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Performance Optimization of Ejector using Computation Fluid Dynamics

M.Prabhahar, S.Prakash, Ihsan Ali Valiyangal, Akash PS, Kattil Salman Shareef

Abstract*: Ejector is a device used for carry low pressure fluids with no mechanical force, high pressure flow. This contains the main nozzle, chamber for suction, chamber for mixing and diffu ser.It is used in vaccum pumps, condensers, steam refrigeration, Because of its simple structure, gas mixing, pneumatic transport (no moving parts) and reliable operation. It is also used in pumps for lifting slurries and waste material containing solids from tanks and sumps. Due to their simplicity and high reliability, however, jet ejectors are widely used in industries with low efficie ncy. The project's goal is to optimize the efficiency of jet ejectors for each operating condition.Consequently, the primary fluid consumption and operating cost is minimized. A commercial computational fluid dynamics tool would be used to analyse the flow characteristics inside the ejector geometry. The results of the CFD simulation could be used to understand the effect of fluid velocity and pressure ratio on the ejector performance. The analysis would also be carried out by varying the primary and secondary nozzle dimensions. Performance of ejectors under various operating conditions is generally obtained through an experimental testing of prototype or scaled ejectors. The availability of performance parameters for such ejectors is limited, and experimental testing can be cost prohibitive.

Keywords: Ejector, CFD, optimization.

I. INTRODUCTION

Stream ejectors are the least difficult gadgets among all blowers and vacuum siphons. They don't contain any moving parts, oils or seals; in this manner, they are exceptionally solid gadgets with low capital and upkeep costs [1]. Besides, most stream ejectors use steam or packed air as the rationale liquid, which are effectively found in synthetic plants. Because of their effortlessness and high unwavering quality, they are generally utilized in compound modern procedures; be that as it may, stream ejectors have a low productivity [2-4]. The significant thought of any ejector is to improve its proficiency at each working condition [5]. Subsequently, the intention liquid utilization and working expense is limited. Numerous variables influence fly ejector execution, including the liquid sub-atomic weight, feed temperature, blending tube length, spout position, throat measurement, thought process speed, Reynolds number, pressure proportion, and explicit heat proportion [6-9].

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II. METHODS AND MATERIALS

Steam stream ejectors are a straightforward option in contrast to mechanical siphons for vacuum - raising applications. The steam stream ejector uses high constrain steam to pack low weight fumes or gases. The significant favorable position of ejectors over vacuum siphons is the way that they have no moving parts and are along these lines require little upkeep. They additionally require next to no space and are effectively and inexpensively introduced. Anyway an ejector must be intended for explicit states of weight both for the intention liquid and the vacuum conditions, and its effectiveness tumbles off quickly outside these conditions. Figure 1 shows the ejector.

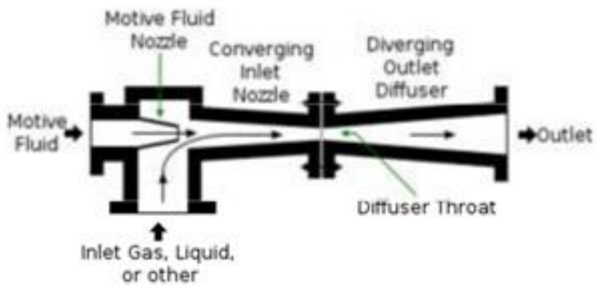


Fig.1. Ejector

High pressure rationale steam extends through a spout and exits at low pressure and at high speed. The low weight initiates a progression of fumes at the suction pressure into the ejector. The two streams for example the low weight - high speed steam from the spout and the entrained fumes blend as they join into the throat of the ejector. After leaving the throat, the gases delayed down and recover pressure.
The utilization of injectors (or ejectors) in different mechanical applications has gotten very regular because of their relative effortlessness and versatility. For example:

Steam jet ejectors are not energy efficient, Liquid ring pumps are more energy efficient than ejectors by a factor of about three under the conditions used in pans and evaporators.

