Tribological characterization of coatings for their suitability as protective coatings for rollers using two-disc model investigations

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This study focuses on testing the suitability of several particle reinforced metallic coatings for protecting the rollers of cold rolling mills. The experimental work is carried out using two-disc model configuration. We evaluated the performance of the coatings on the basis of the damage of the contact surfaces as well as on the test load which could be endured without damage. The tribosystems show two main failure modes, a) failure due to the wear of the coating or b) failure due to the plastic softening underneath the steel counterpart, which are linked to the structure and hardness of the coatings.

Keywords (from 3 to 5 max): coatings, rollers, two-disc investigations

1. Introduction

Rollers of cold rolling mills are subjected to tribological phenomena such as wear, which deteriorates the quality of the rolled products. Therefore, it is of interest to increase the service life of the rollers by protective coatings. This study addresses the directed selection of a good performing particle reinforced coating using two-disc model investigations.

2. Methods

The authors simulated the loading conditions of real life rollers on model scale by discs of 35 mm diameters and 4 mm width using a Plint TE74 test rig. Emphasis was put on the Hertzian loading conditions, the circumferential speed, the slip, the materials as well as the lubricants. After a running-in phase the tests were performed with constant parameters for 60.000 s. The coating materials investigated consisted of different metallic matrix materials (Ni, Co, Cr) and different filler particles (diamond (DI), boron carbide; share 5-30%; size 0.5-20 µm) and were applied in a thickness range from 5 to 50 µm. The counter disc was uncoated steel. We evaluated the performance of the coating on the basis of the damage of the contact surfaces after the tests (degree of damage, plastic deformation of the running pattern profile, surface morphology) as well as on the test load which could be endured without damage.

3. Results

The results from tribotesting and damage analysis show that the tested tribosystems exhibit two main failure modes: a) failure due to the wear of the coating or b) failure due to the plastic softening underneath the steel counterpart, which leads to inadmissible plastic deformations and/or rolling contact fatigue of the steel surface. Figure 1 summarizes those findings.

4. Discussion

Both failure modes are linked to the surface hardness. All coatings which are of inferior hardness than the steel counterpart are removed during the test due to wear processes (red arrow pointing downwards in Figure 1).

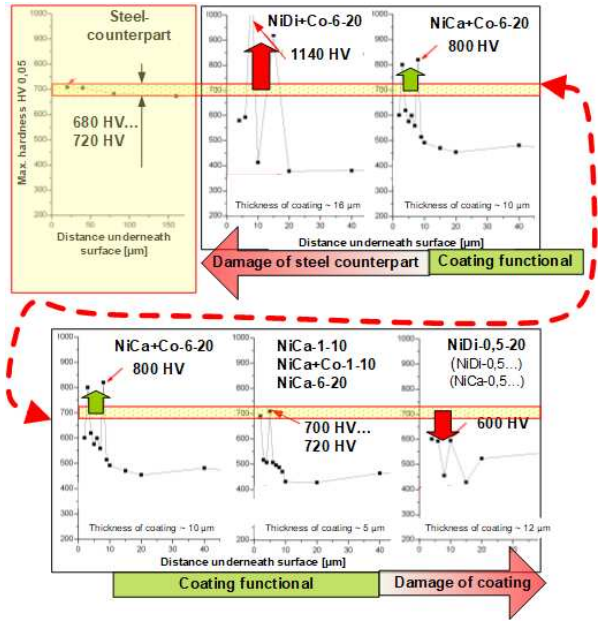

Figure 1: Tribological functionality of the tested coatings

All coatings which are significantly harder than the steel counterpart (e.g. coatings with large diamond particles which possess a Mohs hardness of 10) cyclically stress the steel surface in the plastic regime. In extreme cases these processes lead to failure due to plastic formation of grooves or fatigue (red arrow pointing upwards in Figure 1). In addition, the results exhibit: a) the requirement of a minimal particle size (in our case 1 µm), in order that the particles can take a load bearing function, b) coatings with boron carbide particles protect better as coatings with diamond particles. c) the requirement of a minimal coating thickness (in our case about 10 µm).

5. References

[1] Grün, F. et al., "Tribological functionality of aluminium sliding materials with hard phases under lubricated conditions" Wear, 298-299, 1, 2013, 127-134.