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CFD Analysis of Novel Micro-Channel Heat Exchanger for Natural Gas Cooling Process

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Abstract:

The Heat transfer in the automotive industry is enormously grown from the past decade there are so many techniques that can be used to coolIn current situation the world driven by a automotive sector sooner or later the consumption of fuel will be a par greater task than any other systems sooner or later it will come to an extinct where the availability of fuel can be not possible we are literally seeing at an extinct of petroleum industry at this situation the look or search for the other fuel sources is on demand such fuel found is called the natural gas a natural subsidiary found on the earth which can replace petroleum products. The concept of using micro channel heat exchanger is highly compact solution for any low scale cooling methods in this project the micro channel heat exchanger with noval fins that has tapered chamfer and filleted designs can be used to investigate the heat transfer in the micro channel heat exchanger the fluids used in the natural gas cooling is exhaust gas , R134a and natural gas. The commercial simulation package is used to simulate the model designed with computational fluid dynamics.

Keywords — **Heat transfer , Novel Micro Channel heat exchanger , Natural gas cooling , Noval Fins.**

1.Introduction

In current situation the world driven by a automotive sector sooner or later the consumption of fuel will be a par greater task than any other systems sooner or later it will come to an extinct where the availability of fuel can be not possible we are literally seeing at an extinct of petroleum industry at this situation the look or search for the other fuel sources is on demand such fuel found is called the natural gas a natural subsidiary found on the earth which can replace petroleum products.

The term natural gas is said because of its own properties and where and in which form it is occurring hydrocarbon gas and in some cases other gas mixture. It is a type of fossil fuel which is formed to to the decomposition of the animals and other creatures after death when it is subjected to the immense heat more than a million years the such fossils will form in to the natural gas and the energy that the plants originally stored from the sun is stored in the form of chemical bonds.

The natural gas has many applications such as manufacturing fuel for automobile this fossil fuel has more source of energy to cooling cooking electricity generation and other non renewable energy applications the availability of the gas is very persistent and it is very cheaper when compared with the other petroleum products

Natural Gas often shortly referred as gas where this is to distinguish from other petroleum products where especially in the north America the term gasoline is used for petrol this to reduce the confusion between petrol and the other gas products.

There are so many types of gases that are occurring in the many different form of fossil fuels some of them are given below

- Shale Gas
- Town Gas
- Bio gas
- Crystallised natural gas

2. Literature review

There is a lot of progress in the field of the natural gas production and the emission cooling techniques in the field of heat and mass transfer there might be suitable works for references from which the major key aspect to look at is the cooling of the exhaust gases which is occurring from the exhaust of an engine below are some works that has presented from the works that has been carried out by some authors.

The solidity courseoutcomes in significant heating, which is disagreeable R.C. Elgin, L.C. Kagen P.N. Hchter, K.N. Veyer, W.C. Nurner, R.D. Jabbitt, L.C. Nage S. Menon, H. Ganti, H. Wang C. Hagen [2,3,5] because of amplified detailedbulk demandingenlargedtoilsay, probablehurt to machine stoppers and valving, fluctuations in applianceconcertfollow-onsincecoal pre-heating, besidescurrent food of grease in the smoketorrent

B. Huo, N. Kin, H. Fiu, R. Dhang, J. Vang, [6]. Micro-channel heat exchanger knowledges are emergent as a gifted chillingexplanation presenttall performance, solid size and lower burdendrips associated to conformistfreezing know-hows

N.J. Lhan then the B.Eartaj, [7]. A micro-channel heat exchanger examachieved byHetegenF. Hetegen, K. Naummer, D. Eessiatoun, N. Thadi, [8,9] established a heat handovernumber of

130,00 0 W/m^2 K consuming the non-aqueous refrigerant HFE-7200. The diminished dimensions of micro-channels product in further compact heat-exchangers pluscomplex heattransfer figures as aend of betterexterior area eachentitybulk.

Micro-channel heat exchangers may accomplishexternal area per unit bulk as high as 1500 m^2/m^3 M. Ohadi, L. Choo , N. Hessiatoun, K. Letegen, [10].