- Though the ejector this is an artificial lift system which needs no power supply and is distinguished by a simple design, the absence of moving parts and small dimensions which make it easy to use. installation and maintenance, it is low efficiency device compared conventional jet pump.
- Increasing the ejector efficiency is essential so that the primary fluid consumption and consequently pumping power is minimized.
- To improve the performance of the jet ejector, it is essent ial to understand the mechanism of the flow field inside t he jet ejector.

The CFD method has been shown to be an effective tool for understanding and evaluating complex fluid flow issues, suc h as the processes of entraining and mixing in ejectors.

III. CFD ANALYSIS

Modeling was done using Pro E and exported as IGES. T he ejector models were shown in the figures 2 and 3 below.

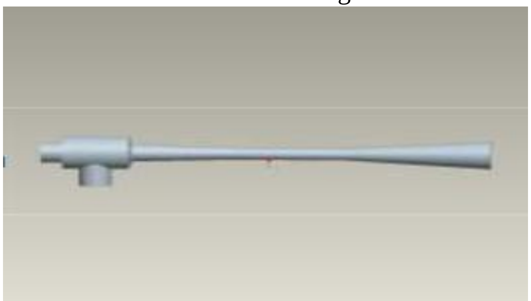


Fig 2 Pro E models of ejector

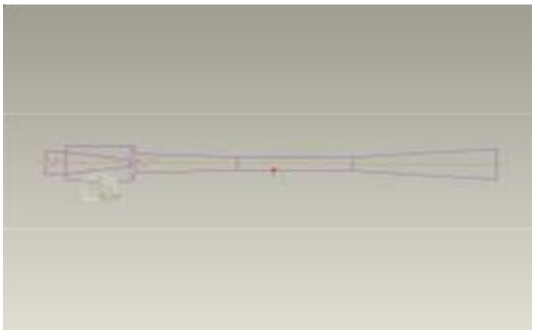


Fig 3 Wireframe Pro E models of ejector

There are five models generated with varying length of primary nozzle and diameter of primary nozzle, the length of the primary nozzle varying the range from 175, 185,195,205 and 215mm.

The measurement of the essential spout differing the range from 31, 34, 37 and 40mm.

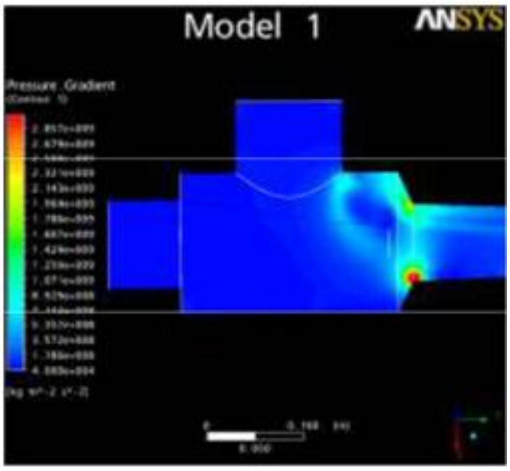
A. Mixing Chamber and Primary Nozzle Dimensions

Diameter of the Primary Nozzle = 28 mm
Diameter of the mixing chamber = 145 mm
Length of the mixing chamber = 225 mm
Secondary Nozzle Dimensions
Diameter of the convergent nozzle = 78.7 mm
Diameter of the throat = 54.4 mm
Diameter of the mixing chamber = 127 mm
Length of the mixing chamber = 348 mm
Length of the throat = 392 mm
Length of the diffuser = 501 mm

IV. RESULT AND DISCUSSION

A. Varying Length of Primary Nozzle – Pressure Gradient

The variation of the pressure gradient along the mixing cham ber and secondary nozzle is shown in Figure 4 (A to E). The pressure gradient in the flow causes the axial velocity to decr ease; causing eddies to increase the dissipation of energy. From the diagram, it was observed that the pressure gradient at the mixing chamber and the convergent part of the nozzle is gradually increasing.The result shows that the gradient of t he stress is significantly high the flow past the throat and at the diffuser area and then decreases. The magnitude of pressure gradient is relatively uniform for all the ejector models. The contour of pressure gradient in the mixing chamber for the ejector models is shown in figure 4. Concentrated pressure gradient has been observed at the entry of secondary nozzle and this may be due to sudden drop in pressure due to increase in velocity. Slightly reduced concentration of pressure gradient has been observed for the model 5.



