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STAR - SHAPED MICROCHANNEL CHIP

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ABSTRACT:

The newly emerging field of MEMS,Lab on a chip device have become quite popular for analysis. This example involves the design of an infuser, a devise that feeds a reactor or analysis equipment with a specific amount of fluid. Controlling pressure is an accurate way to introduce a set quantity of fluid at a certain velocity to some piece of equipment.Flushing the equipment can also important.Optimizing such an infuser to maximize its use would involve spending the least amount of time (and fluid) flushing the equipment.Modeling this process in the time domain can lead to an optimization of the infusing pressure, micro channel design, and time control.

This model demonstrates two useful tools in COMSOL Multiphysics modeling:

1. The ability to easily define a time dependent boundary condition.

2. The ability to sweep meshes into 3D to save memory.

KEY WORDS: MEMS, Reactor, Controlling pressure.

INTRODUCTION:

Lab-on-a-chip devices have become quite popular for analyses in fields such as biochemistry and bioengineering as well as MEMS in general. Through various techniques they incorporate all the equipment involved in a chemical process such as chemical reactors, heat exchangers, separators, and mixers. This example involves the design of an infuser, a device that feeds a reactor or analysis

The example models only fluid flow whose velocity is of a magnitude that suggests laminar behaviour. This implies that you can get a numerical solution of the full momentum balance and continuity equations for incompressible flow with a reasonable number of elements. The equations you must solve are the Navier-Stokes equations in the time domain

$$\rho \frac{\partial u}{\partial t} - \nabla \cdot \mu(\nabla u + (\nabla u)^{T}) + \rho u.\nabla u + \nabla \rho = 0$$

$$\nabla \cdot u = 0$$

Where ρ denotes density (kg/m3), u is the – velocity m/s), μ denotes dynamic

viscosity (Pa·s), and *p* equals pressure (Pa). The fluid in this case is water, with the corresponding density and viscosity values.

The boundary conditions for the inlets and the outlet assume a set pressure; they also assume vanishing viscous stress:

$$[\nabla \mu(\nabla u + (\nabla u)^{T})].\ n = 0$$

$$p = p_i$$

Set the pressure at the outlet to zero; at the inlets, use the time-dependent expressions

$$p_i = 50 + 10 \sin(\pi t + \alpha)\, pa$$

Wher t is time(s),and R is value between zero and one.This simplified example sets the phase ∝ to 0,π/4,π/2,3π/4,or π depending on the inlet boundary.

Apply the no-slip condition to all other boundaries, it states the velocity is zero in the x,y and z directions at the wall:

u = (0,0,0)

COMSOL MODELING:

The use of COMSOL Multiphysics begins with a simple correlation of COMSOL geometry models to physical data. The purpose is twofold: first, it allows a control on experiments by ensuring proper extraction of material properties from our test structure data. Second, it helps to ensure that modeling

complex design geometries in COMSOL yields practical and usable data that allows MEMS designers to build meaningful predictions. Nano-material composites in MEMS fabrication have material properties that are either nonexistent or poorly characterized in present literature. Investigating stationary structural mechanics and Young's modulus (E) in particular in carbon-carbon composites is an initial effort to understand the mechanical fundamentals. COMSOL helps validate that the method used to distil Young's modulus from physical test structures is reasonable. After calculating Young's modulus from test structure data using beam theory, that value of E is entered into the COMSOL model of that structure to make certain that the modelled deflection in COMSOL is reasonably close to the deflection expected from AFM force versus deflection curves.

The next steps involve correlating test data for more complex structures to their corresponding COMSOL models. Good correlation gives confidence that the COMSOL models accurately represent the physical structures and can be usedto guide design. A poor correlation yields useful information as well, pointing to either a disparity between the COMSOL model and the physical structure, or to a misunderstanding of the physical structures or materials due to fabrication errors which are coupled with complex nano-material interactions.

