

Fluid-structure Interaction Modeling of Air Bearing

H.R. Javani¹, P. Kagan², F. Huizinga¹

1. ASML, MAOM, De Run, Veldhoven, The Netherlands

2. ASML, MTD, De Run, Veldhoven, The Netherlands

Introduction: Air bearings are special type of bearings which provide nearly zero friction between two surfaces. This is achieved by a compressed layer of gas between the surfaces. This poster focuses on the modeling of an Air bearing component of in one of our machines, see Figure 1.

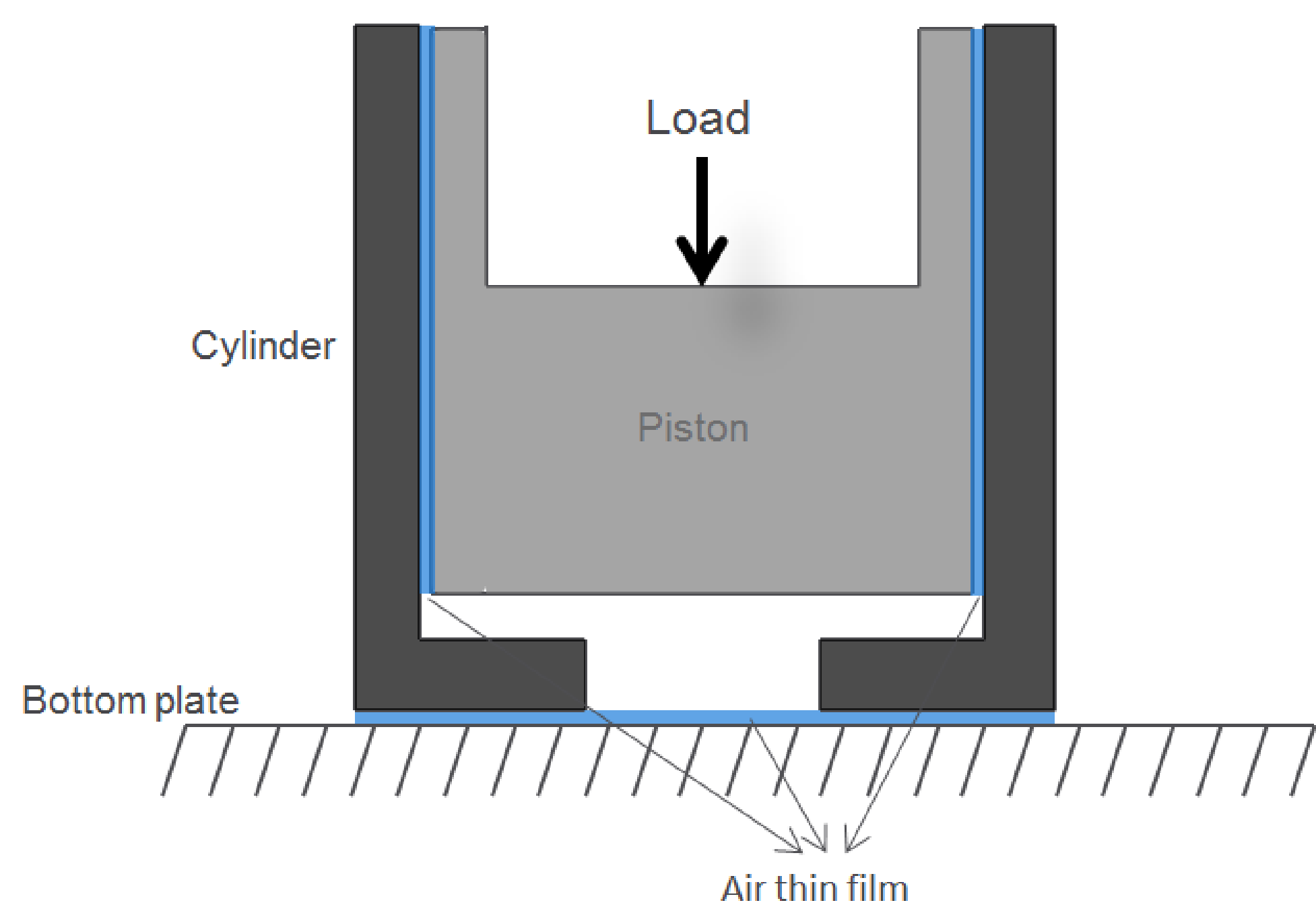


Figure 1. An Air bearing concept

Computational Methods: The thin layer of gas is represented as a thin film and the Thin-Film Flow, Shell Interface module of COMSOL is used to describe the flow behavior. In this model the inertial effects in the fluid in comparison to the viscous effects are negligible.