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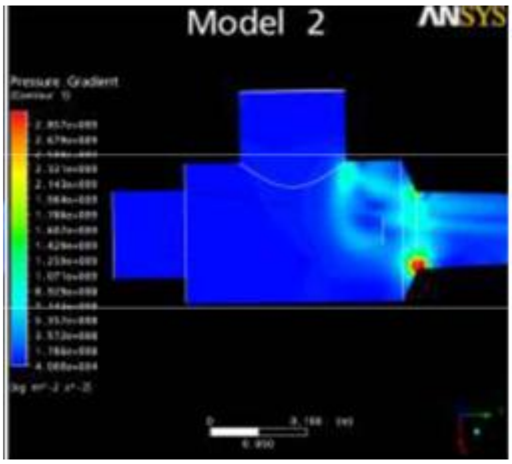

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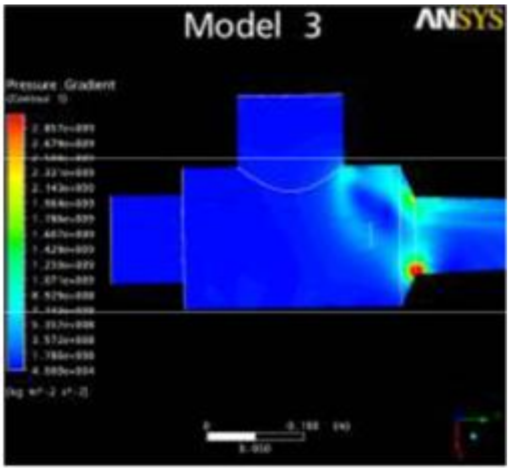

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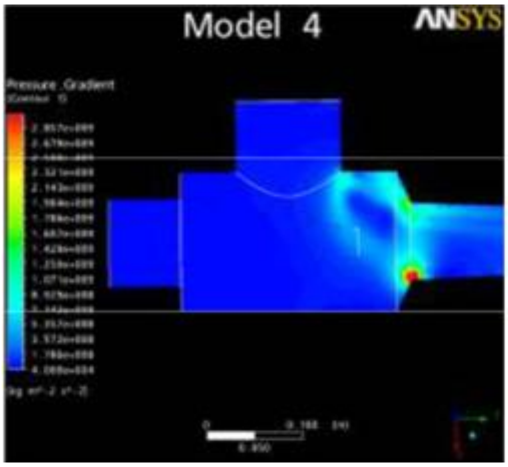

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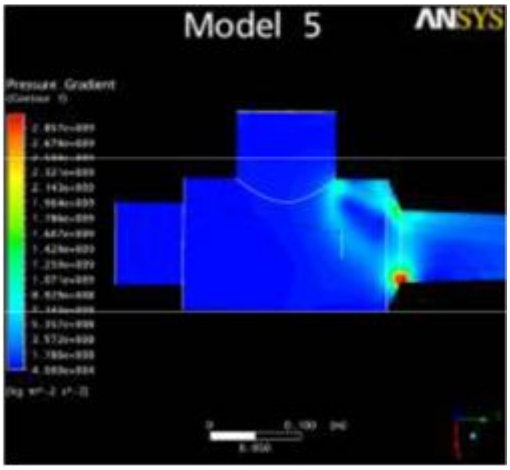


(E)

Fig 4 (A to E) Pressure Gradient – Mixing Chamber

B. Energy dissipation

Figure 5 shows the Energy dissipation per unit mass of the fluid along the mixing chamber and secondary nozzle. Significant increased energy dissipation has been observed at the mixing chamber and it is relatively high for ejector model 2. The energy dissipation decreases sharply at the convergent and diffuser of the secondary nozzle. It remains constant at the throat.

