THERMAL CONTACT RESISTANCE: EFFECT OF ELASTIC DEFORMATION

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OVERVIEW

- introduction and motivation
- microhardness
- model
- present model
- parametric study
- comparison with experimental data
- conclusions

INTRODUCTION

- due to load constraints in *microelectronics* and *avionics* applications, **Thermal Contact Resistance** (TCR) at low contact pressure is important

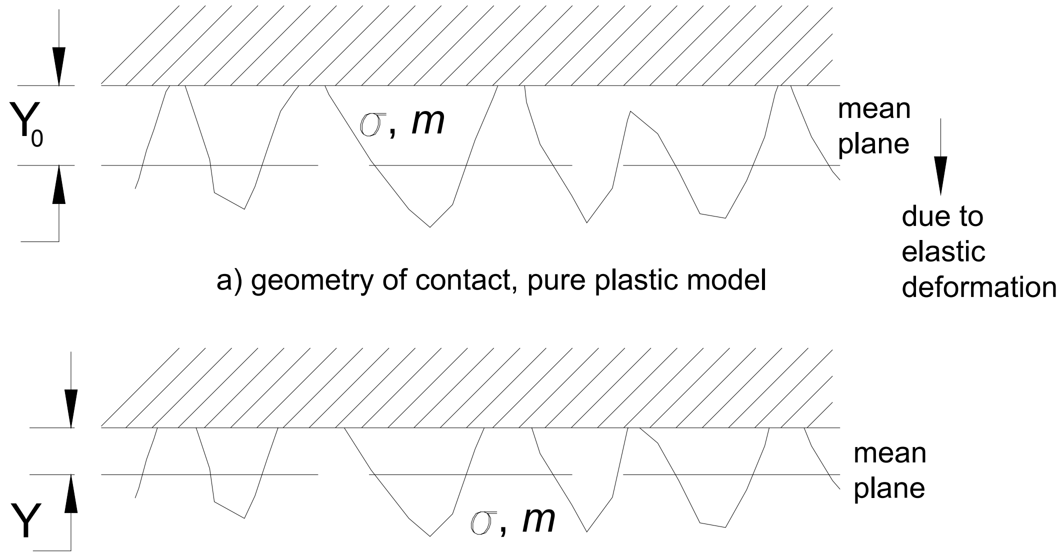
- Milanez et al. (2003) experimentally showed that existing *plastic* models over-predict TCR at low contact pressures

- new analytical model is developed that predicts TCR at low pressure

- model considers the effect of elastic deformation underneath *plastically* deformed microcontacts

PROBLEM STATEMENT

- contact of conforming rough surfaces in a vacuum
- real contact area is less than 1% of nominal contact area
- using plasticity index, one finds the deformation mode of asperities is **plastic**
- existing plastic TCR models neglect the elastic deformation beneath microcontacts



