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CFD Simulation and Analysis of Abrasive Fluid Jet Machining

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Abstract -*Abrasive liquid jet machining is one of the newly established manufacturing techniques. The common nature of movement over the machining, results in speedy wear of the jet which decline the machining performance. The glycerol is used as a lubricating solution for minimizing wear in nozzle. The analysis would be carried out by using water with glycerol and water with acrylamide solution, so as to attain enhanced process considerations for smallest nozzle wear. The readiness of abrasive water jet machining is restricted to water and untried trial can be high-priced. In this event, Computational fluid dynamics study would deliver improved results.*

Keywords- *Analysis, Flow, Performance, Nozzle, Wear*

I. INTRODUCTION

Abrasive water jet machining (AWJM) is a reasonable recognized non-traditional machining practice. It is a practice where material is detached by influenced erosion of higher pressure higher velocity of water with higher velocity of sand abrasives on a work part [1-3]. AWJM has certain advantageous characteristics which helped to achieve significant involvement into manufacturing industries [4]. The abrasive water liquid mix is let into the jet at intake and passed over converging cone to focus tube and departures at nozzle, in which the focus tube is utilized for managing the flow. Flow is assumed as two stage flow mix in which water with glycerol and water with acrylamide is liquid stage and abrasives is solid stage, but combined with the liquid stage. Two stage flow is stable and contains tempestuous flow features [5,6].

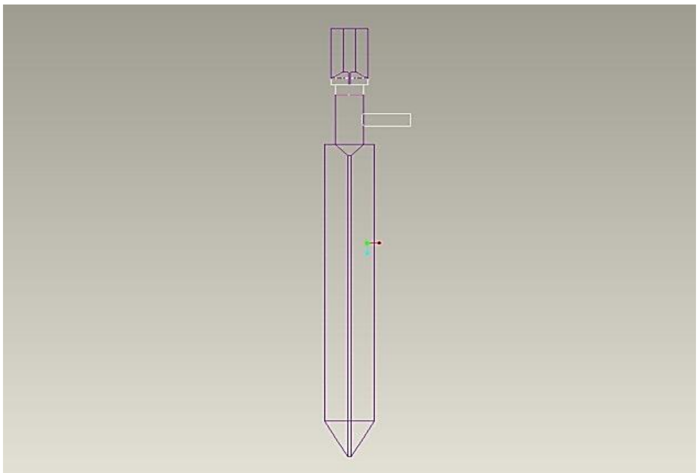

Fig 1 Nozzle Head Model using Pro-E

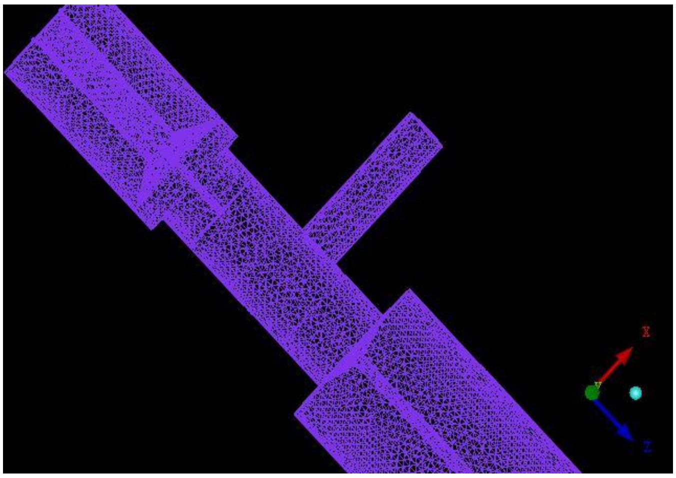

Fig 2 Nozzle Head Model with Mesh

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II. COMPUTATIONAL DOMAIN RESPONSE

The mesh model computational area should be specified at first. Create a water inlet part, abrasive inlet part and mix outlet to the meshed model. The water with glycerol [90:10] and water with acrylamide [90:10] is engaged as continuous fluid, and distributed solid abrasive extent is 1mm. In the boundary condition, provide the type of domain, name of the nozzle head and mix chamber. Also tag the fluid domain and solid domain of jet head and mix chamber. Then provide the water with glycerol and water with acrylamide at water inlet, and at abrasive inlet abrasive will arrive and also provide the boundary particulars. Also provide the domain interface among solid and fluid domain. In CFX Solver, the models are introduced and number of calculations is done and needs to provide number of iterations and run solver and monitor the same [7-9].

