

# HEI Départements Conception Mécanique et Sciences et Techniques Générales

## Équipe de Recherche et d'Étude des Structures



LABORATOIRE  
de MECANIQUE  
de LILLE  
UMR CNRS 8107



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Collaboration entre HEI et l'IUT A de l'USTL dans le cadre du LML – Laboratoire de Mécanique de Lille

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### Thématiques de l'Équipe Étude des Structures d'HEI :

- ⇒ Étude du comportement mécanique des matériaux
- ⇒ Modélisation numérique par éléments finis

### Ténacité d'interface pour caractériser l'adhérence de revêtements projetés thermiquement.

The interfacial toughness  $K_{IC}$ ,  $P_c$  and  $a_c$  denote load and crack length respectively. Where the subscripts  $i$ ,  $s$  and  $c$  stand for interface, substrate and coating respectively.

Measurement of the indentation marks and the lengths of the cracks produced at the interface. The square root of the ratio of the elastic modulus ( $E$ ) divided by the Vickers hardness ( $H_V$ ) at the interface is expressed by:

$$K_{IC} = 0.015 \frac{E^{3/2}}{H_V} \sqrt{P_c} \sqrt{a_c}$$

✓ Simple to perform. Local destruction of the coating. Undisrupted measurement.

✗ Need a good preparation of the interface (polishing) before the tests. Cracks are not always easy to detect.

#### TENSILE ADHESIVE TEST

EN 582 - ASTM C 633-79

Tensile adhesive strength

Bond strength ( $\sigma_{ad}$ )

✓ EN 582 standard test and ASTM C 633-79.

✗ It is not suitable for thin and porous coating because of the penetration of the adhesive agent into the coating.

#### CORRELATION OF BOND STRENGTH AND INTERFACIAL TOUGHNESS

For the indentation test, a mechanically stable crack is introduced into the coating-substrate interface using conventional Vickers indentation. The resistance to crack propagation at the interface is then used as a measure of adhesion, by analogy with the fracture of homogeneous brittle solids. This may be characterized by a fracture resistance parameter or strength parameter. Since this fracture resistance parameter is related uniquely to the bonding across the interface, it is certainly a more fundamental measure of adhesion than the bond strength which is the result of a combination of fracture resistance and size distribution of defects.

However, a general trend has been found, as shown on the right, between interfacial toughness and bond strength. Only the full squared points were taken in consideration in this tendency because of the other points (empty squares) are influenced by the penetration of the adhesive agent into the pores of the coatings. In particular, the porosity in the ceramic coating was found to be up to 7% and the tensile strength of adhesive was found to be ~100 MPa. Therefore, the trend should be considered for the metallic coatings rather than for the ceramic coatings.

Legend:  
 □ Points not considered because of the penetration of the adhesive agent into the porosities of the coating.  
 ■ Points are taken in consideration

## ADHESION TESTS FOR THERMAL SPRAY COATINGS

### Tentative of correlation of bond strength and interfacial indentation

### Étude de la fatigue, sous chargement multi-axial aléatoire.

Extension des travaux de référence à la prévision du réamorçage, sous chargement réel aléatoire.

Développement d'un outil numérique de prévision de durée de vie et de comportement à long terme, sous chargement réel aléatoire, dans l'intérêt de limiter, pour les industriels, les coûts liés à l'expérimentation.



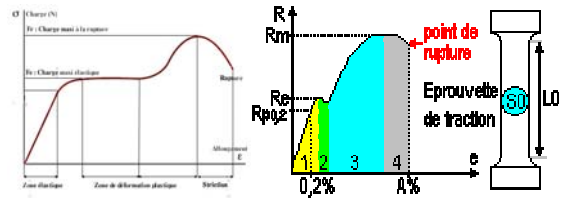
Machine de traction



Eprouvettes de traction  
cylindriques, plates parallélogramiques, axisymétriques entaillées, entaillées pré-fissurées



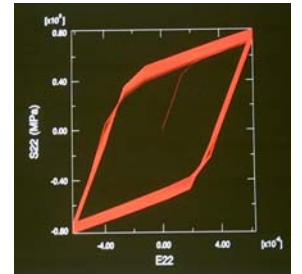
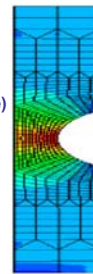
Essai de traction sur des éprouvettes entaillées pré-fissurées



Courbe Charge - Allongement type

Eprouvette modélisée (modèle axisymétrique)

et  
Epreuve de fatigue oligocyclique



### Applications industrielles

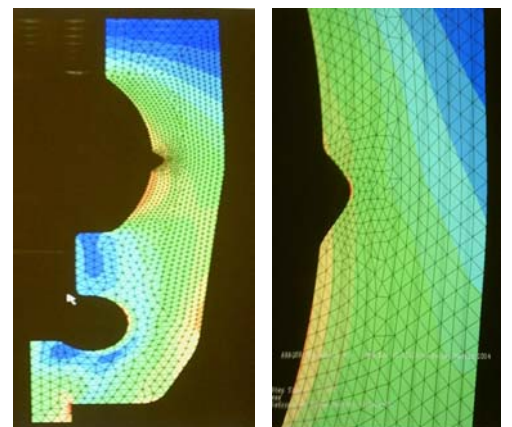
ANALYSE DES RESULTATS

TURBO 1 (2) - Horizontal - Val Freq 11

TURBO 1 - M.L.T PV P1 - Horizontal - Tendance générale Acceleration

TURBO 1 - M.L.T PV P1 - Horizontal - Acc Freq 20000 Hz

SURVITEC



Contraintes corps de vanne sous pression  
Vue d'ensemble et détail au niveau d'une fissure

Machine modèle vibratoire pour l'optimisation de l'équilibrage de machines tournantes