Micro-channels have been fruitfully every day in locomotive air preparingorganisms K. Nan, J. Niu, N. Ci, K. Fuang,[11] , Y.L.A. Honkovich, P.S. Fitzgerald, J.L. Zilka, M.J. LaMont, Y. Wang, D.P.fuel fuel cells [12], and microelectronics D. Bharathan, K. Kelly,[13].

Auto heaters with networksscheduledtherulerof micrometers to millimeters permit the use of fewer refrigerant deprived ofsnowballing extent or heaviness of the refrigerant organizationT.K. Dhecketts, [14].

Extragrowth of micro-channel heat exchanger knowledge has been inspired by wants of definitemethodsurroundingssuch aslittle flo wpercentagethen highfunctionalforces. Predictableregistration type heat exchangers are naturallyesteemed to supremeburdens of 40 bar

N.N.Nbu-Hhader, [15] and have an averageareathickness of around 200 m^2/m^3 V.V. Wade kar[16]. Tests of micro-channelsshown by Wu [17]

Functionalpressuresofextra than 40 bar.The diffusion-bonding process naturallycastoff in the building of micro-channel heat exchangers allows operating pressures as high as 1000 bar [18].

Hence, the use of a micro-channel heat exchanger is exclusivelybeautiful for the 3rd phasefreezing in the currentsubmission agreed the tough bulklimitations and greatfunctionaldensities (of up to 250 bar).

3.METHODOLOGY

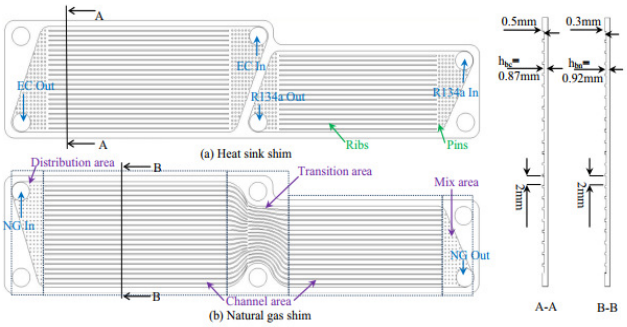


Fig.1.Schematic of natural gas cooling technique.

The problem assembly consists of the two basic regions one is the natural gas shim and other one is the heat sink shim or coolant shim as shown in the above figure thickness of the plate is 0.92 mm as shown in the figure. 2mm is the is the gap between the fins.0.5mm is the height of the fin and the plate in the Heat sink shim is divided in to two regions exhaust gas region and the coolant region. And the natural gas shim is subjected to flow through the NG Shim.

Simulation setup

Solid works flow simulation 14, was laboring to guess the course spreading then burden drop over shims of the micro-channel temperature exchanger. A desktop main frame through 4 Q9400 2.66 GHz super computers then entire of 8 GB RAM was working to route

Geometry of the micro channel

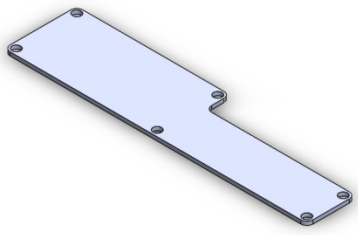


Fig.2.Flat plate cover for microchannel

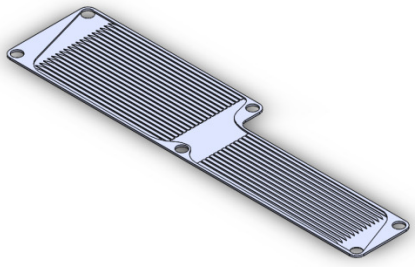


Fig.3.Natural Gas Shim

Natural gas shim is designed in a way that the fluid entering in to the shim is exiting out of the shim through the micro channel fins the fins re designed in a way that the

