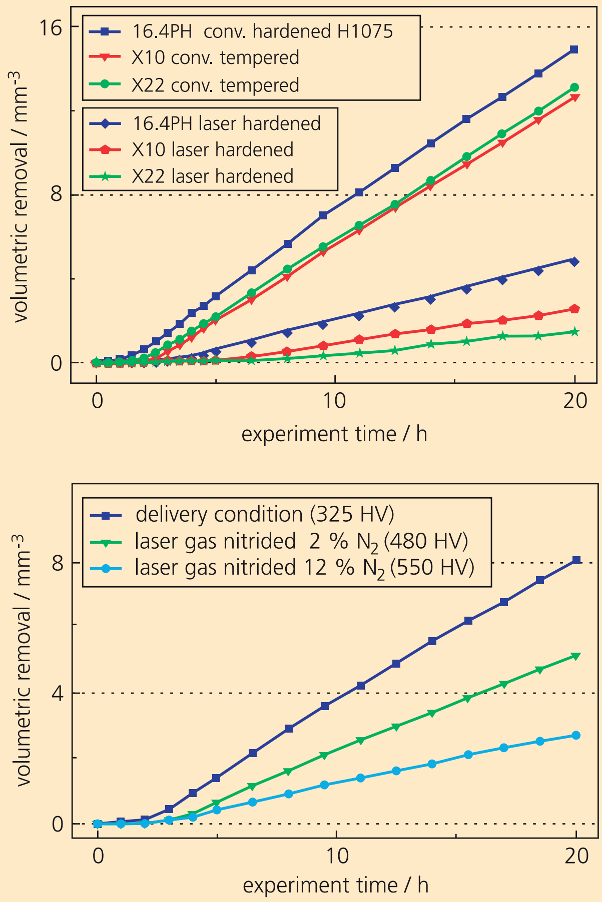
Cavitation wear of various turbine blade steels (upper) and titanium alloys (lower)



specification of the test stand:
Ultrasonic homogenizer VC 501

Test conditions according to ASTM G 32-92:

Test tip diameter:	*Ø 15,9 mm ± 0,05 mm*
Penetration depth:	*12 mm ± 4 mm*
Amplitude:	*100 %*
Frequency:	*20 kHz*
Distilled water	*22 °C + 4 °C*

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RESULTS

Compared to the conventionally treated material surfaces, laser hardened surfaces show clearly increased hardness values. For steels it is usually possible to realize the material specific maximum hardness. For titanium one has to find a good compromise between high hardness combined with high fatigue strength.

By means of laser hardening, the volumetric material removal for high performance steels under cavitation wear conditions was reduced to 1/3rd or even 1/8th. For titanium alloys the data led to identifying correlations between the wear resistance properties, material hardness and the nitrogen concentration in the gas atmosphere during laser gas alloying. The volumetric material removal for the titanium alloy Ti6Al-4V was reduced to about 1/3rd. Thus one can expect a clear increase of the service life of the laser treated component surfaces, even if the cavitation wear test stand is just a model for the real-world wear conditions.

Using the cavitation wear test is relatively inexpensive and a suitable addition to hardness measurements and microstructure analysis of the materials. It supports the evaluation of the wear resistance of materials and surfaces.

1 *Selected turbine blade types for laser processing*

2 *Laser hardening of a turbine blade with scanner optics (type "LASSY")*

3 *cavitation wear test stand*

CONTACT

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