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Performance Optimization of Cold Plate with Mixed Proportion of Ethylene Glycol in Water using CFD analysis

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Abstract - ***The exponential growth of electronics and their use commercially combined with the need for better power dissipation and system cooling, has caused the need to come up with better cooling technologies at affordable costs that are viable for commercial packing. It is largely focused on high heat flux removal from computer chips in the recent years. However, the equally important field of high-power electronic devices has been experiencing a major paradigm shift from air cooling to liquid cooling over the last decade. A detailed study about cold plate and its working under various parameters is studied. The modification is done in design of cold plate to reduce its cost and also to increase the heat dissipation rate. Air-cooling is still the preferred method of cooling electronic systems and especially in terms of cost. Air cooling, however, is starting to reach its limits for some of the higher end electronic systems and as such there is a need to investigate the application of liquid cooling for cooling high end servers. Also, it has been proved that airflow through circuit boards have inherently low heat transfer coefficients and large pressure drops, and hence requires large heat transfer areas with considerable amount of flow sections. The modified cold plate can use water*** **with mixed percentage of ethylene glycol solution** ***to remove major part of heat produced and air for minor part by natural or forced convection.***

I. INTRODUCTION

In this paper a new design of heat sink for cooling of microprocessors is described. The most important feature of presented solution is that it fulfills two requirements: high thermal capacity (which comes off the use of PCM) and high heat transfer surface and heat transfer coefficient in basic mode of operation. Basic thermal characteristics were established and thermal performance of the heat spreader in unsteady conditions was analyzed by means of numerical methods and computer simulation. The high heat flux cooling of electronic equipments and devices with various methods is reviewed. Particularly heat sinks which are used for natural convection and forced convection as passive device is studied. Based on the papers reviewed, it revealed the research needs to be focused to investigate advanced cooling technology that uses high performance heat pipe, thermoelectric coolers, low acoustical novel micro fans for air cooling, and phase change material based cooling to satisfy the thermal technology needs. The challenges of cooling electronic equipments may be expected to continue through the remaining of this decade. As the size of semiconductor is reducing day by day and power dissipation is increasing rapidly, so a breakthrough is needed in advanced cooling to reduce cost without sacrificing effectiveness of cooling. Advances in microelectronic processing led to miniaturization of components. According to Moore's law, the number of transistors on integrated circuits doubles approximately every 18 months. This has resulted in an increase in CPU transistor density, causing rising heat fluxes. Why should this matter for a thermal engineer in the electronics field? What if thousands of data storage components with a working power range of 20W and maximum case temperature of 700C are closely packed together like in data centers? The advancements in microelectronics packaging and fabrication have led to the evolution of cooling techniques to meet the resultant high heat flux densities. Thus, how fast a computer can process information depends directly on how efficiently the processors can be cooled. Thermal systems with air as the coolant are reliable, cheap and easy to maintain. As electronic components get smaller, air is no longer an effective coolant because of low thermal conductivity and thermal capacitance. Liquid cooling provides a means by which the thermal resistance can be reduced significantly. Liquid cooling can be classified as indirect liquid cooling, and direct liquid cooling. Using micro channels is a method of indirect liquid cooling. Micro channels can be machined onto the chip itself or machined onto a substrate and then attached to a chip or an array of chips. Although there are advantages with micro channels, factors like clogging and formation of local hot spots have not yet been resolved. Two phases boiling in micro channels is another indirect liquid cooling method. The flow inside the micro channels is highly unpredictable and can produce large voids and multiple flow regimes inside tubes. As a result, liquid cooling has grown in prominence as a method for cooling high density interconnect (HDI) devices. Water cooling in particular has multiple advantages over air cooling as it has greater heat carrying capacity. Cold plates enable the use of water with its excellent cooling capability and proven reliability. Previously, optimization work has been done for a classic formed tube cold plate by varying parameters for a fixed pumping power. In this paper we address optimizing the design of a contemporary cold plate for a fixed pumping power by varying multiple design parameters such as the contact width, radius of the curvature, height of the tube. A design of experiment (DOE) on Computational Fluid Dynamics (CFD) is created and deployed such that it maximizes the co-efficient of performance of the cold plate. This would serve as a guideline in the future for design of high performance cold plates that would be employed for thermal management of high power single or multichip modules.

