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SPRAY BEHAVIOR ON COMPRESSION IGNITION INTERNAL COMBUSTION ENGINES: A CFD ANALYSIS OF CAVITATION IN THE FUEL INJECTOR

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INTRODUCTION

Cavitation is a common phenomenon in fuel diesel injectors and has a strong influence on engine' performance, research on cavitation phenomenon in fuel injectors and its effect on spray breakup is very important for reduction of emissions, Figure 1, from [1], shows the spray development when cavitation is present in the discharge channel of injectors.

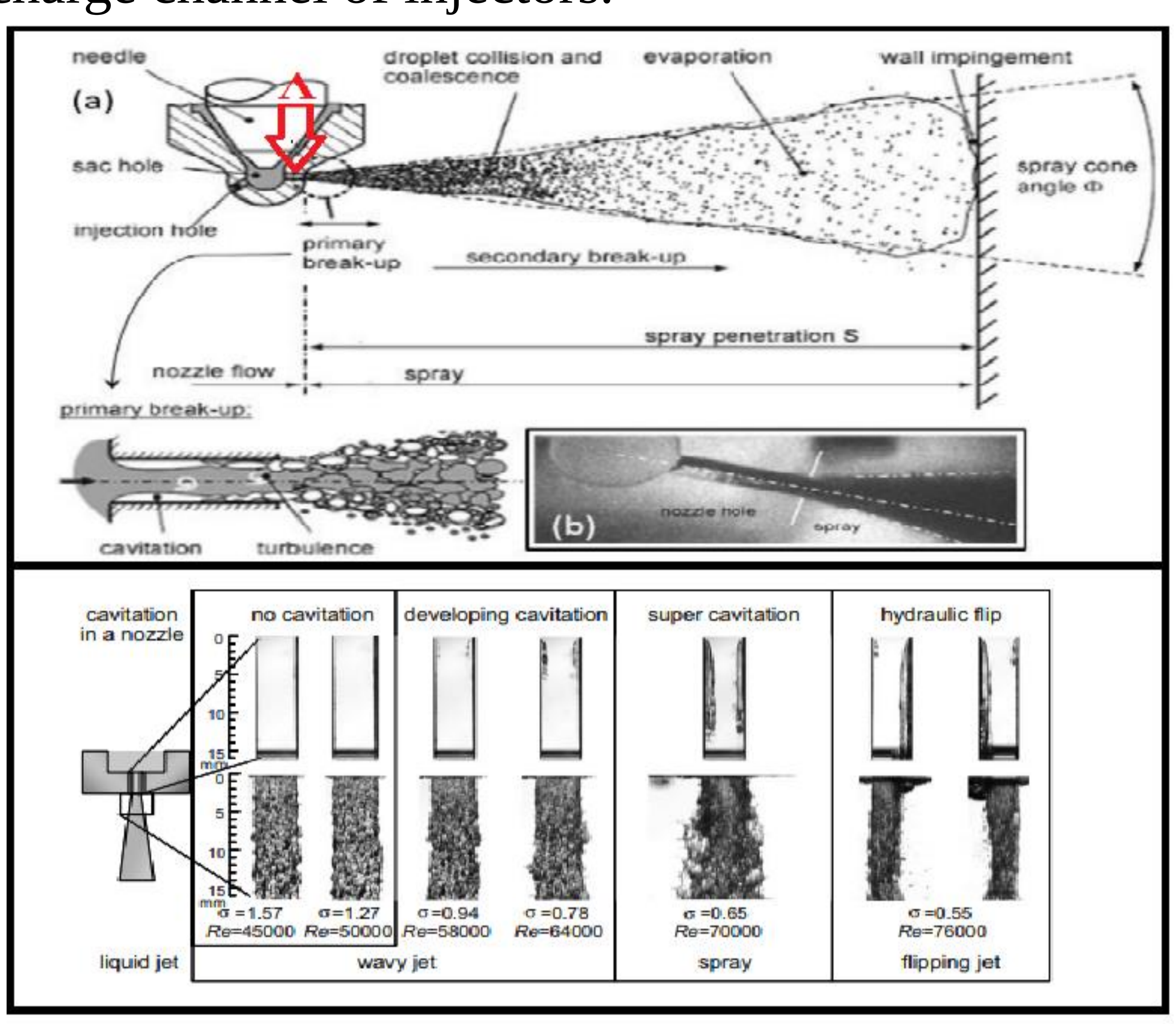

Figure 1. (a) Full-cone spray development in a SAC type injection hole. (b) Effect of cavitation/erosion in the spray symmetry. Adapted from [1]

OBJECTIVE

To numerically analyze the flow of diesel fuel throughout a SAC type injector. In a second part of this work, the combustion process will also be simulated.