Table.1. Model Specifications

Dia. of focus tube	0.75mm
Length of focus tube	75mm
Nozzle taper angle	30^0
Dia. of mixing chamber	6mm
Length of mixing chamber	12mm
Dia. of orifice	0.2mm
Dia. of water inlet	2.5mm
Dia. of abrasive inlet	3mm
Water pressure	400bar
Water density	$1000kg/m^3$

The mass flow and velocity of water and abrasive will be evaluated with the regular sizes and used for domain input. Molecular weight, Dynamic viscosity, Density, specific heat and Thermal Conductivity are found by using mass transfer formulae and given as input parameters with water with glycerol and water with acrylamide and abrasive.

III. RESULTS AND DISCUSSIONS

3.1. EFFECT OF GLYCEROL AND ACRYLAMIDE OF MIXTURE

3.1.1. Velocity Variation

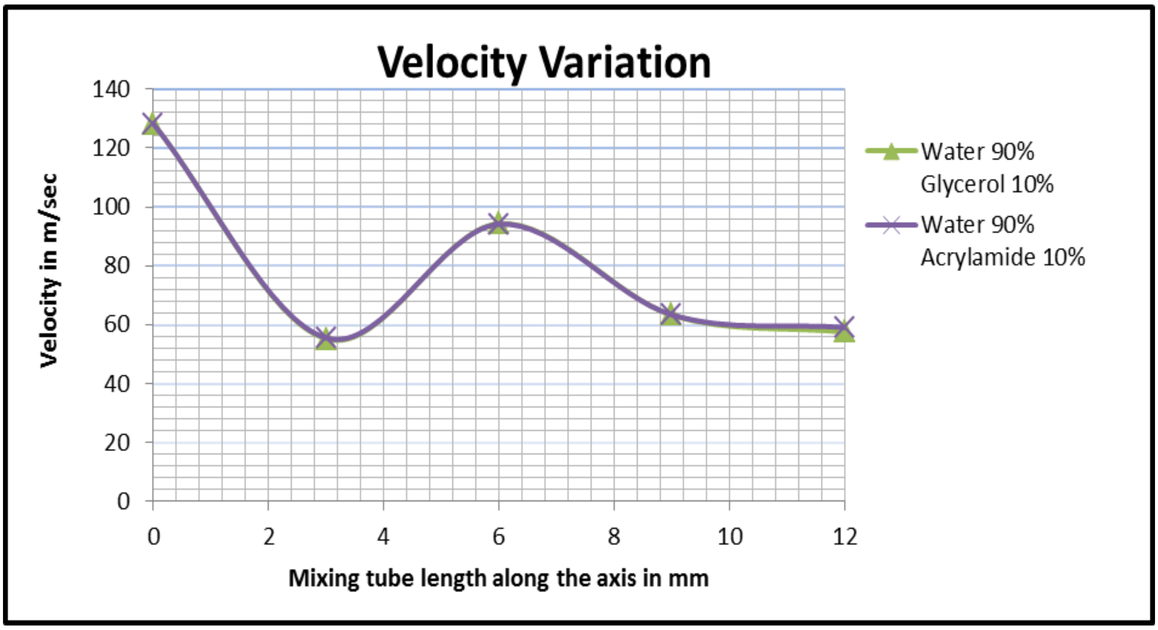

Fig 4.1[a] Velocity vs. Mixing Chamber

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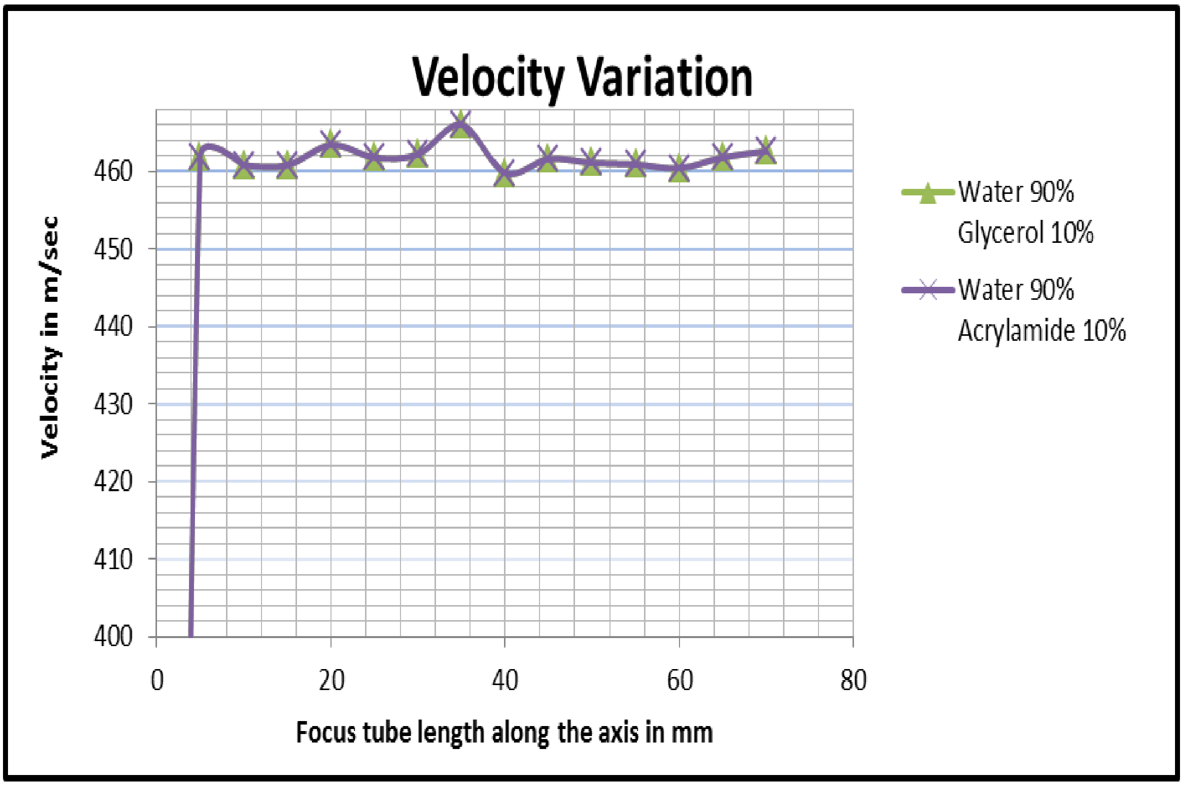

