SCM ENGINEERING SERVICES

Technical Report on

TWO PHASE FLOW IN A MICROWAVE

Executed By:

S Sunil Krishna
sunilkrishna.s@scmengg.com

S Sampath Kumar
sampath.s@scmengg.com

Technical Director

Dr. Subhash Deo
subhash@scmengg.com

SCM Engineering Services
Plot #156, First Floor,
Motilal Nagar,
Begumpet,
Hyderabad 500019,
India.
Ph: 040 – 65449094
Email: projects@scmengg.com
URL: http://www.scmengg.com

INTRODUCTION

The present project involves the study of two-phase flow in a micro channel. The requirement is to estimate the force required to close the flow and also to estimate the change in the air volume after the flow is closed. The analysis has been done to address each problem independently. The analysis is done for three cases of 5, 25 and 100 μl/min flow rates. The system is essentially a micro valve where the flow is restricted by a composite cylinder on a deformable area, consequently affecting the flow characteristics.

The problem has been modeled with the following objectives

(1) To evaluate the force required to be applied on the cylinder to close the flow

(2) To evaluate the change in air volume as a result of above force applied.

It has been experimentally investigated that a 2-phase flow described in the problem statement that the flow parameters like velocity and pressure are not affected by the free surface between air and water. In fact the experiments in similar micro channels have shown that the average velocity of the two-phase flow is the same as the average velocity for the single-phase flow within a certain range of mass flow rates.

METHODOLOGY

Polypropylene is a known hydrophobic surface and thus repels water with a large contact angle. Wetting is hence not allowed at the liquid-wall interface. This would indicate reduced drag forces at the boundary. Also, The shear stress components normal to the surface are negligible and the wall forces are highly dependent on the flow pressures.

This project was accomplished in 80 working hours for a **leading American medical device company.**

The flow characteristics could be expected to resemble a wedging flow where there exists an air gap between the liquid and the PP wall. The pressure drop reduction occurs as a function of inlet velocity of the fluid.

The analysis was first carried out with only the fluid flow. The bubble velocity is assumed to be the same as the mixture velocity.

$\blacktriangle P_{2\text{-phase}} = \blacktriangle P_L / \alpha_L$

where, α_L is the liquid mass fraction – taken here as an alternating 1.(no diffusion)

OBJECTIVES

The study was divided into three parts.

(A) Fluid analysis considering only the fluid region of the given geometry.

Inlet velocity and reference pressure is specified as input to the problem.

(C) To find out the change in air volume as the channel is closed.

