MEMS Cleanroom Particle Contamination Flow Visualization through Fluid-Structure Interaction Simulation

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Introduction: Adverse clean room conditions of poorly maintained pressure, temperature, particle count and relative humidity can lead to contaminant depositions on the MEMS component surfaces, in turn leading to its erroneous performance. Fig-1 shows the fluid-structure interaction computational model of the cleanroom.

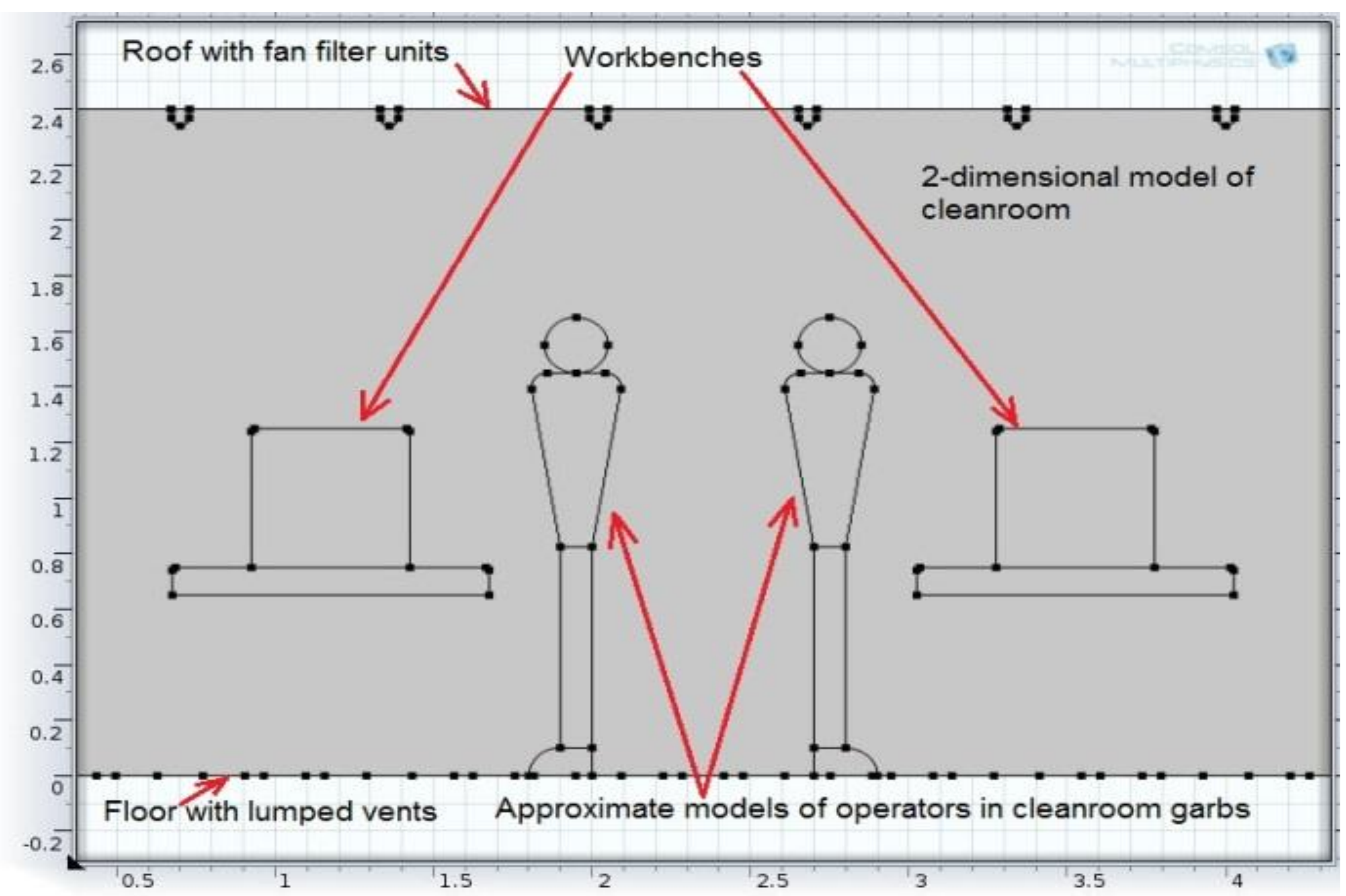

Figure 1. Domain, BCs

Computational Methods: The air flow pattern in the cleanroom was simulated in COMSOL Multiphysics environment as fluid-structure interaction stationary problem. Actual dimensions of the cleanroom and the machinery therein and actual values of cleanroom parameters, namely the number of fan filter units in the ceiling, vents in the floor and flow velocity at the top have been supplied as input. The two-dimensional finite element analysis took about 30 minutes to converge on a typical Core-i5 laptop.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

$$\rho \frac{\partial \mathbf{u}}{\partial t} + \rho(\mathbf{u} \cdot \nabla)\mathbf{u} = \nabla \cdot [-p\mathbf{I} + \tau] + \mathbf{F}$$

