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MODELING TEMPERATURE RISE IN MULTI-TRACK RECIPROCATING FRICTIONAL SLIDING

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ABSTRACT
Temperature rises due to distributed heat flux spot moving over a surface have been long studied for a single pass, and for reciprocation over the same track where temperatures reached during subsequent passes are augmented as they occur atop temperature rises persisting from prior passes. In tribological testing there are instances where it is instead desired to slide over fresh surface, which in reciprocation can be achieved by a sideways increment in position at the end of each stroke, yielding a collection of multiple parallel neighboring tracks. In such a 'multi-track' case it is anticipated that temperature rises during a given pass will again be augmented by those prior passes over neighboring tracks, though not to the same extent as when prior passes are over the same track.

This model considers a circular heat spot of radius a of uniform flux $\dot{q}$ translating over a half-space of thermal conductivity K and diffusivity κ at speed v along the x-direction for length L during each stroke, and being incremented sideways by distance fa in the y-direction at stroke's end to create the subsequent neighboring parallel track during the stroke back, with the z-direction into the subsurface. τ is the period for a full back&forth reciprocation cycle, so at mid-stroke (x=L/2) position τ /2 represents the elapsed time since passage of the heat flux on the neighboring track. To broaden applicability of output the model was non-dimensionalized, normalizing lengths to a, times to a^2/κ, temperatures to $\dot{q}a/K$, and speed represented by Peclet number P_e=$va/(2\kappa)$.

In Fig.1 an example temperature rise history is shown for the case of f=1, τ*=1 and P_e=40 at an arbitrary point of interest z*=0.3 in the subsurface at mid-stroke (x*=L*/2) and y*=6.5 midway between the 7th and 8th pass, where the maximum temperature rise occurs during that 8th pass due to its proximity as well as temperature rises still persisting from the prior equally proximal 7th pass. By repeated runs ΔT^*_{max} may be mapped at any location (y*, z*) in the subsurface cross-section normal to the stroke. In the case of τ*=∞ (temperature rise during any pass independent of prior passes) initially studied, it was found that isotherms at any high P_e≥40 would collapse and superimpose if subsurface position z* and isotherm ΔT^*_{max}value are both multiplied by $\sqrt{P_e}$. As shown in Fig.2 where maximum temperature rises $\Delta T^*_{max}\sqrt{P_e}$ are mapped out in the cross-section between the centers of the 7th and 8th passes in such an f=1 case, as values of τ* are made finite, isotherms of any given value shift and move to greater depths while values of temperature rise reached on the surface increase as heating during prior neighboring passes still persists to indeed augment temperature rises during subsequent passes. Of additional note is that cases with the same product $P_e\tau$* (equivalently L*) seem to produce common isotherms displaying equivalent augmentations.

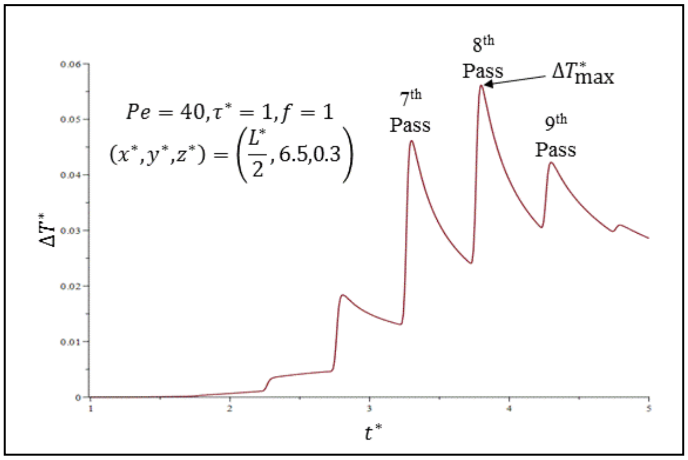

Figure 1 – temperature rise history at a point in multi-track reciprocation

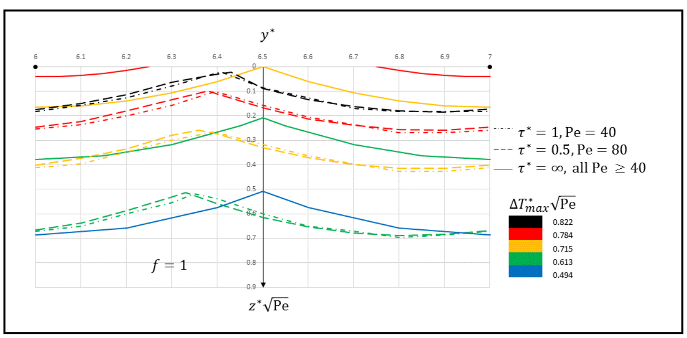

Figure 2 – isotherms of maximum temperature rise mapped through the cross-section between two neighboring successive tracks