LOW WEAR CAPABILITIES OF NI-BASED BULK METALLIC GLASS UNDER ROLLING/SLIDING UNLIBRICATED CONDITIONS IN AIR AND VACUUM

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KEYWORDS
Space Tribology; Experiments in tribology; Wear, Bulk Metallic Glass

ABSTRACT
Bulk Metallic Glasses (BMG) are known to demonstrate exceptional mechanical properties combining very high yield stress and fracture toughness with large elastic strain limit. Over the last 20 years, Ni-based and Zr based BMGs have attracted interests in gears and harmonic drives applications [1,2]. Furthermore, it has been shown that the endurance fatigue life of Ni-based BMG surpasses all the best crystalline alloy used in space applications [3]. Although demonstrating very high potential (wear life increase by 300 times under constant torque) [2], no studies focused on the mechanisms leading to such a high wear life, and none compared performances at iso-contact pressure. Indeed, at iso-resistive torque, considering the BMG Young's modulus is up to twice smaller than the regular gear steels, contact pressure becomes significantly lower. Finally, in pure sliding condition in air, Ni-based BMG can demonstrate very low wear, even when friction coefficient is very high [4].

The proposed study hence aims to study the wear mechanisms of $Ni_{62}Nb_{33}Zr_5$ BMG in rolling sliding unlubricated contact conditions against space grade 15-5 PH stainless steel, in comparisons with 15-5 PH / 15-5 PH contact. Small disc of 5mm in diameter, 1mm thickness, and curvature of 1.3mm are used as rollers. For $Ni_{62}Nb_{33}Zr_5$ they are machined in 1mm thick plates casted by Vulkam. The maximum Hertz contact pressure considered is 750 MPa, the sliding to roll ratio is 0.6%, and the linear sliding speed is 10.47 mm/s for the flat sample. 3 tests per configuration have been performed in air 50% HR, and in vacuum (4.10^{-7} mbar).

Friction coefficient is shown to be significantly improved when using $Ni_{62}Nb_{33}Zr_5$, although it remains very high at steady state (cf. Fig1). In vacuum, both contacts exhibit similar surface morphologies in friction tracks, except that 15-5PH/15-PH contacts exhibit few, but very large and thick debris scattered along the friction track. Otherwise, it is mainly adhesive wear and extruded features. In air, 15-5 PH/15-5 PH exhibits high wear, lots of loose debris and large agglomerates, while the $Ni_{62}Nb_{33}Zr_5$/15-5 PH contact demonstrates narrow friction track with 3rd body layer uniformly distributed over the track with only few loose particles. The study herein sheds light on the tribological properties of Ni-based BMG in sliding/rolling experiments in space related environment. It also shows that advantage of using BMG to lower wear, friction coefficient, and the creation of loose wear debris.

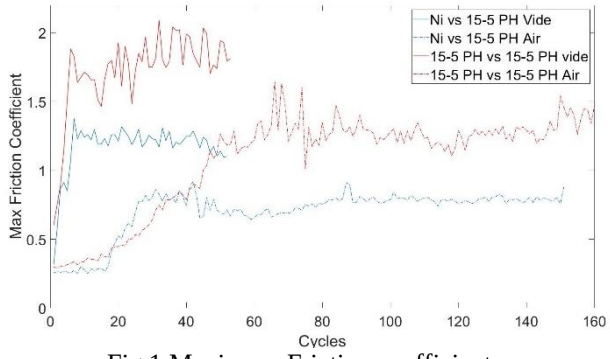

Fig.1 Maximum Friction coefficient

ACKNOWLEDGMENTS
This project has been supported by the French space agency CNES. This work was partly supported by the French RENATECH network and its FEMTO-ST technological facility.

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