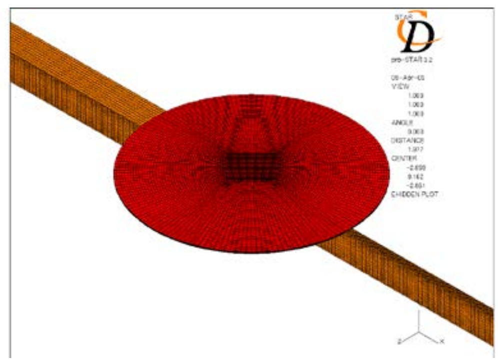


Fig.1 Channel model mesh

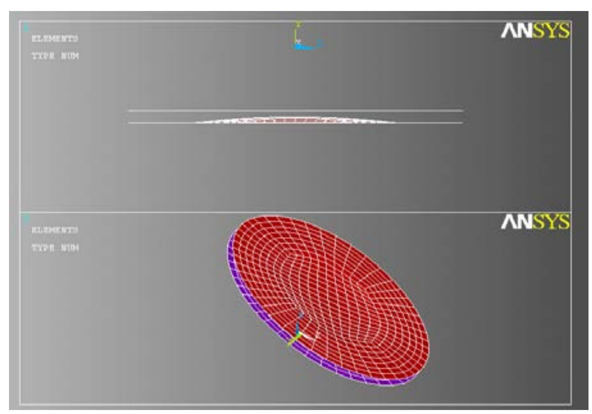
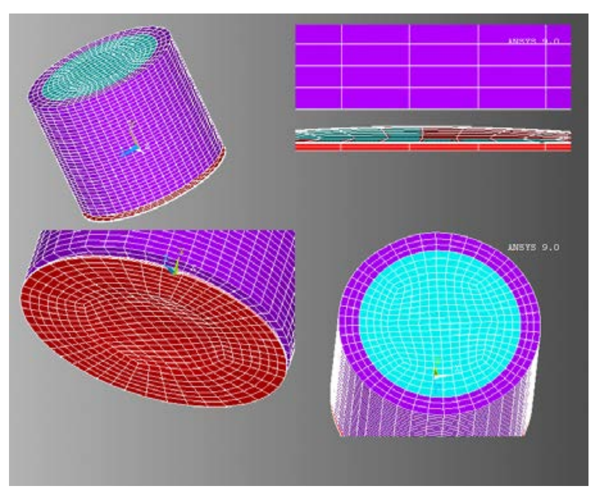


Fig.2 Contact elements



(B) Non-linear contact analysis of the assembly to ascertain the forces required to close the flow with the maximum forces

HARDWARE AND SOFTWARE

HARDWARE

The hardware used for mesh generation, pre processing, analysis and post processing was Intel based windows platform having P4 processor, with 2 GB RAM and 80 GB hard disk.

SOFTWARE

The analysis activity consists of Mesh generation, Pre–processing, Contact analysis and Post-processing. Mesh generation was done using HYPERMESH. The pre & post processing for setting problem and analyzing results was done in ANSYS 9 and STAR CD The real constants were defined in ANSYS for the contact elements.

A hex mesh was used in this analysis and all the quality criteria were by the standards of **SCM Engineering Services**

Fig.3 Composite pressure valve mesh

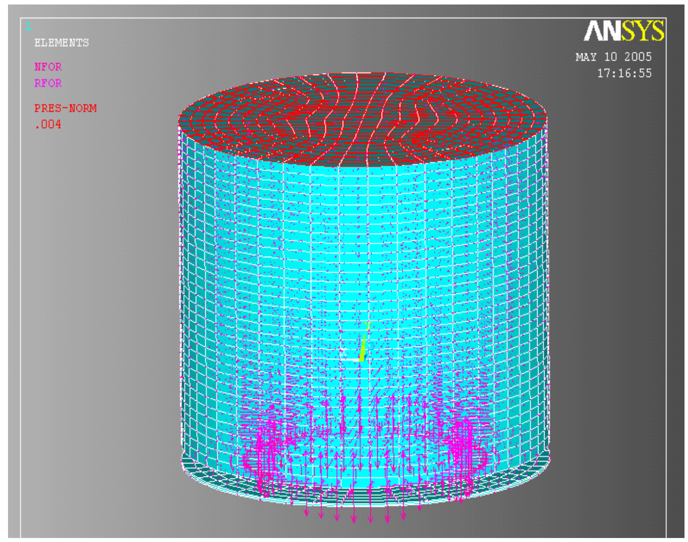


Fig.4 B.C on contact and pressure surfaces

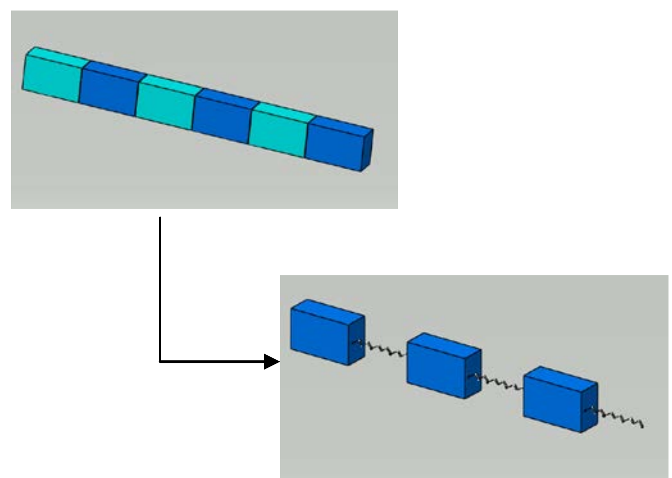


Fig.5 Multi phase flow to a solid mechanics analogy

on **SCM's** strength on some of the challenges that designers and analysts face.

