



42° Convegno Nazionale AIAS, 11-14 Settembre 2013

L'Università degli Studi di Salerno - ospita il 42° Convegno Nazionale AIAS

AIAS2013
42° Convegno Nazionale

Effetto del trattamento di rullatura sulla resistenza a fatica da fretting della connessione forzata albero-mozzo

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Univ. di Padova

Univ. di Ferrara

Univ. di Parma

Univ. di Trento

Univ. di Pisa

Unità di Pisa:

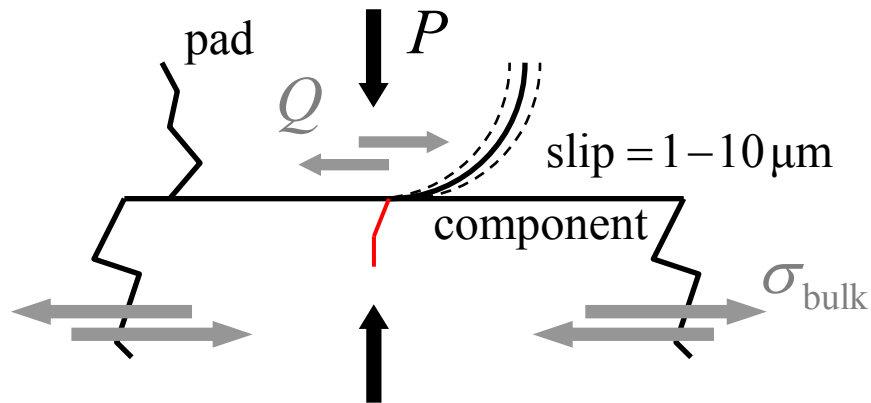
Studio sperimentale e modellazione della concentrazione di tensioni all'estremità della zona di contatto nel **collegamento forzato albero-mozzo** sottoposto a sollecitazione flessionale. Esame degli effetti prodotti sulla resistenza a fatica da un campo di **tensioni residue** di compressione indotto da un trattamento superficiale di **rullatura** con deformazione plastica profonda.

Fretting Fatigue

Elevato gradiente

Stato di tensione triassiale

Fenomeni tribologici (micro slittamento)

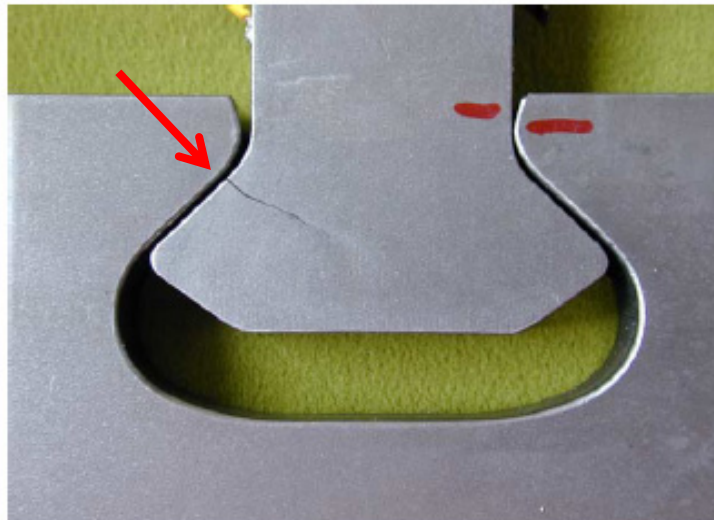
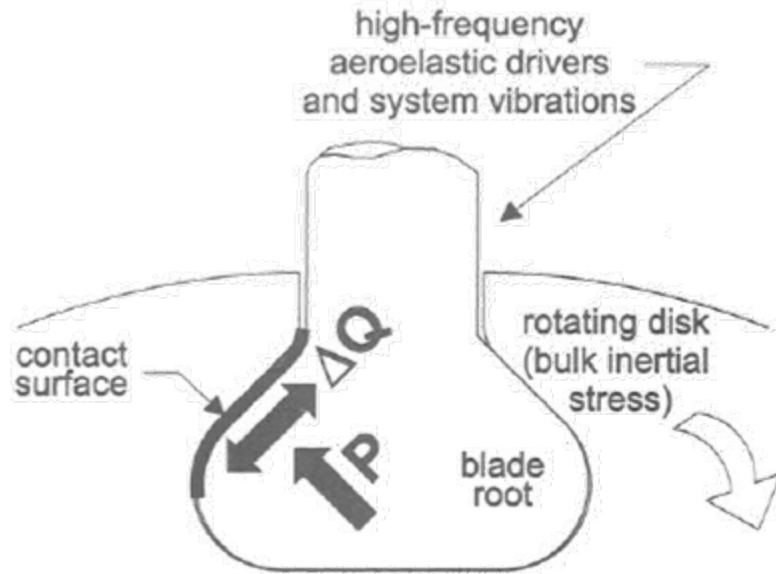


Miglioramento resistenza:

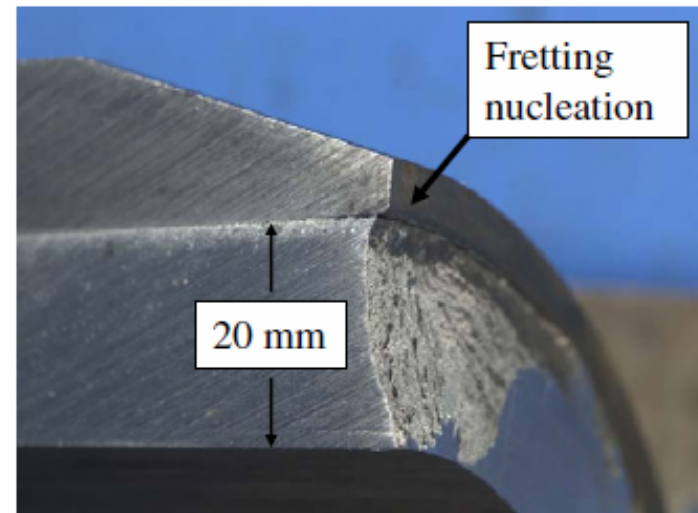
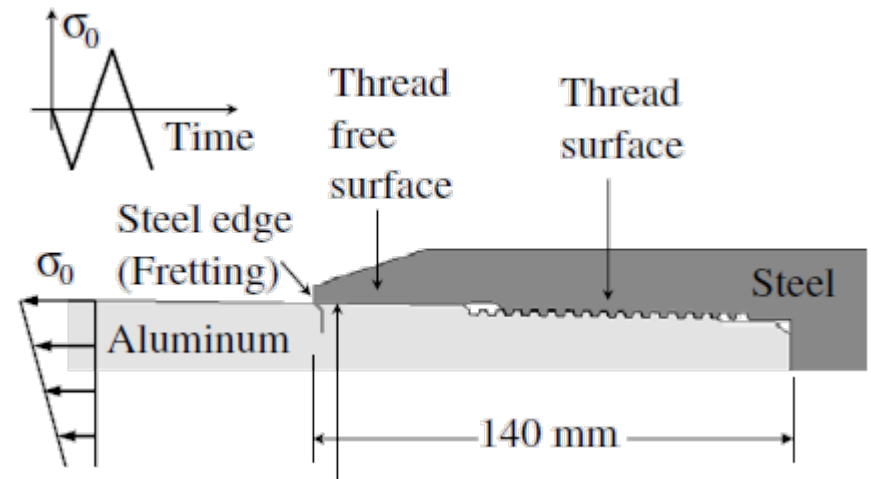
Tensioni residue di compressione: Es. Pallinatura, Rullatura

