THE COUPLED EVOLUTION OF LOAD DISTRIBUTION AND WEAR OF LEAD SCREW THREADS

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ABSTRACT

The manner in which a quasi-static load applied to a lead screw is distributed amongst its engaged threads is investigated using both analytical and numerical solution methods. It is desired to determine the breadth of loads sustained by the threads in a lead screw with wearing nut threads considering applied mechanical loads and varying temperature with thermal expansion mismatch, combined with loads due to initial out-of-tolerance non-uniform thread pitch. Existing research on the distribution of thread loads has been focused on non-wearing applications such as fasteners rather than wearing applications where continued sliding occurs.

A continuous thread analytical solution method is developed considering unworn threads, steady-state thread wear, and operating conditions that are suddenly changed from pre-existing steady-state wear values. Thread contact pressure, and therefore thread load, is proportional to the axial displacement of the screw body, which is an exponentially decaying function of the distance from the start of thread engagement at the loaded end of the screw. Thread stiffness is shown to significantly influence thread load distribution, and to a lesser extent, the engaged thread length is also shown to have an effect.

A discrete thread analytical solution method is developed considering not only the effect of steady-state operation, but additionally, transient operation where operating conditions are suddenly changed from pre-existing thread wear depths that are not necessarily those corresponding to a steady-state wear condition.

A numerical solution method based on a discrete thread model is also developed. The method involves performing a system of static force balances on the threads and then using the resulting thread loads to calculate the thread wear over a given sliding distance increment. Consideration is made for situations where threads

may temporarily become removed from contact due to step or rapid ramp changes in applied load and/or ambient temperature or due to initial thread geometric imperfections or a non-uniform pre-worn thread condition.

Finally, support of the analytical and numerical predictions of distributed thread wear depth is provided by performing measurements of two worn nut samples.