CFD Analysis of Ejectors

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Introduction: Ejectors are the devices used to carry out the mixing and recompression of two fluid streams, with different energies. The high energy fluid is passed through the primary C-D nozzle of the ejector which exhausts the fluid at Supersonic speeds. This supersonic flow at the exhaust of the primary nozzle creates low pressure region inducing secondary fluid into the ejector and mixes with the primary fluid exhausting from the primary nozzle.

In the present work an attempt is made to study the entrainment of primary fluid with secondary fluid of a single phase fluid in the ejector by simulating the flow using commercially available CFD package COMSOL.

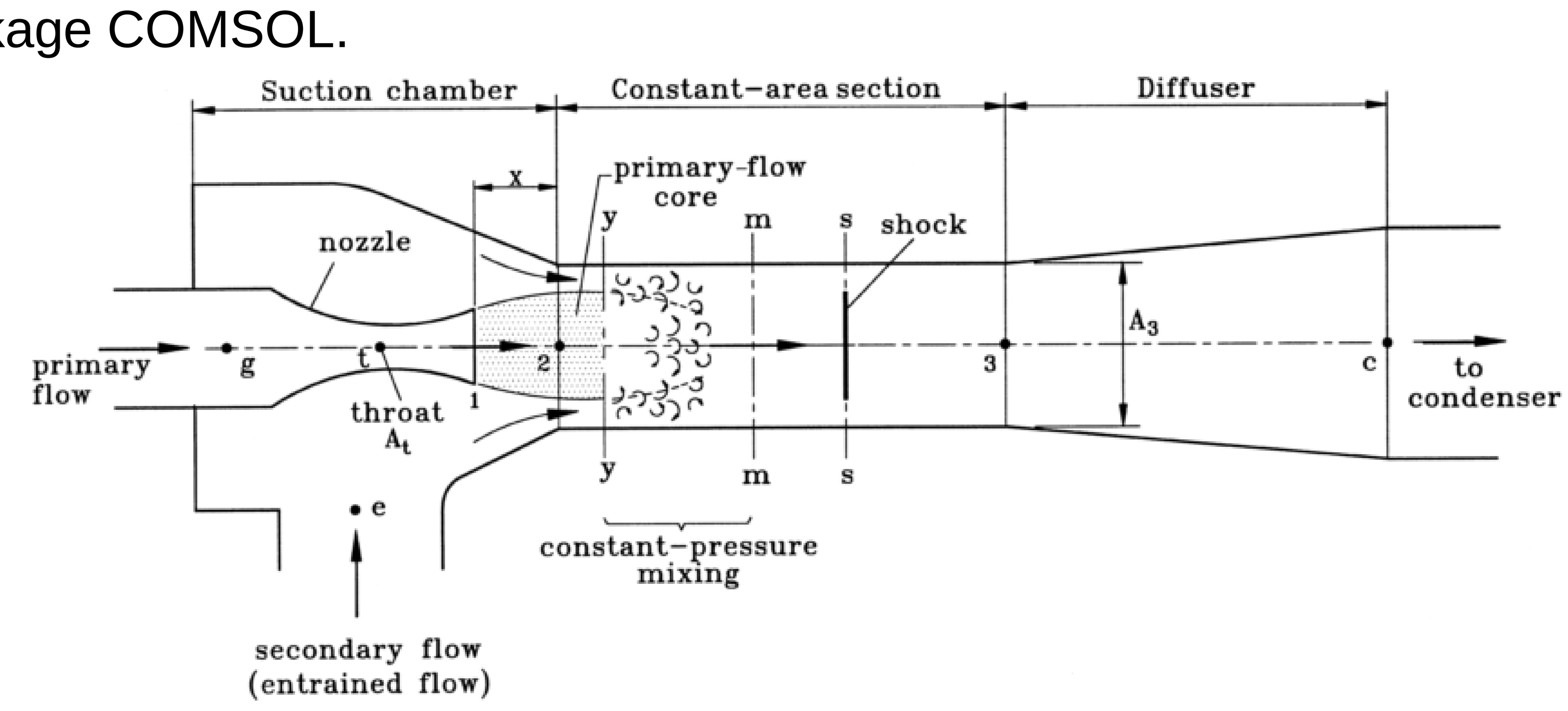

Figure 1. Schematic Diagram of Ejector

Computational Methods: Geometry specifications adopted are summarized by figure (2) and table (1)[2]. Two geometrical model with different area ratio (R5/R2) are considered. R141b-(1,1- Dichloro-1-fluroethane) was chosen as working fluid for the purpose of analysis.

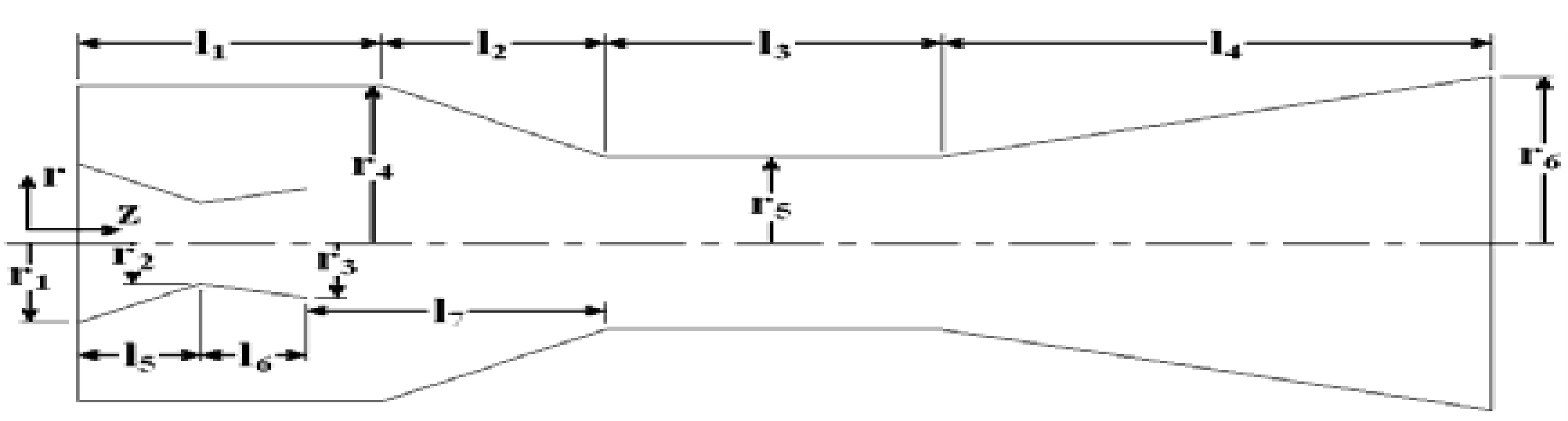

Figure 2. Geometrical dimensions

	L1	L2	L3	L4	L5	L6	L7	R1	R2	R3	R4	R5	R6
S	40	32.24	35.6	56.94	18.32	18.32	35.6	6.65	1.32	2.25	11.55	3.49	7.04
L	40	32.24	35.6	56.94	18.32	18.32	35.6	6.65	1.32	2.25	11.55	3.67	7.04

Table 1. Geometry(All dimensions in mm)

Boundary conditions used is summarized in the table 2.