Applicazioni soggette a fatica da Fretting

“Dovetail” blade-disk root

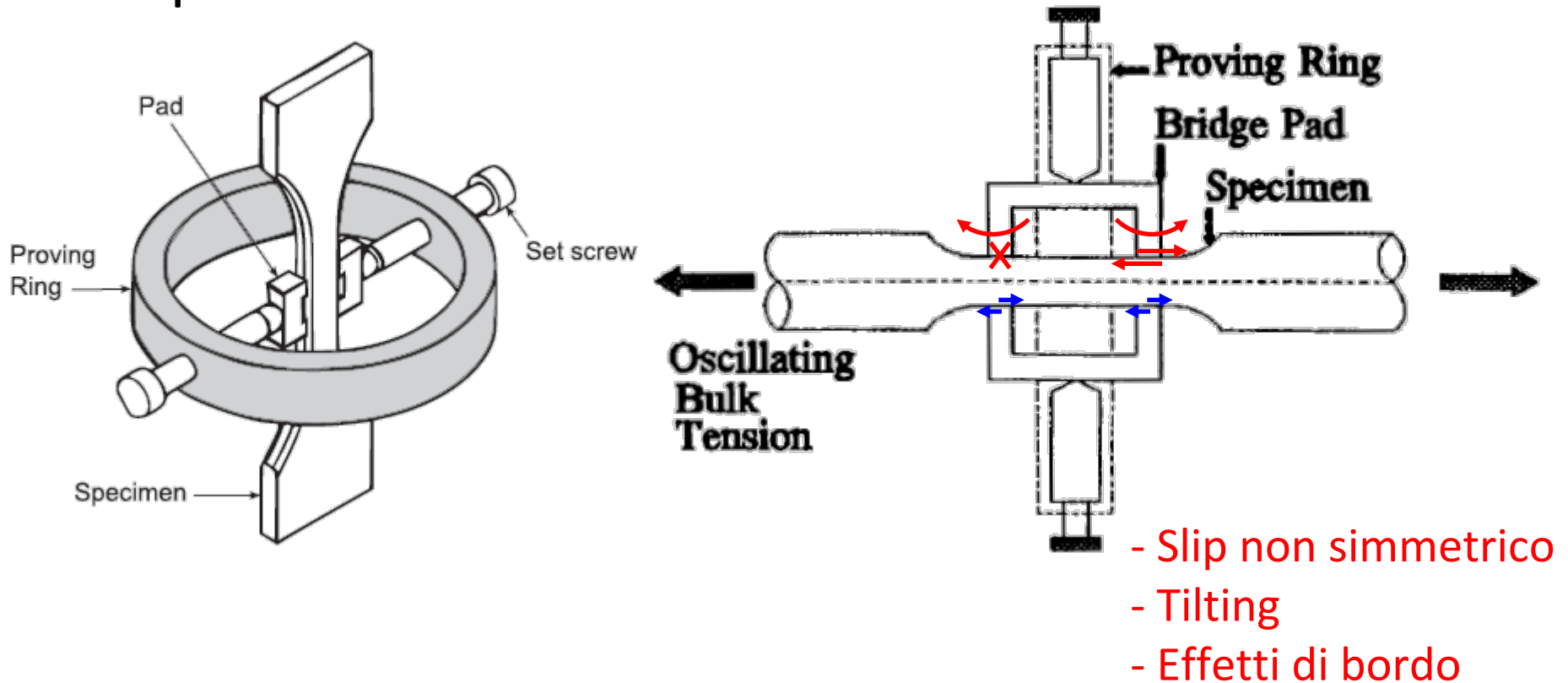


Shrink-fitted tubular connection



Fretting test – Condizioni di contatto controllate

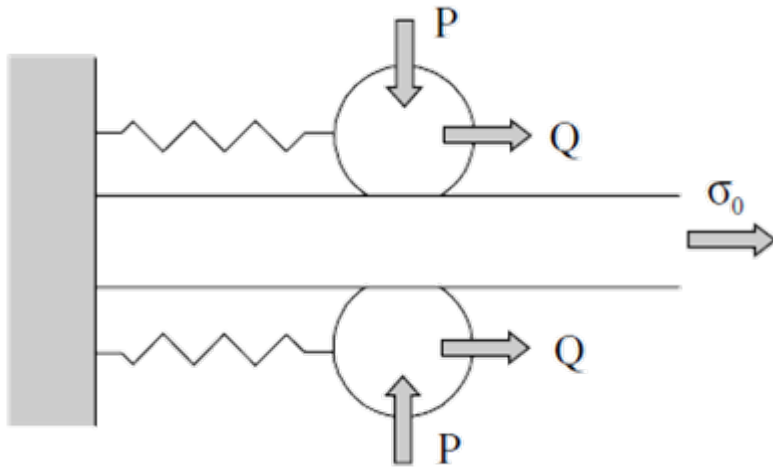
Bridge type setup



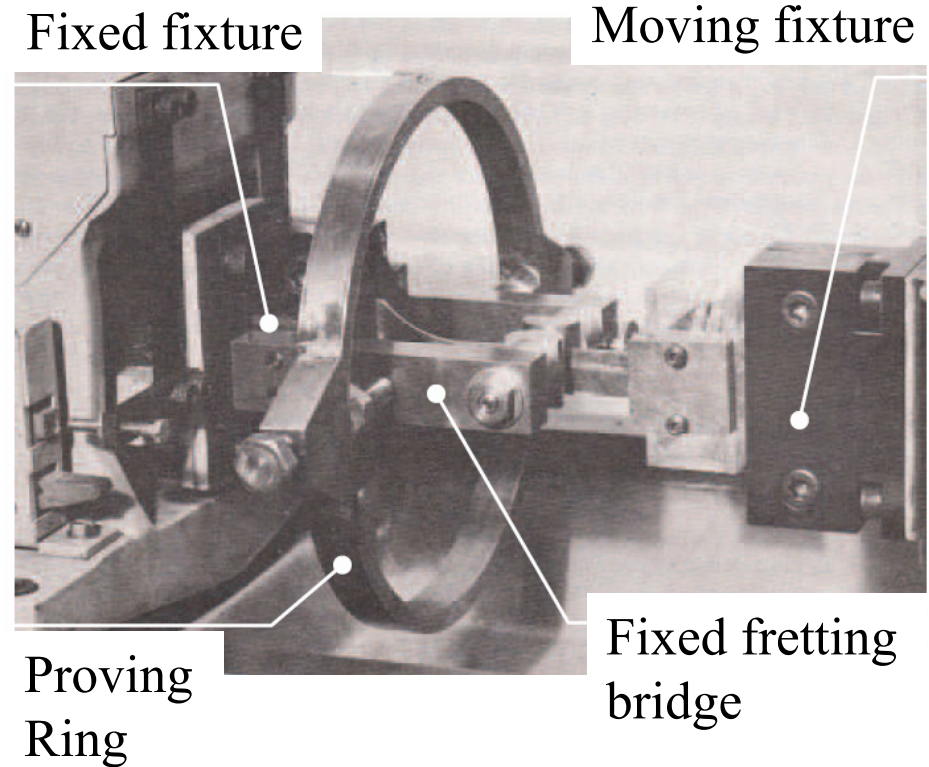
D.A. Hills, D. Nowell, Mechanics of Fretting Fatigue, ed. Kluwer Academic Publishers, 1994

Fretting test – Condizioni di contatto controllate

“Half” bridge setup



- Solo contatto Hertziano (cilindrico o sferico)
NO flat and rounded
- Effetti di bordo

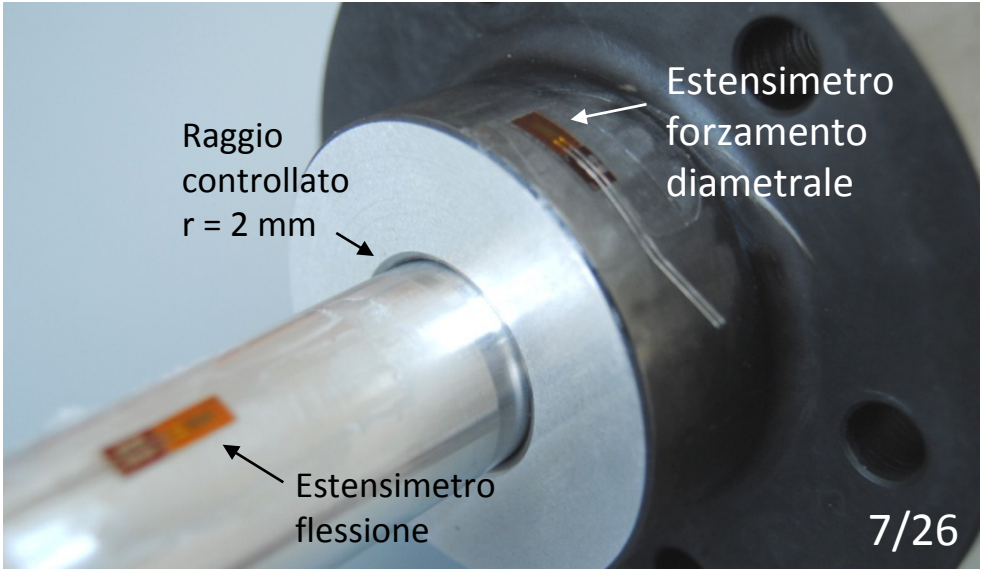


D. Nowell, D. Dini, D.A. Hills, “Recent developments in the understanding of fretting fatigue”, Engineering Fracture Mechanics, 73(2), 207-222, 2006

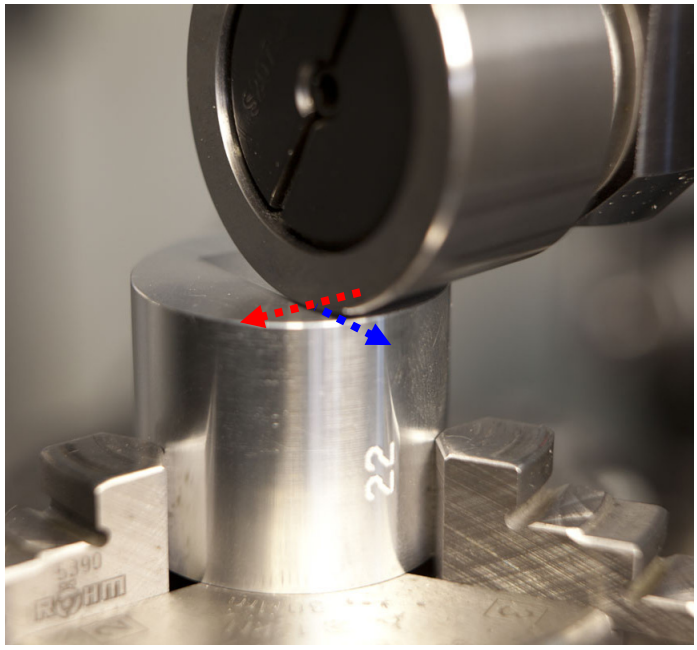
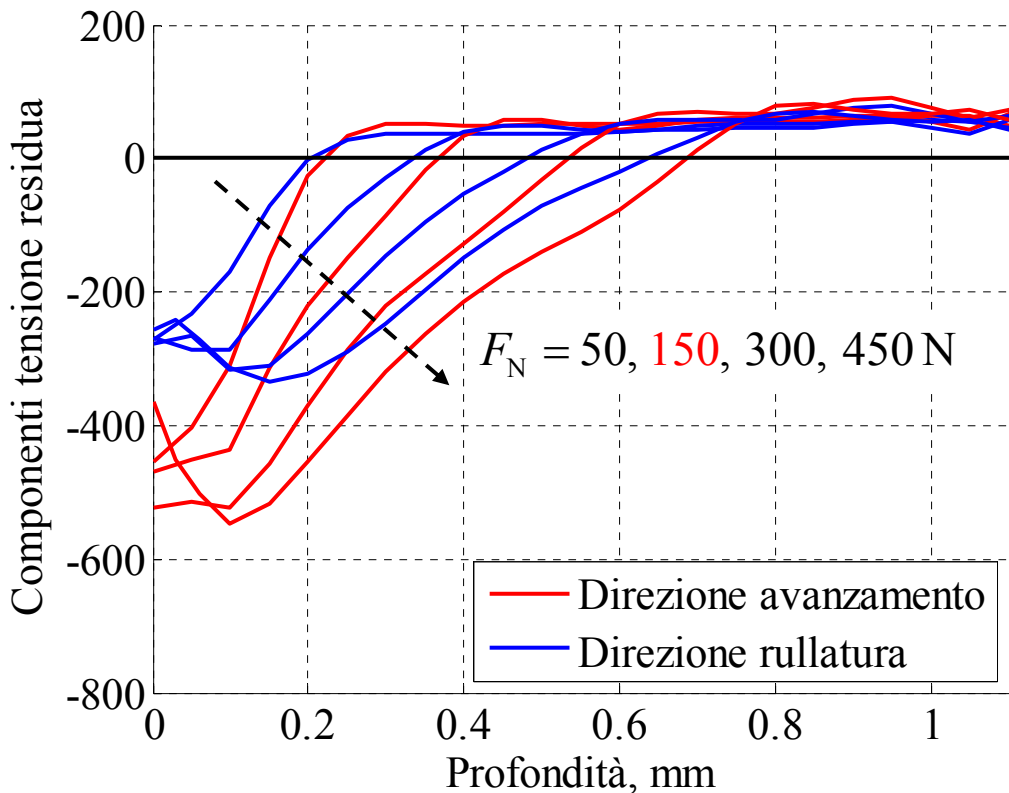
Connessione forzata albero-mozzo



