A new concept in cavitation modelling

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In lubrication modelling, predicting friction and load carrying capacity are the main objectives and many different physical aspects need to be taken into consideration. The lubricant behaviour, including cavitation and reformation - the transitions between its liquid and its gas phase, is key in predicting load carrying capacity and is very important when estimating the friction losses as well. In lubrication theory, it is therefore essential to (as correctly as possible) model the effect of cavitation. Today's most well used cavitation algorithm in lubrication, is the Elrod and Adams [1,2] type of formulation that efficiently enforce the JFO-conditions to be satisfied throughout the whole domain. Since 1975, when it was first introduced, this cavitation algorithm has been frequently used, further developed and in many ways justified by others. Vijayarghavan and Keith [3] broadened this work by starting from the assumption that the fluid is a compressible medium also in its liquid phase, instead of incompressible as in Elrod and Adams. Even though many publications show very similar results when applied to the same model problem, the cavitation algorithm by Elrod and Adams wasn't properly justified until 2007 when Bayada et al. presented their mathematical proof on existence and uniqueness of the solution [4].

By first introducing a reformulation of the Elrod and Adams model, where the two unknowns are made complementary throughout the whole domain, Giacopini et al. obtained a very elegant mass conservingcavitation model, which after discretisation becomes a Linear Complementarity Problem (LCP). The advantage with the LCP formulation is that standard techniques can be used to solve the problem numerically, e.g., Lemke's pivoting algorithm. This alleviates the problems associated with discrete formulations that changes at the boundaries between the cavitated and the full film zones. Moreover, this solution technique finds the solution in a finite number of steps hence issues related to iterative processes are completely avoided.

This paper presents a development of the model by Giacopini et al. It starts from the assumption that the fluid is a compressible medium in both the liquid and gas phase and represents a generalisation allowing for a wider range of lubricants to be modelled. Moreover, this paper introduces a new concept on how to model cavitation.

References

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