Following a successful correlation of the complex physical structures to corresponding models in COMSOL, the models will guide design optimization by enabling us to parametrically sweep through a wide range of key dimensions for each design and fine-tune the design for the desired responses. Using COMSOL for the design optimization phase will considerably shorten both the time required and the materials consumed for optimization by eliminating the necessity of fabricating and testing numerous structures with small design variations.

Model geometry:

This exercise arbitrarily sets the geometry and conditions of the microchannel lab-on-a-chip (Figure 1). The differential pressure at the five inlets relative to the outlet pressure is time-controlled so that the inlet flow passes from one to the next in a smooth way. At any particular instant, one of the inlet flows dominates, although flow could be significant from more than one inlet. The pressure at the outlet is set to zero.

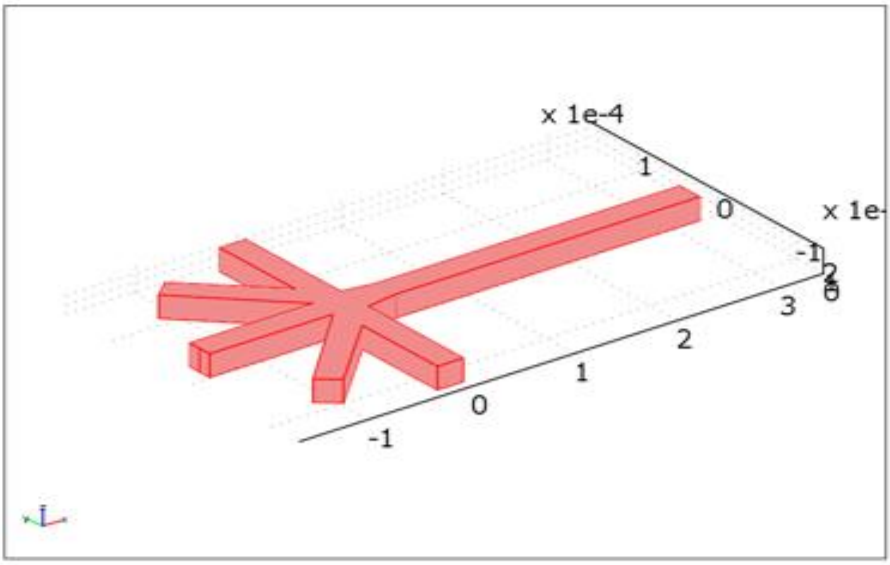


Figure 1: Model geometry for a star-shaped infuser with five inlets and one outlet. The model sets up a varying pressure differential at each inlet in the time domain in such a way that the dominant inlet flow alternates among them.

Results:

Figure shows the velocity field as a combined slice and arrow plot through the middle of the geometry at t= 0.5 s. Setting up and observing the plot as an animation gives the informative qualitative description of the process.

