SCM ENGINEERING SERVICES

Technical Report on

LEAK PROOF FLOW ANALYSIS IN A MICRO CHANNEL

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INTRODUCTION

Modern medical applications require a high degree of accuracy and often involve multiple domains. In the present analysis of a micro channel used in a chip cooling system, the flow needs to be analyzed along with forced contact on the chip. The study is made in order to prevent leaks occurring in the channel in this pre-stressed condition. **This was accomplished in 50 hours for a leading American client.**

The study is on the effects of applied forces on a highly deformable gasket with non-linear properties. Fluid flow channel is with in the substrate. At the bottom of the substrate the fluid flow path is surrounded by gasket and chip. Leakage might occur at the contact interface between the parts because of the fluid pressures.

OBJECTIVES

The study was divided into three parts.

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

(B) Structural analysis of the assembly to ascertain complete contact between the chip and substrate interface upon the application of pressure at the bottom of the plate.

(C) Analyses of coupled forces in the critical regions by the vector addition of all the forces.

METHODOLOGY

The cracks in the substrates are assumed to occur when the resultant stress in the substrate exceeds the tensile strength of the material. However, any inherent surface cracks may cause localized stress concentrations and may also lead to crack propagation. This can be avoided by limiting the equivalent stress on the channel surface to lesser or equal to 60% of the tensile strength of polypropylene.

The objective was then reduced to first finding the force required for contact between the substrate and the chip and then consequently analyze the stress in the substrate with all the forces.

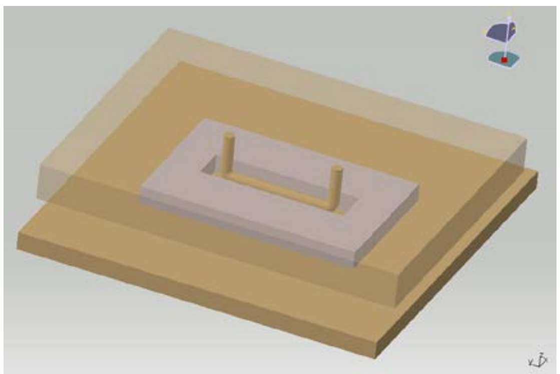

Fig.1 CAD model of the simplified system

SOFTWARE AND HARDWARE USED

SOFTWARE

The analysis activity consists of Mesh generation, Pre–processing, Fluid-Structural analysis and Post-processing. Mesh generation was done using ANSYS. The pre & post processing - for setting problem and analyzing results, The analysis was also done using ANSYS.

HARDWARE USED

The hardware used for mesh generation, pre processing, post processing and the ANSYS solver was Intel based windows platform. The problem was run on P4 processor, with 1 GB RAM and 40 GB hard disk.

THE GEOMETRY AND MESH GENERATION

For the first part of analysis i.e. Fluid flow analysis - mesh for fluid flow path was done with fluid element (142) using ANSYS.

For second part of analysis i.e. Structural analysis - mesh for substrate-membrane was done with solid elements (solid186/187/45) using ANSYS software. The deformation analysis was done using SOLID 45 elements. The mesh used for the complete structural analysis was a hybrid mesh with pyramidal interface elements.

MESHING CONSIDERATIONS

Considering the various topology and grid quality requirements a hybrid mesh containing 20-node solid186 and 10-node solid 187 tetrahedral elements was used for mesh generation.

The strain of the gasket was modeled separately with only 8-node brick elements (solid45) for accuracy.

The hybrid mesh was generated with tet elements and brick elements and constraint equations were used to couple DOF's at interfaces.

RESULTS AND DISCUSSIONS:

Material properties were then assigned to the three entities.

The analysis was first carried out with only the fluid flow. The deformation effects were noted. Then pressure was applied to the bottom face of the chip starting at a low value with a step increment of 0.5N.

The results were computed for three cases of mass flow rates. The conditions for leak