Fig 4.1 [b] Velocity vs. Focus tubes

Figure 4.1 displays the velocity difference along with the mixing and focus tube length. In the event of mixing tube the velocity diminishes steadily and rises when at the mixing region and then it decreases gradually in both cases near the tube end. In the event of focus tube length, the increase in velocity is detected when the flow past the jet. The velocity variation remains almost same for both glycerol and acrylamide mixture.

3.1.2. Wall shear stress

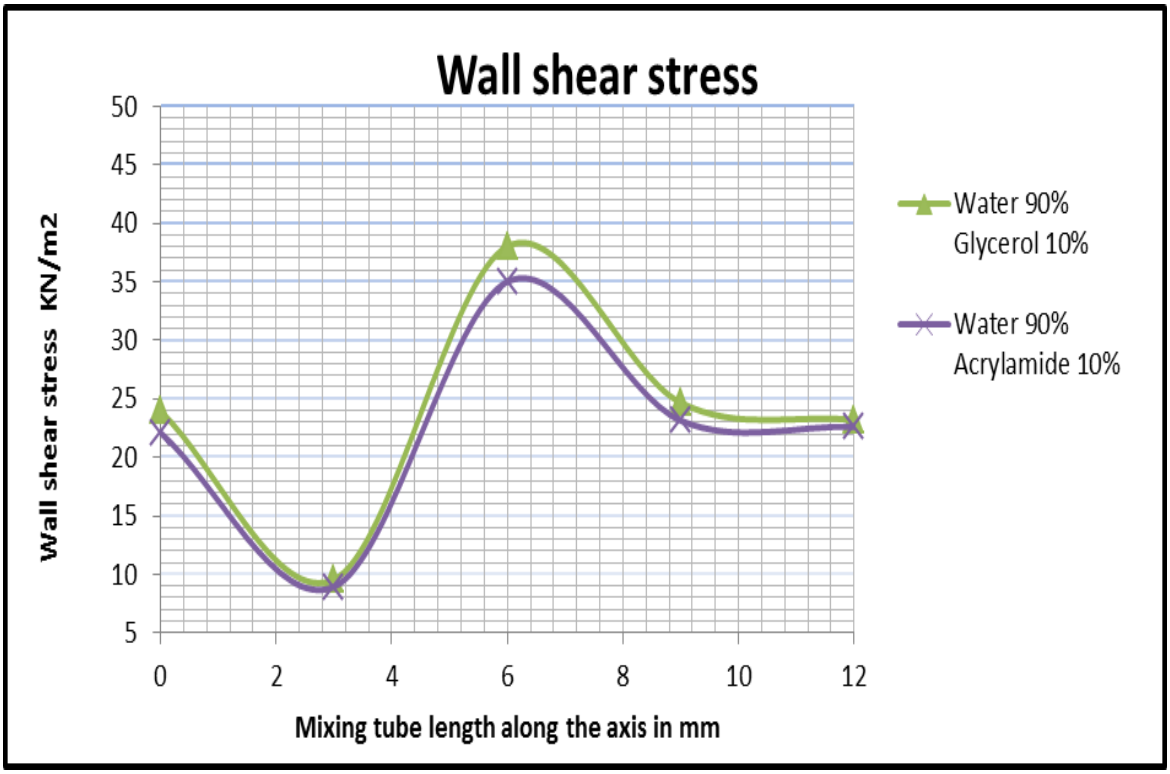

Fig 4.2[a] Wall shear stress vs. Mixing Chamber