- Riproduzione in scala della connessione tubolare

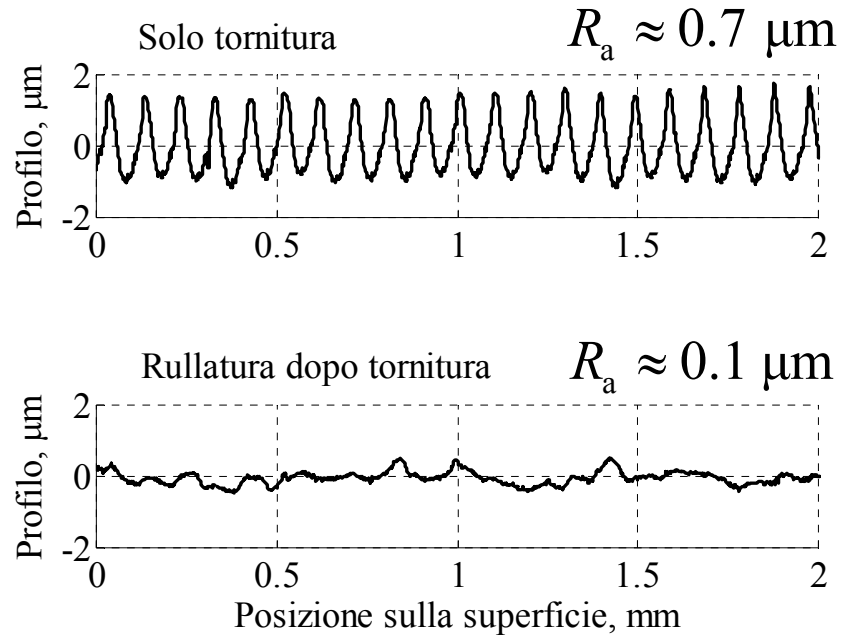
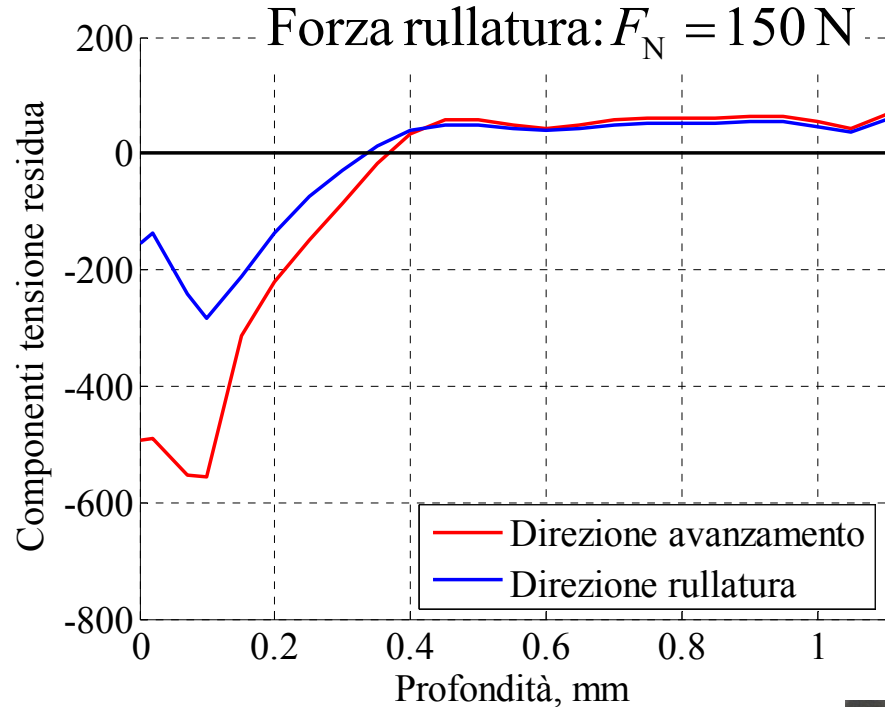


Rullatura – ottimizzazione con Cilindretti campione

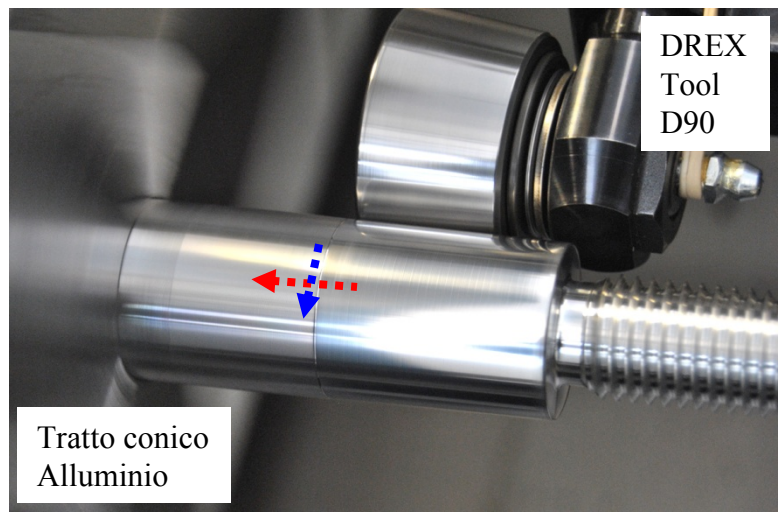


M. Beghini, B.D. Monelli, C. Santus. "Stato di tensione residua di rullatura su elementi per prove di fatica da fretting con collegamento forzato albero mozzo". XLI congresso AIAS, Vicenza 2012

Rullatura provini conici

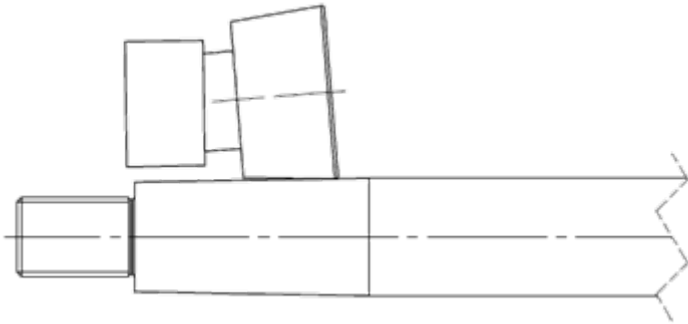


- Componente maggiore in direzione assiale
- No profondità eccessiva

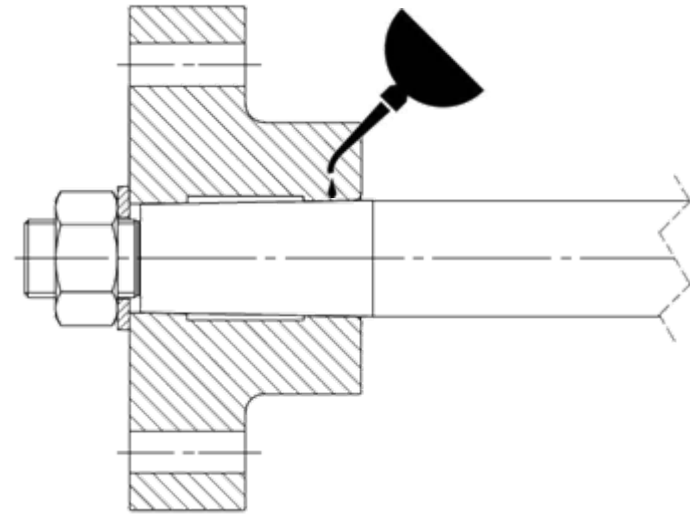


Campagna di prove – condizioni testate

Tensioni residue (rullatura)



Lubrificazione applicata al contatto



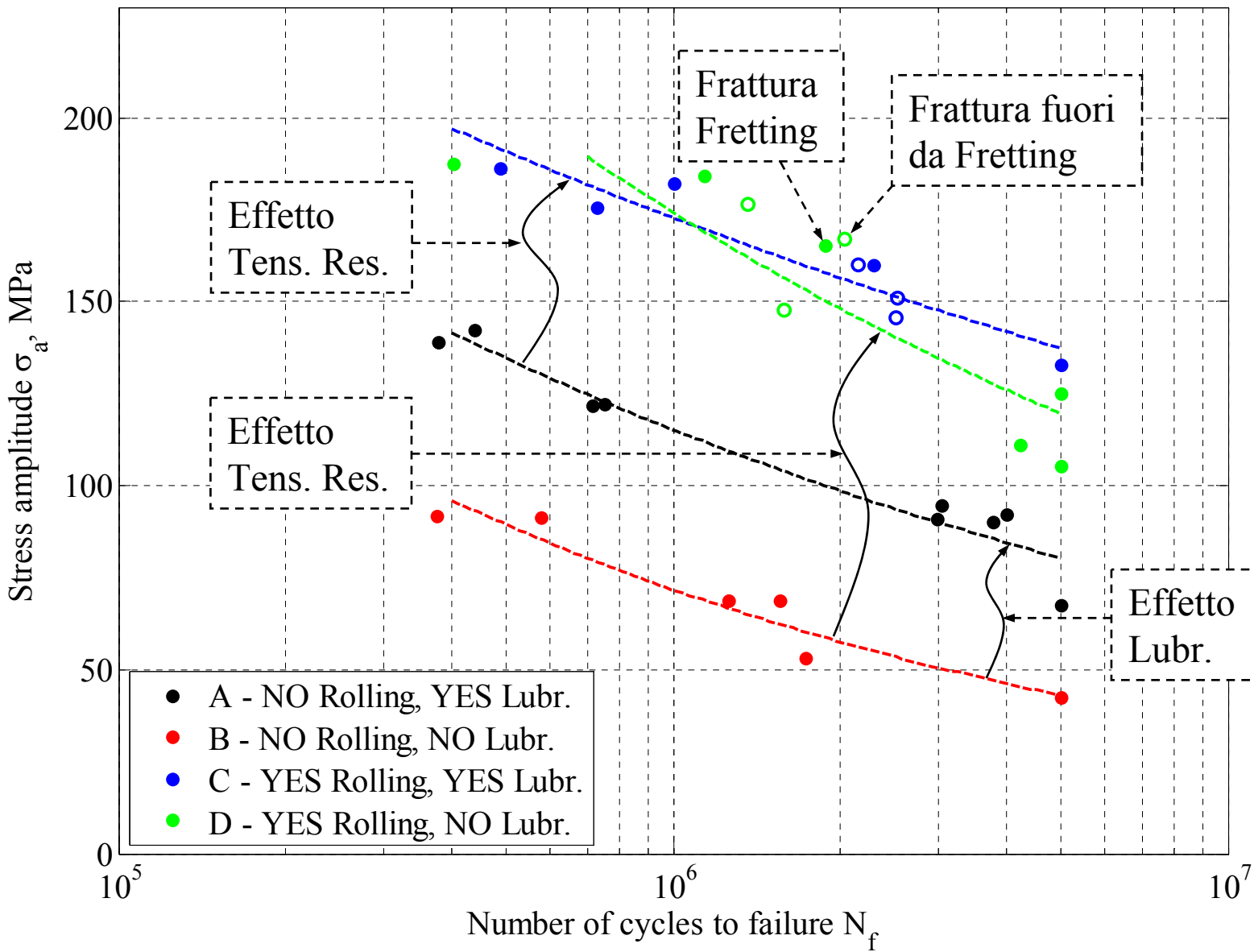
Serie di prove A: **NO** rullatura, **SI** lubrificazione