MATERIALS AND METHODOLOGY

Pressure, temperature, fuel liquid and vapor phases as well as surface erosion are numerically investigated inside the discharge channel of the diesel injector. Three injector operation parameters: (a) fuel pressure, (b) fuel temperature and (c) needle lift were varied in order to understand the fluid flow trend in the discharge channel of the injector. The AVL-FIRE™ CFD commercial code was used in this work. Figure 2(a) shows the simplified geometry and mesh used in this work. A simplified DOE was used for numerical experiments:

Numerical experiment #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pressure factor	0.5	-	2	-	-	-	-	-	0.5	2	0	2	2	2	2
Temperature factor	-	2	-	0.5	-	-	2	0.5	-	-	0.5	2	2	0.5	0.5
Needle lift variation (%)	-	-	-	-	0.25	-0.25	-0.25	0.25	0.25	-0.25	0.25	-0.25	0.25	-0.25	0.25

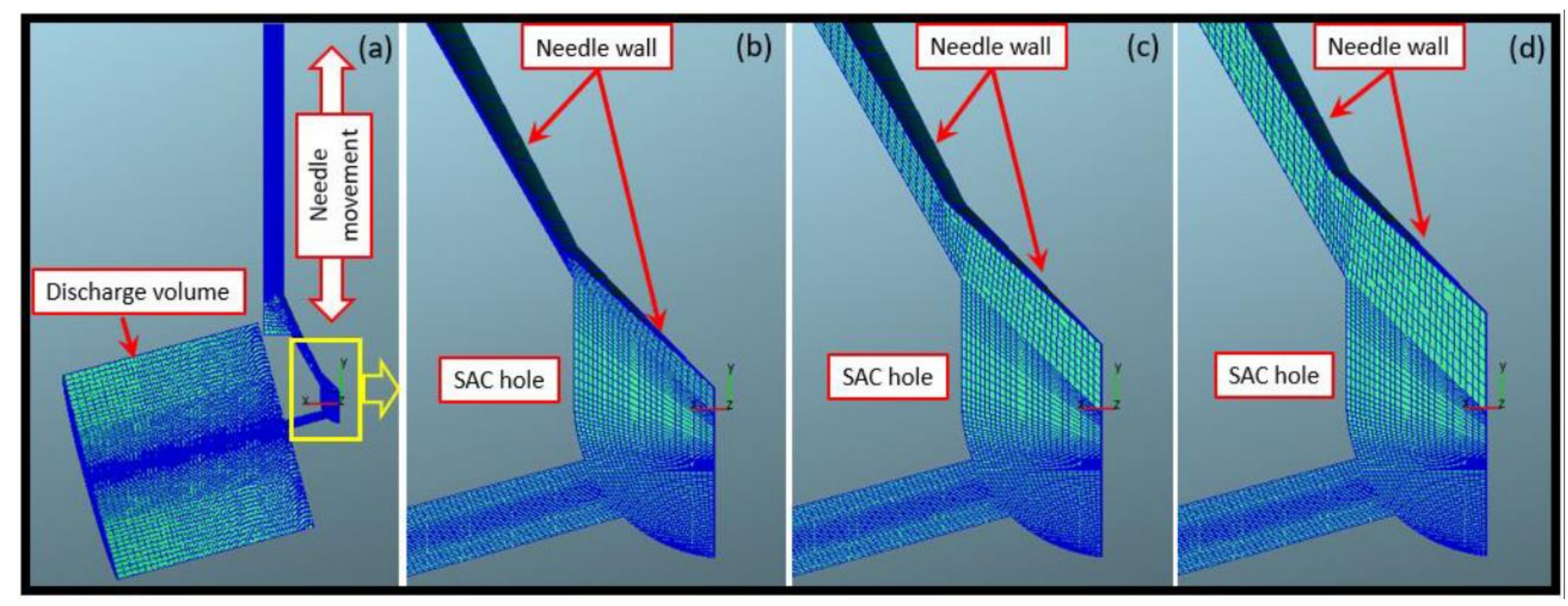

Figure 2. Comp. mesh. (a) full domain, (b), (c) and (d) meshes at tree lift position showing the effect of changing the aspect-ratio [2].

The comparison strategy was based on initial pressure change, initial temperature and needle lift. For temperature and pressure, we varied half on the value up and down, from 283.15 K to 313.15 K and 100 MPa to 200 MPa, respectively. The needle opening treatment should have an increase of 0.25% greater and 0.25% smaller compared to the initial opening.