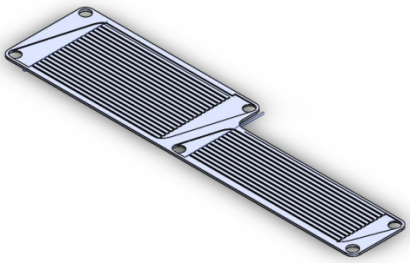


Fig.4.EG and Refrigerant shim

In the Above figure The Model is representing the Exhaust gas and Refrigerant shim Where two separate domains are Divided with two different inlets and the outlets the Given design is same as the natural gas shim but with a dividend wall between them

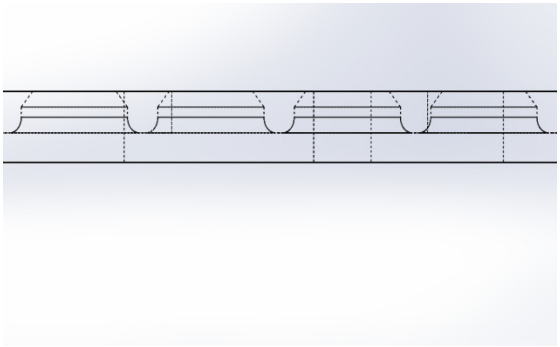


Fig.5.Fin Design

As far as the above figure is concerned the wireframe representation of the 3D model is represented where the side by side fins are placed with chamfered and filleted edges for

better flow rate. The consecutive arrangement of fins are done in the figure w.r.t to both natural gas and Refrigirant Shim.

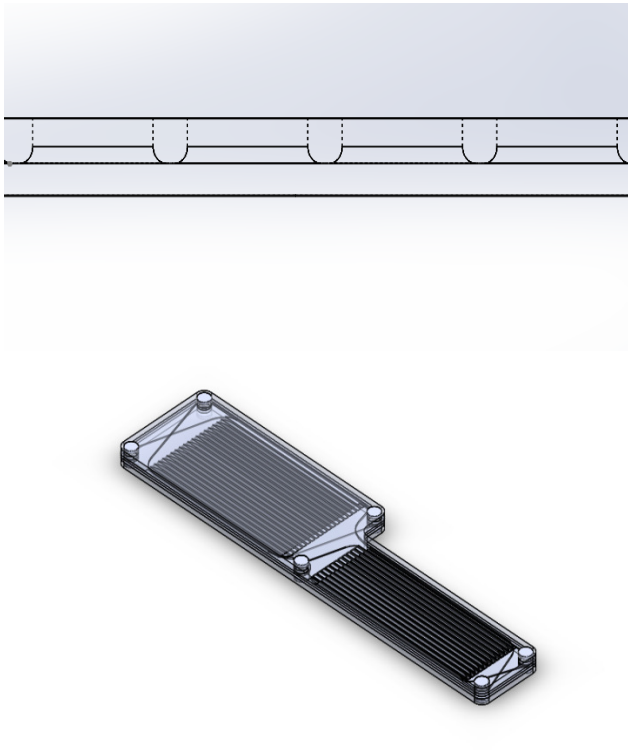


Fig.6.Assembly of the micro channel heat exchanger

The Total design is divided in to 3 types of plates one is Channel another is Shim and total heat exchanger Where The channel is again divided into 3 areas 1 is EG Channel which has a length of 96.6mm Width of 2mm and height of 2 mm which is shown in above fig at the starting of the chapter and another channel I R134a with the length of 84.3mm and the width off 2mm and the height of 0.5mm and when it comes to the NG shim 213mm length and the 2 mm width and 1.37mm height as shown In figure

4. RESULTS

Mesh data

Number of Cells

Total cells	37543
Fluid cells	600
Solid cells	17127
Partial cells	19816
Irregular cells	0
Trimmed cells	0

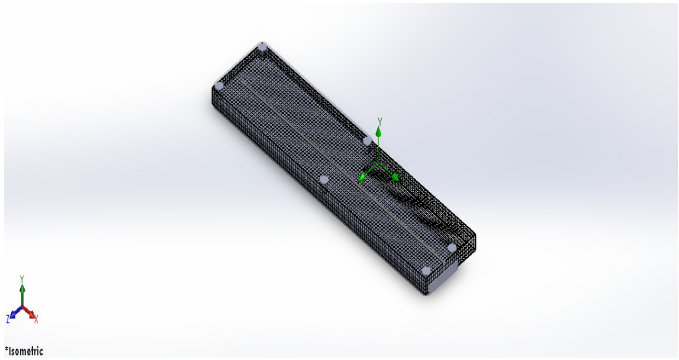


Fig.7.Discretized model

Discretization is the method of dividing single entity into number of sub division thus it form by creating nodes and elements in this case total volume is divided into to the finite set of sub volumes therefore the volume is totally discretized.

