OR2606

Optimization of the Scratch Test for Specific Coating Designs

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Thin film coatings increase the life time and reliability of tools and contribute considerably to productivity. Optimization of a coating-tool-design is still a challenge due to the many influencing variables: material matching between coatings and coating and tool, influence of work piece material and cutting condition on wear mechanism, thermal and mechanical stresses during cutting and many others.
A physical description to quantify the interfaces between layer and tool and in multi-layer coatings will allow the faster optimization of the coating-tool design and reduce the costs for cutting tests. Utilizing the measured data from a sophisticated scratch test, spatial stress profiles are simulated considering realistic material properties. The von Mises stress characteristics during loading of the coated substrate for an initial load range is calculated. Based on this, simulations are used to suggest scratch parameters adapted to specific regions in the layer-tool architecture. This procedure allows the investigations of critical interfaces, transition layers and substrate regions with depth resolution. The method can also be applied to study stress profiles created in multi-layers and in thermal cycling.
To illustrate basic features of the optimization method, inserts were coated with test layers of Al(0.33)Ti(0.67)N, Ti(0.5)Al(0.5)N and CrN with and without oxide top-layers of Al(1.34)Cr(0.66)O3. The refined scratch parameters were evaluated. The quantifications for selected coating-tool interfaces and nitride-oxide interfaces are given. It is shown that the optimization method also works for rough coatings without post-treatment and can be used under typical in-service conditions in tool coating business. Turning cutting in tests in steel 1.1191 (C45) were performed and correlations between the failure modes of the coated insert and the test results are established and the optimized coating design is proposed.

Keywords
scratch
simulation
interface
stress
von Mises