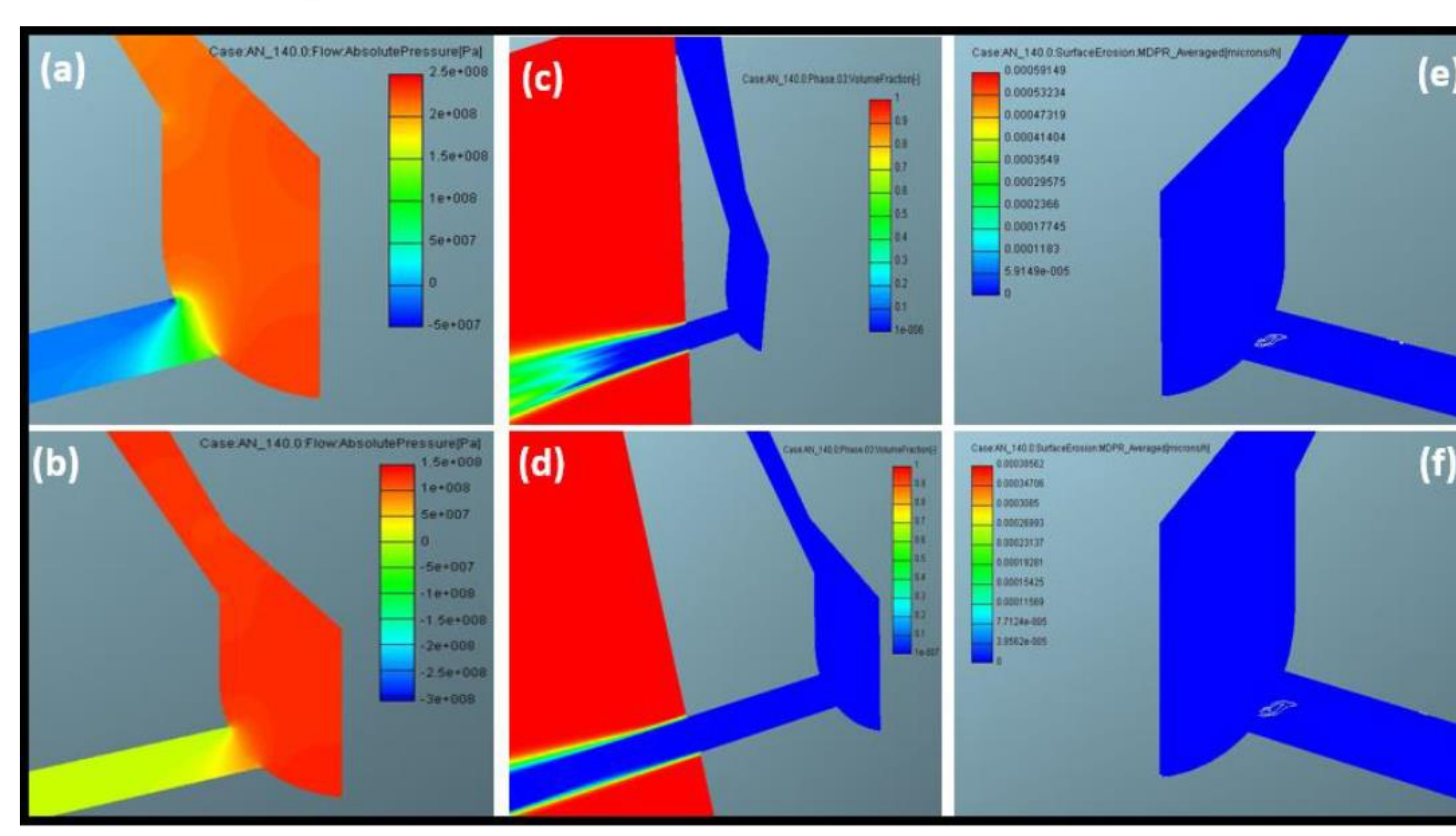

Figure 3. Pressure field: (a) 200~MPa inlet pressure, (b) 100~MPa inlet pressure. Volume fraction of vapor phase: (c) 200~MPa inlet pressure, (d) 100~MPa inlet pressure. Mean depth of penetration rate of surface erosion (MDPR): (e) 200~MPa inlet pressure, (f) 100~MPa inlet pressure. [2]

CONCLUSION

The higher velocities involved aid in the effect of pressure drop in the injection hole, added to the geometric effect of the flow failure between the SAC and the channel, resulting in an environment conductive to cavitation due to a marked pressure drop. The results of this work will be useful for a next stage of simulation involving the combustion process.

REFERENCES

[1] Baumgarten, C., 2006. Mixture Formation in Internal Combustion Engine. Springer-Verlag Berlin Heidelberg. doi:10.1007/3-540-30836-9.

[2] Adao, W.B., 2018. “Spray behavior on compression ignition internal combustion engines: A computational analysis using cfd”. Thesis - Automotive Engineering, 51 pages. Available at http://labmci.ufsc.br/tccs-concluidos/.

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