TRIBOLOGY OF AMORPHOUS METALLIC ALLOYS: TRIBOCHEMICALLY OR MECHANICALLY DRIVEN?

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Friction, Wear, Tribofilms and 3rd bodies, Amorphous Metallic Alloys.

ABSTRACT

Amorphous Metallic Alloys (AMA), also known as metallic glasses, have exceptional mechanical properties compared to their traditional crystalline counterparts: yield strength close to theoretical limit, high hardness, high elastic deformation capacity, high fatigue strength [1]. Despite their interesting mechanical properties, tribological studies conducted over the last two decades showed that AMAs exhibit erratic tribological behaviour, often mediocre but sometimes excellent, and especially unpredictable or even often contradictory [2-5]. Thus, a better understanding of the "composition / friction condition / tribological behaviour" coupling is necessary in order to make the tribological performance of AMAs more reliable. The compositions of AMAs tested for tribological application in which sliding occurs, are alloys mostly based (main element in weight%) on Cu, Zr, Ni, Fe, or Ti [3,5-6]. The Cu, Ni, and Zr-based materials are displaying among the best performances.

Consequently, 4 different alloys (Cu-based, Zr-based, CuZr-based, and Ni-based) were chosen for this study. They were tested in reciprocating ball-on-plate pure sliding configuration with a ± 1 mm stroke. They are studied in terms of friction coefficient evolution over 10,000 cycles of friction, estimation of damaged volume at the end of the test, and wear track morphologies and compositions using SEM and EDX analysis. To study the impact of the initial contact conditions on their tribological behavior, AMAs are tested under two different initial contact pressures (310 and 680 MPa).

Results show that the Cu, Zr and CuZr-based alloys exhibit very similar friction coefficient under both conditions, but the Ni-based alloy exhibit a dramatic change in friction coefficient when the contact pressure increases (Figure 1). In the latter case, the volume of damaged material only slightly variates and most importantly remains almost null! This peculiar behaviour is due to selective tribochemical reactions leading to the creation of a specific 3rd body. Interestingly, selective tribochemistry takes place in all the contacts studied. In some case it protects the AMA and deteriorates the crystalline ball, some the opposite, leading to high or low wear.

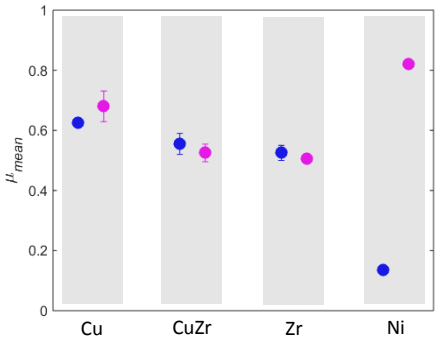

Figure 1 - Mean friction coefficient of AMAs at 2 different contact pressures: 310 MPa (Blue) and 680 MPa (Pink)

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