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Effect of the curvature for the indented solid with curved surface using flat punch indentation

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Summary

Depth-sensing instrumented indentation tests are widely used to probe the mechanical properties of materials at a local area and small scales. Generally, indented solid was assumed semi-infinite plane solid because the contact region is small comparing the indented solid. However, for some biomaterial, such as skin, cornea and sclera, the effect of the curvature of the surface cannot be ignored. Using systematic finite element analysis and dimensional analysis, a method to determine the elastic modulus of the materials with curved surface is proposed using flat punch indentation in this paper.

An axisymmetric, two-dimensional model was adopted and four-node bilinear axisymmetric elements with reduced integration and hourglass control were used to model the semi-infinite solid. The boundary conditions were such that the outer surface nodes were traction-free with fixed lower surface nodes. The size of the indented solid is taken to be large enough compared with the maximum contact radius, thus the boundary conditions basically have no effect on the computational results.

. The material is assumes as linear elastic materials with the Poisson's ratio 0.49. Then, the indention force can be expressed as a function, including the elastic modulus of the indented solid, the indentor radius, the indentation depth and the curvature radius of the indented solid.

According to the dimensional analysis and finite element analysis, for a certain ratio value of indentation depth to the indentor radius, a dimensionless function expression of indention force can be obtained. Then, the elastic modulus can be determined using dimensionless function and the indentation test. It is shown from the results that the effect of the curvature will reduce with the ratio value of indentor radius to curvature radius of the indented solid.