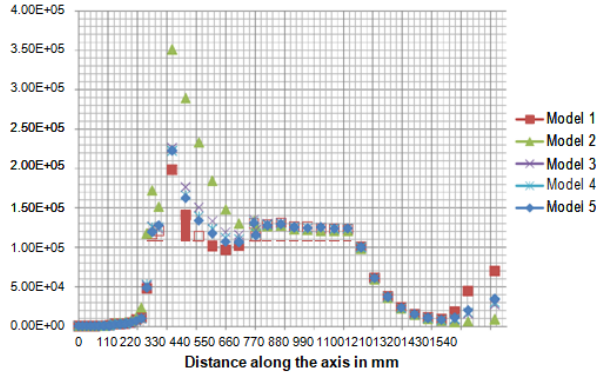
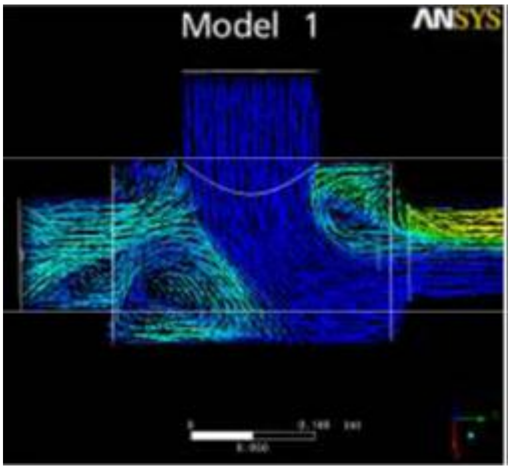


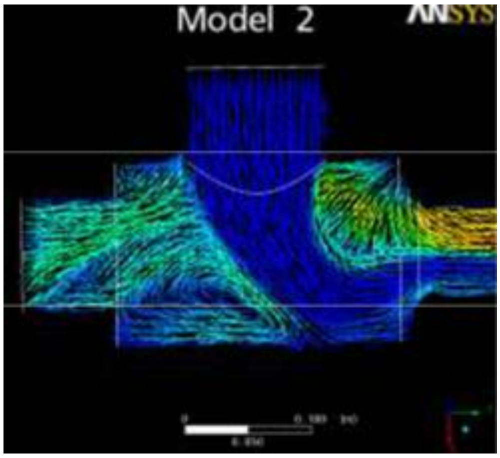
Fig 5 Energy Dissipation along the ejector

C. Velocity vector

Figure 6 (A to E) shows the velocity vector along the mixing chamber. It has been observed the result that strong recirculation zones have been observed at lower part of mixing chamber for all the ejector models. Generally recirculation creates wake zone which causes energy loss in the flow. Comparatively less recirculation zones have been observed for the ejector model 2.



(A)



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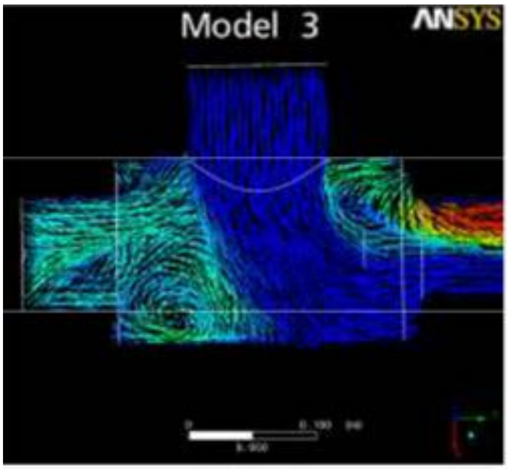

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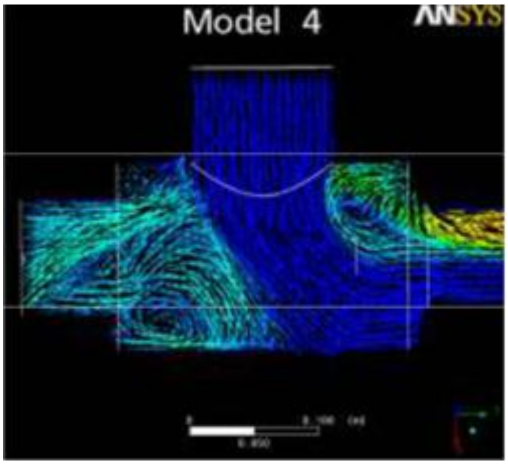