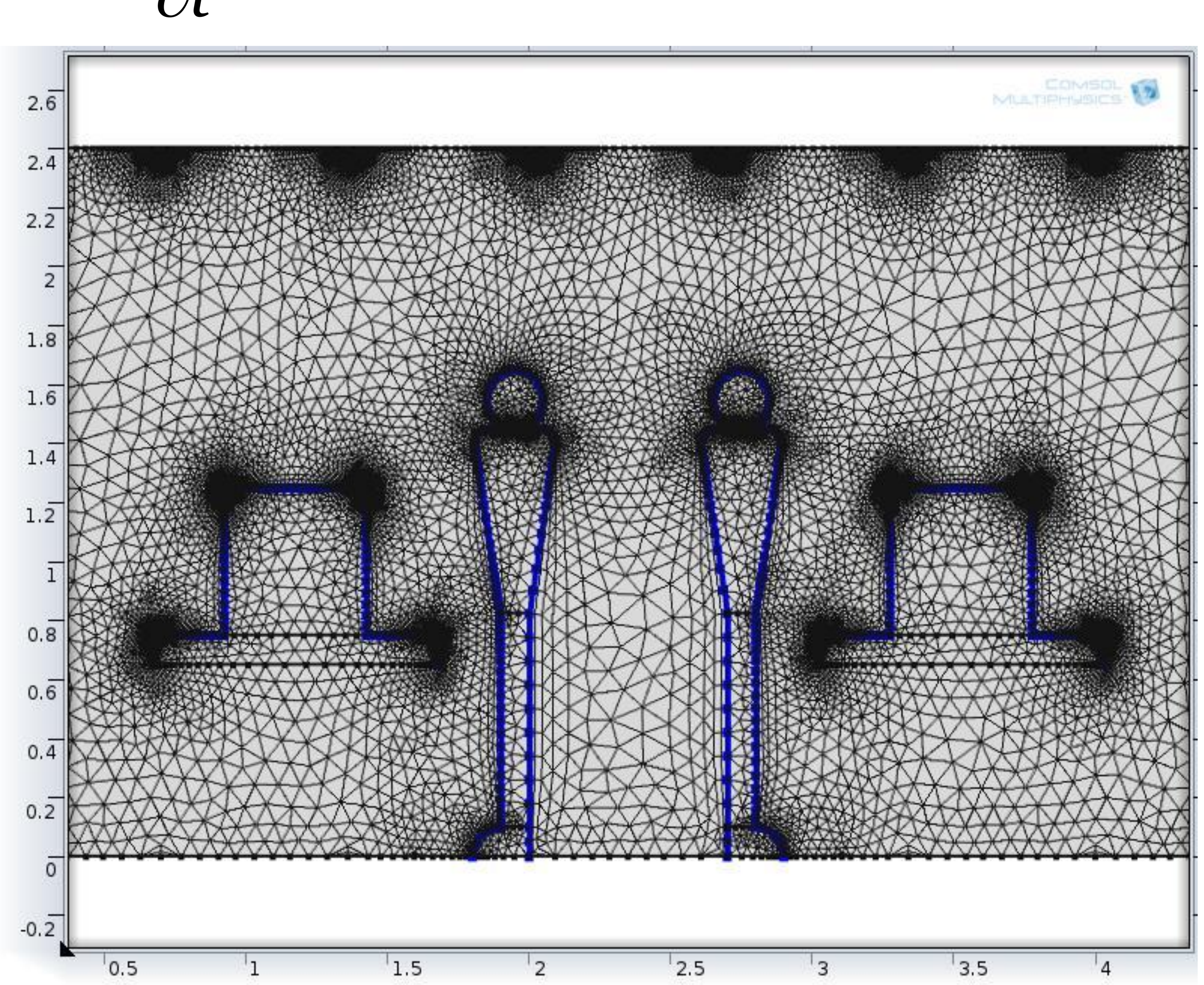

Figure 2. Meshing of the model

Results: Fig-2 shows the problem Multiphysics modeling and meshing. Note the mesh refinement at the corners of the tables and human models. Fig-3 shows the flow distribution. The arrow plot of the flow indicates that the flow along with the particle contaminants can reach the top of the MEMS component thus contaminating it.