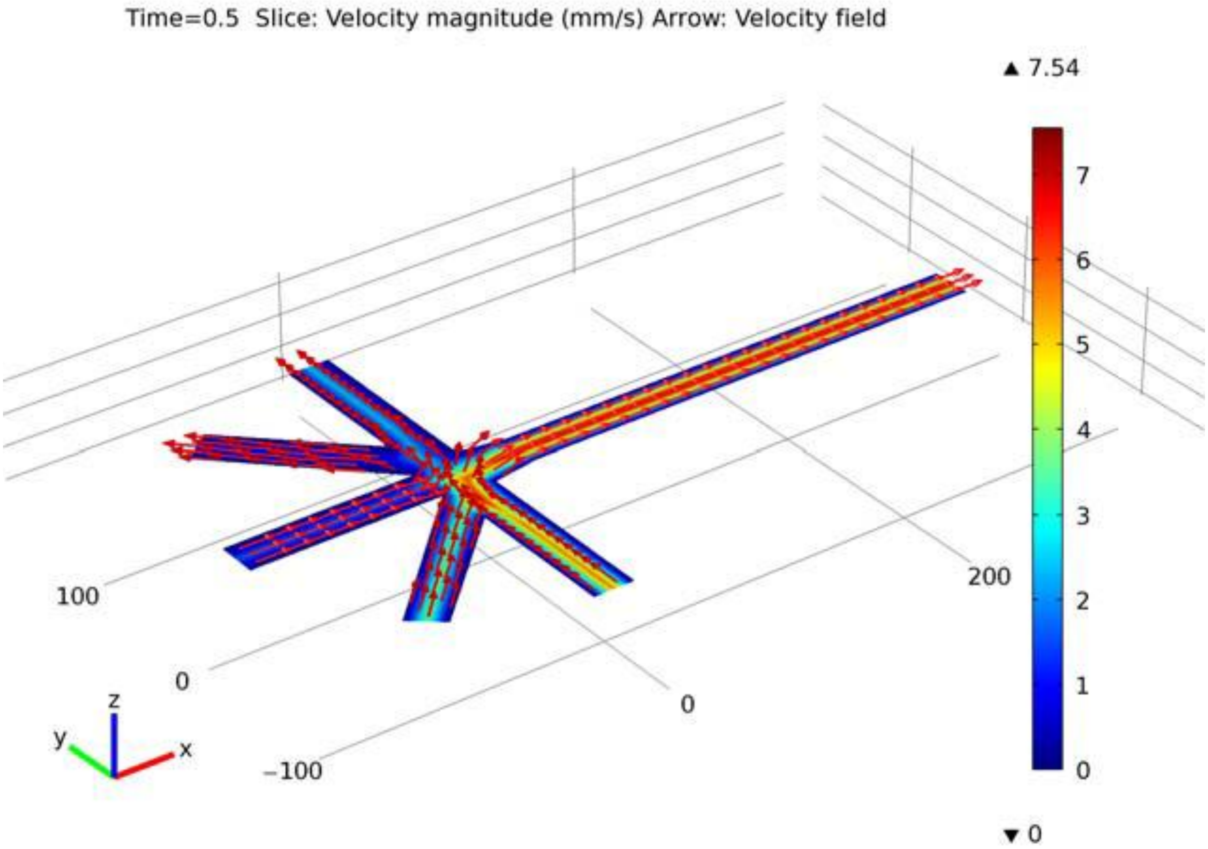
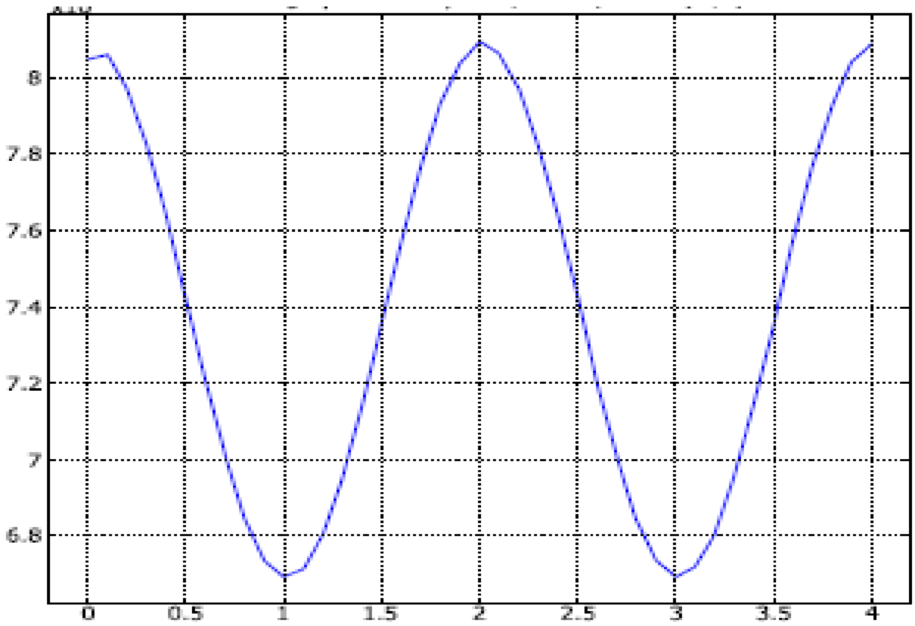


Figure 2: The velocity field in a microchannel infuser through the middle of the geometry.

