

Reply to comments on: Fundamental aspects and technological implications of the solubility concept for the prediction of running properties

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Reply to comments on "Fundamental aspects and technological implications of the solubility concept for the prediction of running properties"

Contaminating films can have a substantial effect on the sliding behaviour of metallic couples, the actual influence depending on the type and thickness of the particular film involved. We thank Dr. de Gee for stressing this point.

From ref. 1 at least three regimes of film influence on dry sliding may be suggested, *i.e.* (1) regime A where the contaminating film has a negligible effect on metallic interaction, (2) regime B where the contaminating film has a mitigating effect on metallic interaction and (3) regime C where the contaminating film has a positive effect on metal transfer. In addition a regime D may be discerned for certain material combinations and experimental conditions in which the contaminating layers strongly reduce wear [2].

Regime A occurs if no or hardly any film can be formed because of the purity of the environment (*e.g.* ultrahigh vacuum) or if potential thin films are ruptured at the real contacts during sliding because of insufficient mechanical support by a weak substrate (*e.g.* silver on pure iron in an inert gas containing less than 0.5 ppm O₂ [1]). In this regime direct metallic contact between the sliding members prevails over nearly the whole real contact area, usually resulting in metal transfer.

Regime B occurs at slightly higher oxygen pressures, *e.g.* 50 - 100 ppm O₂ in argon for de Gee's tests with Au-Ag alloys against steel [3]. Very thin iron oxides are supposed to shield the surfaces partially from metallic interaction. The remaining interaction causes a behaviour as predicted by the "classical" solubility concept. This behaviour seems to agree rather well with common engineering practice and reasons can be found to explain why regime B prevails in contacts not heavily loaded.

For regime C, somewhat higher oxygen pressures are required (over 1000 ppm O₂ in argon for silver on steel [4]). The films formed now seem to act to a certain extent independently of the metallic substrate (at least, the applicability of the solubility concept is excluded) and favour the occurrence of transfer.

Although the experiments and calculations in ref. 5 concern regime A, we feel that the model proposed will be applicable to regime B as well. Further, because the low accessibility of running surfaces to oxygen in

