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On the transient thermomechanical contact simulation for two rough sliding bodies – WTC 2021, Lyon

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A thermomechanical contact model is presented that takes into account the influences of transient contact areas, temperature evolution and thermoelasticity. To this end, the classical contact simulation approach is extended by an additional thermomechanical part. The time dependency can be attributed to the two sided roughness and results in time dependent contact forces, contact areas and temperatures. Friction itself is therefore understood as transient process.
Keywords (from 3 to 5 max): transient, thermoelasticity, contact mechanics

1. Introduction

How big are the contact forces or the coefficient of friction between two contacting bodies? This question has been occupying researchers for many years and still cannot be answered precisely. It is at least known that surface roughness plays a significant role. Nevertheless, measurements or empirical friction laws also highlight the importance of sliding speed, a fact that suggests to look at temperature evolution due to frictional heat and its consequences as well. Therefore, a thermomechanical contact model with inclusion of roughness, velocity and associated frictional heat appears to be a realistic one.

2. Thermomechanical model

In order to simulate the transient thermomechanical contact for two rough sliding bodies the following steps are necessary.

2.1. Basic equation
Heat conduction equation and Lamé-Navier equations

$$\kappa\boldsymbol{\Delta}\theta = \frac{\partial\theta}{\partial t}, \quad \theta = T - T_0$$
$$\boldsymbol{\Delta r} + \frac{1}{(1-2\nu)}\boldsymbol{\nabla}(\boldsymbol{\nabla}\cdot\boldsymbol{r}) = \frac{2(1+\nu)}{(1-2\nu)}\alpha\boldsymbol{\nabla}\theta$$

are solved for one mechanically/thermally loaded element with lengths $2a \times 2b$ on the surface. So-called influence functions are obtained which couple the surface loads analytically to stresses, displacements and temperatures within and on the bodies.

2.2. Assumptions
Further assumptions that are included in the solution process are that the rough bodies may be modelled as halfspace, that the frictional power is completely transformed into heat $q = \tau_s v$ using linear heat partitioning law and that the surfaces are thermally insulated. In general, the yield shear stress τ_s can be a function of temperature θ and sliding velocity v.

2.3. Solution Procedure
A time dependent inverse contact problem

$$\boldsymbol{Cp} = \boldsymbol{w} + \begin{cases} \boldsymbol{w}_p \in \Gamma_{ic} \\ \boldsymbol{g} \in \Gamma_{nic} \end{cases}$$
$$0 \le p \le H$$

is obtained in which $\boldsymbol{w}$ additionally contains the thermoelastic distortions in comparison to pure mechanical contact simulations. The system of equations is solved with the classical Conjugated-Gradient method including active sets [2]. Pressures p are limited to positive values below the hardness H of the softer material. An additional inner iteration loop has to be added in order to map the temperature field adequately.

3. Results & Discussion

Some typical results are shown in figure 1 and 2 for two periodic rough sliding surfaces. The transient temperature rise is shown in a steady state in figure 1 and is also periodic due to the periodicity of both surfaces. Typical flash temperatures can be observed which are frequently reported in literature.
Figure 2 depicts a calculated friction coefficient that oscillates with sliding distance due to the two sided roughness and consequently changing contact conditions. Friction itself is therefore understood as transient process.

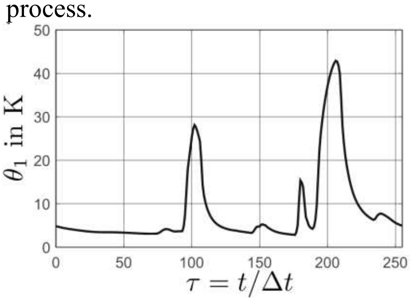

Figure 1: Transient temperature

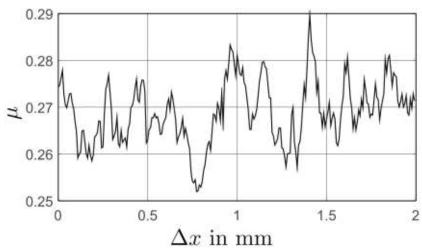

Figure 2: Transient friction coefficient

4. References

[1] Johnson, K.L. (1987). *Contact Mechanics*. Cambridge University Press.
[2] Allwood, J. (2005). Survey and performance assessment of solution methods for elastic rough contact problems. *J. Trib.*, *127*(1), 10-23.