Serie di prove B: **NO** rullatura, **NO** lubrificazione

Serie di prove C: **SI** rullatura, **SI** lubrificazione

Serie di prove D: **SI** rullatura, **NO** lubrificazione

Risultati prove sperimentali



Superfici di frattura

NO rullatura

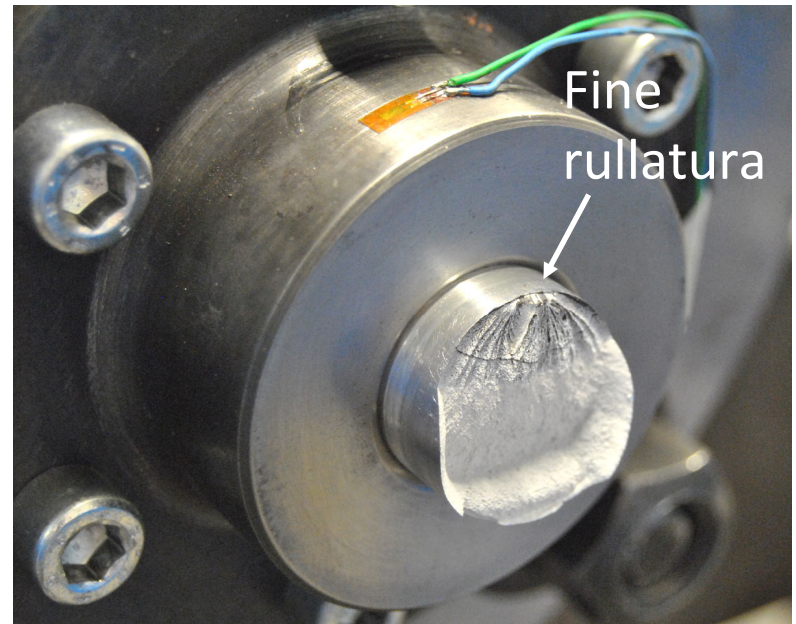


Superfici di frattura

NO rullatura

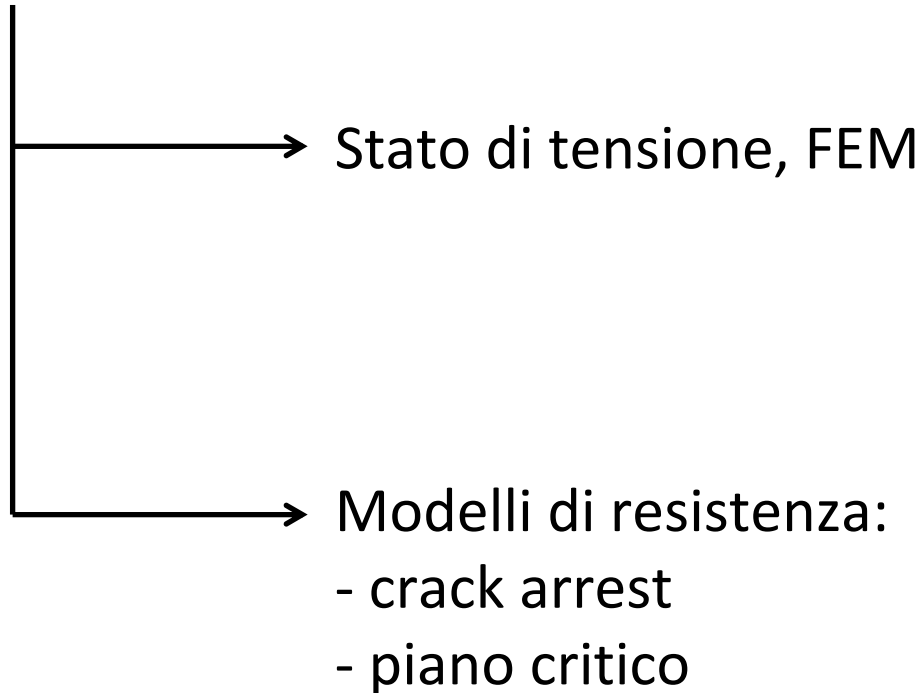


SI rullatura

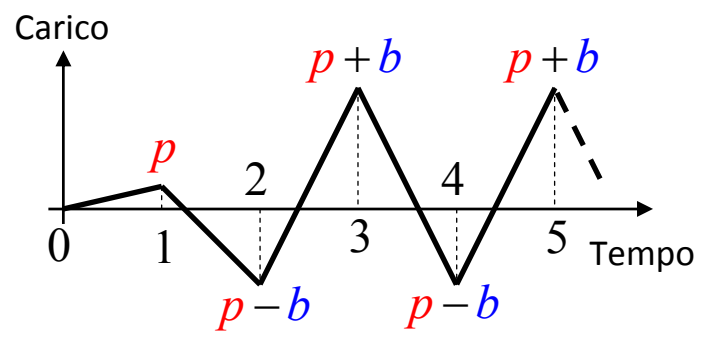
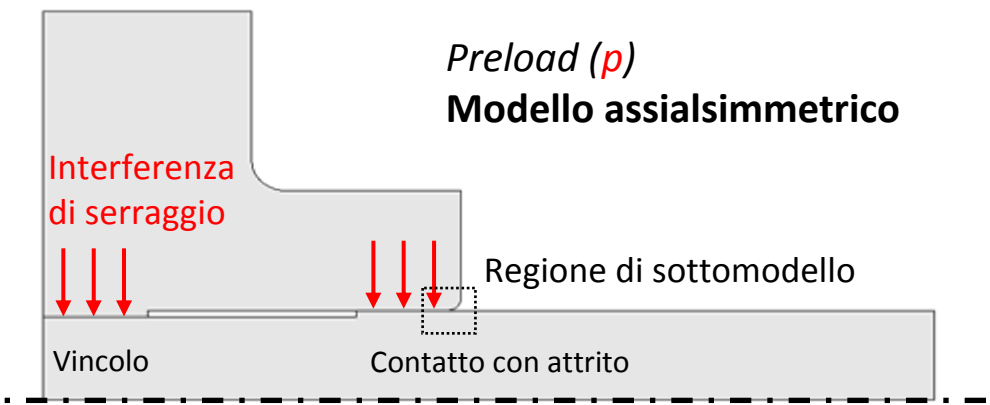


Innesco fessura, fuori
dalla zona di fretting

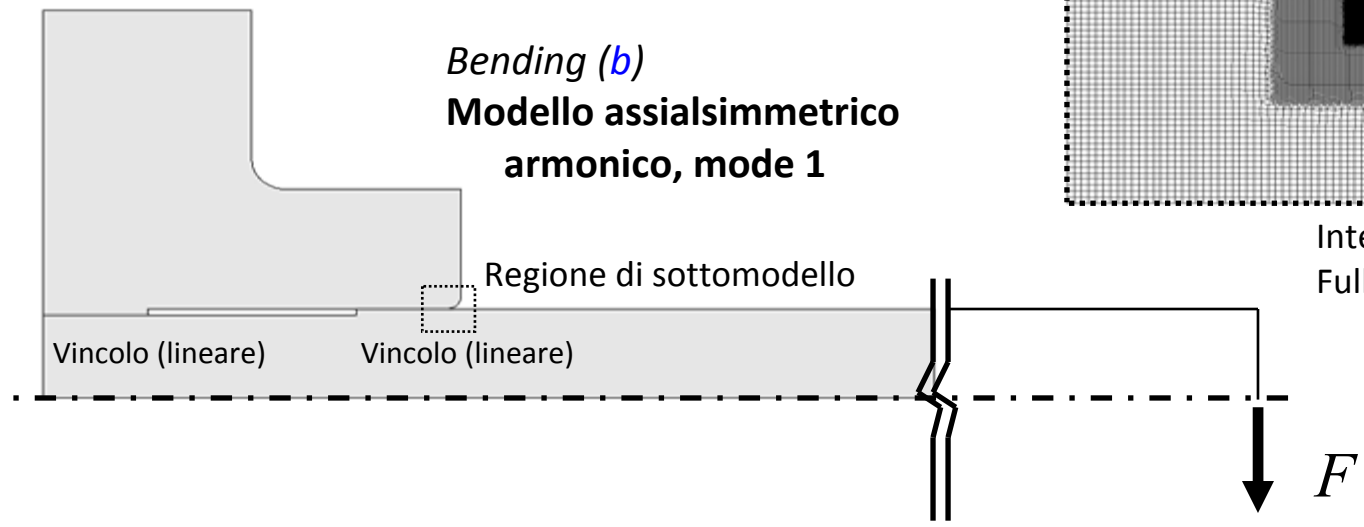
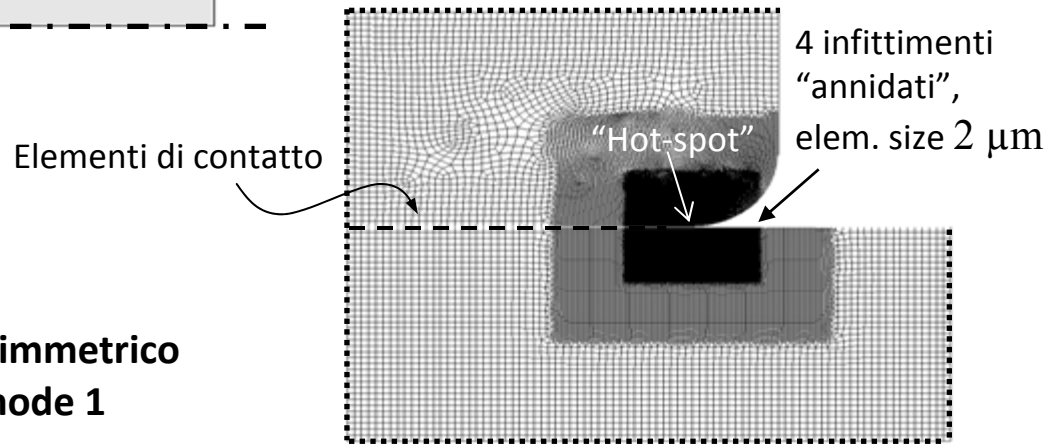
Interpretazione dei risultati
delle prove