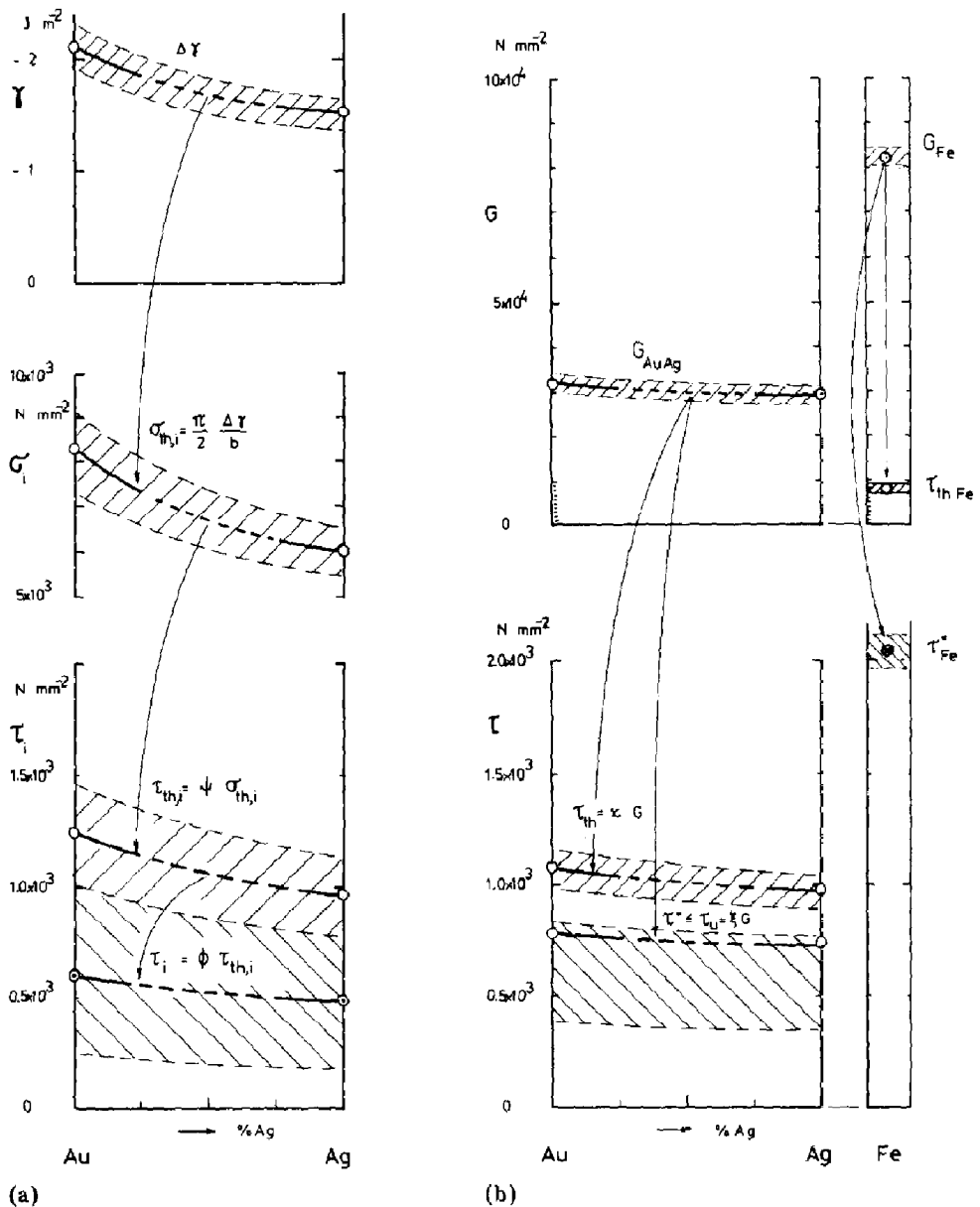


Fig. 1. (a) Interfacial shear strength $\tau_{th,i}$ of the atomic contacts between Au-Ag alloys and iron as a function of the alloy composition, and indication of the derivation of τ_i from the work of adhesion $\Delta\gamma$. (The shaded areas suggest the possible spread of the quantities involved.) (b) Values of the shear strengths τ_{th} and τ^* of running surface materials for the atomic and real contacts respectively.

lubricated systems makes such systems comparable with regime B, the model will also be relevant to engineering situations.

The value of the junction strength ratio T is taken as a criterion for the possibility of metal transfer where

$$T = \frac{\text{shear strength of the interface of a junction}}{\text{shear strength of the adjacent junction material}}$$

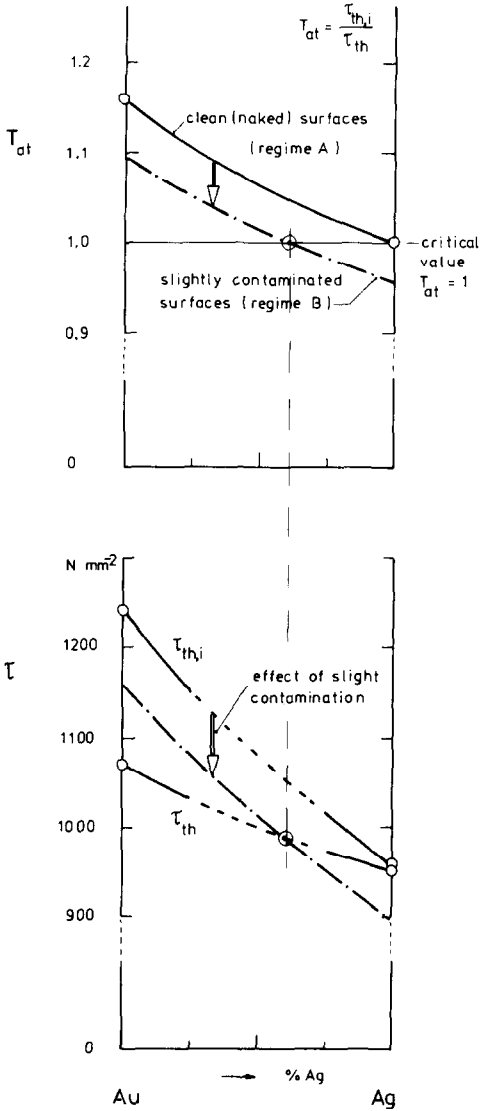


Fig. 2. Comparison of the interfacial and weakest running surface material shear strength values for atomic contacts between Au-Ag alloys and iron, and the ratio T of these quantities. The reductions in $\tau_{th,i}$ and T_{at} caused by very slight surface contamination (regime B instead of regime A) are indicated by the arrows.

T can be applied to atomic contacts ($T_{at} = \tau_{th,i}/\tau_{th}$) and to real contacts ($T_r = \tau_i/\tau^*$). When both T_r and T_{at} are greater than or less than unity a strong transfer tendency or no transfer respectively may be expected, while for $T_{at} > 1$ and $T_r < 1$ an intermediate behaviour seems probable. Figure 1 depicts schematically the derivation of the interfacial and running surface shear strength values for uncontaminated contact between Au–Ag alloys and iron or steel, and Fig. 2 shows T_{at} as a function of the alloy composition for the weakest contact member. Obviously for all compositions transfer is predicted, in accordance with our experimental findings. If slight contamination of one or both surfaces causes a reduction in the interfacial strength T_{at} will be reduced in regime B with respect to regime A as depicted by the arrow in Fig. 2, and consequently transfer becomes probable up to a critical silver content only, as found experimentally by de Gee. In view of our approach the fact that the critical composition in ref. 3 equals that for vanishing iron solubility might be more coincidental than fundamental, the more so as the solubility of the alloy in the iron is not relevant. This point does not alter the fact that mutually soluble couples generally have a stronger tendency to metal transfer than do insoluble couples.

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