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DESIGN AND ANALYSIS OF C-D NOZZLE INCREASE THE EFFICIENCY USING CFD

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Abstract -- The performance of a two phase flow nozzle, as an expander to generate is power. Mostly high pressure and temperature energy sources are investigated. The passing water is having temperature lower than 100 c through the convergent-divergent nozzle. Nozzle is thermal energy is converted to kinetic energy. Design of Nozzle is change with geometries. To increases the velocity of the nozzle. CFD analysis of flow the water in convergent-divergent nozzle .work is carried out in two stages, 1.modelling and analysis of flow for supersonic nozzle .In this initially modelling of the nozzle has been done in solidwork12 and Analysis has been carried out in ANSYS fluent12.0 and various contours like velocity, pressure and temperature have been taken.

***Keywords* --** Two phase Nozzle, Geothermal Energy, Power Generation, supersonic flow

I. INTRODUCTION

Geothermal energy has been utilized for power generation through three conversion systems; the flashed steam system, the binary cycle system and the total flow system. In the flashed steam system, high temperature geothermal water is introduced directly to a separator where separation of vapour and liquid occurs. The extracted brine is injected back into the field and the vapour is passed through a turbo generator for power generation.

Since scaling of turbine components, corrosion and erosion could be caused by carryover of salts with the vapour. Since in a single flash system, at best, only approximately 10% of the thermal energy can be converted, the overall thermal efficiency is low.

In order to utilize brines at relatively low temperatures, brines containing large amounts of non-condensable gases or dissolved solids, the binary cycle system was introduced for conversion of hot water geothermal energy. In this method, a heat exchanger is required to transfer the internal energy of the brine to a clean secondary fluid. The advantage is that the turbine is protected from the brine by using the secondary fluid.

Also, In order to optimize energy transfer per unit of exchanger area, the brine outlet temperature must be high. This results in a relatively low overall thermal efficiency as is the case for the flashed steam system.

In the total flow system, the entire well head product (liquid or liquid vapour mixture) is fed directly into an impulse or reaction turbine. This involves expansion of the fluid through converging-diverging nozzles to convert the enthalpy of the high temperature fluid into kinetic energy in the form of low temperature, high-velocity, streams of vapour- liquid mixture (nozzles are discussed in more detail in the next section). The advantage of this system is the potential for achieving higher utilization of thermal energy than either the flashed steam or binary method.

The total flow process involves the expansion of the fluid from a geothermal well (including water, vapour, and dissolved solids) through a single energy-conversion machine.

Three characteristics of the total flow process are especially important:

1. It has the potential for the highest resource utilization efficiency because most of the available energy of the well head product is used.
2. It broadens opportunities for successful exploitation of high temperature/ high-salinity resources.

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II. LITERATURE SURVEY

Gutti Rajeswara Rao et al., (2013) [1] Analysed The effects of Mach number and Nozzle pressure ratios (NPR) on Mass flow rate, Maximum pressure, and Maximum velocity and on Maximum force are studied using Fluent Analysis. The code fluent has been used to compute flow using a coupled and axisymmetric Convergent Divergent nozzle for different nozzle ratios and for different Mach numbers.

Nazar Muneam Mahmood (2013) [2] was conducted the research a simulation of steady flow of a gas through a convergent divergent nozzle which has a varying cross sectional area will be considered. The characteristics of gas flow i.e.(Mach number, static pressure, density, velocity magnitude and static temperature) distributions for the convergent divergent nozzle are implemented by using the ANSYS Fluent 12.1 software to solve the quasi-one dimensional nozzle flow. Menandro S.beranr (2014) [3**]** was carried out the Efficient nozzles cause high pressure recovery in ejectors. Converging-diverging nozzles with divergence angles of 0.076°, 0.153°, 0.306° and 0.612° were tested in a blow down device during our previous study on supersonic two-phase flow of CO_2.The dependence of efficiency and optimum divergence angle to pressure drop was determined. The overall optimum divergence angle was 0.306° in the range considered which had the highest efficiency of 70% at a pressure drop of 7.3MPa.

III. METHODOLOGY

Case 1: M<1 dA, dp have the same sign. Thus, as A increases, p increases. dA, du have opposite signs. Thus as A increases, u decreases. Diverging duct in subsonic flow: pressure increases, speed decreases. Converging duct in subsonic flow: pressure decreases, speed increases.

Case 2: M>1 dA, dp have opposite signs. Thus as A increases, p decreases. dA, du have the same sign. Thus as A increases, u increases. Diverging duct in supersonic flow: pressure decreases, speed increases.

Case 3: M=1 dA/dx is 0. Thus we have either a maximum or minimum of area. The maximum area case is not of much interest, since there is no way to reach Mach 1 at this point, with flow.

The created model is to be meshed for that it was imported into the meshing software in the required format. The model which represents a single volume is being segregated into two volumes, fluid and solid. Then the two volumes where meshed separately with Quad elements and the necessary cell zones were specified. The create model is to be meshed and sizing of the element. Stain steel of the materials used it. Denote the inlet, throat, wall, and outlet. Inlet is given to the pressure of nozzle.

