COATINGS TO PREVENT ADHESIVE WEAR IN STEELS

IGOR VALCHUK, MYKHAILO HETMAN, OLEKSIY KOVTUN, VOLODYMYR DYTYNIUK

Khmelnytskiy National University, Ukraine

The study investigates adhesive build-up formation on tool steels under dry friction. Experimental tests were performed on alloyed steels (AISI 9262, AISI T31507) and high-speed steel (AISI M3) using a UMT-2168 tribometer under loads of 20–60 N and sliding speeds of 0.6–1.5 m/s. The results show that AISI 9262 and AISI T31507 are most prone to build-up at the initial stage of friction, accompanied by temperature rise and increased friction torque. Electrolytic Ni and Cr coatings promoted build-up due to microstructural defects, while chemical chromium coatings effectively suppressed build-up and improved tribological performance. Composite coatings demonstrated partial effectiveness, with Cu–Ni bilayers reducing build-up and Ni–Al_2O_3 eliminating it under moderate regimes but increasing wear. The findings highlight the role of coating type and steel microstructure in controlling adhesive build-up and improving wear resistance.

Keywords: adhesion, build-up, friction, wear, contact pressure, tool steels, coatings (chemical and electrolytic)

Introduction. Adhesive build-up is a common phenomenon observed during metal cutting and in frictional machine components. In cutting operations, it leads to changes in tool geometry, increased cutting forces, and reduced dimensional accuracy and surface quality. In closed systems, such as shaft–bushing or piston–cylinder pairs, build-up can cause jamming. Despite the negative effects, some build-up-prone materials may have attractive mechanical and tribological properties. Literature data do not fully describe the behavior of build-up under friction, which complicates their industrial use. Therefore, it is important to investigate the mechanisms of build-up formation, evaluate the influence of coatings, and propose preventive strategies [1].

Methods. Experiments were carried out on a modified UMT-2168 universal tribometer with continuous recording of wear, friction torque, and contact temperature. Samples were made of alloyed tool steels (AISI 9262, AISI T31507) and high-speed steel (AISI M3). The counterbody was AISI G51320 steel (HRC 55). Tests were performed under normal loads of 20–60 N and sliding speeds of 0.6–1.5 m/s, generating Hertzian contact stresses of 1300–2000 MPa. To enhance wear resistance and suppress build-up, various coatings were applied: nickel, chromium (electrolytic and chemical), and composite Ni-based layers containing Cu or Al_2O_3. The coating thickness was 10–15 μm.

Results and discussion. The steels AISI T31507 and AISI 9262 showed the highest tendency to build-up formation during the initial stages of friction. Build-up

was accompanied by a sharp rise in temperature and friction torque, particularly under high loads and sliding speeds. Electrolytic nickel and chromium coatings promoted build-up due to their defective microstructure and microcracks, while chemical chromium coatings with nearly defect-free surfaces effectively prevented build-up, reduced friction torque, and stabilized temperature.

When using AISI 9262 steel with a troostite temper structure (tempering temperature 400 ^{0}C) for electrolytic chromium coating, scale formation is observed in all friction modes, but wear is reduced by 3...5 times, depending on the friction mode when using this coating (Fig. 1).

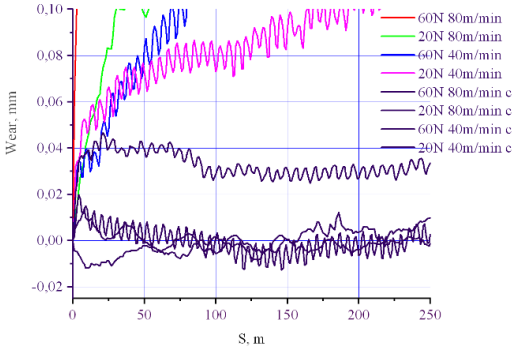

Fig. 1. Linear wear of AISI 9262 steel with electrolytic chromium coating.

Composite Cu–Ni bilayer coatings reduced build-up intensity but did not eliminate it completely. Ni–Al_2O_3 coatings suppressed build-up under moderate conditions, but at the cost of increased friction and faster wear. The structural state of the steel matrix strongly influenced coating efficiency: for AISI 9262 tempered at 300 °C (tempered martensite), chromium coatings reduced wear significantly despite some build-up.

Conclusions. Continuous tribological monitoring enables detection of both build-up and micro-welding phenomena during tests. High-strength Cr–Mn tool steels are the most susceptible to build-up formation. Electrolytic Ni and Cr coatings promote build-up regardless of friction regimes. Chemical chromium coatings effectively suppress build-up and improve tribological performance. Optimizing the steel microstructure combined with multilayer or composite coatings provides promising solutions for reducing adhesive build-up in friction pairs.

1. *Makovkin, O., Dykha, O., Valchuk, I. Adhesive built-up edge on tool steels due to friction and wear // Problems of Tribology. – 2024. – 29(3/113). – P.56–64. https://doi.org/10.31891/2079-1372-2024-113-3-56-64*