PhD Thesis **Student: Federica Adamo**

Fretting wear on mechanical systems: innovative design and graphene-based improvements

Abstract

The research activity is based on the study of the phenomenon of fretting wear in spline couplings from the theoretical, numerical and experimental point of view. The fretting wear occurring in mechanical systems when sliding parts are in contact, leading to surface damage. The mechanical components affected from fretting wear experience malfunction, noisiness and loss of efficiency. The most common model to describe the fretting phenomenon is called Archard law. Starting from the Archard law, the goal is the analysis of the main parameters influencing the fretting and the consequent individuation of their effect on the spline couplings. Basing on the Archard law the wear volume depends on: contact pressure, sliding and material properties. Through an iterative design process, based on the development of a dedicated FEM model, the micro-geometric parameters of the component directly related to the contact pressure value and distribution have been identified, such as the crowning radius and the tooth profile. Moreover, for the sliding, the main sources, as misalignment and variable torque have been described. In order to reduce the entity of the sliding, the effect of the variation of the tooth stiffness has been evaluated, by means a progressive reduction of its thickness. Continuing with the analysis of the Archard law parameters, the study focuses on the wear volume. Given the difficulty to estimate the amount of loss material, the evaluation of the wear volume in damaged spline couplings have been discussed: a method able to calculate it using a 2D profilometer and some mathematical assumptions have been presented. Moreover, the difficult to carry out experimental tests for spline coupling characterized by high dimension (as that for high power transmissions) make necessary to develop a way to predict the wear volume. Then, a method for the prediction, based on the use of a pin on disc tribometer have been developed and discussed. The last parameter involving on the Archard law is the wear coefficient that depends on the materials and on the lubrication conditions. In order to find solutions to mitigate friction and wear, a series of experimental tests have been developed on the dedicated test bench. The purpose of these tests is the measurement of the friction coefficient following the addition of Graphene Nano-Platelets (GNP) into the grease for spline couplings. A series of preliminary Pin-on-disc tests on three different greases have been carried out: three different greases were added, using different percentages of GNP respectively. The results of both test bench test and pin on disc test confirm the good effect of graphene in reducing coefficient of friction. Finally, the possibility to use graphene as solid lubricants for steel have been investigated. For the production of the specimens, different techniques of graphene production and coating were used; the characterization of

the surfaces following both the covering process and the tribological tests was carried in order to define the wear mechanisms affecting the surface. A series of pin-on-disc tests have been carried out confirming the possibility to use graphene as solid lubricant.