3.1 Dimensions of the convergent-divergent nozzle

Convergent	**Dimension**
Diameter	30mm
Length	50mm
Angle	28°
Divergent	
Diameter	14.75mm
Length	110mm
Angle	6°
Throat	
Diameter	3.5mm

3.1 Table for Dimension of the convergent-divergent nozzle

IV. DESIGN AND ANALYSIS OF THE CONVERGENT-DIVERGENT NOZZLE

4.1 MODELLING

The convergent-divergent nozzle is generated model is generated by using CAD modelling software Solid works 2012. To increase the convergent area that increases the velocity. The model of the

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convergent-divergent nozzle is done. To improve the velocity changes the convergent duct. The modelling of the convergent-divergent nozzle is shown in figure3.1. Thermal energy is converted to kinetic energy. To create the convergent duct is higher than to divergent duct.

Figure 3.1 Modelling for convergent-divergent Nozzle.

4.2 ANALYSING

Analysis of convergent-divergent nozzle is using the Ansys fluent 12. To contour plots of the velocity, temperature and pressure distribution below shown in figures.

4.3 Feed water temperature at 96^{0}c

4.4 Pressure

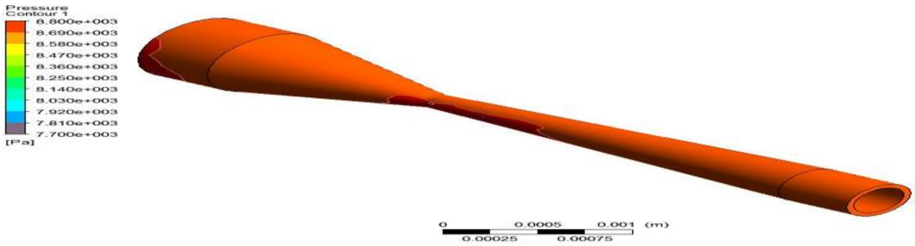

Figure 3.2 pressure of the convergent-divergent nozzle

Minimum pressure- 7.7e003pa maximum pressure-8.8e003pa

The pressure of the nozzle is increased to convergent duct to divergent duct. Feed water passed through the temperature is 96^{0}c. Feed water density is 1000 kg/m^3. The range of the pressure is 7.7e003-8.8e003pa. Mass flow rate is 0.0722 kg/s .

4.5 Velocity

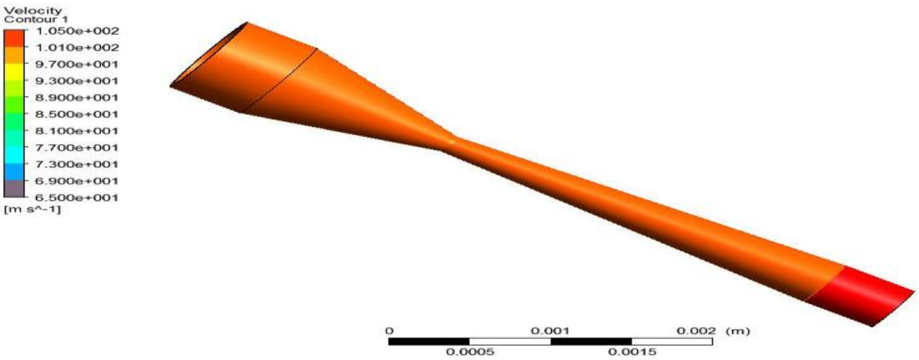

Figure 3.3 velocity of the convergent-divergent nozzle

Minimum velocity-6.5e001 Maximum pressure-1.05e002

The velocity of the nozzle is increased to convergent duct to divergent duct. Feed water passed through the temperature is 96^{0}c. Feed water density is 1000 kg/m^3. Convergent duct area is increased automatically increased the velocity.

4.6 Mathematical Calculation

Feed water temperature-96^{0}c, density of the feed water-1000 kg/m^3 and

Enthalpy - 5731.4kj/kg

Mass flow rate:

$\dot{m} = \rho A v$

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$=1000\times6.857\times10^{-7}\times106$
$=0.0722$ kg/s

Force:

$F = u_e \times \dot{m}$
$= 106\times0.722$
$= 7.6532$ N

Enthalpy:

$h_e = h_{in} - \frac{u_e}{2}$
$= 5731.4 - \frac{(105)^2}{2}$
$= 368.72$ kj/kg

Thrust coefficient:

$c_T = \frac{u_e}{u_{es}}$
$= \frac{106}{164}$
$=0.6463$

Efficiency:

$\eta_s = c_T{}^2$
$= 0.6465$
$= 0.4177$

The above value par with the experimental efficiency obtained by vahaji (8)

V. CHANGE THE GEOMETRIES OF CONVERGENT-DIVERGENT NOZZLE

Convergent	**Dimension**
Diameter	30mm
Length	45mm
Angle	30°
Divergent	
Diameter	14.75mm
Length	100mm
Angle	5°
Throat	
Diameter	1.5mm

4.1 Table for change the geometries of convergent-divergent nozzle

5.1 MODELLING

The convergent-divergent nozzle is generated model is generated by using CAD modelling software Solid works 2012. To increase the convergent area that increases the velocity. The model of the convergent-divergent nozzle is done. To improve the velocity changes the convergent duct.