a) geometry of contact, pure plastic model

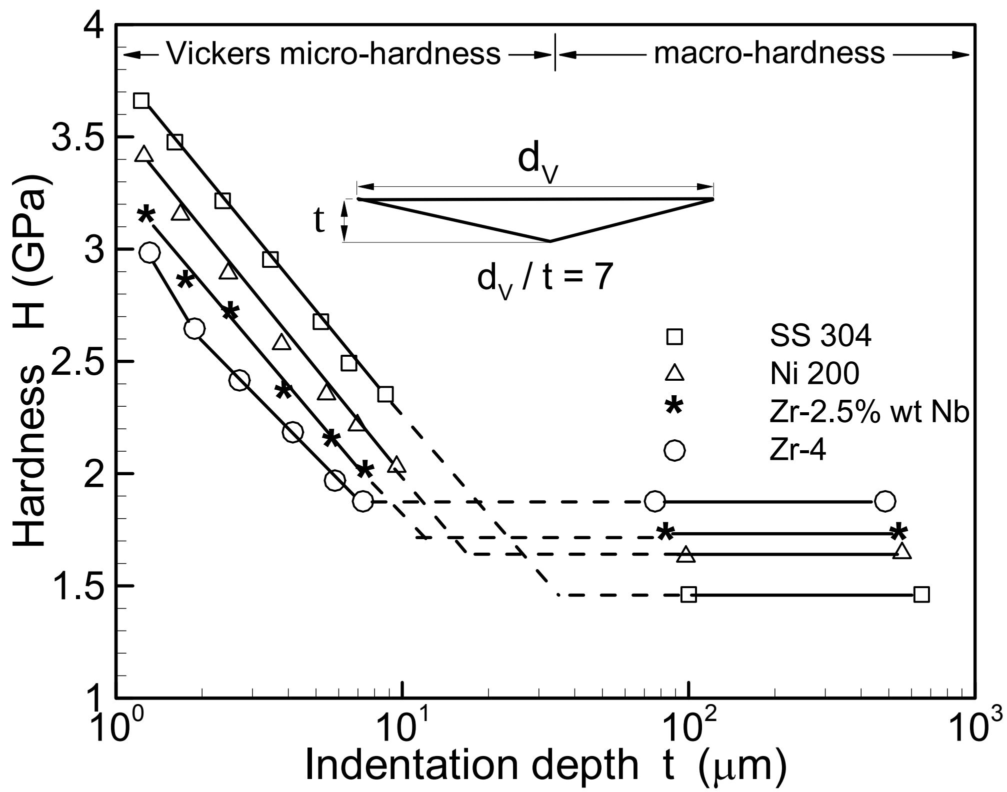
b) plastically deformed asperities with elastic deformation

as a result of elastic deformation, separation between planes reduces, thus:

- more microcontacts are created

MICROHARDNESS

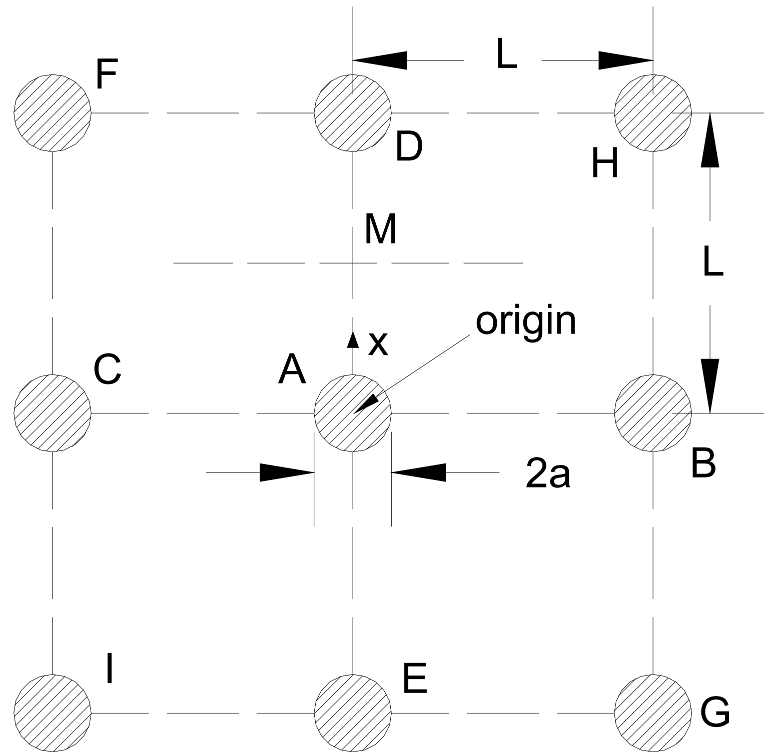
- microhardness is not a constant of material
- as indentation depth increases, microhardness decreases



experimental data from Hegazy (1985)