Case 1

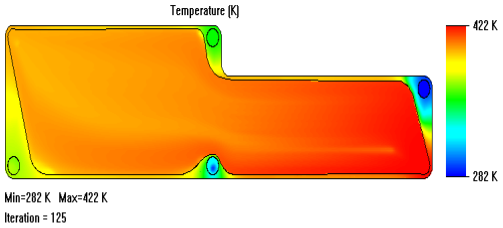


Fig.8.Temperature of the Natural Gas Shim

The figure is the pictorial or the contour representation of the natural gas shim which is flowing from the right bottom end of the model to the left top end of the model from the representation and the contour from the colored representation occurred the temperature of the natural gas flowing inlet to outlet is decreasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is natural gas shim with no fins present in it.

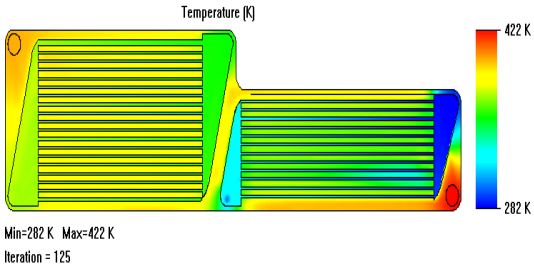


Fig.8.Temperature of the Refrigerant Shim

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the temperature of the Coolant flowing inlet to outlet is Increasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is Refrigerant shim with fins present in it.

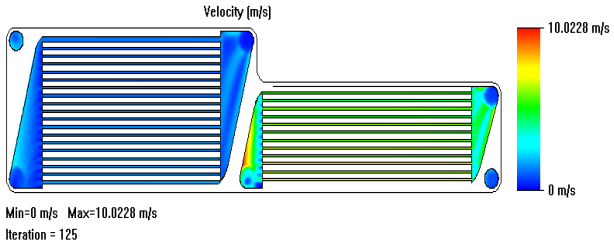


Fig.9.Velocity in Refrigerant region

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Velocity of the Coolant flowing inlet to outlet is Remaining in between area because of the Fins present between Flow region and the solid fins. The shim showing in the figure is Refrigerant shim with fins present in it.

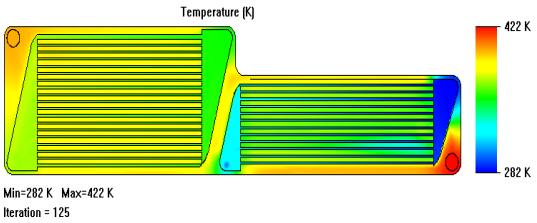


Fig.10.Total temperature of the Heat exchanger including solid temperature in refrigerant area

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Total temperature of the Coolant shim flowing inlet to outlet is Increasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is Refrigerant shim with no fins present in it. The picture is representing the total temperature of the shim both solid and fluid temperatures.

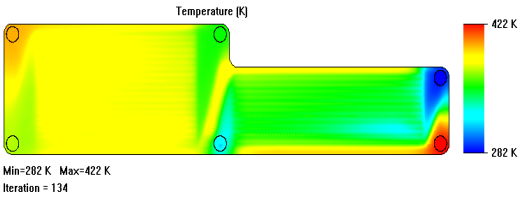


Fig 11 Total temperature of the NG shim include solid temperature

The figure is the pictorial or the contour representation of the natural gas shim which is flowing from the right bottom end of the model to the left top end of the model from the representation and the contour from the colored representation occurred the temperature of the natural gas flowing inlet to outlet is decreasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is natural gas shim with no fins present in it. The total Temperature is known as both solid plate and the fluid temperature.

