CT2M

Center for Mechanical and Materials Technologies

Scientific Interaction Meetings

Meeting nº 6

2008.01.23 – 14h-15h

Room: B1.13

Agenda:

14h : **Mihaela Buciumeanu, Prediction of Fretting Fatigue Life**
14h 30 : **Eduarda Silva, Computational Model of the Fluid Dynamics in Abdominal Aorta and Renal Branches**

All are welcome to the 6th SIM session on 23rd January 2008. The more details of the presentations are as follows

1. Prediction of Fretting Fatigue Life by Mihaela Buciumeanu (mihaela@dem.uminho.pt)

Abstract: Fretting fatigue is a deteriorating process that arises in many mechanical components and has been recognized as a failure mode of major importance. The fretting phenomenon occurs where low amplitude vibratory motion takes place between two metal surfaces loaded together. Fretting is a term commonly used that includes fretting fatigue, fretting corrosion and fretting wear. It should be noted that these forms of damage often coexist in the same contact. The knowledge of fretting fatigue phenomenon requires an understanding of the interaction among fatigue, contact mechanics, material science and fracture mechanics. Eden, Rose and Cunningham were the first that noted the formation of iron oxide on the surface of a fatigue specimen in the areas contacting the grips of a test machine, in 1911. In 1927, Tomlinson was the first to actually study this process. In 1941, Warlow-Davies became the first to examine the effect that fretting could have on fatigue properties. Later work by McDowell studied the simultaneous action of fretting and fatigue. Many developments in understanding the mechanism of fretting fatigue occurred during the last years. The interest in fretting fatigue continues, as the problem has not been solved because of the various parameters that are involved in this process.

The purpose of this work was to achieve a better understanding of the fretting fatigue phenomena, underlying the mechanisms that lead to crack initiation and early growth in fretting fatigue conditions. This thesis is focused on the influence of the material properties over the mechanism of crack nucleation, namely stresses, strains and displacements. This research consisted on theoretical, experimental, and computational approaches to the problem of fretting fatigue for three different materials (Al7175, Ck45, and Ti6Al4V) with different cyclic properties, in contact with a classical steel 34CrNiMo6. It is known that materials that have high plain fatigue strength do not necessarily have high fretting fatigue strength. The reason for this may lie on their wear performance and consequent damage evolution. To check the validity of this assumption plain fatigue, fretting fatigue and reciprocating wear tests were carried out. Two new devices for fretting fatigue and reciprocating wear tests were specially developed and built in the laboratories of the Mechanical Engineering Department of Minho University, Guimaraes, Portugal. The fretting fatigue device is assembled on a universal servo hydraulic testing machine and the reciprocating wear device is assembled on a PLINT-TE67 machine. Moreover, several plain fatigue tests were carried out to examine the effect that fretting can have on fatigue life. Among the several different parameters that affect the fretting fatigue behaviour of materials, the study of the influence of the wear damage evolution was another focal point of the present work. Thus reciprocating wear tests were carried out with the specimens

manufactured from the same materials as the ones used in fretting fatigue and fatigue tests. All tests were performed at room temperature and laboratory environment conditions. As a direct application of fretting fatigue phenomenon an investigation was carried out on an automotive-formed suspension component that was supposed to last at least 300.000 load cycles, but that did not meet the necessary fatigue requirements. The main damaging factor was related to fretting fatigue. Design improvement, in order to avoid the fretting phenomena, was then carried out on the suspension car component. Some linear and nonlinear analyses using “cosmos works” were carried out to determine the stress state along the component. At the end, a significant improvement in fatigue life was achieved.

Because the fretting fatigue process is a local and evolving process, it is very dependent on specific material properties. How local wear does evolve and how does it affect the contact stresses? Understanding this phenomenon in a comparative way for different materials may be the key to bring analysis to more intrinsic properties of materials and develop broader and more robust predictions.

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2. Computational Model of the Fluid Dynamics in Abdominal Aorta and Renal Branches

Eduarda Silva, (pl@dem.uminho.pt)

Abstract: Blood flow in arteries is highly unstable and variable along the cardiac cycle, reaching high velocities during systole and low velocities during diastole. These complex and variable characteristics are even more evident when associated to cardiovascular diseases. Atherosclerosis is the most common cause of vascular disease and is associated with a restriction in the lumen of vessels. The progression of atherosclerosis can lead to vascular damages and consequently to situations of ischemia and myocardium infarct. For these reasons, the study of blood flow in arteries is important to understand the relation between hemodynamic characteristics in flow and the occurrence of vascular diseases.

In the present work, computational methods (Computational Fluid Dynamics) were used in order to study blood flow in the abdominal aorta and renal branches. This localization is of particular interest because it has been demonstrated that atherosclerosis usually occur in the portion along the posterior wall of the relatively straight abdominal aorta downstream of the renal arteries and also in the renal arteries.

In the current study the commercial software Fluent, based on Finite Volume Method, was used as computational tool. A three-dimensional model was developed to describe the velocity and wall shear stress distributions along the cardiac cycle. The geometric domain was developed based on previous literature models and was assumed as rigid. Different grids were tested and it was possible to conclude that hexahedral elements are usually more accurate. Although, the Re numbers are low, the flow was modeled both as laminar and turbulent, because the turbulence may occur resulting from the complex geometries. The computational results permit the identification of regions of recirculation in the walls of the abdominal aorta and renal branches. The recirculation induces perturbations in blood flow and is variable along the cardiac cycle, being more evident in the deceleration phase. The presence of regions of recirculation is associated with low wall shear stress. This relation between regions of recirculation and low wall shear stress has been associated to a predisposition to atherosclerosis.