GEOMETRY OF MODEL

- microcontacts are assumed to deform **plastically**
- elasticity theory is used to determine elastic deformation of half-space due to microcontacts
- elastic deflections due to self and neighboring microcontacts are superimposed to find total deformation



modeled geometry of contact

ELASTIC DEFORMATION BENEATH MICROCONTACTS

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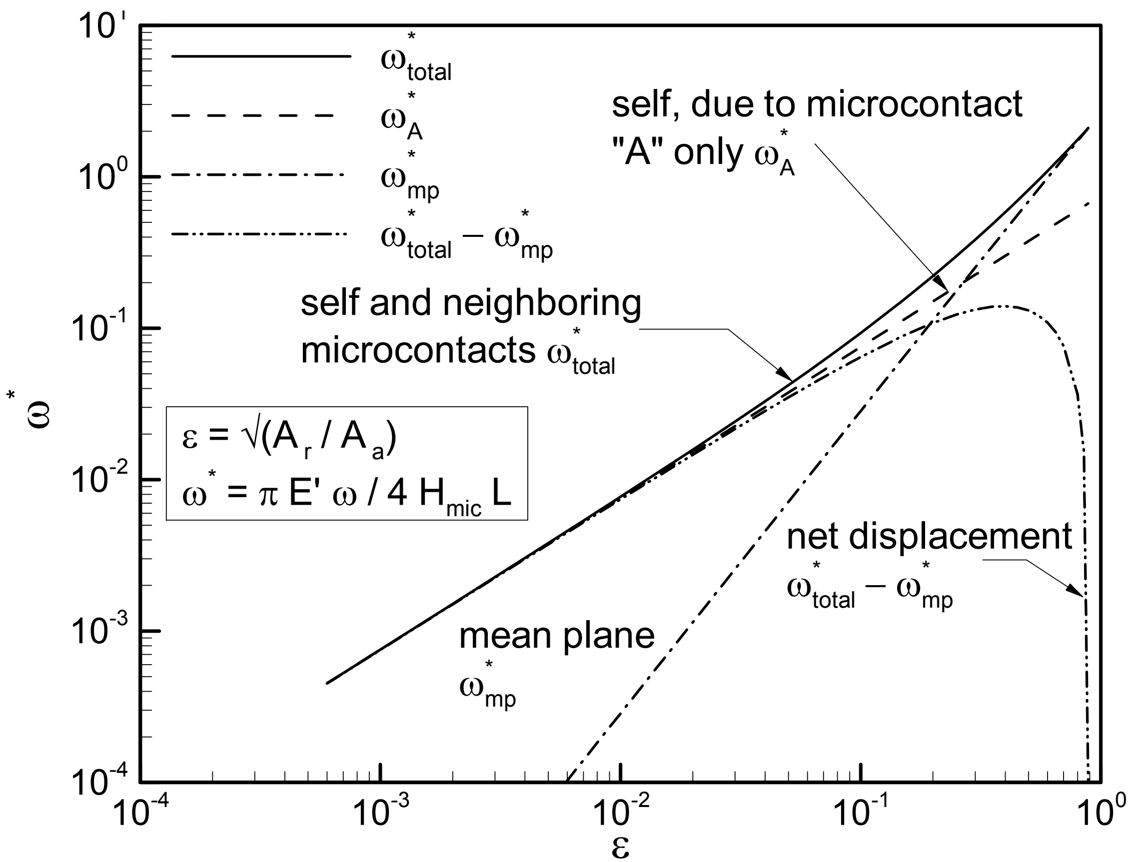
- at low contact pressures, effects of neighboring microcontacts can be ignored.
- as ε increases, effect of neighboring microcontacts become significant, also displacement of mean plane increases
- as a result, the net elastic deformation beneath the microcontact becomes smaller and eventually approaches zero at relatively large loads

