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Abstract

In this paper we propose a Finite Element model for analyzing closed membranes ("bags") interacting with internal and external (surrounding) fluids. The approach is based on embedding a Lagranian monolithic model describing the membrane containing an internal fluid into an Eulerian external fluid model. The combination of kinematic frameworks allows us to accurately track the location of the membrane and naturally represent flow variables discontinuities across it. In order to obtain stable coupling for membrane materials with low density, a slight fluid compressibility is assumed. The coupling between the membrane and the internal fluid is automatically accounted for by a monolithic set-up. The filled membrane and the external fluid are coupled in a Dirichlet-Neumann fashion. The model is validated in several numerical examples and its potential application to a civil engineering problem of coast protection via water-filled bag reefs is shown.

1. Introduction

Fluid-membrane interaction is found many engineering problems and biosystems. Examples of the latter include lungs, blood vessels and urinary bladder. Among engineering systems one can mention vehicle airbags, water-filled bags, parachutes, sails, tents, inflatable civil engineering structures and many others. One can distinguish between problems involving "open membranes" (such as sails) and those dealing with "closed membranes" (such as bags or balloons), where no direct interaction between the fluid filling the membrane and the surrounding fluid takes place and the two fluids may be different. The objective of the present paper is to develop an ad-hoc model particularly suitable for analysis of "closed membranes" interacting with both the surrounding and the internal fluids.