.

RESULTS AND DISCUSSIONS

Since the channel does not deform and the volume change is only dependent on the change in length. Hence we simplify the problem to a one-dimensional spring-mass problem. The maximum forces and the contact pressure is increasing until the channel is closed and the contact analysis was set up on the same principle.

CONCLUSIONS

The results are focused towards an optimum value of pressure required to close the flow and the subsequent change in air volume. This change in air volume is used then to accurately time the micro-valve so as to allow only the air to be filtered out of the channel.

Some of the figures showing results on two-phase flow analysis along with equivalent stress, contact stress, membrane deformation and velocity vectors.

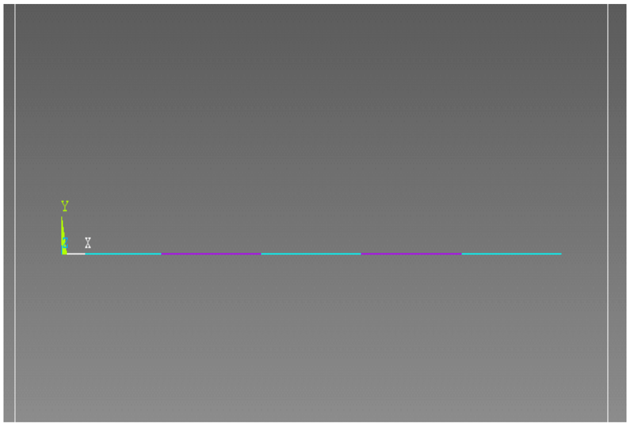


Fig.6 Two phase flow – one dimensional

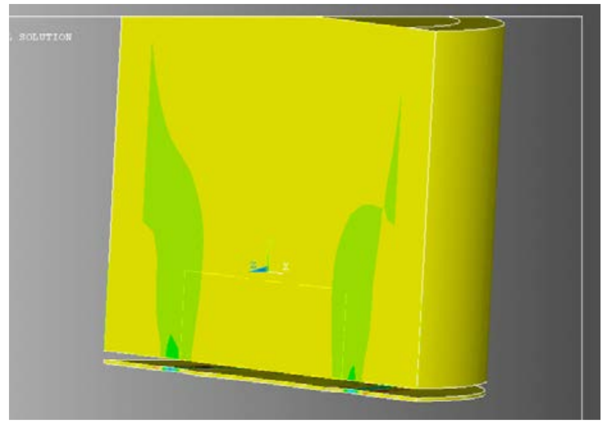


Fig.9 Principal strains in cylinder after deformation of the membrane