II. INPUT PARAMETERS:

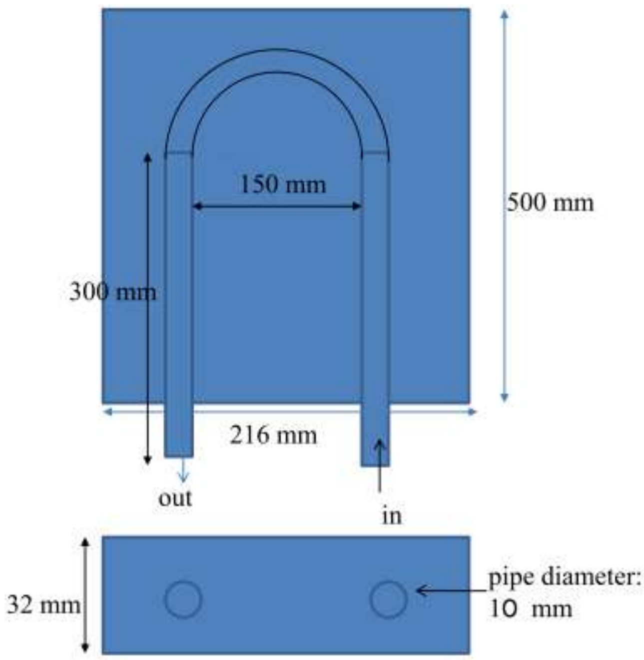

Fig 1 Cold Plate

Cold Plate Specification:
Length: 500 mm
Breadth: 216 mm
Width: 32 mm
Pipe length: 300 mm + 300 mm +200 mm = 800 mm
Pipe dia: 10mm
Distance between to pipe: 150 mm
Coolent Used: water mixed with different percentage of ethylene glycol.
Ambient air velocity: 0.002m/s
Inlet Temp.: 20^{0}C