Modellazione numerica, FEM

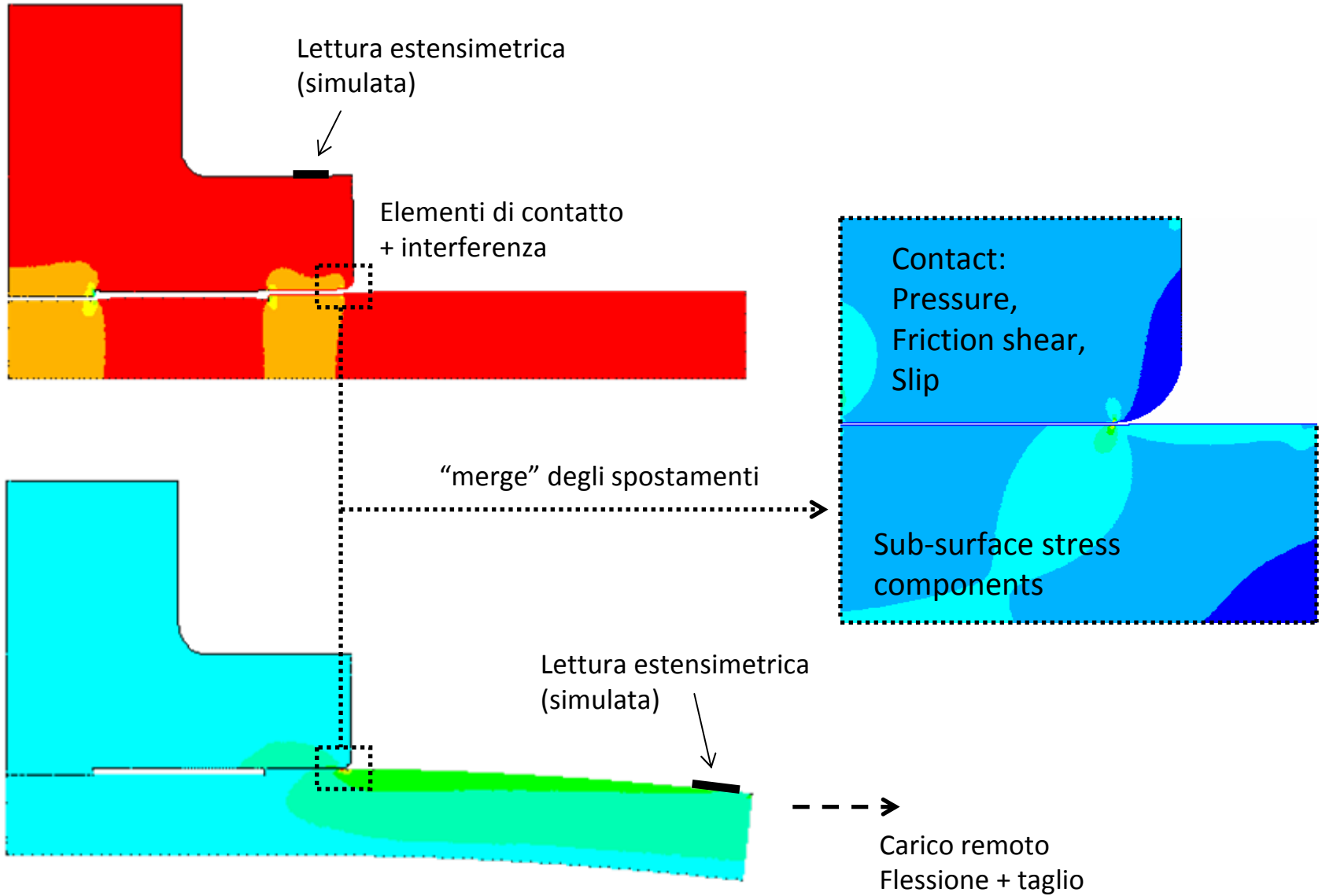


Sottomodello: Plane Strain

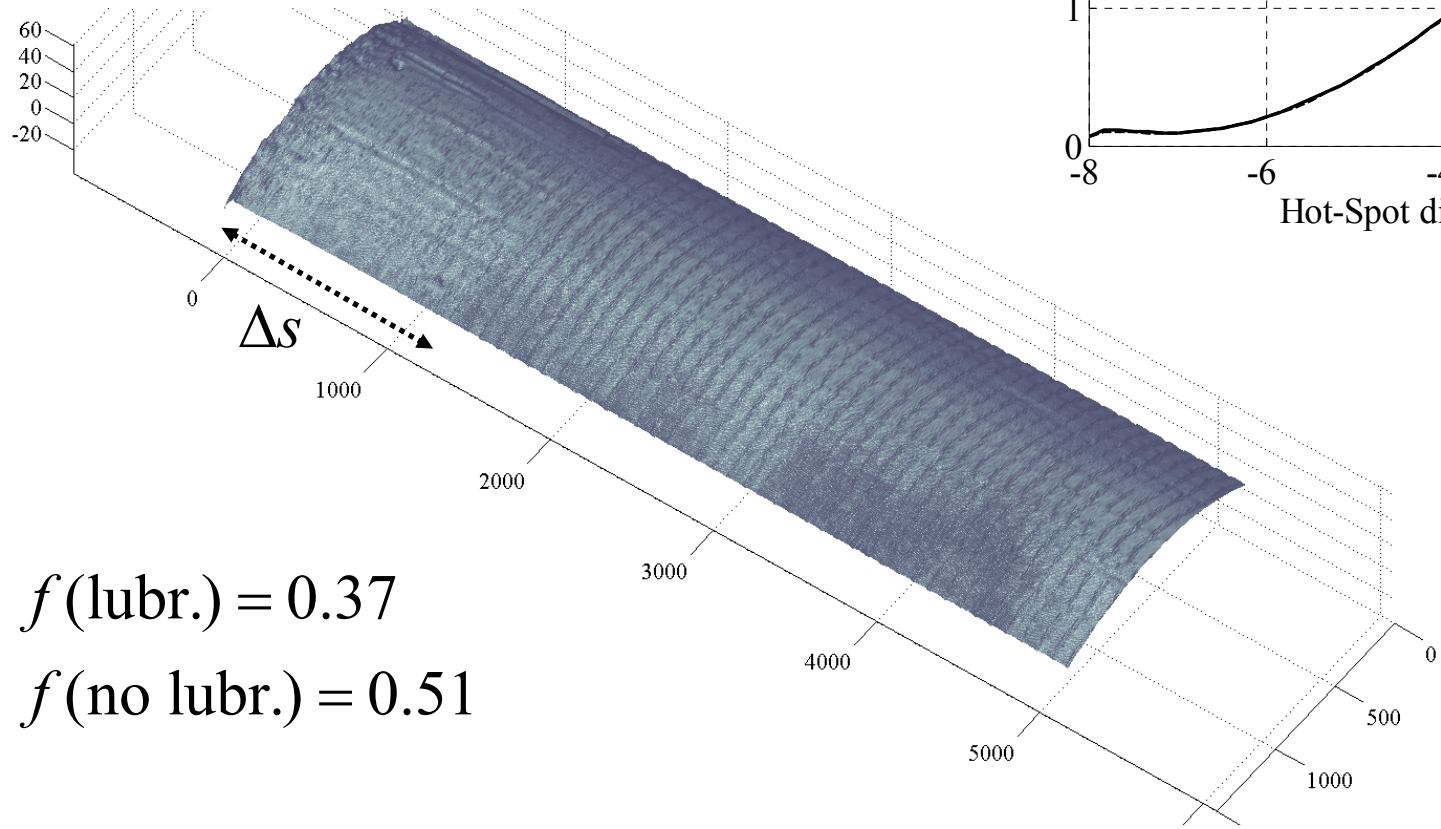
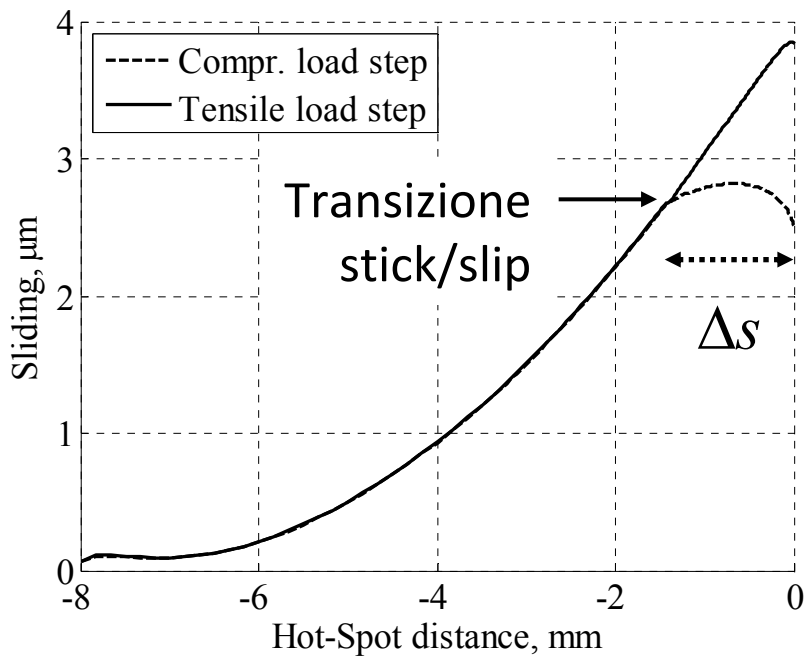
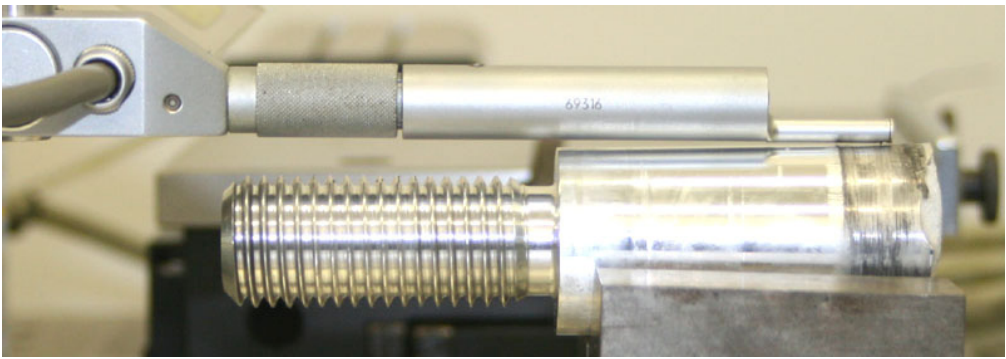