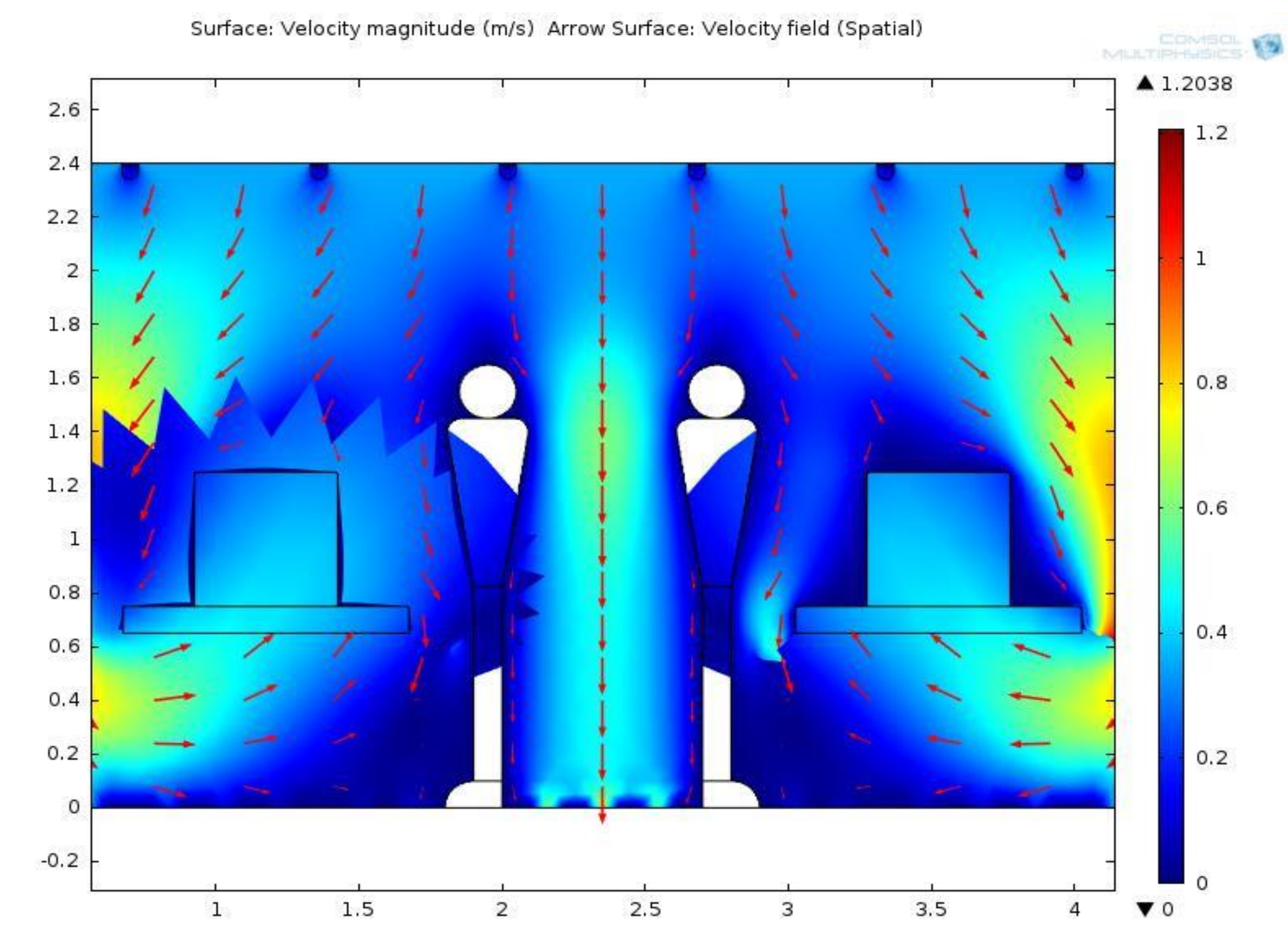

Figure 3. Flow pattern in the cleanroom

Fig-4 shows the von-Mises stress distribution in the MEMS cantilever beam in one of the numerical experiments.

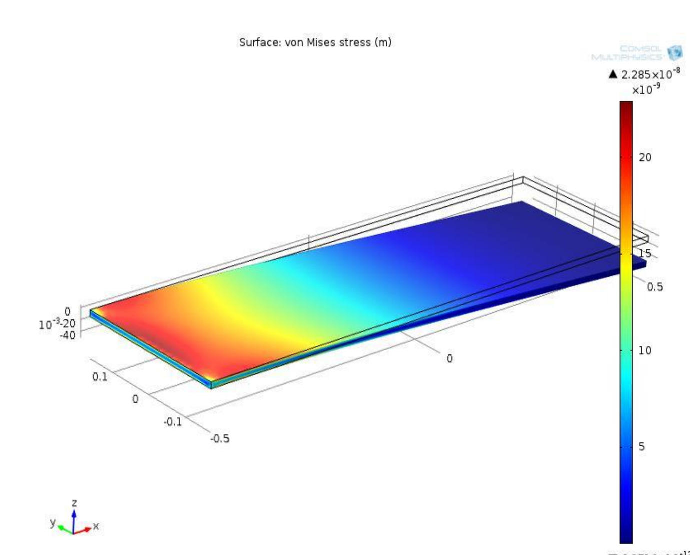

Figure 4. von-Mises stress in MEMS cantilever

Conclusions: COMSOL Multiphysics software and its fluid-structure interaction module have been successfully used to obtain a qualitative estimate of flow pattern in a cleanroom. It gave an idea and qualitative estimate of extent of contaminant particle that can reach along with the flow of air and deposit on the MEMS component surface.

References:

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