

## Abstract

The primary goal of this thesis is to present a better understanding of contact problem of an inflated spherical nonlinear (hyperelastic and viscoelastic) membrane. This is achieved by considering different (adhesive and non-adhesive) contact conditions. To keep the geometry simple, an inflated spherical nonlinear homogeneous and isotropic Mooney-Rivlin hyperelastic membrane pressed between two rigid plates is considered. All three cases, namely frictionless, no-slip and stick-slip conditions are considered separately in the plate membrane contact region. The stretch of the membrane, and the surface traction (for no-slip contact) are determined. For the stick-slip case, the sliding front is observed to be initiated at the contact periphery which moves towards the pole. The state at which the impending wrinkling condition occurs is determined. Based on this, the minimum initial stretch (inflation) required to prevent wrinkling at any point in the membrane is determined. Some effective mechanical properties (such as bulk modulus, Poisson's ratio, stiffness etc.) of the spherical membrane are also determined. The contact problem for an inflated neo-Hookean membrane under frictionless contact and large initial inflation is solved analytically.

Moving onto the contact problem with adhesion, we develop a phenomenological model for the contact mechanics and the dissipation mechanism at an oscillatory contact. We consider an inflated spherical hyperelastic membrane held between two large rigid static/oscillating parallel flat plates. For the contact problem, the critical energy release rate criterion is used to determine the detachment of the membrane from the plate surface. An analytical relation between the adhesion energy and the adhesive bond force is established. For the geometry considered, we obtain a relation between the adhesive bond force (and hence also the energy release rate) and the displacement of the plate at equilibrium without any external force. In the oscillatory contact problem, the plates are assumed to provide a kinematic oscillating boundary condition. The effective energy dissipated through hysteresis during a period of oscillation of the plate against the membrane is determined.

Next, we study the contact mechanics, displacement controlled relaxation response, force controlled creep response, dynamic contact and energy dissipation due to oscillatory contact considering viscoelastic membrane material. For this study, we choose Christensen viscoelastic material model. The effective stiffness and damping in the membrane plate assembly are determined, and a phenomenological model is developed. Under oscillatory contact condition, the energy dissipation per cycle is determined. Further, using the free vibration test, the damped natural frequency of the membrane plate system is calculated.

Keywords: Contact problem, Large deformation, impending wrinkling, stick-slip, adhesion, oscillatory contact, hysteresis, viscoelasticity, dynamic contact, damped frequency, phenomenological mode