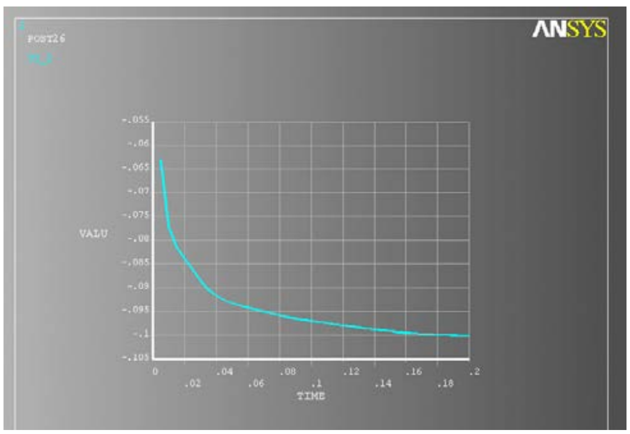


Fig.7 D-T data on the tip of the contact interface

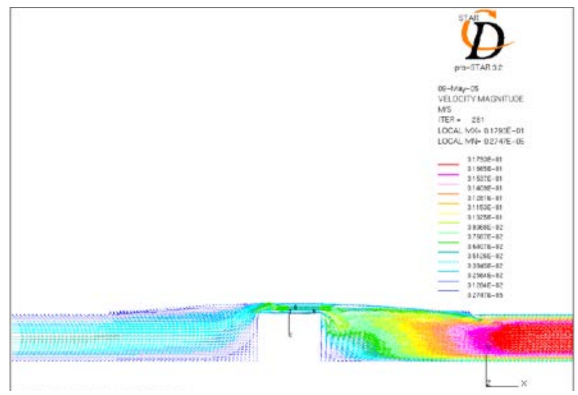


Fig.10 Velocity vector plot in micro-channel

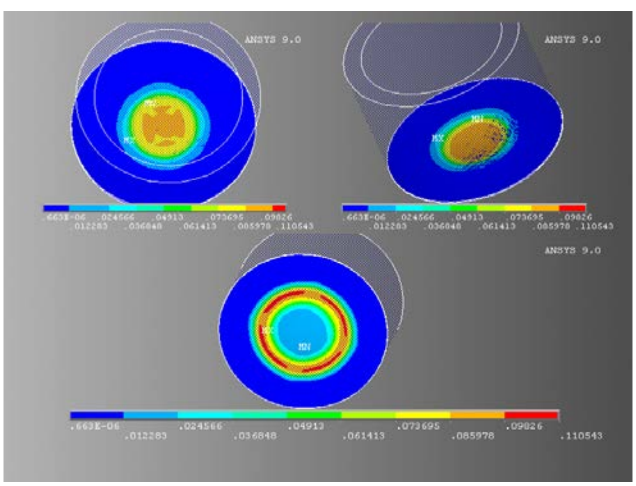


Fig.8 Eq stress at the contact interface

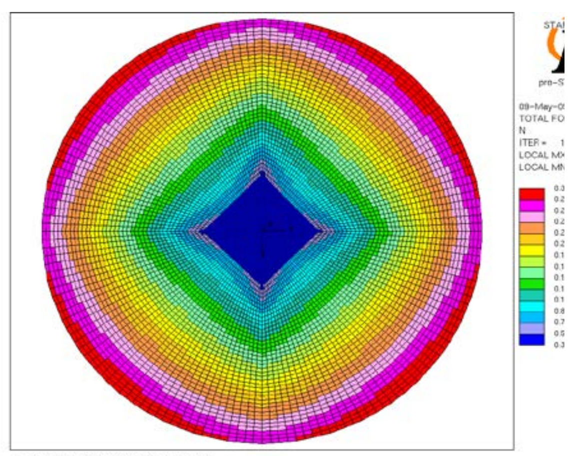


Fig.11 Upward forces on the membrane

REFERENCES

1. ‘Laminar drag reduction in micro channels using ultra hydrophobic surfaces’ Jia Ou, Blair Perot, and Jonathan P. Rothstein, *Department of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, Massachusetts 01003-2210*

2. ‘Transport of bubbles in square microchannels’ Thomas Cubaud and Chih-Ming Ho *Mechanical and Aerospace Engineering Department, University of California at Los Angeles, 420 Westwood Plaza, Los Angeles, California 90095*

3. ‘Multiphase flows in micro fluidics’, Charles N. Baroud a, Hervé Willaime b,
a *LadHyX, École Polytechnique, 91128 Palaiseau cedex, France*
b *Laboratoire MMN, ESPCI, 10, rue Vauquelin, 75005 Paris, France*