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Multi-physics analysis for MEMS meshing micro-gear contacts

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Abstract: Recent scientific and technical advances have enabled deposition of thin coating layers, such as silica or alumina (down to a few nano-meters). These have enabled the manufacture of complete micro-scale interconnected structures in the emerging micro-electro-mechanical systems (MEMS). Most MEMS contain a significant number of micro-size gears, transmitting small torques at fairly high speeds. The very small size of these elements implies that in most cases the inertial forces are insignificant, and therefore, they can withstand relative velocities and accelerations, which are prohibitive for their macro-scale counterparts. Although the methods of manufacture have been relatively successful, the established theories based on continuum mechanics do not immediately extend to some of the micro-scale interactions. Consequently, there is an element of empirical approach in their fabrication, which manifests itself in their inherent unreliability, particularly vis-à-vis tribological performance.

This paper provides an alternative approach, integrating within the same multi-physics framework the dynamics of a typical micro-scale gear mechanism and contact mechanics of the meshing teeth flanks, governing the overall behaviour of the loaded nano/micro-scale tribological conjunctions. The interactive nature of these phenomena calls for such a holistic approach. The emphasis is put upon the hierarchical and interactive nature of the problems of varying physics of scale, including surface interactions, lubricated concentrated contacts, and the structural vibrations of the interacting surfaces.