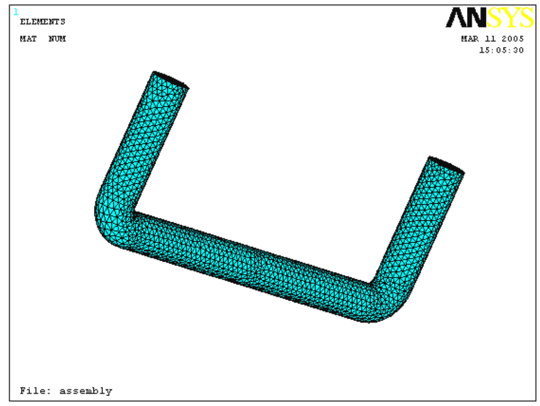

Fig.2 Channel mesh

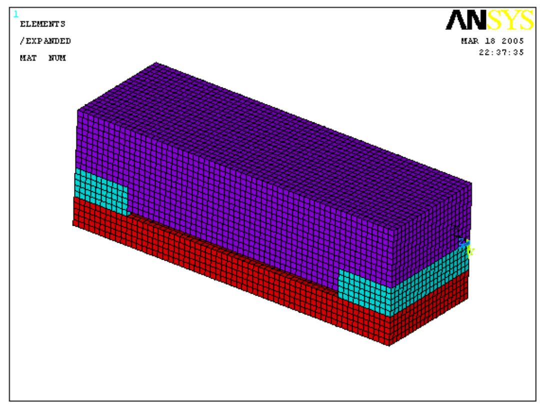

Fig.3 Half sym model for structural Analysis

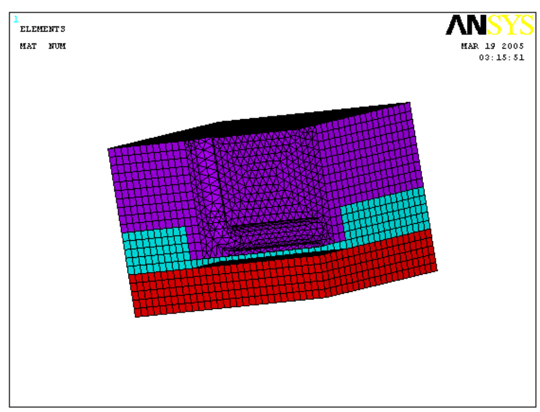

Fig.4 Hybrid mesh for coupled analysis

proof flow were then derived in terms of input pressure on the chip.

The results were then compared to simplified analytical results for accuracy.

The results converged on strict conditions imposed.

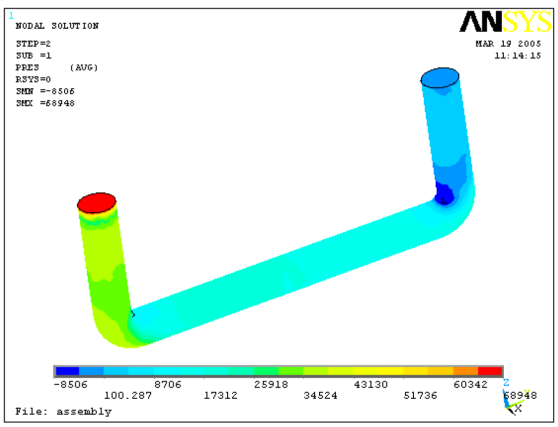

Fig. 5 Flow analysis

CONCLUSIONS

The results from the analysis can be used to improve on the design at an early stage. Necessary changes can be made in properties or geometry during the design.

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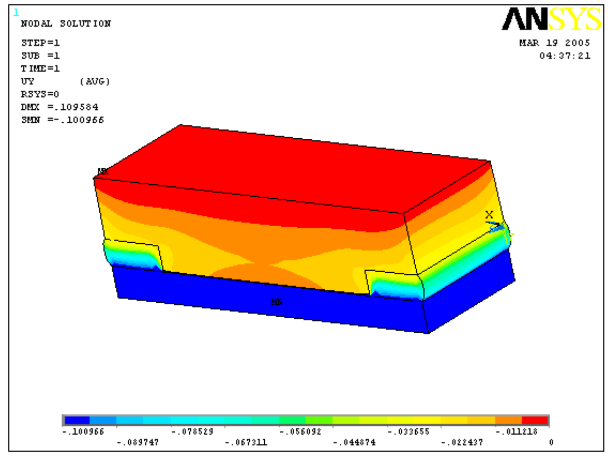

Fig.6 Structural deformation analysis

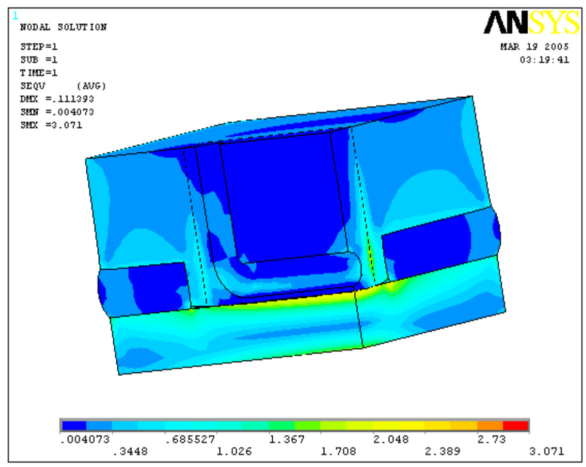

Fig. 7 Fluid structure analysis

REFERENCES

ANSYS INC theory and reference

FLUID Mechanics – Streeter and Wylie