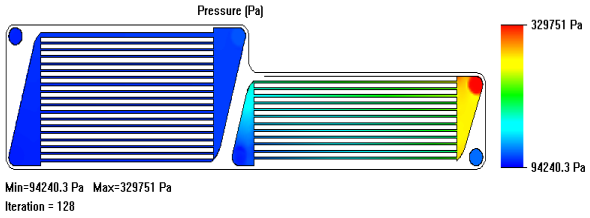


Fig.12.Pressure Distribution in the Refrigerant Shim

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Pressure of the Coolant flowing inlet to outlet is Remaining in between area because of the Fins present between Flow region and the solid fins. The shim showing in the figure is Refrigerant shim with fins present in it.

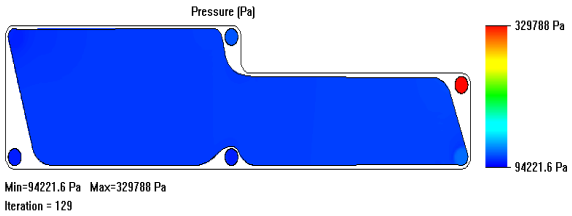


Fig.13.Pressure Distribution in NG shim

The figure is the pictorial or the contour representation of the NG shim which is flowing a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Velocity of the Coolant flowing inlet to outlet is Remaining in between area because of the Fins present between Flow region and the solid fins. The shim showing in the figure is NG SHIM with no fins present in it.

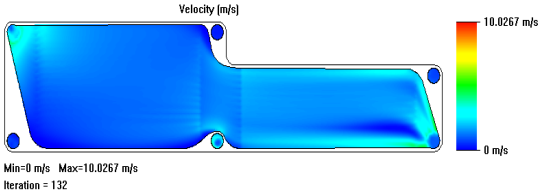


Fig.14.Velocity Distribution in NG shim

The figure is the pictorial or the contour representation of the NG shim which is flowing a from the Left Bottom end of the model to the right top end of the model from the representation and the contour from the colored representation occurred the Velocity of the Coolant flowing inlet to outlet is Remaining Constant with minimal changes The shim showing in the figure is NG SHIM with no fins present in it.

Case 2 Narrow Fillet Fins

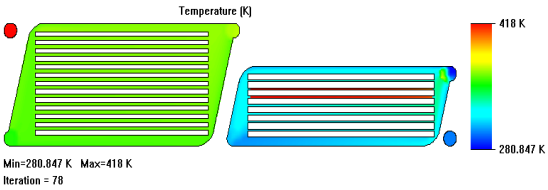


Fig.15.Temperature of fillet fins in refrigerant region

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the temperature of the Coolant flowing inlet to outlet is Increasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is Refrigerant shim with fins present in it.

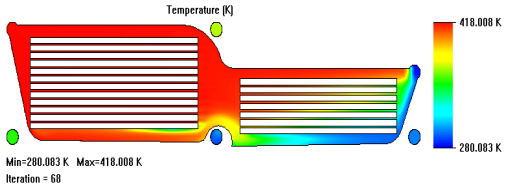


Fig.16.Temperature Distribution In NG SHIM

The figure is the pictorial or the contour representation of the natural gas shim which is flowing from the right bottom end of the model to the left top end of the model from the representation and the contour from the colored representation occurred the temperature of the natural gas flowing inlet to outlet is decreasing because of the heat transfer between cold shim and natural gas shim. The shim showing in the figure is natural gas shim with fins present in it.

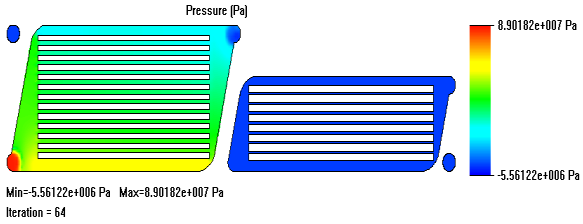


Fig.17.Pressure Distribution in Coolant Shim

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Pressure of the Coolant flowing inlet to outlet is Remaining in between area because of the Fins present between Flow region and the solid fins. The shim showing in the figure is Refrigerant shim with fins present in it.