III. RESULT

3.1) FIrst Case: Coolent 20% Ethylene Glycol in Water

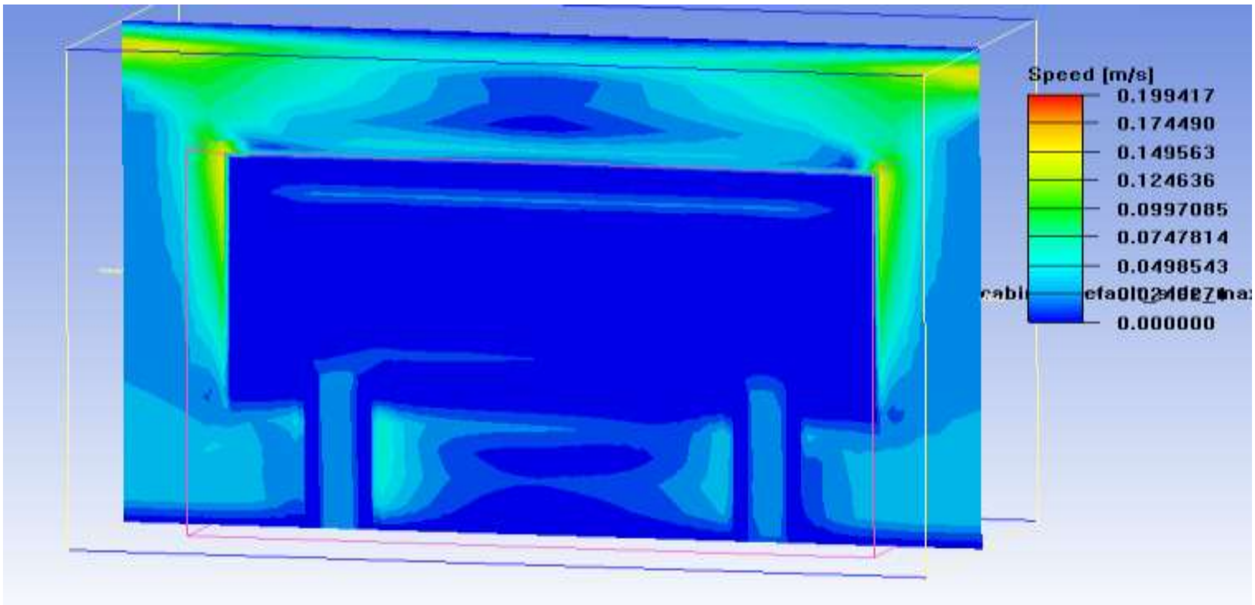

Fig 2 Velocity Profile

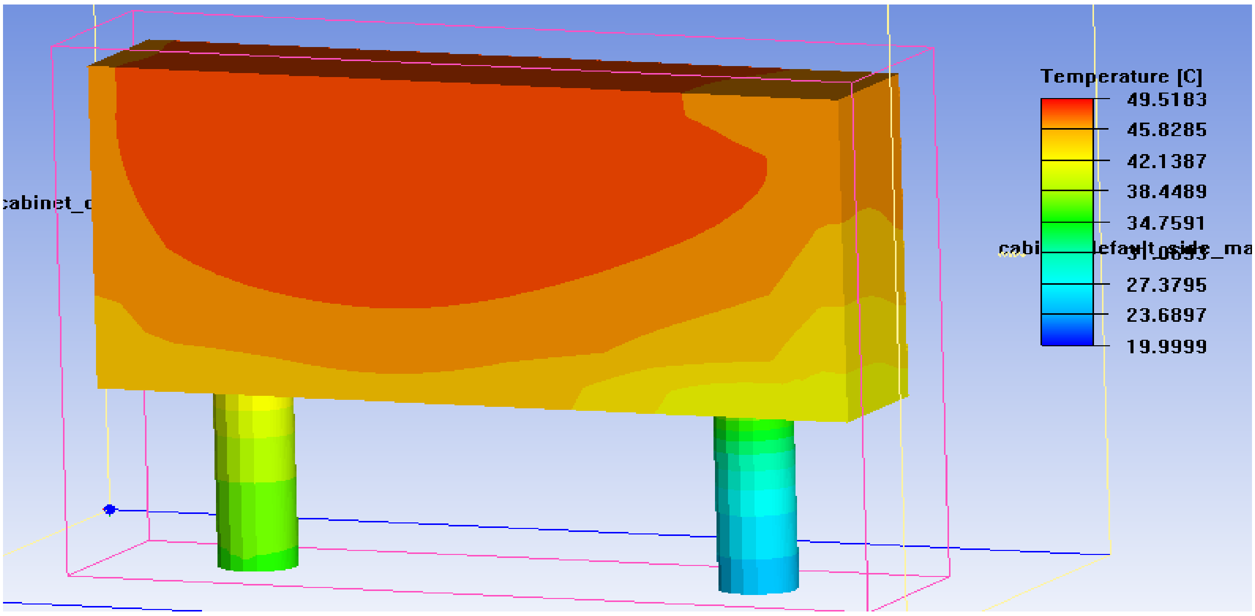

Fig 3 Temperature Profile