Interpolazione DoF:
 Fullmodel \rightarrow Submodel

Modellazione numerica, FEM

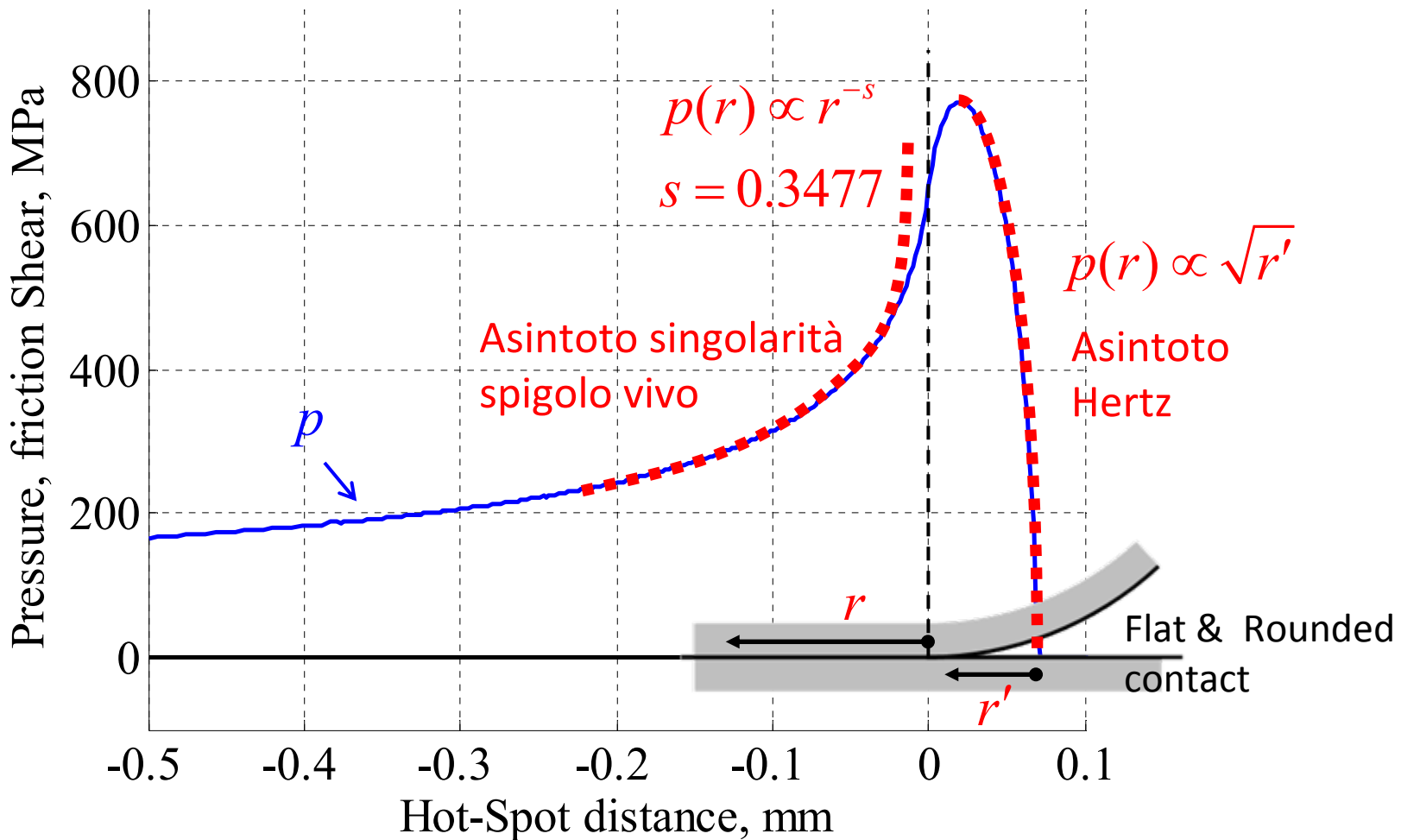


Determinazione coefficiente d'attrito

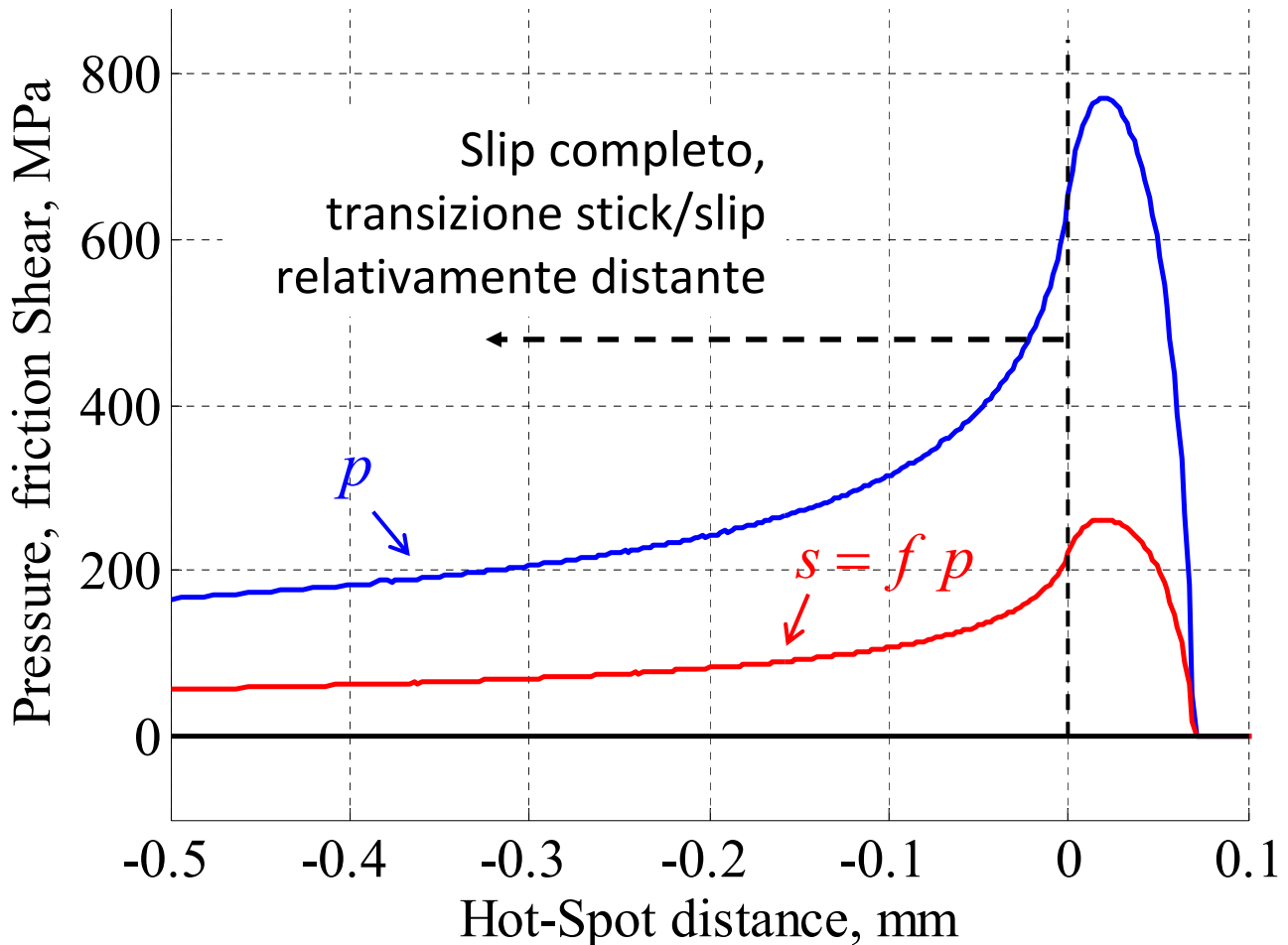


$f(\text{lubr.}) = 0.37$
 $f(\text{no lubr.}) = 0.51$

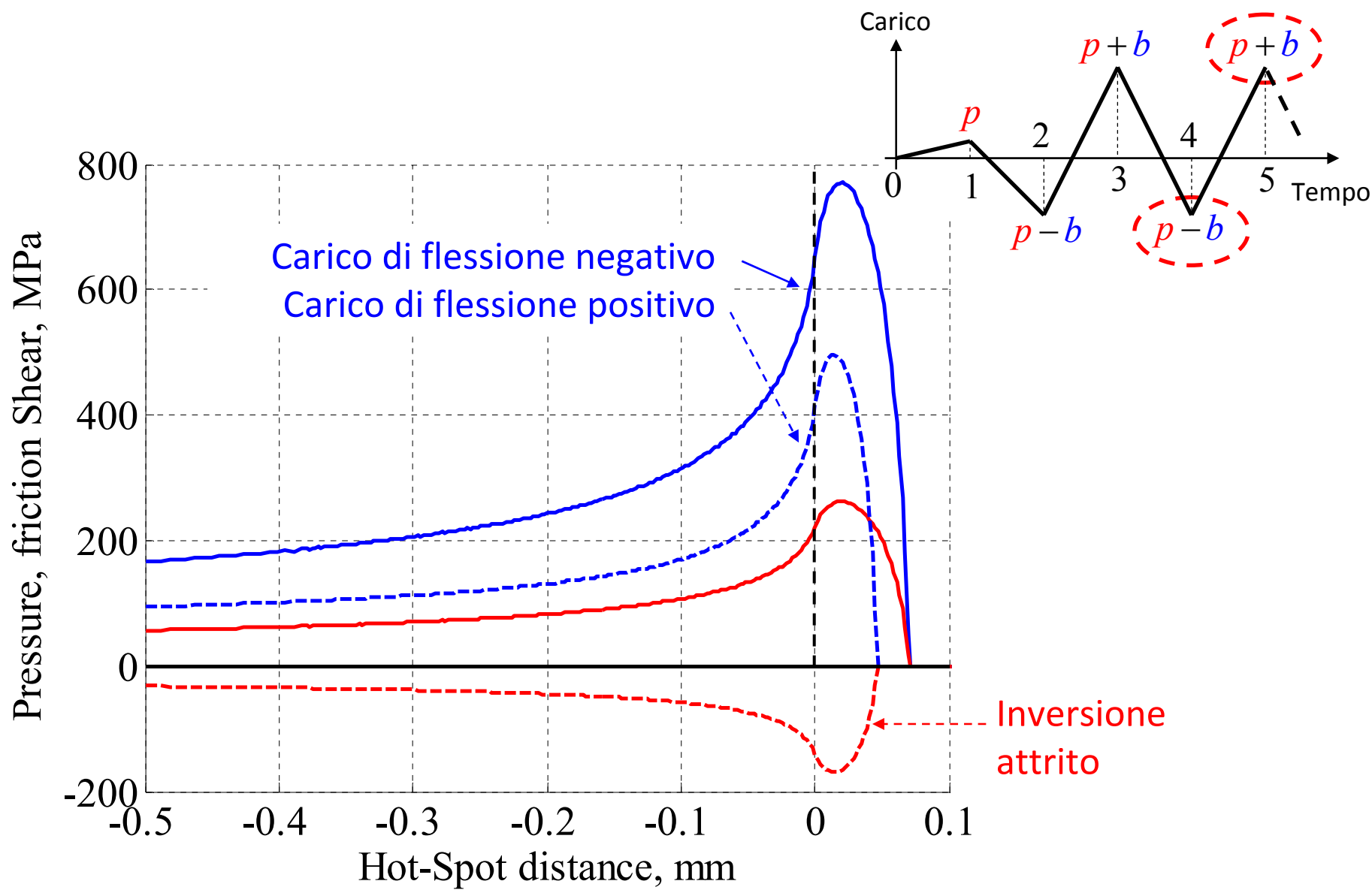
Distribuzione delle pressioni di contatto



Distribuzione delle pressioni di contatto

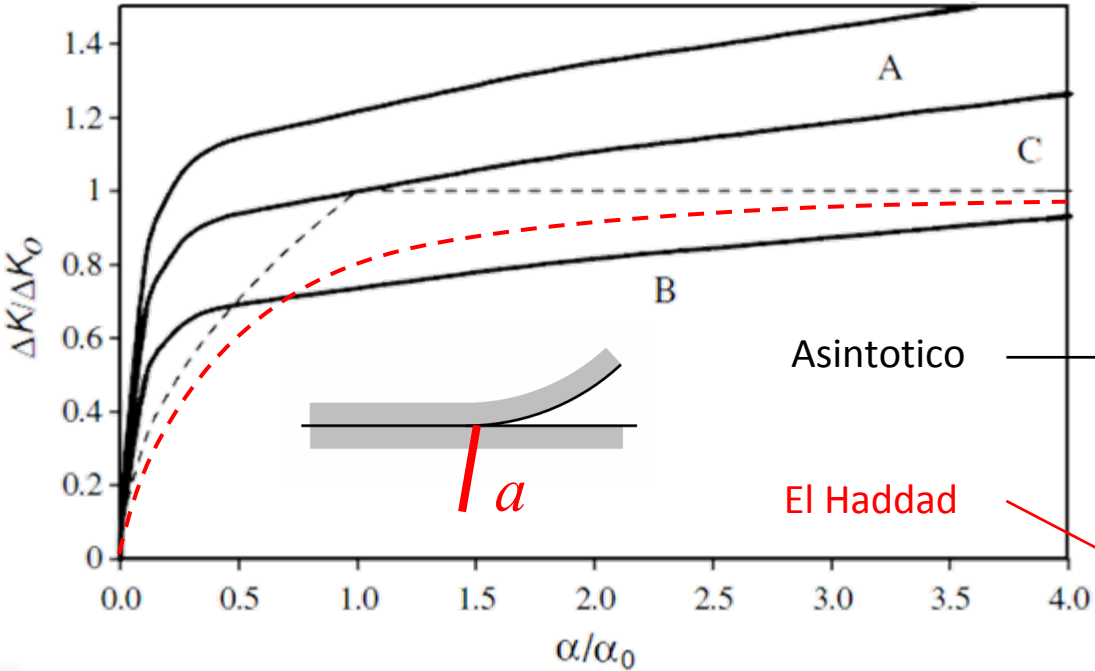


Distribuzione delle pressioni di contatto



Modello (Short) Crack Arrest

Kitagawa-Takahashi diagram



$$a_0 = \frac{1}{\pi} \left(\frac{\Delta K_{th}}{\Delta \sigma_{fl}} \right)^2$$

$$\Delta K_{th} = \Delta K_{th} \sqrt{\frac{a}{a_0}}, \text{ se: } a \leq a_0$$

$$\Delta K_{th} = \Delta K_{th}, \text{ se: } a > a_0$$

$$\Delta K_{th} = \Delta K_{th} \sqrt{\frac{a}{a + a_0}}$$



D. Nowell, D. Dini, D.A. Hills, "Recent developments in the understanding of fretting fatigue", Engineering Fracture Mechanics, 73(2), 207-222 (2006).