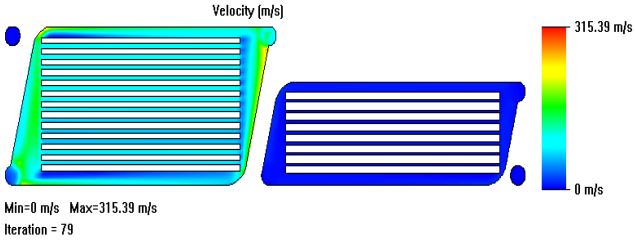
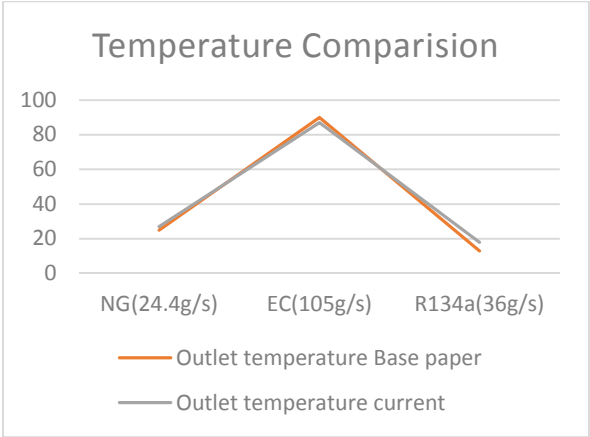


Fig.18.Velocity Distribution in Coolant shim

The figure is the pictorial or the contour representation of the Refrigerant shim which is flowing in two different compartments one with refrigerant R123a from the right Top end of the model to the Middle Bottom end of the model from the representation and the contour from the colored representation occurred the Velocity of the Coolant flowing inlet to outlet is Remaining in between area because of the Fins present between Flow region and the solid fins. The shim showing in the figure is Refrigerant shim with fins present in it.

Validation with Base paper



The above Representation of the Outlet temperatures represent there is a significant improvement in the temperature of cooling the gas at exhaust using R134a and the Natural gas the graph is compared with the base paper for the better validation

Plots

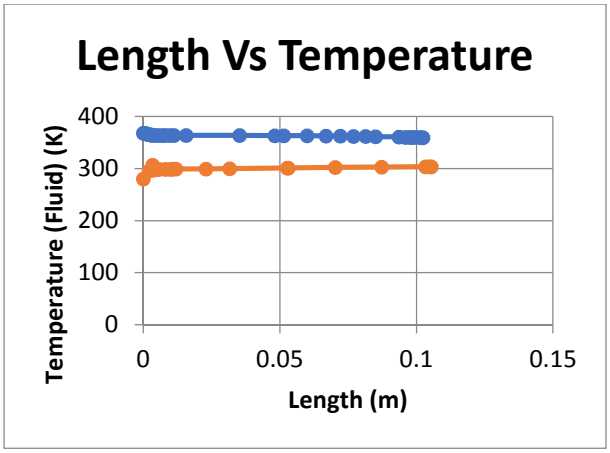


Fig.19.Length Vs temperature

The above plot is a X-Y plot between length and temperature WhereX-axis represents length in meters and the y-axis represents temperature in Kelvin in the curves u can observe a slight increase in the temperature of the hot fluid and the slight decrease in the temperature of the cold fluid this behavior is because of the heat transfer between the natural gas shim and the refrigerant shim.