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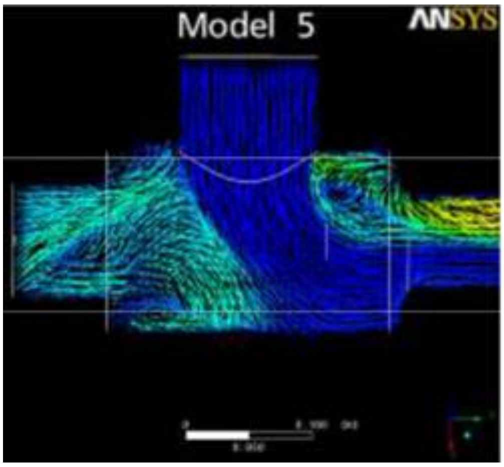

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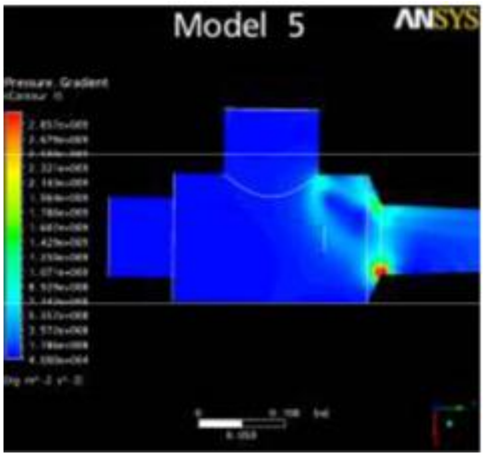
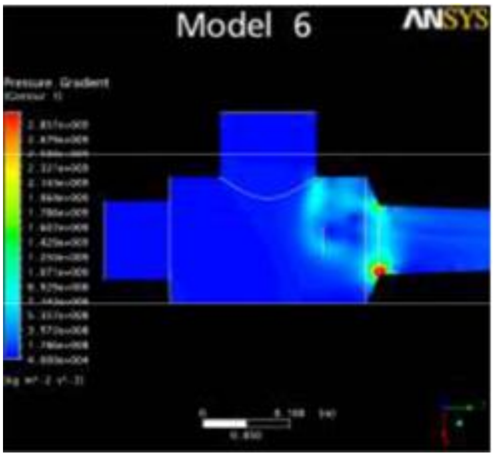
Fig 6 (A to E) Velocity Vectors – Mixing Chamber

D. Varying Diameter of Primary Nozzle– Pressure Gradient

Figure 7 (A to E) shows the variation of Mixing chamber and secondary nozzle temperature gradient. The graph shows that the pressure gradient in the mixing cha mber and the convergent part of the nozzle gradually increas es. The result shows that the pressure gradient is significantly high when the flow past the throat and at the diffuser area and then decreases. The magnitude of pressure gradient is relatively uniform for all the ejector models. The contour of pressure gradient in the mixing chamber for the ejector models is shown in fig 7. Concentrated pressure gradient has been observed at the entry of secondary nozzle and this may be due to sudden drop in pressure due to increase in velocity. Slightly reduced concentration of pressure gradient has been observed for the models 6 and 9.



(A)



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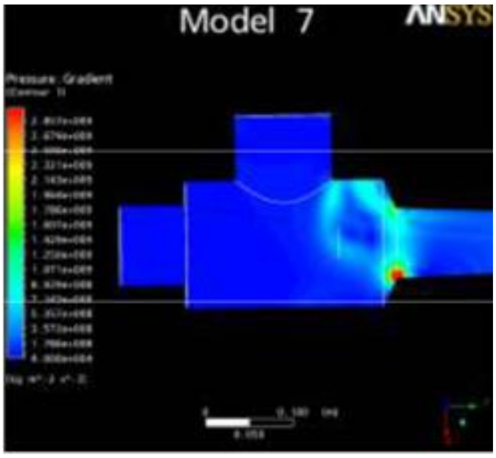

