Multi-scale 3D simulation of the temperature distribution in a sliding contact under severe conditions

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The interface temperature in a sliding contact is hard to measure experimentally whereas it is a key parameter governing friction and wear. This paper presents a multi-scale approach to estimate the 3D temperature distribution at the contact interface by coupling a meso-scale thermomechanical contact model and a full scale heat transfer model. A sensitivity study is first performed to highlight the influential factors while a dedicated laser-based inverse procedure has been applied to calibrate the pin & pin holder thermal contact conditions. It is shown that a reliable temperature prediction can only be achieved by considering the problem at all scales.

Keywords: modeling, heat transfer, finite element analysis, severe conditions

1. Introduction

Monitoring the temperature distribution in a sliding contact still remains a true scientific and technical issue, especially at high contact pressure and sliding velocity. Attempts have been performed using infrared imaging but the limited spatial resolution, large temperature gradients and out-of-plane phenomena make the quantification very critical [1]. To alleviate this, the numerical simulation appears as a relevant alternative to investigate the thermal contact conditions [2] in such confined and strongly coupled tribosystems. A dedicated methodology thus has to be developed to properly model the thermal problem and achieve reliable predictions.

2. Numerical & Experimental methods

2.1. Numerical strategy

A cemented carbide pin sliding against a medium carbon steel are considered in this work. A first thermally-coupled scratching model was developed under an explicit framework (Fig. 1a) to assess the thermomechanical loadings withstood by the pin at the microscale. The simulated heat flux distribution was then used as a heat input in a full scale 3D heat transfer model (Fig. 1b) to reach the thermal steady-state and give an insight into the temperature reached in the contact zone. A sensitivity analysis showed that the thermal contact resistance (TCR) between the pin and pin-holder was the key factor (Fig. 2d), not only affecting the final temperature but also kinetics by controlling the dissipation rate to the pin-holder.

2.1. Experimental identification of the TCR

A dedicated set-up with a laser source was used to heat either a pin alone or a pin+pin-holder system equipped with thermocouples. An inverse method, based on a FE model of each configuration, was employed to identify the actual TCR value based on the best fit between experimental and simulated temperature measurements.

3. Main conclusions

The proposed multi-scale approach showed that reliable 3D temperature distribution could be achieved but requires the consideration of the full 3D problem as well as properly calibrated boundary conditions (TCR).

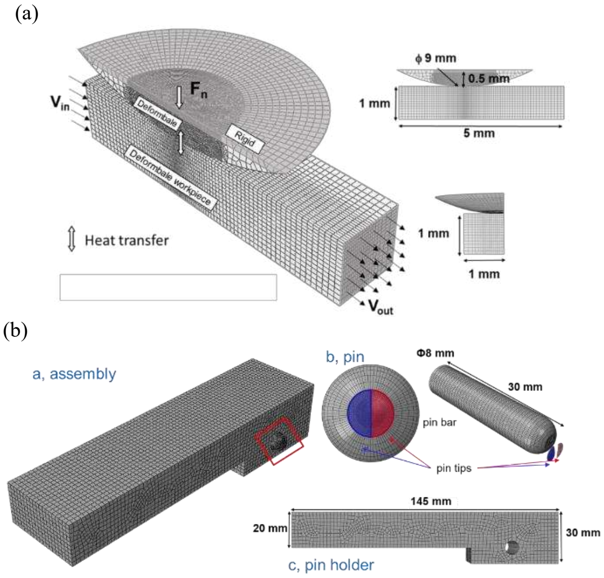

Figure 1: (a) Thermomechanical meso-scale scratch model [1]. (b) Full scale coupled thermal model.

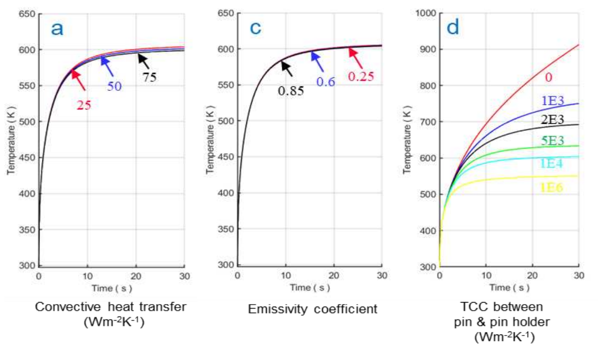

Figure 2: Influence of the boundary conditions on the average pin surface temperature.

4. References

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