THE EFFECT OF CHROMIUM CONTENT ON CUTTING PERFORMANCE AND OXIDATION RESISTANCE OF TiAlCrN COATINGS

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ABSTRACT

Improvement of the durability and cutting performance of coatings designed for tools is an ongoing engineering challenge. There are two main paths to achieve such ambitious goal: to enhance oxidation resistance and/or to decrease friction. In this investigation we is focused on laboratory and industrial performance of TiAlN coating with higher oxidation resistance due to various content of chromium. The objective of the work is to increase the cutting speed of drillers.

TiAlCrN coatings with different content of chromium were deposited by unbalanced pulsed magnetron sputtering CemeCon 880 MLT industrial apparatus. TiAlN coatings were deposited as reference. The coatings were deposited on WCCo standard drills and cutting inserts to test their performance either in laboratory by drilling high-speed steel and Inconel as in real production by industrial partner. To measure oxidation resistance, oxidation speed was measured by thermogravimetric analysis (TGA); in this case fecralloy substrates were used. Tribological measurements were performed on CSM tribometer at temperatures up to 800°C. The worn surfaces, both from tribometer and real tools, were investigated by scanning electron microscopy equipped with Energy-dispersive X-ray spectroscopy (EDX) and by Raman spectroscopy. The wear was measured by 3D white light optical profilometry. Oxidation tests and tribological properties obtained in laboratory were compared with the behavior of the coatings deposited on tools.

Keywords: TiAlCrN, coating tribology, thermal stability.

INTRODUCTION

Machining industry is the biggest customer for PVD deposited super hard coatings. Applications of these coatings are used for cutting tools such as drills, mills, cutting inserts, etc. Performance each coating has to have is thermal stability, high hardness, toughness, low friction and adhesion resistance.

Nowadays, TiAlN is the most widespread coating because of its sufficient thermal stability, up to 900°C, high hardness, oxidation resistance and adhesion resistance. The ability of TiAlN to retain its hardness even in the high temperatures is based on spinoidal decomposition of the structure. Metastable cubic solid solution of TiAlN is decomposing into c-AlN and c-TiN. Upon increasing the temperatures even higher, domains of c-TiN and c-AlN grow and c-AlN is transforming into stable but less hard h-AlN and the hardness of coating decreases. Adding chromium to TiAlN compound is hindering the spinoidal decomposition by slowing the diffusion and formation of c-TiN and c-AlN domains. Unlike
titanium chromium has much better oxidation resistance and its segregation to grain boundaries in the surface regions significantly improves oxidation resistance.

RESULTS AND CONCLUSION
The coatings, Figure 1, exhibited a hardness of 27 GPa and an excellent adhesion (critical load higher than 80 N). The structure of the as-deposited film, with a dominant cubic NaCl-type nitride phase together with hexagonal Cr$_2$N, was thermally stable and oxidation resistant up to 900 °C. Further increase in temperature led to the formation of the wurtzite AlN phase and the decomposition of the cubic phase together with surface oxidation; nevertheless, the coating was not fully oxidized even at the highest temperature, 1050 °C. The wear rate of the film was very limited up to 600 °C. The analyses of the wear track cross-sections after the sliding tests at 800 °C showed that the multilayer structure was able to limit the propagation of the cracks from the surface. This feature together with a significant columnar distortion during the sliding process had a positive impact on the wear resistance. The main wear processes identified in this study were tribo-oxidation and delamination of very thin coating layers close to the surface of the wear track.

![Fig. 1 - SEM micrograph of annealed coating cross-sections and corresponding top surface view](image)

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