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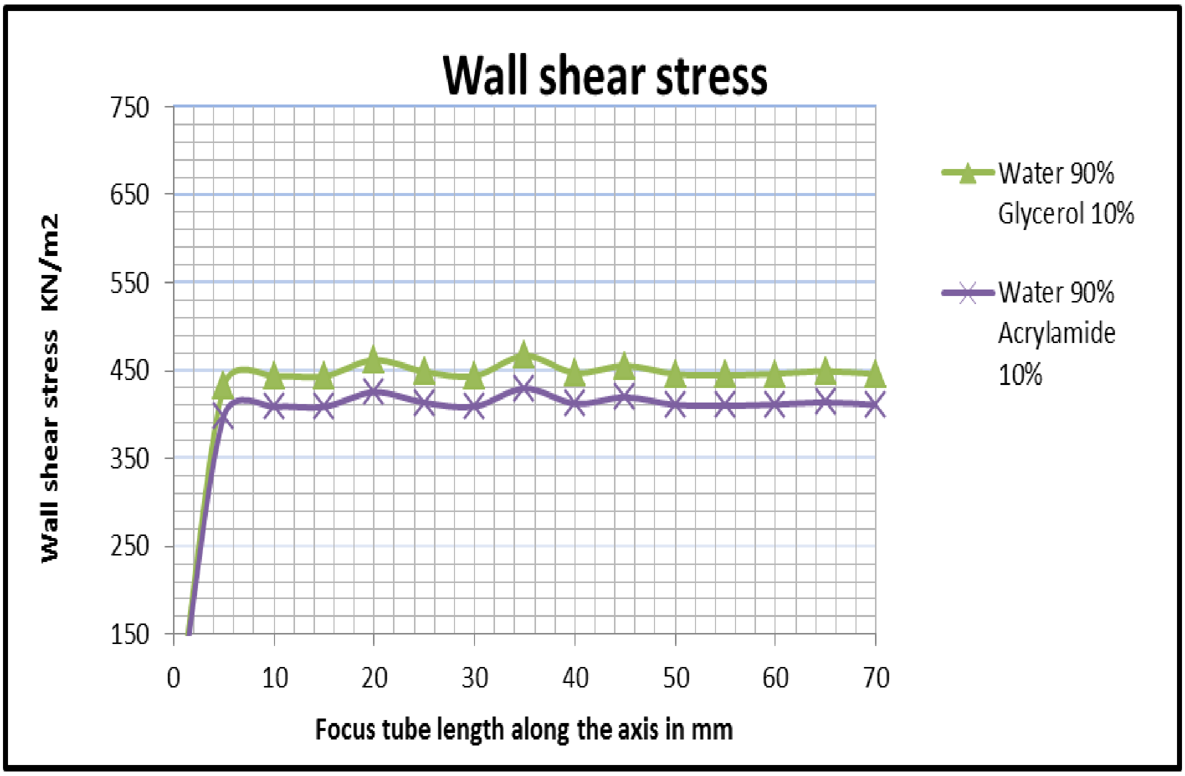

Fig 4.2[b] Wall shear stress vs. Focus tube

Figure 4.2[a] displays that minimal rise wall shear at the entrance of mixing tube for glycerol mixture and it continues along the flow. The magnitude increases at the mingling region after that it declines steadily when the flow reaches the end of the tube. Figure 4.2[b] displays that the wall shear rises when the flow past the nozzle in both the cases. Relatively enlarged magnitude of wall shear has been witnessed for glycerol mixture.