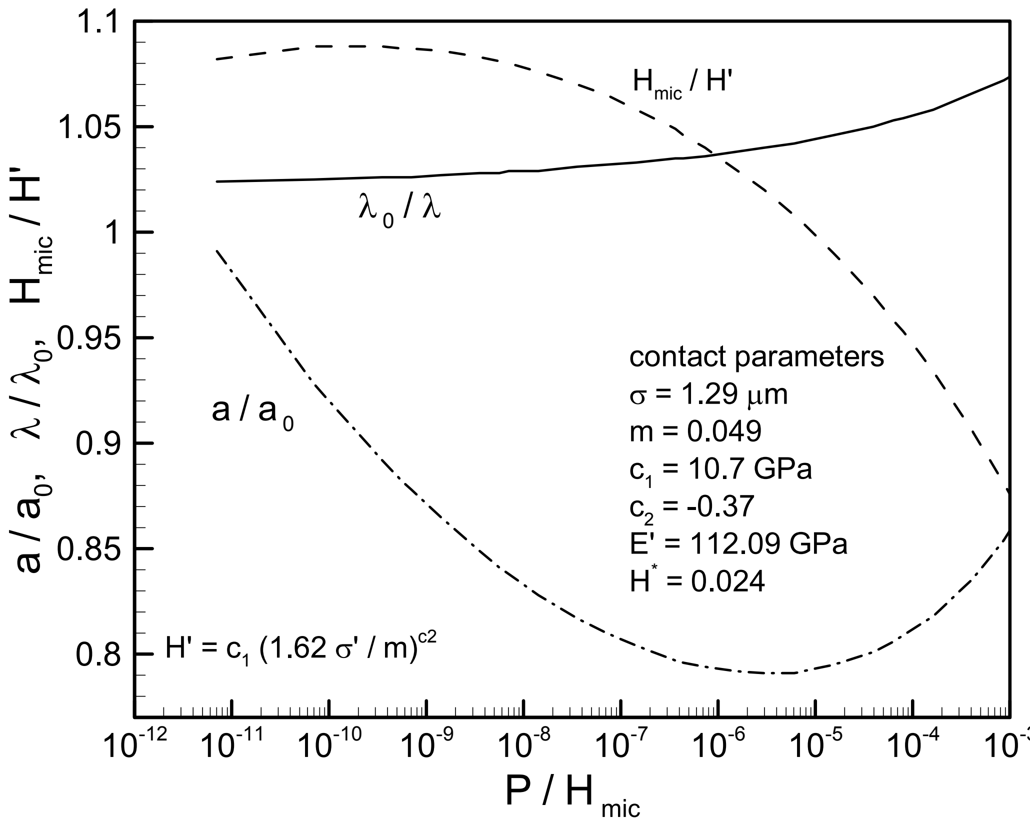


EFFECT OF ELASTIC DEFORMATION ON CONTACT PARAMETERS

- ratio of separations $\lambda_0/\lambda > 1$, due to elastic deformation effect

- ratio of microcontacts radius $a/a_0 < 1$, but absolute radius of microcontacts, a, increases by increasing the load

