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Effect of martensite volume fraction on tribological behavior of dual-phase steel at microscopic scale

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In this work, the influence of martensite volume fraction, load and attack angle on hardness, friction and wear of ferrite and martensite phases of a dual-phase microstructure is investigated through nanoindentation and scratch tests with conical tips. Friction coefficient increases with the attack angle and is always higher for ferrite than for martensite. For martensite phase, friction coefficient increases and wear resistance decreases as martensite volume fraction increases. As the attack angle increases, wear mechanism changes from ploughing to cutting for martensite. Experimental results correlate to the Axén & al. approach based on the Equal Pressure model.

Keywords : dual-phase, abrasion, nanoindentation, scratch

1. Introduction

Previous studies have focused on tribological behavior of dual-phase steels by using the macro hardness as the main material property to control friction and wear [1], [2]. However, they do not take into account the varying properties of the phases with the martensite volume fraction. This work proposes a study on the mechanical properties and tribological behavior of the individual ferrite and martensite phases in dual-phase microstructures.

2. Methods

2.1. Material and heat treatment

Dual-phase microstructures with varying martensite volume fraction are obtained from 25CD4 low alloy steels samples submitted to various heat treatment.

2.2. Hardness measurement

Hardness of martensite and ferrite phases are obtained through nanoindentation tests.

2.3. Scratch test

Scratch tests are realized at constant load using conical tips with different attack angles.

2.4. Modelling

Experimental data is compared to the models for friction and wear of Axén & al. [3], [4]

3. Discussion

When martensite volume fraction increases, martensite hardness decreases while ferrite hardness is constant. Whatever, the martensite volume fraction, the friction coefficient is proportional to the tangent of the attack angle of the conical tip for both phases but is higher for ferrite than for martensite. The friction coefficient of the martensite presents a small increase with martensite volume fraction. Specific wear resistance of martensite decreases when martensite volume fraction increases and is constant for ferrite. When the attack angle of the conical tip increases, wear mechanism is always ploughing for ferrite but shows a transition from ploughing to cutting for martensite. Finally, implementing these experimental results into Axén & al. models for multiphase materials shows that the equal pressure model applies well to the scratch behavior of dual-phase microstructures.

Table 1 : Conical tip attack angle and corresponding friction coefficient and wear mechanism on martensite

Tip	Attack Angle	Friction Coefficient	Wear Mechanism
A	18.8°	0.23	Ploughing
B	33.2°	0.41	Wedging
C	47.5°	0.69	Cutting
D	55°	0.75	Cutting

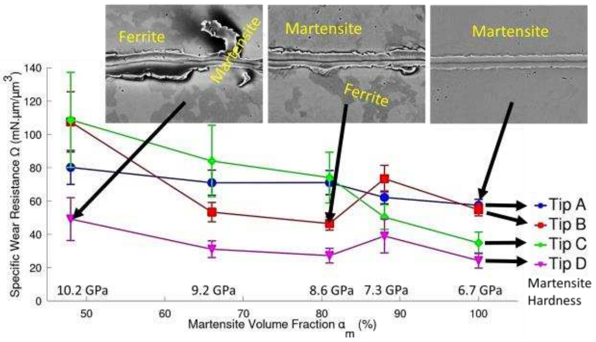

Figure 1: Evolution of the specific wear resistance of martensite with martensite volume fraction and conical tip attack angle

4. References

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