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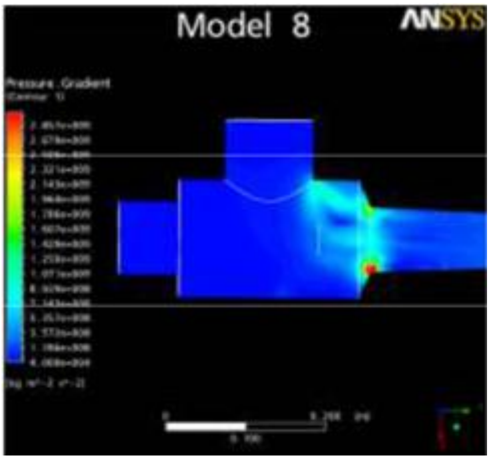

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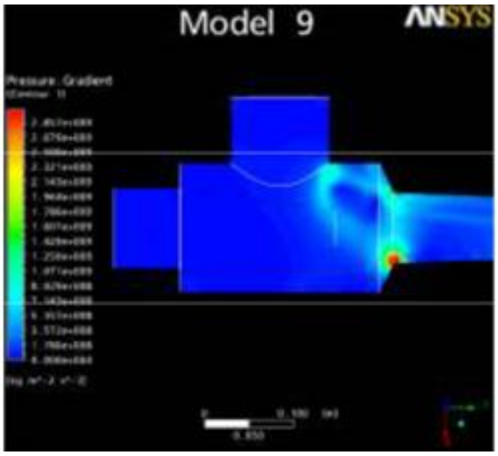

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Fig 7 (A to E) Pressure Gradient – Mixing Chamber

E. Energy dissipation

Figure 8 shows the Energy dissipation per unit mass of the fluid along the mixing chamber and secondary nozzle. Significant increased energy dissipation has been observed at the mixing chamber and it is relatively high for ejector models 6 and 7. The energy dissipation decreases sharply at the convergent part of the secondary nozzle. It remains constant at the throat for all the models.

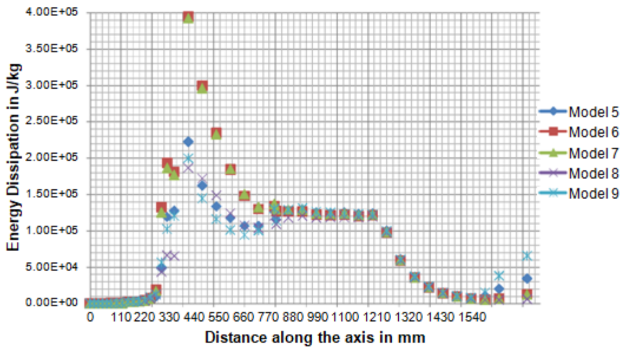
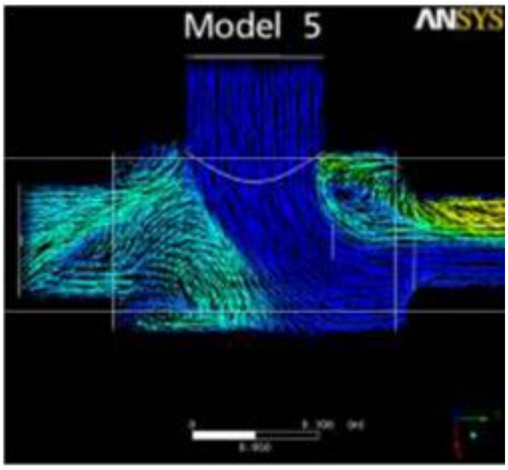


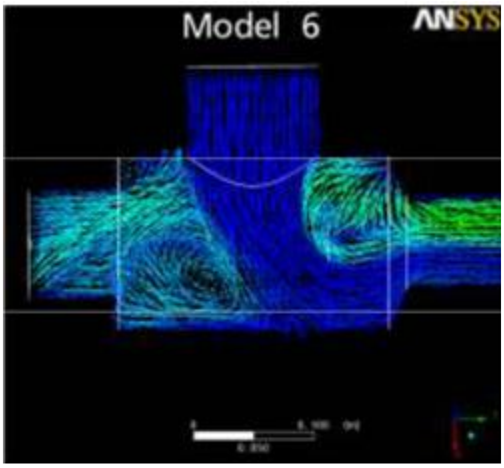
Fig 8. Energy Dissipation along the ejector

F. Velocity vectors

Figure 9 (A to E) shows the velocity vectors along the mixing chamber. It has been observed the result that strong recirculation zones have been observed at lower part of mixing chamber for all the ejector models. Generally recirculation creates wake zone which causes energy loss in the flow. Comparatively less recirculation zones have been observed for the ejector model 6 and 9.