3.1.3. Shear Strain Rate

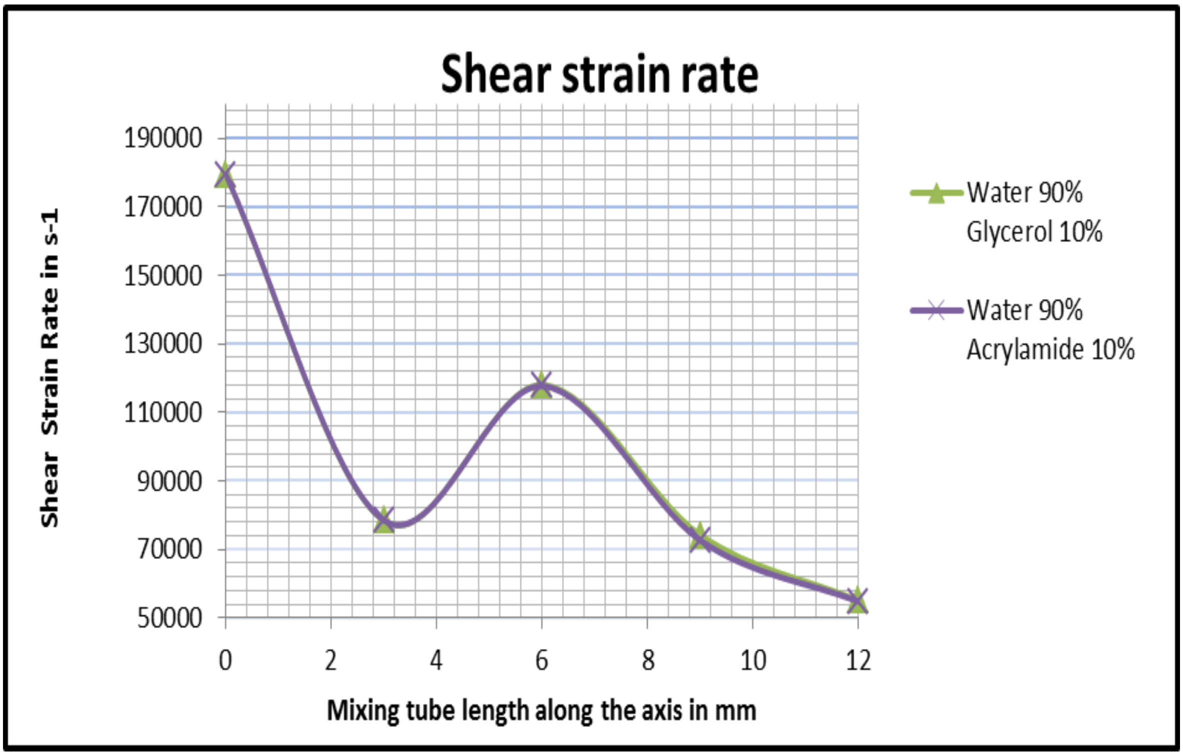

Fig 4.3(a) Shear Strain Rate vs. Mixing Chamber

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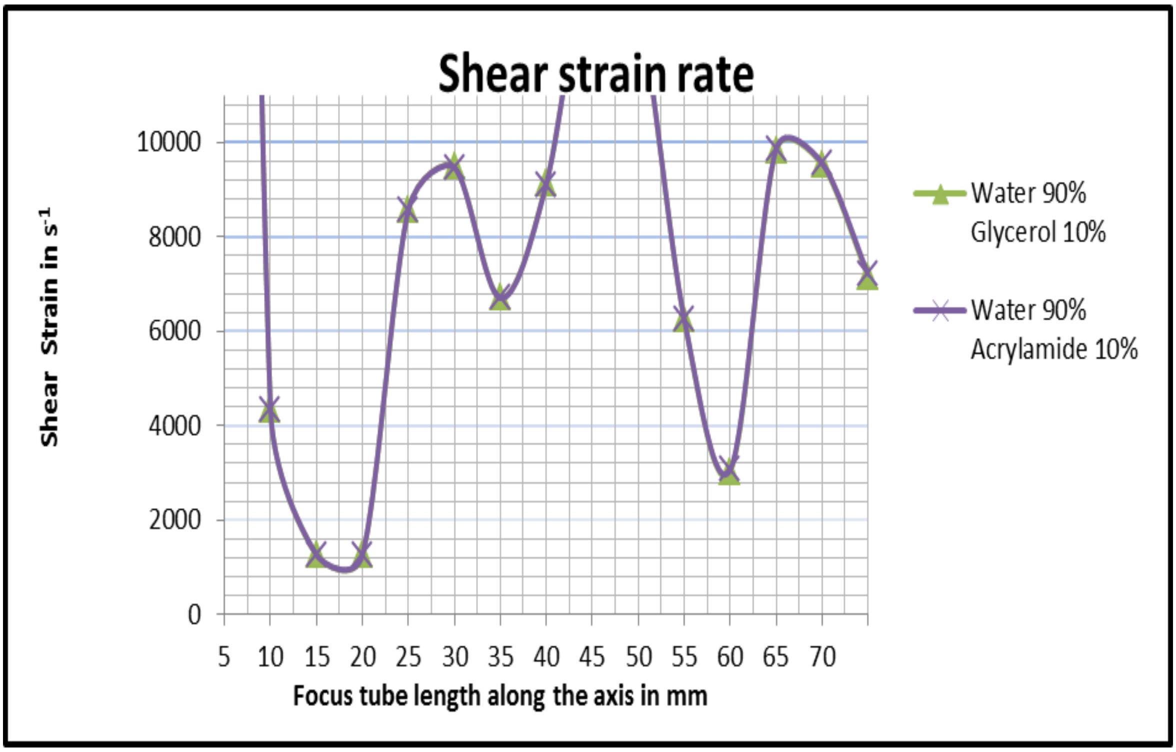

Fig 4.3(b) Shear Stress Rate vs. Focus tube

Figure 4.3[a] displays that strain rate is higher at entrance of mixing tube for both cases and it declines steadily along its flow and it raises in the mixing region. Figure 4.3[b] displays that shear rate is significantly high along the focus tube for both glycerol and acrylamide mixture and the fluctuating magnitude have been observed along the flow.