Figure 3 shows the velocity in the x direction and the pressure in a point near the outlet as functions of time.

Point graph: Velocity field, x component (m/s)



Point graph: Pressure (Pa)

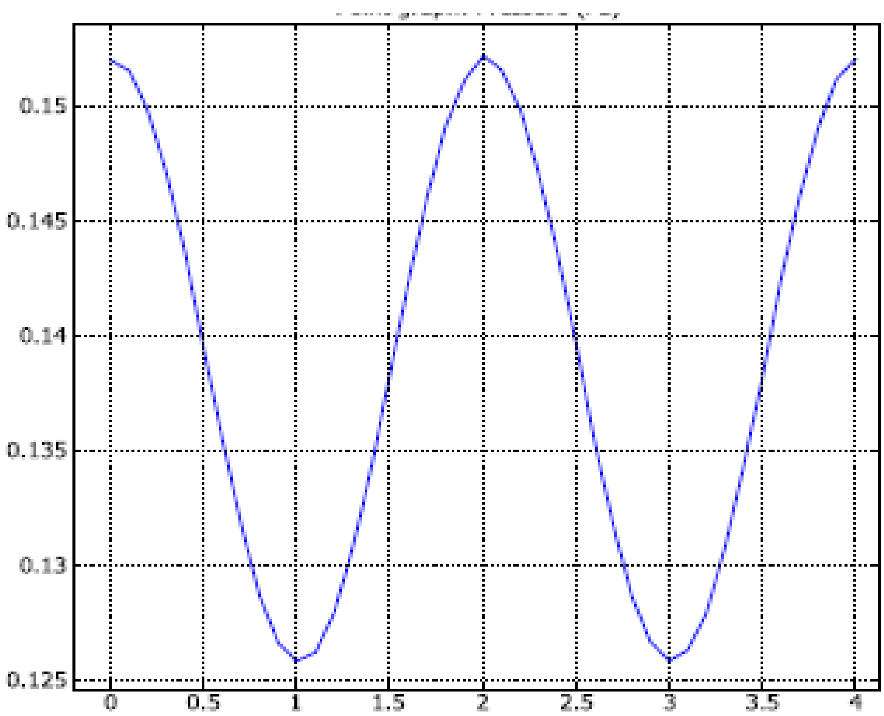
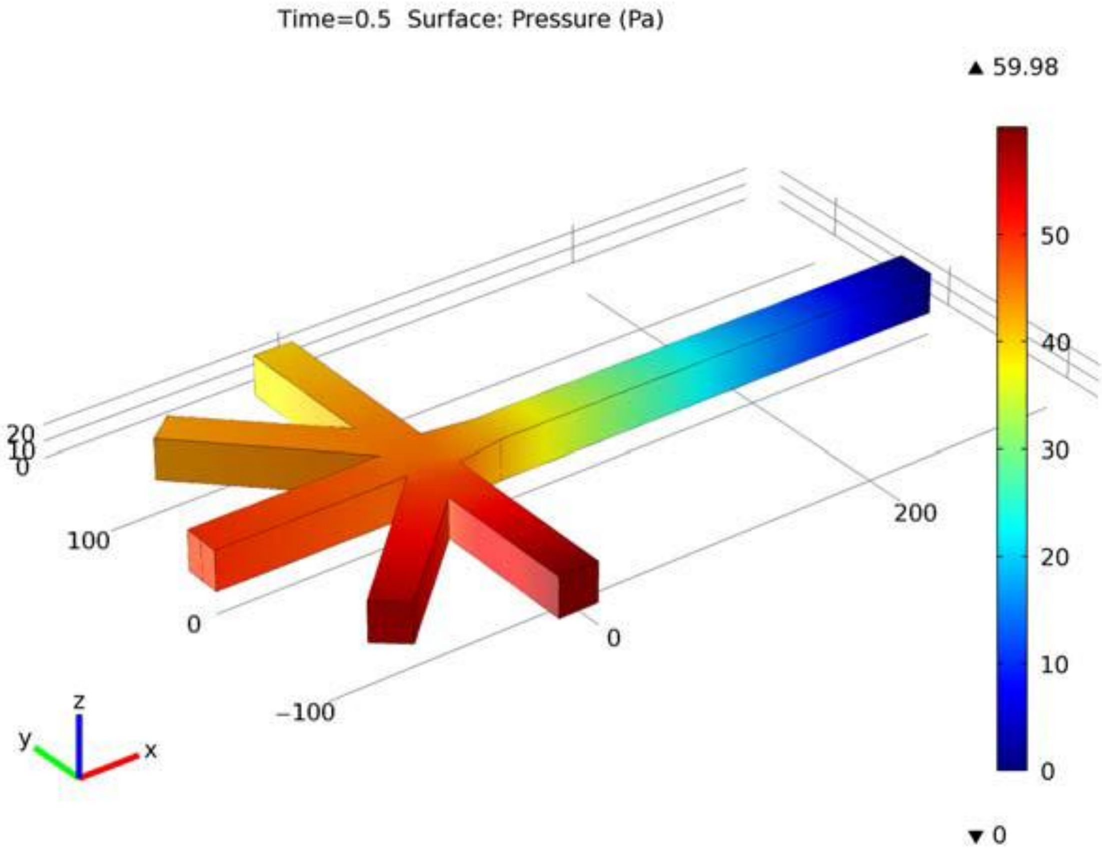


