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Surface degradation and wear mechanisms of uncoated and PVD-coated cemented carbide dies in steel wire drawing

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Wire drawing is one of the oldest and most used metal forming processes. In a conventional wire drawing process, the cross-section of the wire is reduced to the final dimension by drawing the wire through a series of drawing dies made of cemented carbide or poly crystalline diamond. Despite the use of different types of lubricants wear of the dies, frequently resulting in time-consuming die changes, is a problem which limits the possibility to increase the productivity of the process. Also, the requirements for a high wire surface quality have become very high during the last years, especially for products such as spring steel wires. In the present work, the gradual surface degradation and wear of uncoated and PVD-coated (AlCrN+DLC) cemented carbide drawing dies have been investigated when drawing low alloyed carbon steel wire.
The results show that the initial wear of uncoated cemented carbide dies is due to preferential removal of the Co binder metal in combination with plastic deformation and cracking of individual carbide grains resulting in a topographic surface. The increased surface topography tends to increase the tribological interaction with the mating steel wire surface increasing the tendency for cracking and fragmentation of the carbide phase and the wear rate (steady state wear conditions). PVD coated cemented carbide dies exhibit an increased wear resistance compared to uncoated cemented carbide dies by significantly reducing the wear initiation of the cemented carbide and extending the transition from the initial wear regime (low wear rate) to the steady-state wear regime (high wear rate). The prevailing wear mechanisms are illustrated and characterized using optical surface profilometry, high resolution scanning electron microscopy and energy dispersive X-ray spectroscopy.

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