High temperature wear resistance of CrVN coatings and the effect of V content

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Hot forming, especially hot forging is a very demanding forming application requiring tool material with high strength and toughness and above all good wear resistance at elevated temperatures. Prevailing wear mechanisms in hot forming are abrasive wear and galling, with abrasive wear leading to dimensions mismatch and galling to unstable friction and poor surface quality of the forgings. In order to reduce tool wear and improve forming process different wear resistant coatings are used, often combined with solid lubricants to prevent work material adhesion.

Chromium nitride (CrN) coating is considered as one of the best candidates for wear protection in many different forming application where adhesive wear and galling dominate. However, relatively high coefficient of friction of CrN coatings against soft metals hinders their applicability, still requiring the use of different lubricants in the most demanding applications. Vanadium nitride (VN), on the other hand has attracted increasing interest as VN is easily oxidized to form Magneli phase vanadium oxides with easy slipping shear planes, leading to self lubricating properties. It has been shown that doping CrN with V may result in CrVN coating with improved tribological properties at elevated temperatures. However, there is a lack of knowledge how V content influences on the high-temperature wear resistance of CrVN coatings.

Therefore, the aim of our work was to study the effect of V content on the galling resistance of CrVN coatings at elevated temperatures when used in contact with different work materials. CrN coatings doped with V in concentrations from 15 to 30 % were deposited by industrial DC-magnetron sputtering system and tested using Load-Scanner. Load-Scanner utilizes cross-cylinder contact geometry where normal load is gradually increased during sliding, providing information on the coefficient of friction vs. load and determination of critical loads for galling initiation and transfer layer build up. Furthermore, each point along the wear track corresponds to unique load without being influenced by the loading history. Thus, tribological testing of CrVN coatings with different V content was performed at elevated temperatures (up to 700°C) against typical structural steel and Al alloy for hot forging and results evaluated in terms of coefficient of friction vs. load, critical load for galling initiation and wear track surface analysis. Surface analysis was focused on the formation of self lubricating surface layers and phases.

Keywords: CrVN coating, galling, high-temperature tribology, hot forming, self-lubrication.

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