Determination of stable center, edge, and ring detachment sizes in the poker chip problem

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The so-called “poker chip” problem is one of the fundamental problems studied by researchers in the field of adhesion. In this case, the detachment process between a rigid substrate and a cylindrical elastic layer is investigated. The detachment can be modelled as a crack propagating along the contact interface of the two bodies as they are separated. Fig. 1. (A) illustrates the axisymmetric problem for the edge crack case.
We can categorize the detachment types into the following three groups: center crack, edge crack and ring crack. Center and edge cracks (defects) are the most relevant ones for poker chip geometries. These type of cracks initiate from the center and perimeter of the chip, respectively. Ring cracks (or ring-like defects) have great importance for mushroom-shaped geometries (an extension of the basic problem) and are initiated usually just beneath the punch domain of the mushroom fibril.
The stability analysis of the crack propagation phenomenon is used to identify the stable and unstable domains of the parameters in the particular problem under investigation. It is crucial to know the boundary of the stable and unstable crack propagations (or separations). Using the theory of linear elastic fracture mechanics, one can use the variation of the energy release rate to determine the stability limits. This approach is widely adopted by researchers.
Our primary goal in this report is to obtain stability maps for the poker chip problem. We conducted a parametric study involving the chip thickness h and the Poisson’s ratio ν of the elastic layer. We investigated the stability of the crack growth and the stress distribution along the interface between the elastic chip and the rigid substrate. Both parameters have significant impacts on the results. Despite previous studies, this problem is not yet fully understood. Our simulations revealed the existence of some stable “islands” in the parameter space, which were previously not described and identified. These stability islands exist for all investigated Poisson’s ratios for edge crack. The numerical calculations were performed using Abaqus/Standard controlled with Pythons scripts.

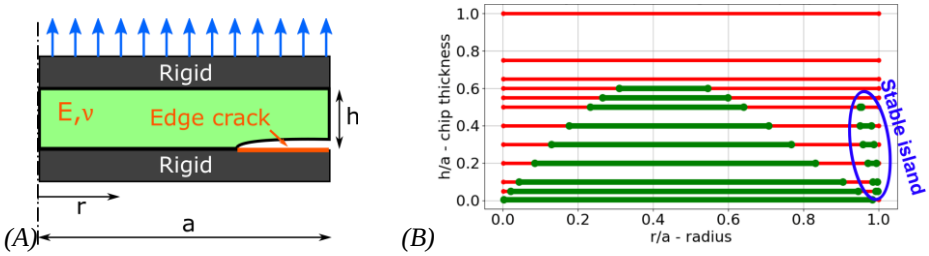

Fig. 1: Schematics of the axisymmetric problem (A); Stability map for edge crack (B)

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