On the other hand the gas volume is supplied through nozzles which their dimensions and size is not to be neglected. Figure 2 shows the arrangement of nozzle and thin film.

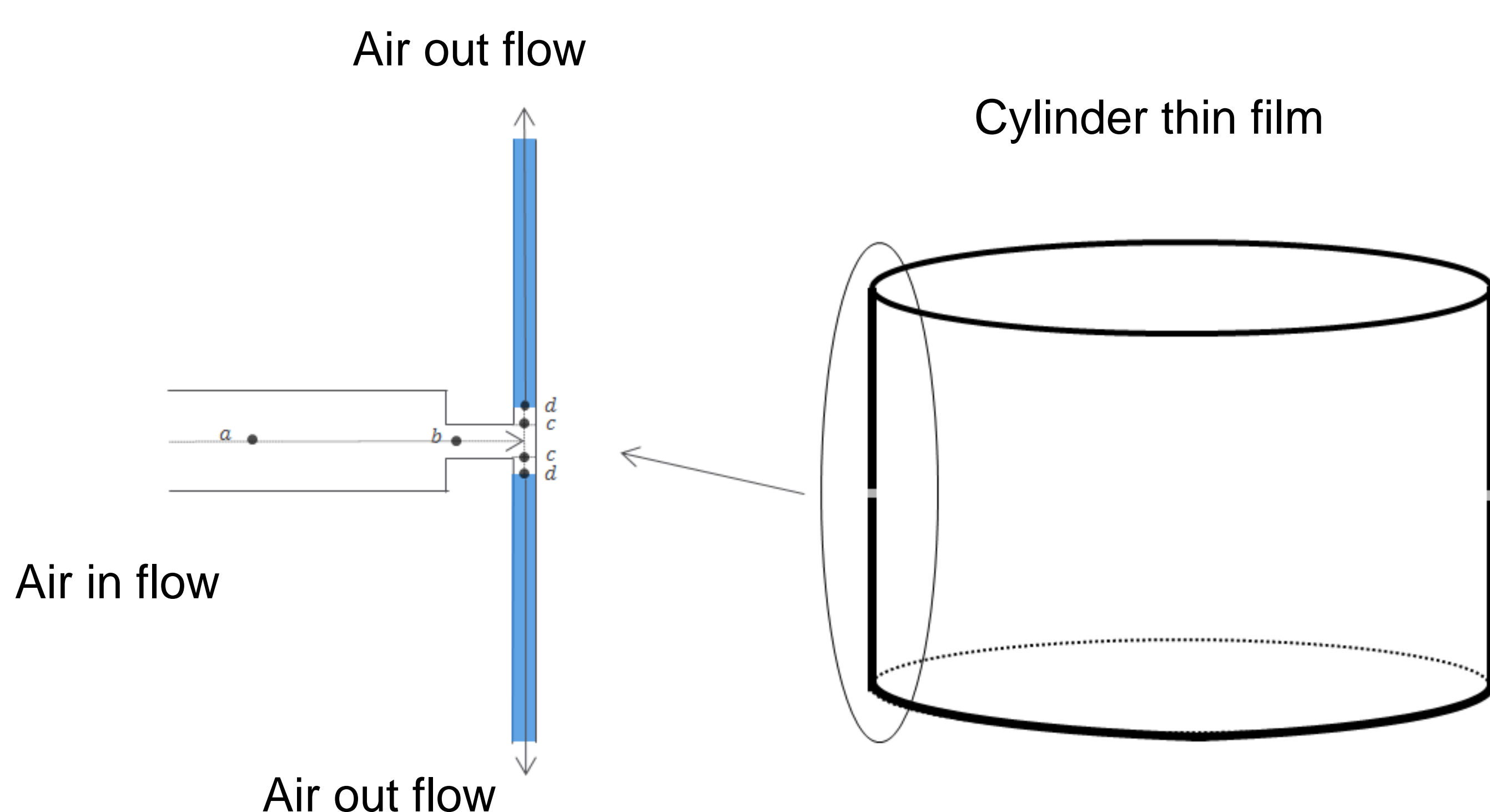


Figure 2. Nozzles connected to thin film

Results: The thin film is coupled to nozzles using Bernoulli's equation that would otherwise necessitate the use of real 3D Navier-Stokes simulations in the gap and feeding holes which significantly increases the simulation time without notably influencing the accuracy.

