NASA TECH BRIEF

Marshall Space Flight Center

Thermal Contact Resistance in a Non-Ideal Joint

If heat is passing through a thermally conducting body, its energy level will drop linearly along the length of the conductor. However, if the body is divided by an interface, this energy drop will not be linear, but will normally show a sharp dip in the area of the interface. This additional resistance to heat flow caused by the presence of the interface is called the contact resistance. Contact resistance has been attributed to various phenomena including quantum effects due to misalignment of the crystal lattices, surface films, and heat flow constriction. The predominant effect, however, is constriction resistance.

An analysis has been conducted to determine thermal contact resistance at the interface of two heat conductors and the effect of the roughness of the mating surfaces on the pressure distribution. The analysis concerns three systems and encompasses the contact of two rough wavy surfaces, the contact of two rough but nominally flat plates pressed together over a concentrated area, and the contact of two rough but nominally flat plates bolted together. Specifically, the respective models for the above are: two spherical surfaces, two discs of finite radius, and two discs of finite radius with center holes.

In all three systems, the pressure distribution is calculated as a function of the surface and as a function of the surface properties. To solve the overall problem, force-deflection relationships are needed for asperities, spherical surfaces, and discs both with and without holes. The former two had been developed previously; the latter are developed as part of the study. Both discs with and without holes are treated as a classical mid-plane stress problem. With this treatment, a multiple Fourier-Bessel series technique provides accurate solutions for various models.

The investigation reveals how heat transfer resistance may be decreased or increased by changing the surface properties of the particular interface being considered. Due to the microscopic roughness, surfaces will not have 100% contact, but are in contact only where the asperities touch. The actual area of contact may be only 0.1% of the apparent contact area. Naturally, the heat will only flow through the actual area of contact, with significant constriction to the heat flow presented by the air gaps. When the surfaces are roughened, however, it is assumed that the actual contact area may increase and improve the heat conduction.

Two general conclusions have been drawn from this analysis. One is that a roughened interface shows no significant improvement in heat conduction. The second conclusion is that the multiple series technique used to develop these solutions has been proven successful in this application.

Notes:
1. Information concerning this study may be useful to engineers and scientists in the aircraft and electronic industries.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Code A&PS-TU
   Marshall Space Flight Center, Alabama 35812
   Reference: B73-10105

Source: R. T. Roca, B. B. Mikic of
Massachusetts Institute of Technology
under contract to
Marshall Space Flight Center
(MFS-21775)

Category 03, 02