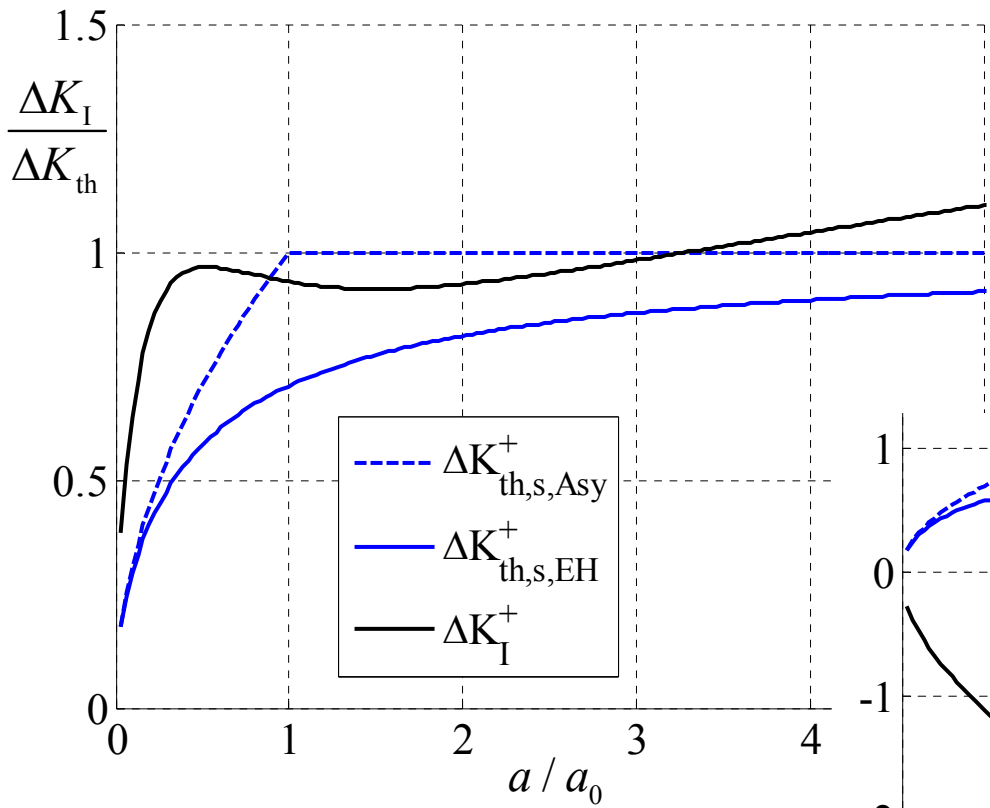
D.A. Hills, A. Thaitirarot, J.R. Barber, D. Dini, "Correlation of fretting fatigue experimental results using an asymptotic approach", International Journal of Fatigue, 43, 62-75 (2012).

J.A. Araújo, D. Nowell, "Analysis of pad size effects in fretting fatigue using short crack arrest methodologies", International Journal of Fatigue, 21(9), 947-956 (1999).

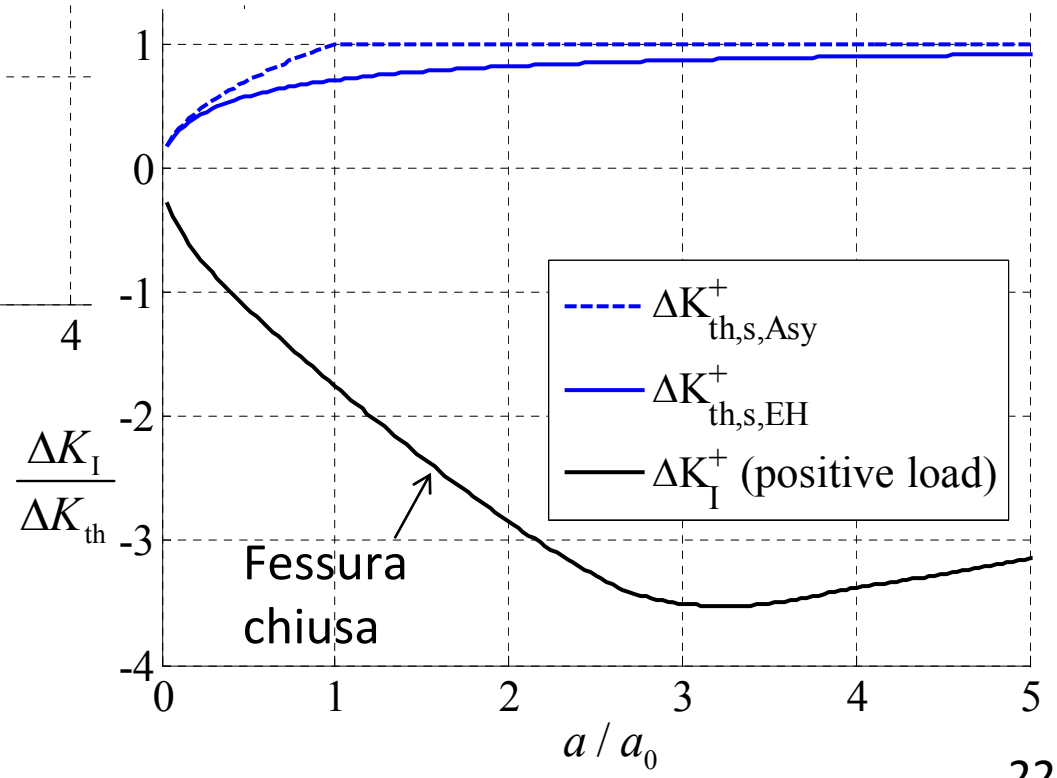
D. Dini, D. Nowell, I.N. Dyson, "The use of notch and short crack approaches to fretting fatigue threshold prediction: Theory and experimental validation", Tribology International 39(10), 1158-1165 (2006).

Modello Crack Arrest

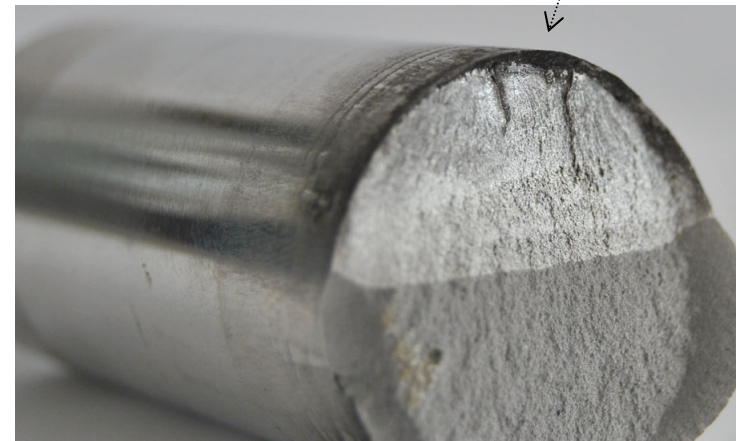
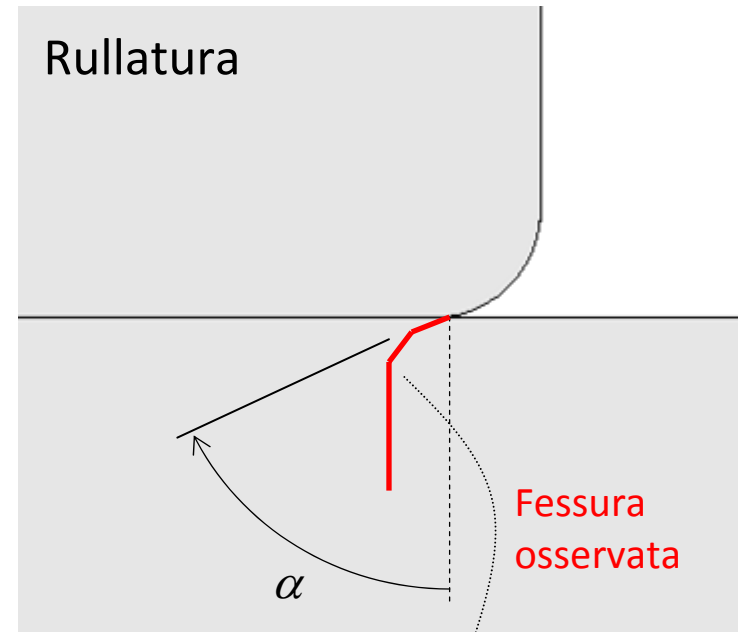
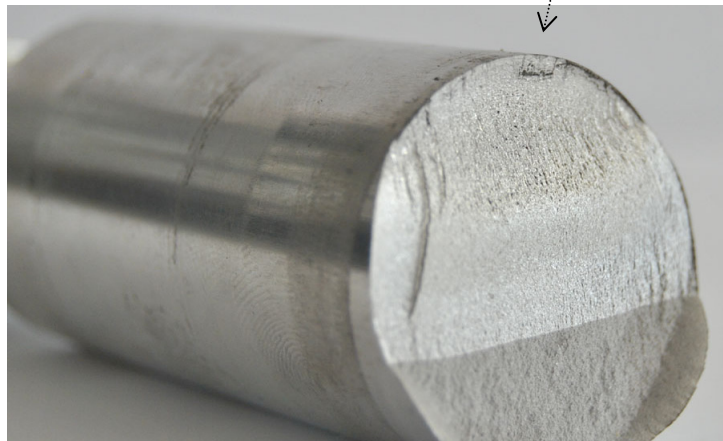
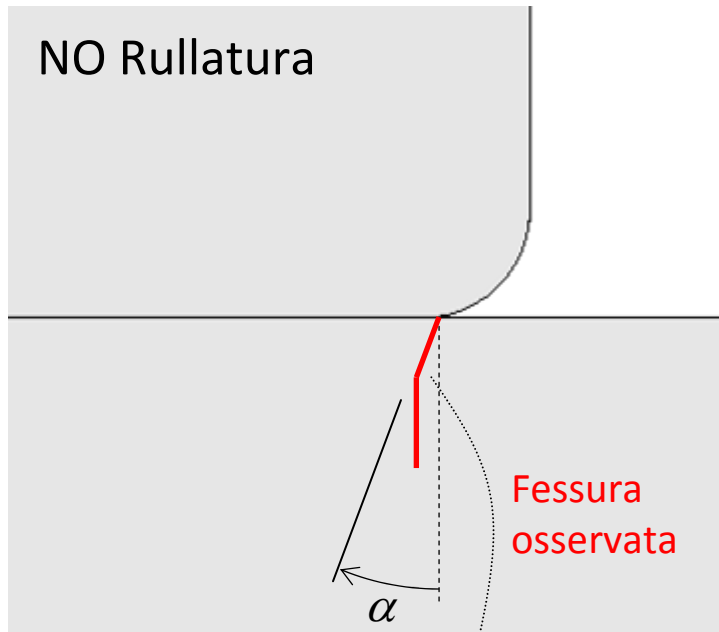
NO rullatura