- effective microhardness H_{mic} decreases as load increases



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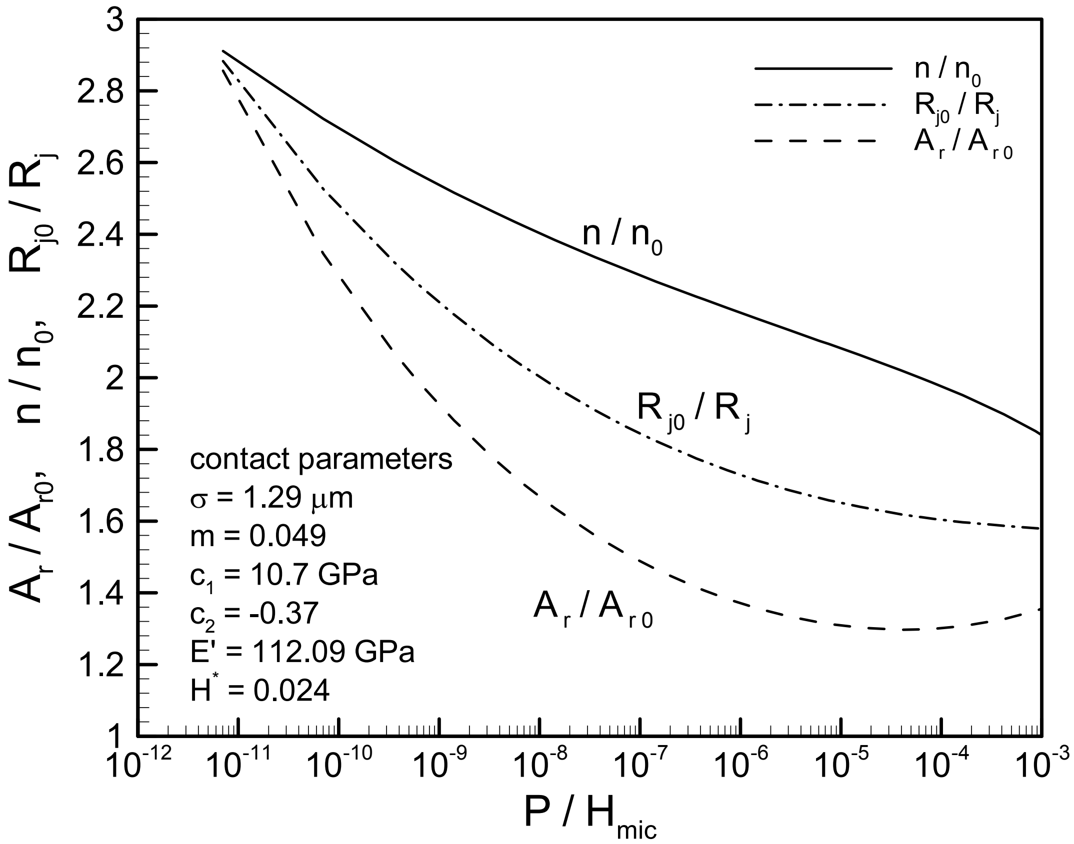
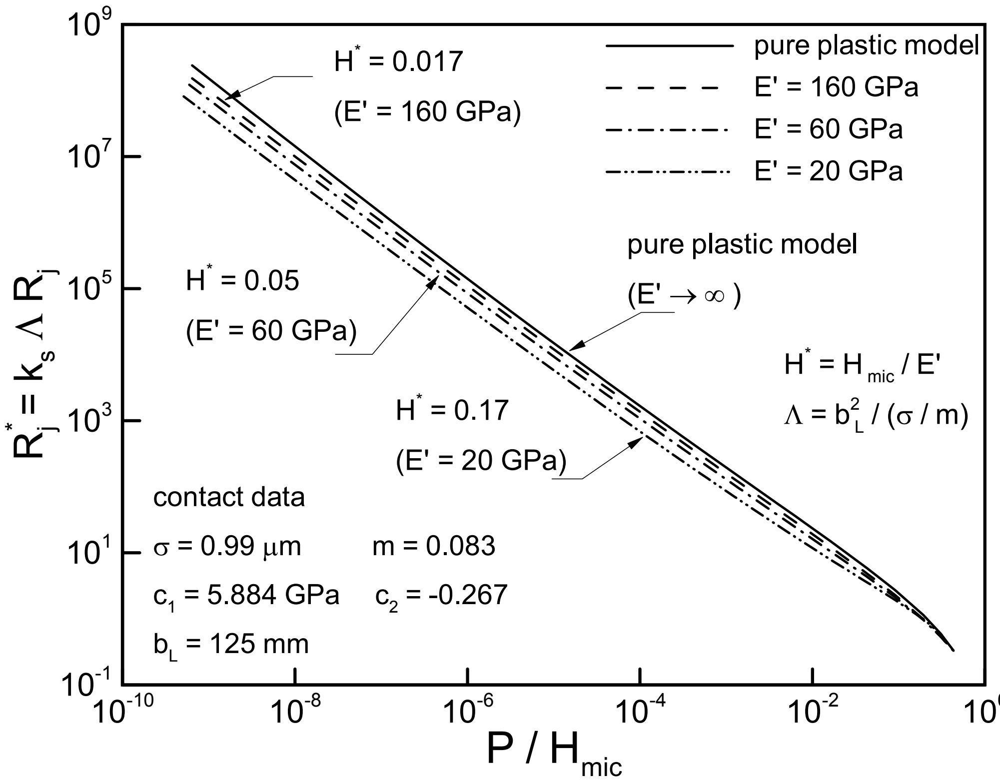
- as a result of smaller separation:
- more microcontacts are formed *$n / n_0 > 1$*
- real contact area is increased, *$A_r / A_{r0} > 1$*
- thermal resistance is decreased, *$R_{j0} / R_j > 1$*



