i9MASKS Group:

Bernardo Almeida Leite Faria
Cláudia Gabriela Lopes de Oliveira
Tutors: Nélson Rodrigues & Senhorinha Teixeira

Numerical Simulation : A study of porosity and space

Universidade do Minho
Escola de Engenharia

Introduction

- Numerical simulation is a viable way of predicting the behaviour of a physical system, i.e. its inherent properties : **material** and **spatial.**
- This study is composed by two sub-studies : **a study of porosity** and a **study of space**.
- The aim of this study is to have the most realistic **simulation of human's face + mask dotted of porosity** as possible **under the hardware and software limitations.**

Materials and methods

- **Materials** : personal laptops and ANSYS 2020 R2 ACADEMIC software.

Sub-Study: Porosity

Specified models

- **Species Transport**
- **DPM**: Injections of water particles
- **Porous Jump**
- **Simple case of study** :

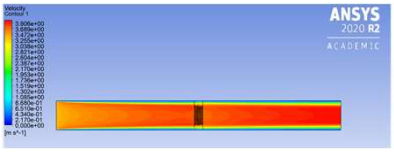

Figure 1. A simple case of study of porosity-velocity effect

$$\Delta p = -(\frac{\mu}{\alpha}v + C_2\frac{1}{2}\rho v^2)\Delta m$$

Equation 1. Porous jump equation for pressure variation [1] with parameters description in Table 1

Table 1. Parameters used for porous jump definition

Parameters	Values
Permeability (α) [m^2]	4.87e-7
Thickness (Δm) [m]	0.002
Inertial Resistance (C_2) [1/m]	2.125
Density (ρ) [kg/m^3]	997
Viscosity (μ) [Pa.s]	1.72e-05
Inlet Velocity [2] (v) [m/s]	3.4

Sub-Study : Spatial

- Due **to hardware and software limitations** is necessary **to simplify** the 3D case geometry: Figure 2.
- **Simplified 2D model**: Figure 3
- **Ansys Geometry .**

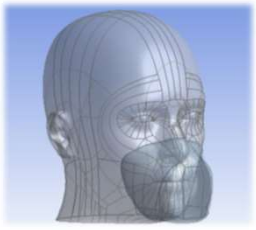

Figure 2. 3D model: human's face + mask

Figure 3. Simplified 2D model of Figure 1

Results

Simulation Geometry: Figure 2.
Simulation Parameters: Table 1
Simulation Time-Window: 30 seconds.
Simulation Results for:
1. No mask: Figure 4.
2. With Mask dotted of porosity: Figure 5.
Inlet: nose and mouth

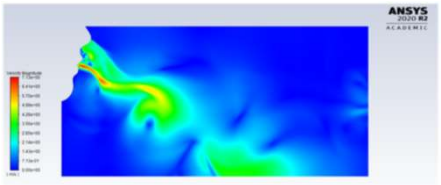

Figure 4. Simulation of flow's velocity magnitude for a sneeze with no mask

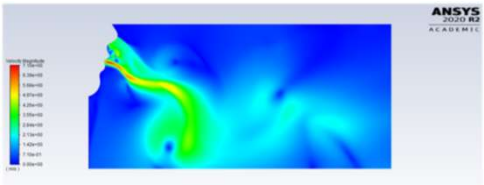

Figure 5. Simulation of flow's velocity magnitude for a sneeze with mask dotted with porosity

Conclusions

- The model, as defined, did not filter the water particles.
- Due to the complexity of the 3D model it is not possible to simulate over it.
- The use of a mask with porosity can reduce the magnitude velocity of air flow of a sneeze, i.e. the maximum reachable distance.

References

[1] M.I.M da Vinha, "Study of the Flow in a Modular Bag Filter", Master's Thesis, Universidade do Minho, Guimarães, 2019

[2] P. Bahl, C. M. de Silva, A. A. Chughtai, C. R. MacIntyre, and C. Doolan, "An experimental framework to capture the flow dynamics of droplets expelled by a sneeze," *Exp. Fluids*, vol. 61, no. 8, pp. 1–9, 2020.

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UMINHO CMEMS CENTER FOR MICROELECTROMECHANICAL SYSTEMS
MEtRICs Mechanical Engineering and Resource Sustainability Center