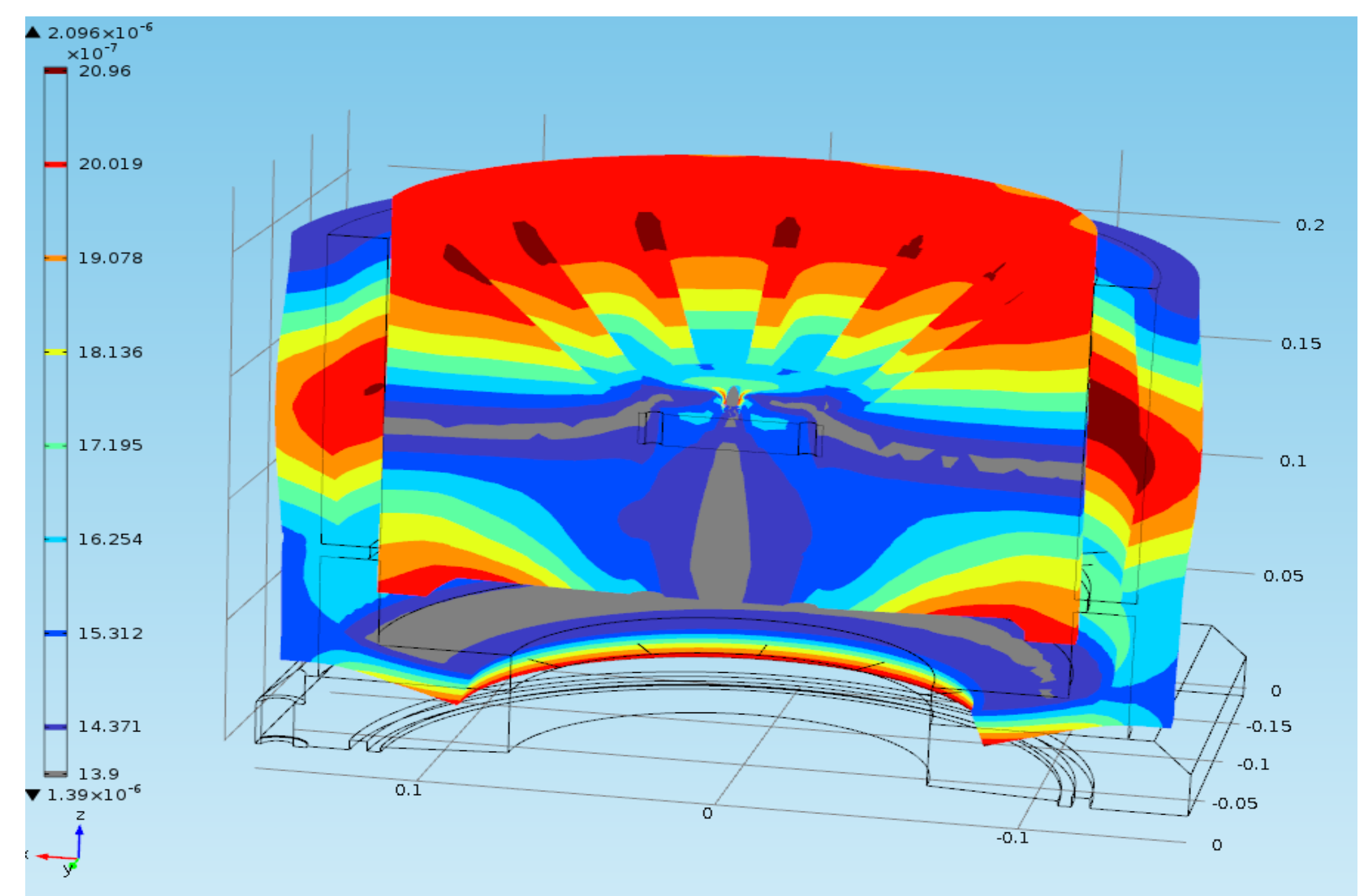


Figure 3. Radial deformation of Cylinder and Piston

Figure 3 shows the deformation of the Cylinder and Piston. By applying a moment on the piston, there will be a rotation which is enough to develop a pressure distribution in the thin film, which compensates the applied moment (provides stiffness).

Conclusions: COMSOL is used to efficiently solve a coupled Fluid-Structure Interaction analysis. Computational time is significantly reduced compared to other solution technologies like segregated method. Additionally the model is set up quite easily and the expected physics is captured adequately.

References:

1. W.A. Gross, Gas Film Lubrication; John Wiley and Sons, New York, 1962
2. I. Malakhovsky, P. Kagan, GID Air Bearing, ASML internal report