PhD in Mechanical Engineering

Research Title: EXperimental and THEoretical iNvestigation of jointED structures – EXTHENdED.

Funded by	Politecnico di Torino

Supervisor	Daniele BOTTO – DIMEAS daniele.botto@polito.it

Contact	http://www.aermec-dimec.polito.it/

Context of the research activity	This research will be performed in close collaboration with the Northwestern Polytechnical University (NPU) in Xi'an, China. Half of the PhD period, at least 18 months, will be spent in this University. This study aims to investigate the interaction between contact interfaces and the dynamic behavior of assemblies. The purpose of the proposed activity is to develop and validate reliable contact models of the interface. These contact models are expected to predict the nonlinear relationships between the contact force and the cross-interface displacement. These relationships are the ultimate step for a dependable dynamic simulation of jointed structures. This research concerns contact and wear mechanics with dry friction and involves both theoretical and experimental activities. During the theoretical activity, the PhD will develop numerical contact models of smooth surfaces with a multi-physics approach. Methods to solve the normal and tangential contact problem will be developed for both constant and variable normal loads. Surfaces roughness will be introduced in the contact models and the effect of asperities will be studied with analytical and numerical approaches. Morphology of different surfaces is needed to create an asperity database parametrized with the surface roughness, friction, wear conditions, core material, coating and so on.

	The database will be used to define the asperities distributions and the fractal analogy for the analytical approach. The smooth surface model will be merged with the asperity models to build a comprehensive model of the contact. The expected result is a reliable predictive method to determine the nonlinear normal and tangential stiffness of rough surfaces. An experimental campaign will be planned and performed to evaluate the contact parameters in a wide range of conditions: materials, specimen shape, normal load, temperature and so on. Wear test will be also performed to evaluate the effect of wear on contact conditions. The results of this campaign will be used to assess the contact models.

Objectives	The current modelling capabilities are very much less advanced with respect to joints than for any of the components that they connect, despite the importance that joints have on the assemblies' safety. For this reason, the lack of reliable predictive models of joints is a fundamental barrier to the optimal design of many critical assemblies. Therefore, the scientific objective of this research is to advance engineer's capabilities in modelling interfaces with dry friction, to increase the accuracy of the dynamic design of assemblies. Interfaces can no longer be assumed as a continuum, and ad hoc models must be developed to correctly simulate the behavior of joints and their correlation with the dynamics of assemblies. The overall objective is pursued through the following specific objectives. • The very first step is to grasp the most advanced methods of interface modelling, by reviewing the literature and the recent developments about contact mechanics. • Then, it is of paramount importance to identify which are the parameters driving the phenomenon: temperature, contact pressure, relative displacement and roughness are only few examples. • An important step in the research is to put forward enhanced contact models or advance existing contact models. • A test rig must be designed and manufactured to evaluate the contact parameters and the effect of fretting wear on the interface behavior. • Experimental plans must be set up and an extensive experimental campaign performed to collect data and

	validate exiting or newly developed contact models.

Skills and competencies for the development of the activity	The successful candidate is highly interested in topics correlated to contact and fretting mechanics, nonlinear joint modeling, and dynamics of jointed structures. Essential skills are a very analytical mind, questioning and problem solving ability. The successful candidate has the capability to deeply investigate, both theoretically and experimentally, the given problem. Good capability to accomplish an experimental job are needed. In detail, the candidate knows how to perform modal analysis, dynamic response and fretting tests. Important skills are an advance knowledge of commercial computational software (MATLAB), CAD software (SOLIDWORKS, CATIA, PROE) and finite element tools (ANSYS). Interpersonal skills are desirable.