(A)



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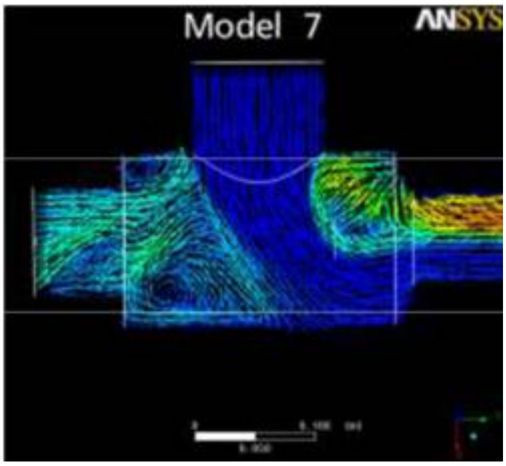

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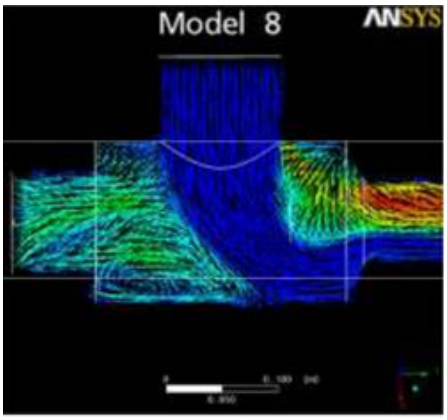

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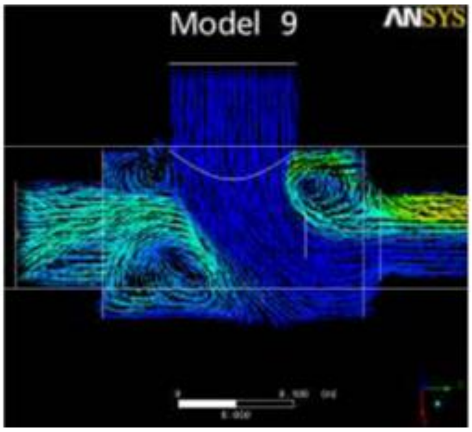

(E)

Fig 9 (A to E) Varying Inlet pressure of Primary Steam

V. CONCLUSION

Thus CFD analysis of ejector for optimizing its performance has been carried out and the following conclusion has been drawn.

Effect of varying length of primary nozzle

- Increased entrainment ratio has been observed along the secondary nozzle for the model 5
- Efficiency being maximum at the exit of mixing chamber and decreases sharply and it remains constant for the rest of the flow for all the models.
- Volume fraction of secondary steam has relatively increased for the model 5
- Energy dissipation is maximum at the mixing chamber and it remains constant along the throat and it decreases at the diffuser for all the models

Effect of varying primary nozzle diameter

- Increased entrainment ratio has been observed along the mixing chamber and secondary nozzle for model 6.
- Volume fraction of primary steam has reduced for the model 6 which will reduce the primary steam consumption.

Effect varying inlet pressure

- Entrainment ratio increases along the secondary nozzle at lower inlet pressure.
- Efficiency being maximum at the exit of mixing chamber and decreases sharply and it remains constant for the rest of the flow for varying inlet pressure of steam.
- Reduced primary steam volume fraction has been observed along the secondary nozzle at the lower inlet pressure which may ultimately reduce the primary steam consumption.

Energy dissipation is maximum at the mixing chamber and it remains constant along the throat and it decreases at the diffuser for all pressure.

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