	BC 1	BC 2
Primary nozzle inlet	P = 0.4006 Mpa T=351.15 K M = 0.01	P = 0.4655 Mpa T = 357.15 K M = 0.01
Primary nozzle outlet	Supersonic	Supersonic
Secondary nozzle inlet	P = 0.03999 Mpa T = 281.15 K M = 0.2	P = 0.03999 Mpa T = 281.15 K M = 0.2
Secondary nozzle outlet	Subsonic P = 0.065 Mpa	Subsonic P = 0.065 Mpa

Table 2. Boundary conditions

Results: After running the simulations, the mass flow rates for the primary and secondary CD nozzles were obtained through which the entrainment ratio was calculated for each of the configurations. These results were compared to 1-D mathematical analysis made by Huang et al. [1]

R141b	Primary Pressure Mpa	Primary Temp K	Secondary Pressure Mpa	Secondary Temp K	M_p Kg/s	M_s Kg/s	ω-1D analytical	ω-CFD
S1 R5=3.49	0.4006	351	0.03999	281	0.03555	0.0160	0.4422	0.45289
L1 R5=3.67	0.4006	351	0.03999	281	0.0668	0.025	0.4609	0.37673
S2 R5=3.49	0.4655	357	0.03999	281	0.04455	0.0139	0.3042	0.3123
L2 R5=3.67	0.4655	357	0.03999	281	0.07088	0.0166	0.3704	0.23457

Table 3. Summary of result obtained

The fluid is at stagnation at the entry of the primary nozzle. It gets chocked at the primary throat and it is supersonic at the exit of primary nozzle. This low pressure, high Mach primary fluid entrains the secondary fluid which is relatively at much higher pressure followed by mixing of two fluids at the mixing chamber. Further the mixed fluids undergo static pressure recovery at the diffuser section of the secondary nozzle as a result of an irreversible supersonic compression shock wave.