3.1.4. Rate of Energy Dissipation

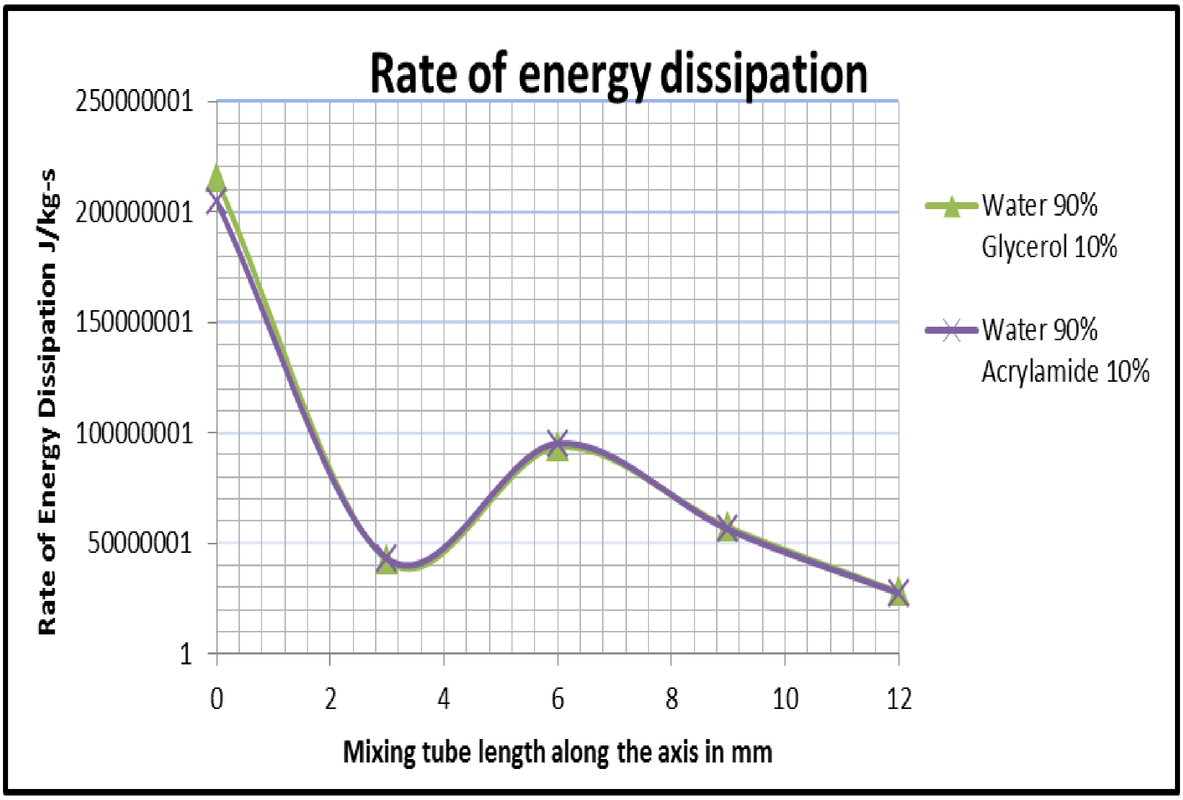

Fig 4.4(a) Rate of Energy Dissipation vs. Mixing Chamber

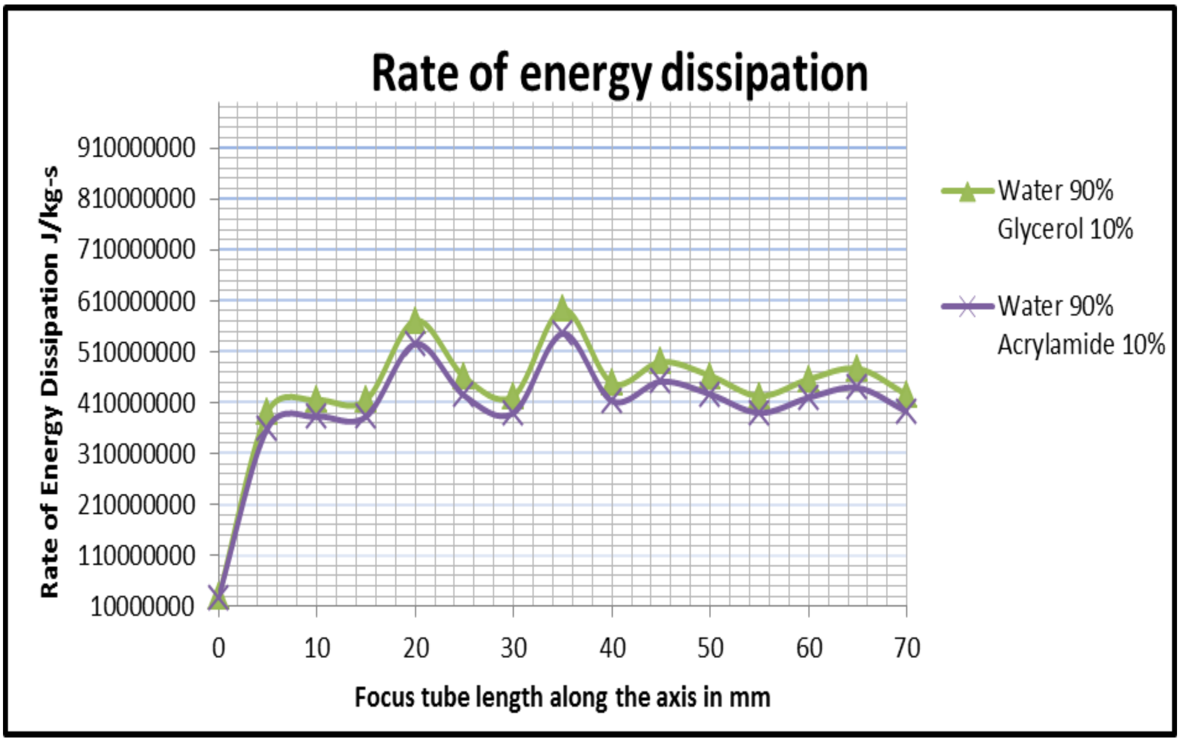

Fig 4.4(b) Rate of Energy Dissipation vs. Focus tube

Figure 4.4[a] displays that is high at inlet of the mixing tube for both glycerol and acrylamide mixture. Its magnitude declines suddenly along with the flow just before the mixing region and increases in the mixing region. A marginal increase in rate of energy dissipation has been observed at the entry of mixing chamber for glycerol mixture. Figure 4.4[b] displays the rate of energy dissipation along the focus tube. It has been observed from the result that it increases at the nozzle and it continuously varies till the end of focus tube for both glycerol and acrylamide mixture. Its magnitude is high for glycerol mixture in the focus tube.