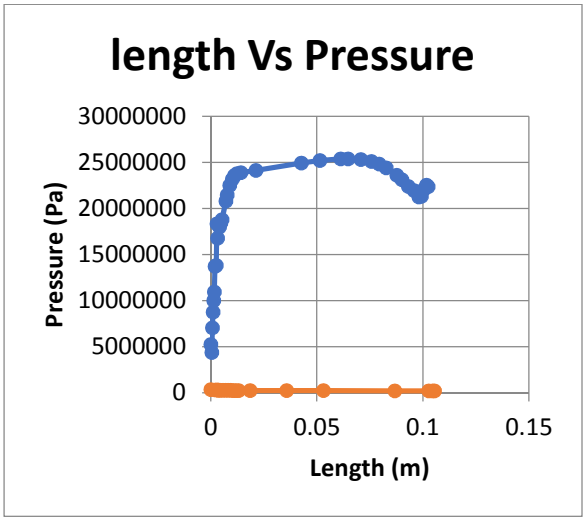


Fig.20.Length Vs pressure

The above plot is a X-Y plot between length and Pressure Where X-axis represents length in meters and the y-axis represents Pressure in pascal in the curves u can observe a increase in the Pressure of the coolant of the Cold fluid fluid and the slight decrease in the Pressure of the hot fluid this behavior is because of the Fins present in the coolant shim between the natural gas shim and the refrigerant shim.

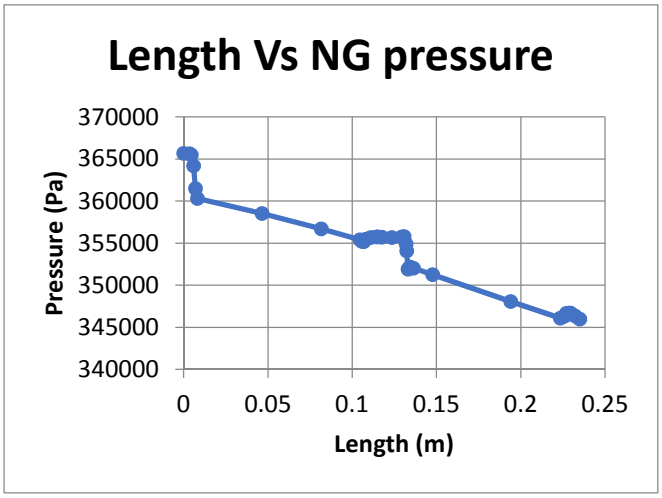


Fig.21.Length Vs Temperature NG SHIM

The above plot is a X-Y plot between length and Pressure Where X-axis represents length in meters and the y-axis represents Pressure in pascal in the curves u can observe a increase in the Pressure of the coolant of the Cold fluid fluid and the slight decrease in the Pressure of the hot fluid this behavior is because of the Fins present in the coolant shim between the natural gas shim and the refrigerant shim.

5.CONCLUSION

The Project has been to enhance the flammable gas cooling successfully utilizing micro channel heat exchanger idea The 3 bays gaseous petrol fumes gas and coolant bays are thought to be homogeneous deltas where as the books balance shapes are adjusted from Deng et al to smoothen the way inside the small scale channel to diminish the distribution and to enhance the heat exchange from the two outline we have made and recreated utilizing the limit condition the novel blade shape with rough shape is performing with more heat exchange. With the NG outlet temperature of 373K

The extrapolation technique gave a palatable approximation of the execution of the heat exchanger while saving time and computational assets.

The channel region represents 17– 28% of the aggregate weight drop for the EC and R134a

areas, while the zone between the appropriation and blend region of the NG space accounts for55– 65% of the aggregate weight drop over the scope of stream rates considered.

The liquid conveyance is comparable in each layer and the stream is equally appropriated to the channels inside a layer.

Although heat exchange symmetry may not entirely exist for this situation, the geometry of the heat exchanger was discourage mined to be adequately near symmetric to take into consideration the utilization of a symmetry limit condition which enormously diminished the computational load while giving sensibly precise outcomes.

The temperature dispersion of the heat exchanger shows that most of the heat move happened just in the appropriation territory and the channel gulf region of the NG area, recommending that the heat exchanger has a higher cooling limit than required by the test conditions. Also, warm anxiety may significantly affect the execution of the smaller scale channel heat exchanger, as territories close to the delta funnels may encounter a substantially higher temperature than the encompassing ranges.

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