A variational energy-based Boundary Element approach for 3D adhesive contacts

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The interplay between surface roughness and adhesion plays a central role in both industry and biology. Indeed, it is well established how adhesive effects can be highly reduced, or even neglected, by surface roughness. Hence, this fundamental relation has gathered the interest of the scientific community worldwide, thus leading to analytical theories for smooth contacts [1,2], together with numerical and experimental analyses [3,4]. However, the numerical procedures proposed based on the definition of an *ad-hoc* potential modelling the adhesive interaction: this assumption clearly introduces a strong dependance of the numerical predictions on the set of parameters selected to shape the adhesive potential, so that a very small change in one of these would lead to dramatic change in the adhesive interaction between the contacting solids.

Hence, we present an innovative variational energy-based Boundary Element methodology to investigate 3D contacts when adhesive effects are considered at the contact interface. Specifically, the methodology requires the total free energy to be minimized for a fixed value of penetration and, crucially, does not ask for a specific adhesive potential. Indeed, the adhesive interaction is fully characterized by the work of adhesion $\Delta\gamma$, which can be determined experimentally. Furthermore, the optimization procedure is served by a proper topographical description of the contact area patches, thus providing a more efficient and numerically time-saving optimization strategy, aiming at determining the real contact area corresponding to a minimum in the total free energy. To this regard, the solution up to a desired value of penetration is retrieved by moving with very small increments of indentation from a non-contact condition and minimizing the total energy at each step.

Ultimately, it is important to stress that the proposed methodology is not restricted to smooth contacts, as it can be deployed to assess rough contact problems and, most importantly, it is not limited to the adhesive case. This flexibility blazes the way to further studies where different surface energy contributions are governing the problem.

References

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