3.1.5. Pressure Gradient

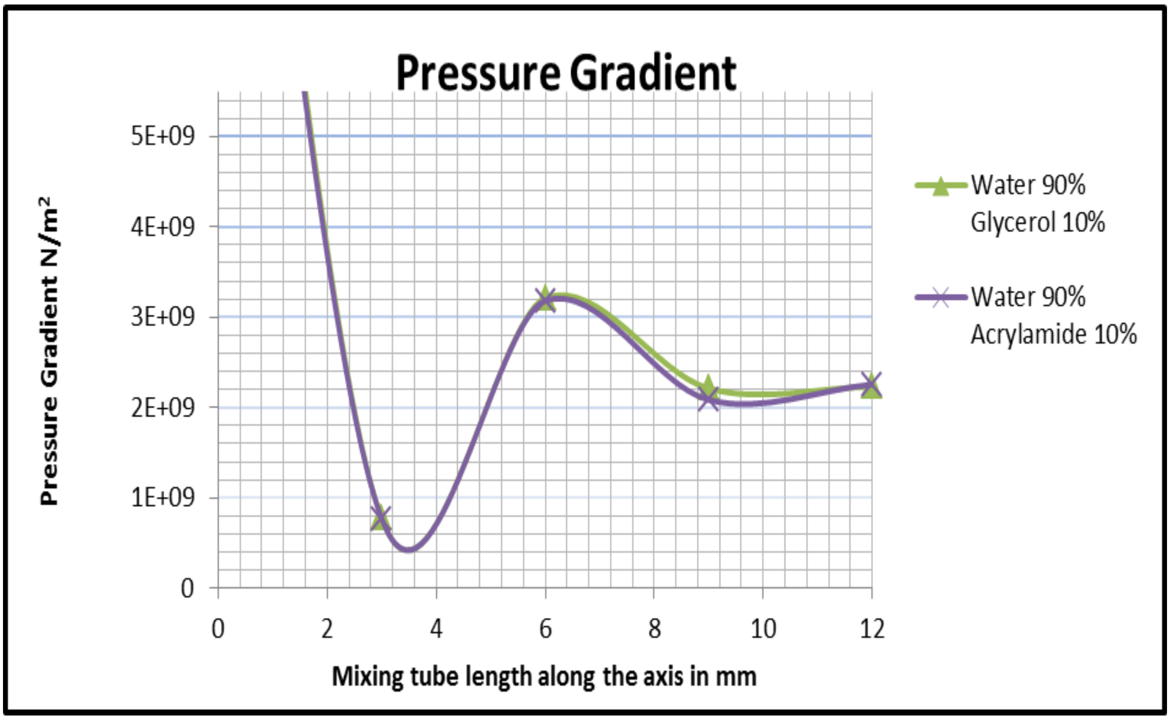

Fig 4.5(a) Pressure Gradient vs. Mixing Chamber

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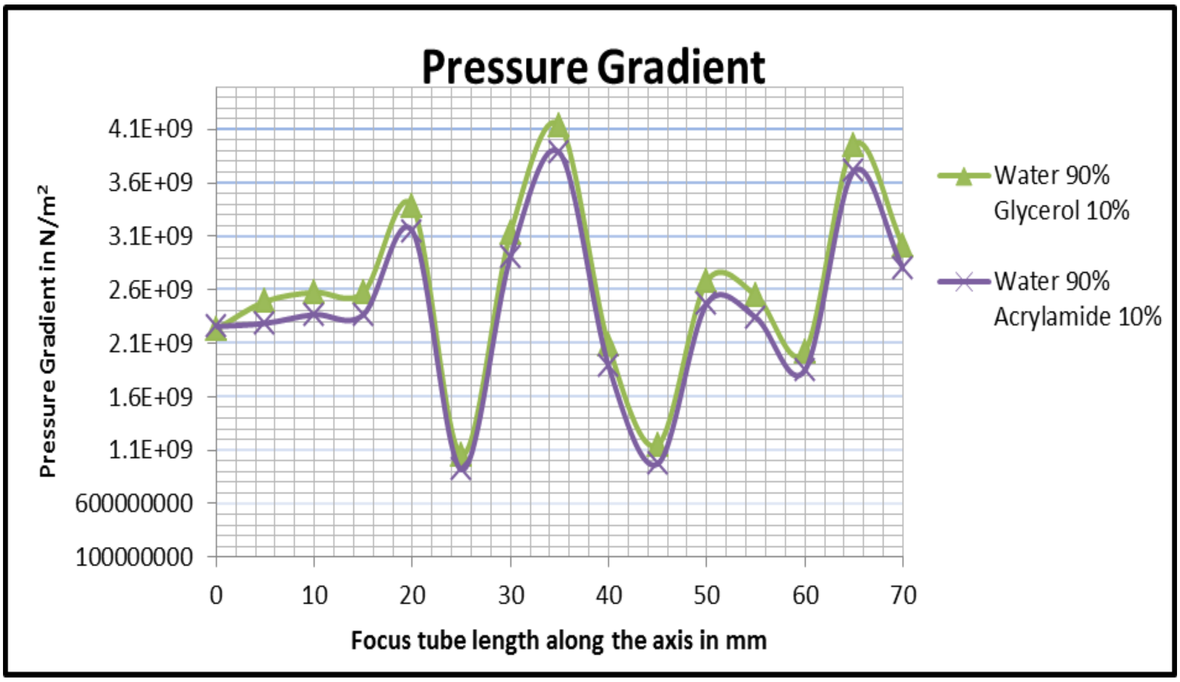

Fig 4.5(b) Pressure Gradient vs. Focus tube

Figure 4.5(a) and 4.5(b) displays the pressure gradient along with the mixing and focus tube length. The pressure gradient in the flow causes the axial velocity to decline and cause for eddies which will consequently increase the energy dissipation. It has been witnessed from the chart that the pressure gradient is significantly high at the inlet of mixing tube for both the cases its magnitude declines sharply just before the mixing region. The pressure gradient is maximum at the mixing region. There has been marginal rise in pressure gradient has been observed for glycerol mixture near outlet of mixing tube. The pressure gradient is relatively low at the entry of the nozzle for both the cases.

IV. CONCLUSION

CFD simulation of flow over jet head of abrasive water jet cutting has been conceded and the subsequent inference has been made.

- Comparatively reduced wall shear stress and energy loss in the flow have been observed for acrylamide mixture along the nozzle and focus tube.
- The velocity gain and shear strain rate is relatively uniform for glycerol and acrylamide mixture.
- Marginal decrease in pressure gradient has been observed for acrylamide mixture in the focus tube.
- The optimal solution of water with acrylamide is in the ratio of 90:10 of nozzle head.

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