Figure 4.1 Modelling for convergent-divergent Nozzle

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5.2 Feed water temperature at 60^0c

5.3 Pressure

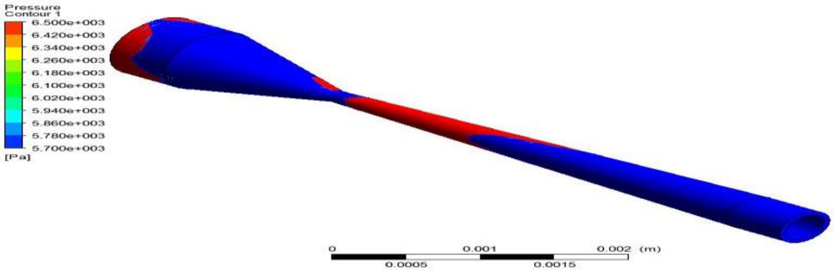

Figure 4.3 pressure of the convergent-divergent nozzle

The pressure of the nozzle is increased to convergent duct to divergent duct. Feed water passed through the temperature is 96^0c. The pressure range is 5.780e003- 6.5e003. The density of the water is 1000 kg/$m^{3.}$

5.4 Velocity

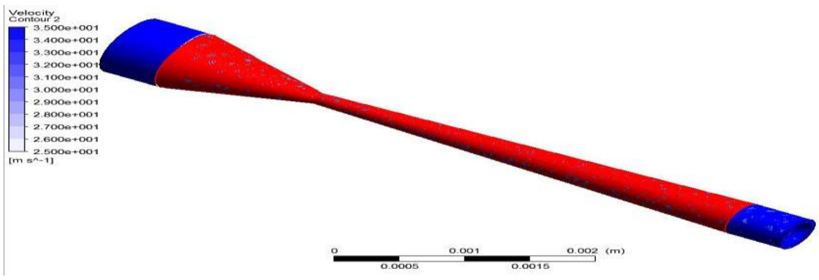

Figure 4.4 velocity of the convergent-divergent nozzle

The velocity of the nozzle is increased to convergent duct to divergent duct. Feed water passed through the temperature is 96^0c. Feed water density is 1000 kg/$m^{3.}$ The velocity range is 2.5e001-5.5e001. . Convergent duct area is increased automatically increased the velocity.

4.5 Feed water at 95^0c

5.6Velocity

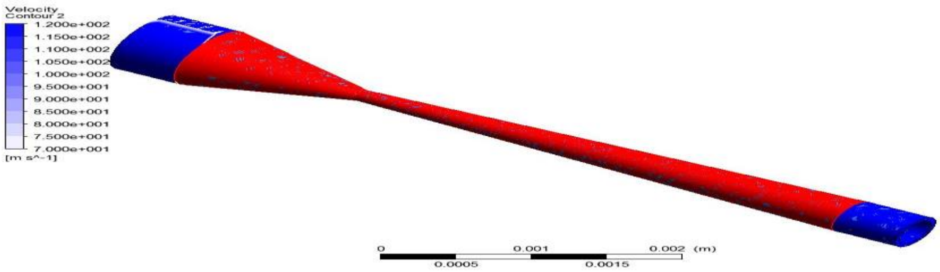

Figure 4.5 velocity of the convergent-divergent nozzle

The velocity of the nozzle is increased to convergent duct to divergent duct. Feed water passed through the temperature is 96^0c. density of the feed water is 1000 kg/m^3. Mass flow rate is 0.822 kg/s. The velocity range 7.0e001-1.20e002 m/s. Convergent duct area is increased automatically increased the velocity. Increase the efficiency of the nozzle.

5.7 Different temperature & dimension using the C-D nozzle

SI. No	Angle		Feed water temperature ^{0}c	Velocity m/s	Mass flow Rate kg/s	Thrust Coefficient c_T	Efficiency η_s
	Convergent Duct	Divergent Duct					
1	14	3	95	105	0.072	0.6463	0.4177
2	15	2.5	95	120	0.0822	0.7352	0.5535

4.3 table for Different temperature & dimension using the C-D nozzle

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VI. CONCLUSION

Two phase flow in convergent- divergent nozzle have been carried out various fluid conditions. The feed water temperature as low as 100°c flow of the inlet in convergent-divergent nozzle. The given dimension and change the geometries of the convergent-divergent nozzle is modelled of the CAD Model of solidworks12.analysis of the convergent-divergent nozzle using the ANSYS fluent 12. The contours are above plotted.

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