New multilayer effect detected by crater grinding

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It is shown that the abrasive wear resistance of multilayer PVD coatings, combining relatively soft but tough chromium (Cr) and harder but more brittle chromium nitride (CrN), exceeds that of both its phases. This striking exception from simple rules of mixtures – the *multilayer effect in abrasion* – is discussed with reference to physical mechanisms, layer thickness dependence and implications for multilayer design for abrasive applications.

Eight different coatings the Cr/CrN system were evaluated, all of approximately 4.5 μm thickness. The series included Cr and CrN as single layers, and six multilayers all combining 50% Cr and 50% CrN with different individual layer thicknesses ranging from 20 to 525 nm. All coatings were deposited on high speed steel using reactive magnetron sputtering. The coatings were characterised with respect to microhardness and abrasive wear resistance against a slurry of 2.5 μm diamond abrasives. The abraded surfaces were investigated by scanning electron microscopy and optical profilometry to reveal the microscopic wear mechanisms. A physical model for the layer thickness dependence for wear resistance of multilayer coatings was developed. Despite its simple structure, the model agrees very well with the experimental results.

The advantage of the Cr layers is their tendency to deform plastically rather than becoming removed by wear; the drawback is lack of penetration resistance. The penetration resistance, is however, the main advantage of the CrN layers. It is proposed, based on experimental results and theoretical considerations, that the multilayer effect is explained by the reduction of abrasive penetration depth in the Cr layers due to the underlying harder CrN layer.

The presentation is based on:

Berger, M., Wiklund, U., Eriksson, M., Engqvist, H. and Jacobson, S., The Multilayer Effect in Abrasion – Optimising the Combination of Hard and Tough Phases, *Accepted for publication in Surf. Coat. Eng.*, (1999)