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Design of a Puff Rheometer

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The puff rheometer is a rheometer that performs rheological experiments without physical interaction with the material. Using the FEM model based on the experimental setup of a puff rheometer, a simplified model has been made to predict material response while undergoing an oscillatory pressure function. The simplified model is capable of making good approximations for Newtonian materials without surface tension. The model can predict material behavior regarding surface height amplitude and the phase shift of the material with respect to the applied pressure.

The simplified model has been created using the Buckingham-Pi theorem and combining its dimensionless groups with the solution to the force balance of a Maxwell model representing the material. The simplified model consists of two equations as functions of the dimensionless groups: one for height amplitude and one for phase shift. In order to predict material behavior using the simplified model, the characteristic radius R has to be found by fitting the simplified model to the simulations of the FEM model.

Regarding the research question, it is possible to determine material properties using oscillatory puffing. When the characteristic radius is known for the problem, all parameters that are needed to describe the problem with the simplified model are known. Using the fitted simplified model, an accurate prediction of phase shift and amplitude of oscillation of the surface height can be determined. Finally, when the phase shift of a material is known for a known setup, it is also possible to determine the viscosity of that material.