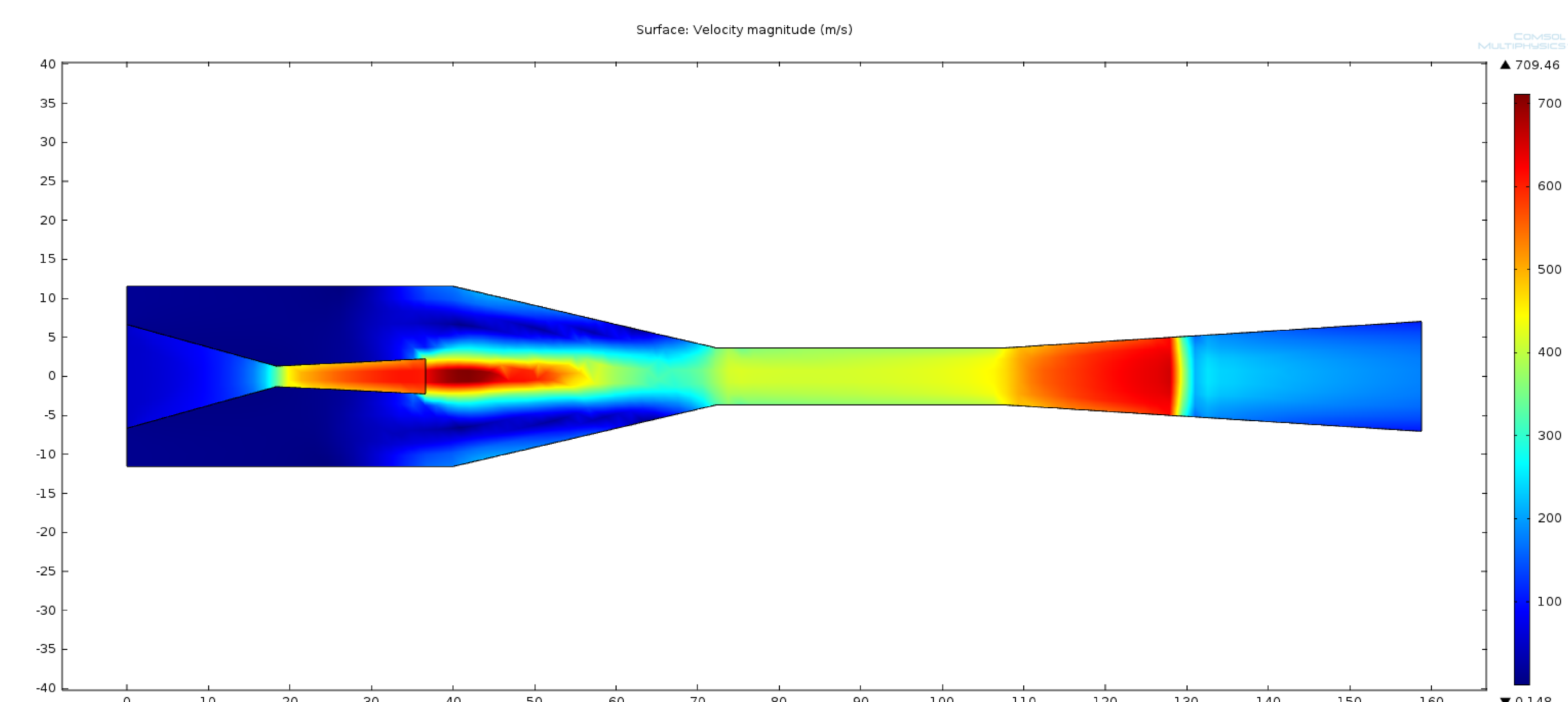

Figure 3. Surface velocity profile for R141b-L1

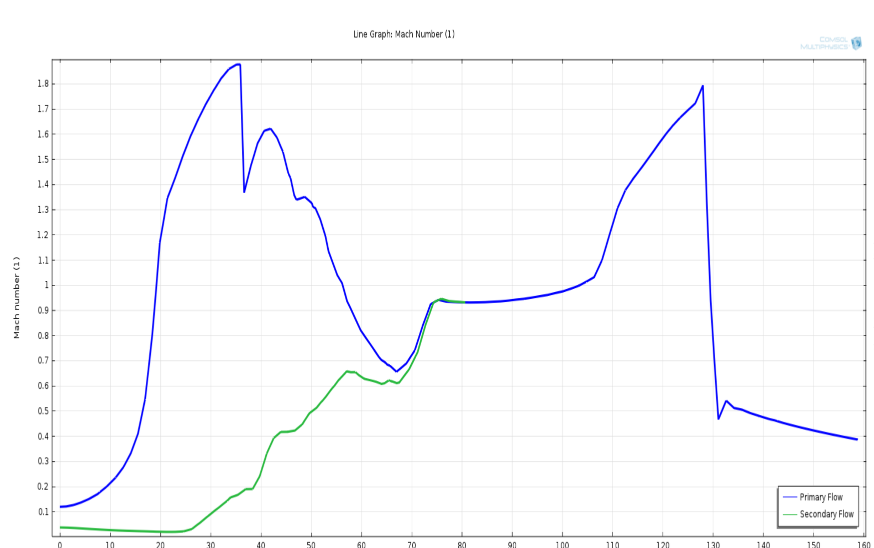

Figure 4. Mach variation along the ejector

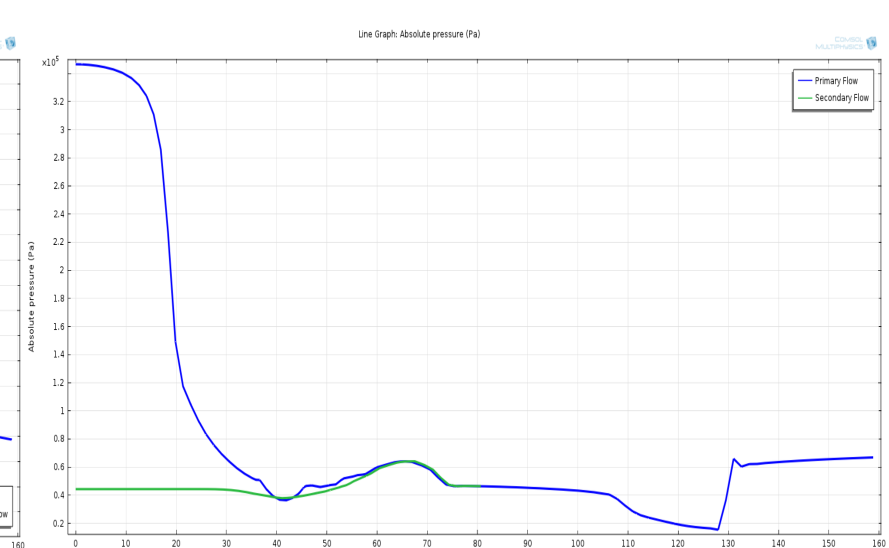

Figure 5. Static pr. variation along ejector

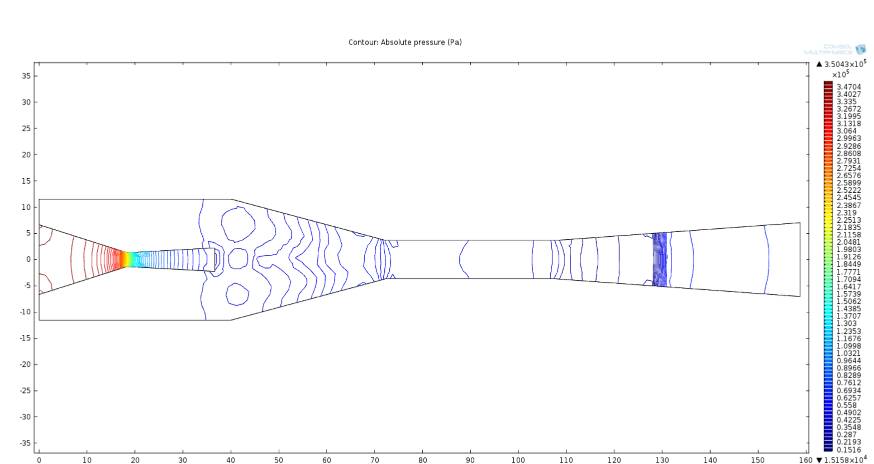

Figure 6. - Pressure contours along the ejector (R141b-L1)

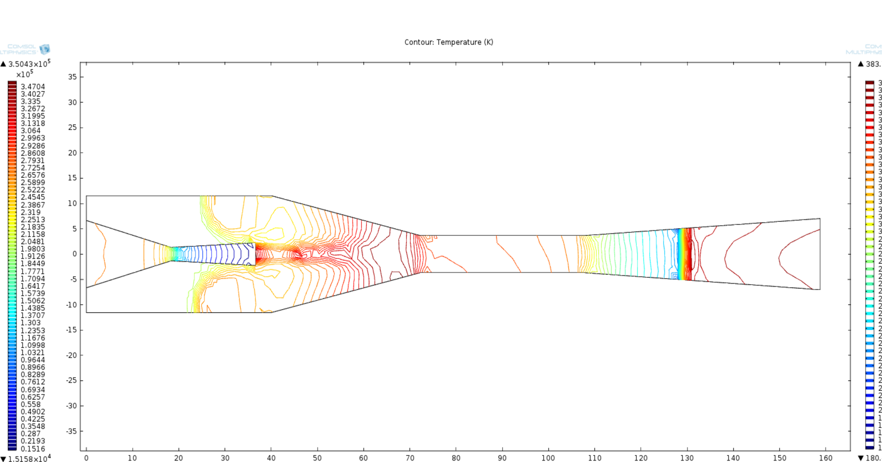

Figure 7. Temperature contours along the ejector (R141b-L1)

Conclusions: The CFD model was created in commercial package COMSOL and is validated with the available 1-D model. It is found that the CFD model is in good agreement with the 1-D mathematical result over the range of inlet boundary conditions. Huang's constant pressure theory is found to be accurate for the given boundary conditions from the analysis made.

References:

1. B.J. Huang, J.M. Chang, C.P. Wang, V.A. Petrenko . A 1-D analysis of ejector performance.(1999)
2. David SCOTT, Zine AIDOUN, Omar BELLACHE and Mohamed OUZZANE.CFD Simulations of a Supersonic Ejector for Use in Refrigeration Applications.

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