Figure 3: Velocity in the x direction (top) and pressure (bottom) at a point near the outlet.

Conclusion:

This example illustrates how to use time-dependent boundary conditions to simulate a changing process. You can implement this scenario using a boundary condition that is a function of time. The user interface provides direct access to the built-in time variable (*t*) and the mathematical functions you need. In 3D models, results at the walls are important but they can also hide what occurs within the geometry. This example also illustrates how to better display results with the help of hidden boundaries. Finally, this model approaches meshing in a way that deviates from the default settings. In most cases COMSOL Multiphysics automatically generates a 3D mesh made completely of tetrahedrons. Here—as is the case in many other micro channels and mini channels —the top and the bottom boundaries are significant in modeling the flow profile because the distance between them is of the same magnitude as that between the two sides. This means that you must model the device in 3D. However, because the micro channel's height does not change along its length, the software does not require much meshing to resolve this dimension. As an alternative to its default meshing, it is possible to extrude a mesh. To illustrate this concept, you create the mesh in this model by first taking a cross section of the full geometry to construct a 2D geometry. After meshing that, you then extrude the geometry and sweep the mesh in the height dimension. This approach provides some mesh and memory conservation.



Reference:

1. G.Whitesides, et. al. "Fabrication and Characterization of Glassy Carbon MEMS", Chem. Mat. 1997, 9, 1399-1406
2. M. Madou, et. al. "Fabrication of suspended carbon microstructures by e-beam writer and pyrolysis",2006, (13), 2602-2607
3. R. Mcreery, et. al. " Photoresist-Derived Carbon for Microelectromechanical Systems and Electrochemical application" Journal of The Electrochemical Society, 147, (1) 277-282

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4. Polsky, et. al." Lithographically Defined Porous Carbon Electrodes", vol. 5, (24), 2792-2796

5. T. Yamada, et. al." A stretchable carbon nanotube strain sensor for human motion detection", Nature NanoTech., 3/27/2011, DOI: 10.1038
6. T. Ramanathan, et. al. "Functionalized graphene sheets for polymer nanocomposites", Nature NanoTech., 6/2008, vol.3, DOI: 10.1038

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