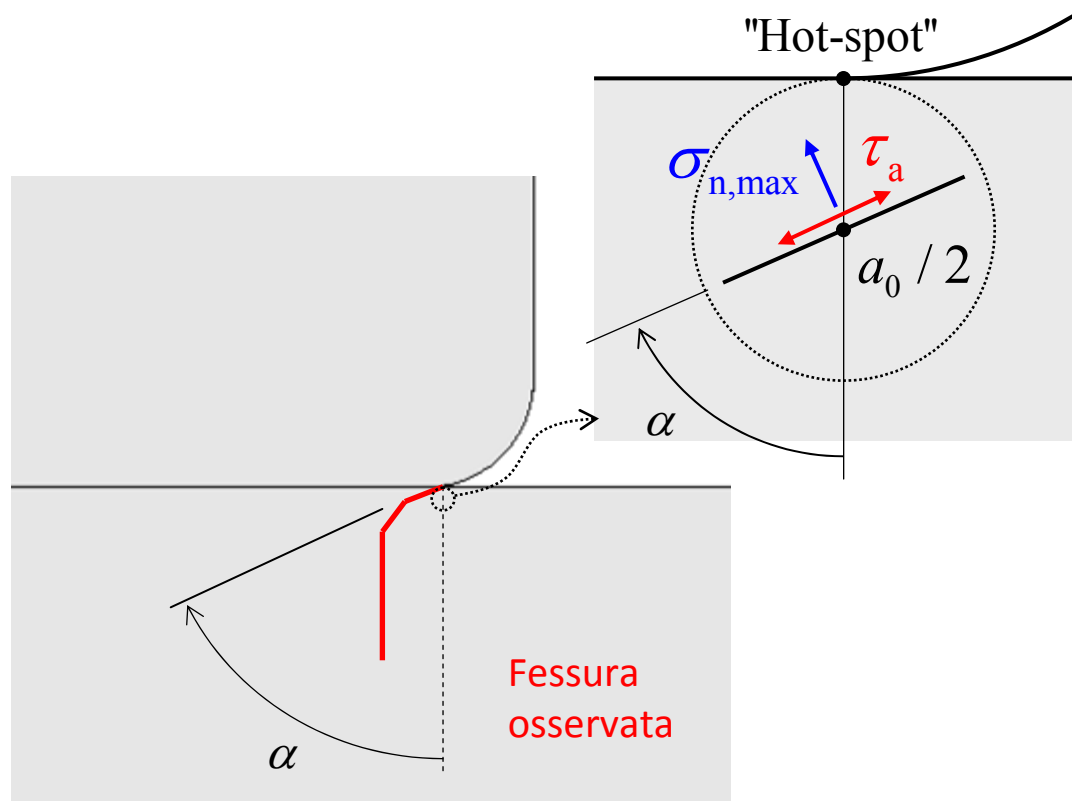
SI rullatura (tensioni residue compressione)



Evidenza sperimentale, inclinazione fessura



Modello - Critical Plane



Piano critico,
taglio (ciclico)

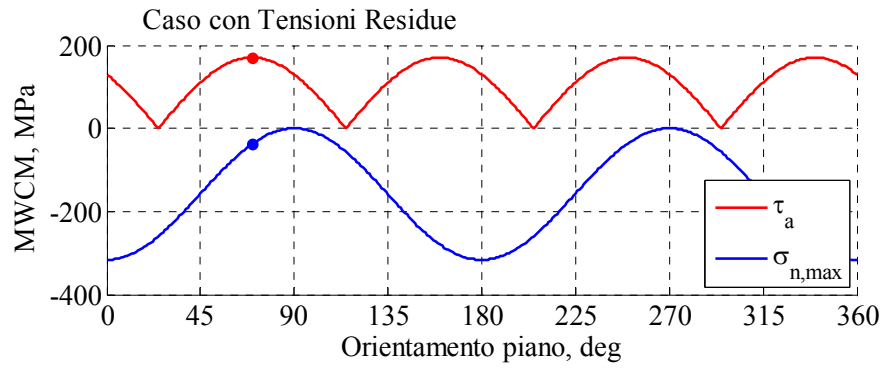
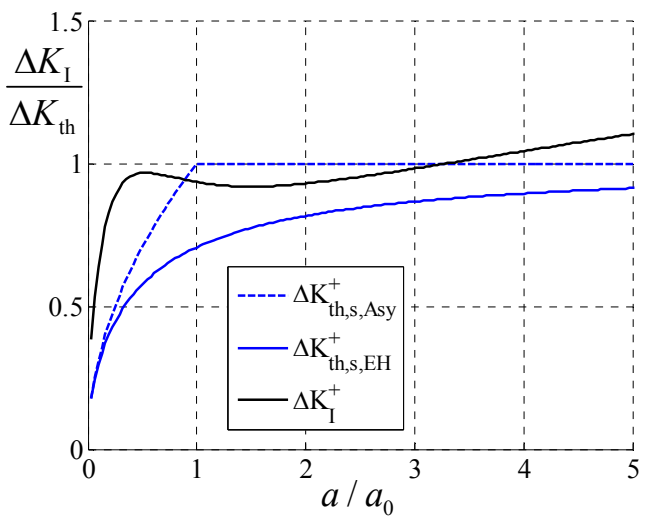
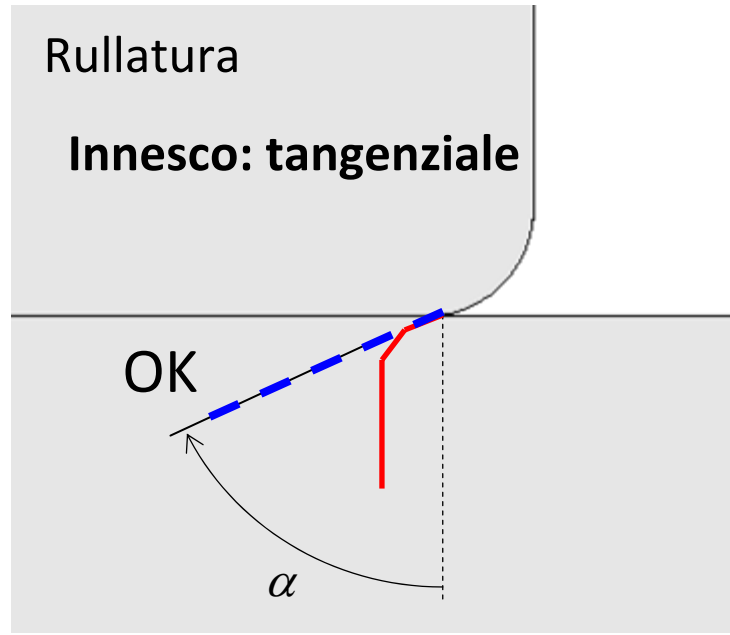
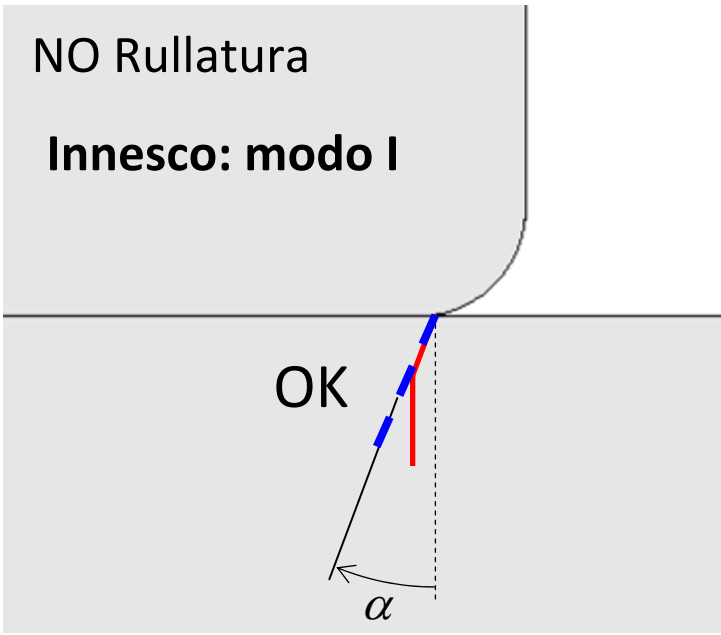
MWCM:

$$\tau_{a,eq} = \tau_a + K \frac{\sigma_{n,max}}{\tau_a}$$

J.A. Araújo, L. Susmel, D. Taylor, J.C.T. Ferro, E.N. Mamiya, "On the use of the Theory of Critical Distances and the Modified Wöhler Curve Method to estimate fretting fatigue strength of cylindrical contacts", International Journal of Fatigue, 29(1), 95-107 (2007).

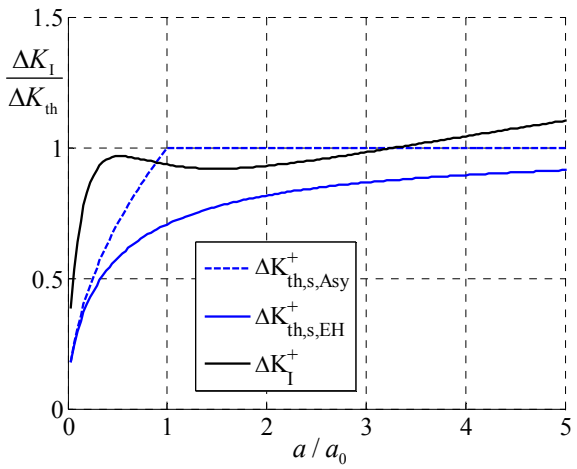
J.A. Araújo, F.C. Castro, "A comparative analysis between multiaxial stress and ΔK -based short crack arrest models in fretting fatigue", Engineering Fracture Mechanics, 93, 34-47 (2012).

Crack Arrest NO rullatura, Critical Plane rullatura



- Nuovo setup di prova *Fretting Fatigue*
- Effetto della lubrificazione sull'interfaccia di contatto
- Incremento di resistenza dovuto alla Rullatura
- Modello *Crack Arrest* valido per il caso senza tensioni residue
- *Critical Plane* valido per i rullati, OK angolo iniziale fessura

Grazie per l'attenzione ...



domande?