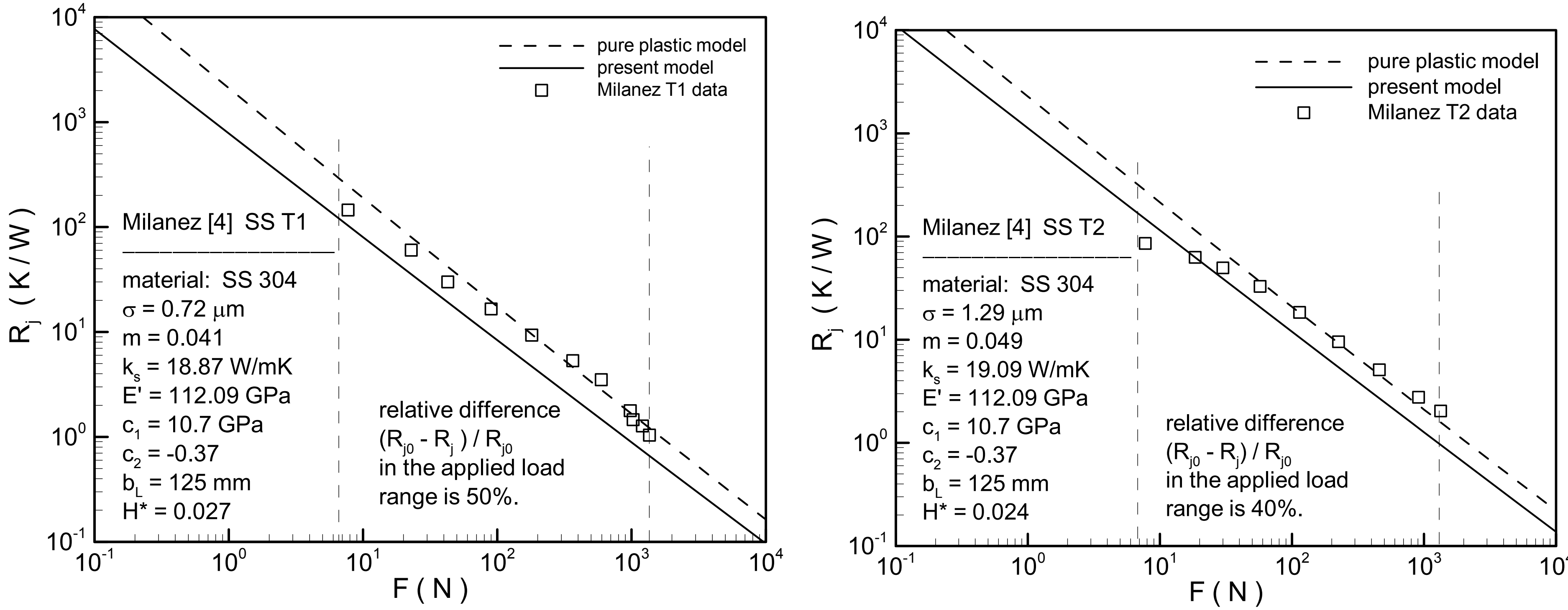
PARAMETRIC STUDY: ELASTIC MODULUS

- four values of E' = 20, 60, 160 GPa, and ∞ (pure plastic model) selected
- difference between model and pure plastic model decreases as P/H_{mic} increases
- beyond certain pressure, difference between pure plastic model and the present model (three values of E') becomes negligible



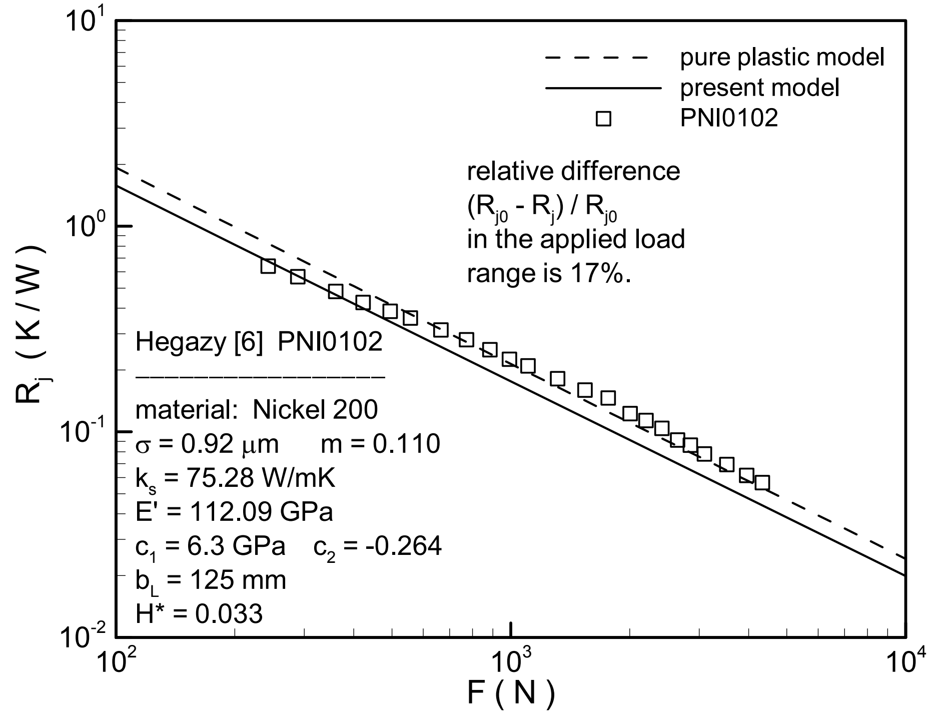
effect of elastic deformation is more important at low loads

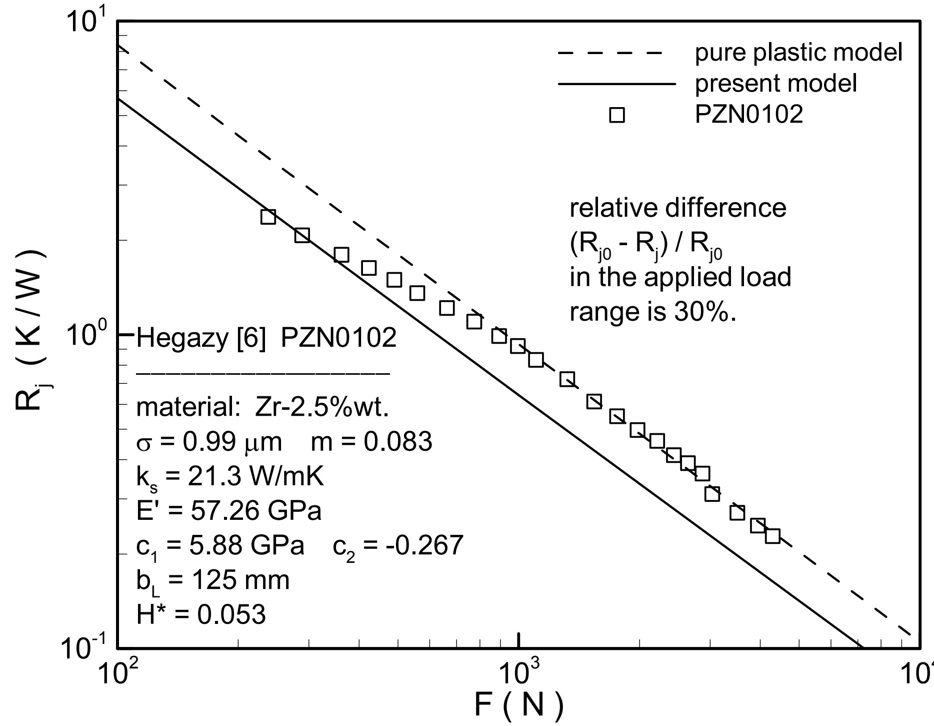
COMPARISON WITH MILANEZ ET AL DATA



experimental data from Milanez et al. (2003)

COMPARISON WITH HEGAZY DATA





experimental data from Hegazy (1985)

SUMMARY AND CONCLUSIONS

- new analytical model is proposed for TCR of conforming rough joints in vacuum that accounts for elastic deformation of substrate

- as a result of elastic deformation, mean separations between two contacting surfaces becomes smaller; thus
  - more microcontacts are nucleated,
  - real contact area is increased,
  - thermal contact resistance is decreased

- elastic deformation effect becomes less important at higher loads

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QUESTION?

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