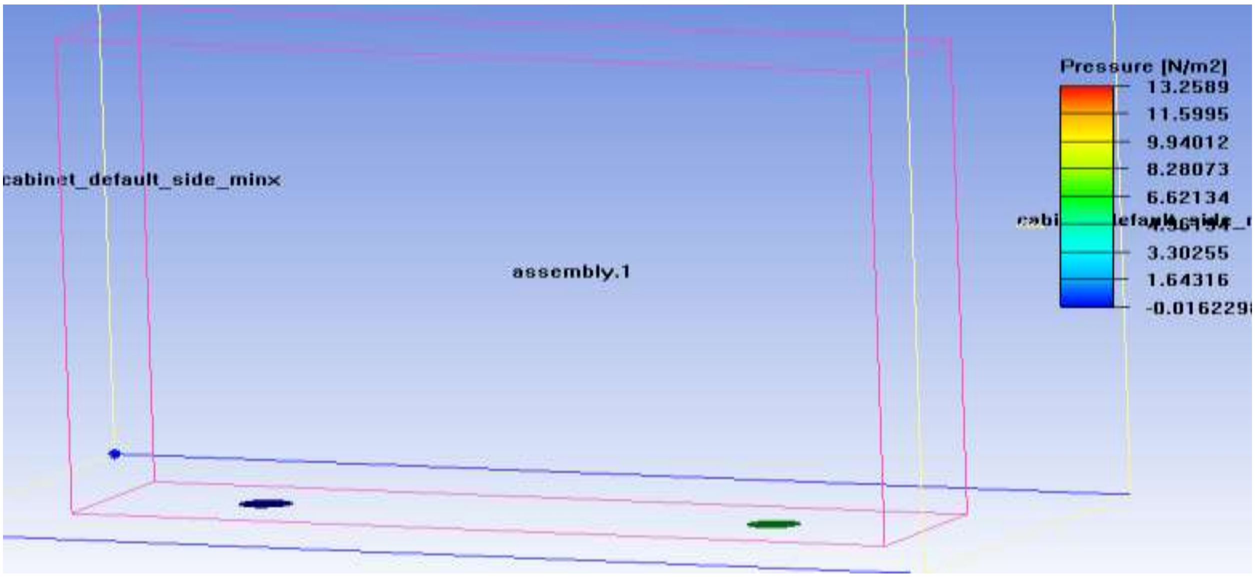

Fig 4 Pressure Profile

3.2) Second Case: Coolent 50% Ethylene Glycol in Water

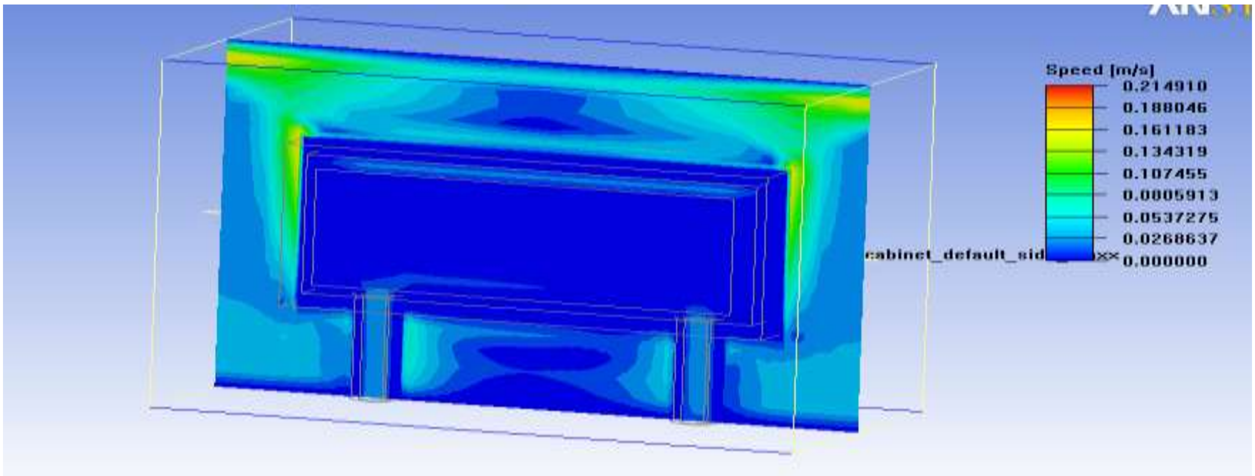

Fig 5 Velocity Profile

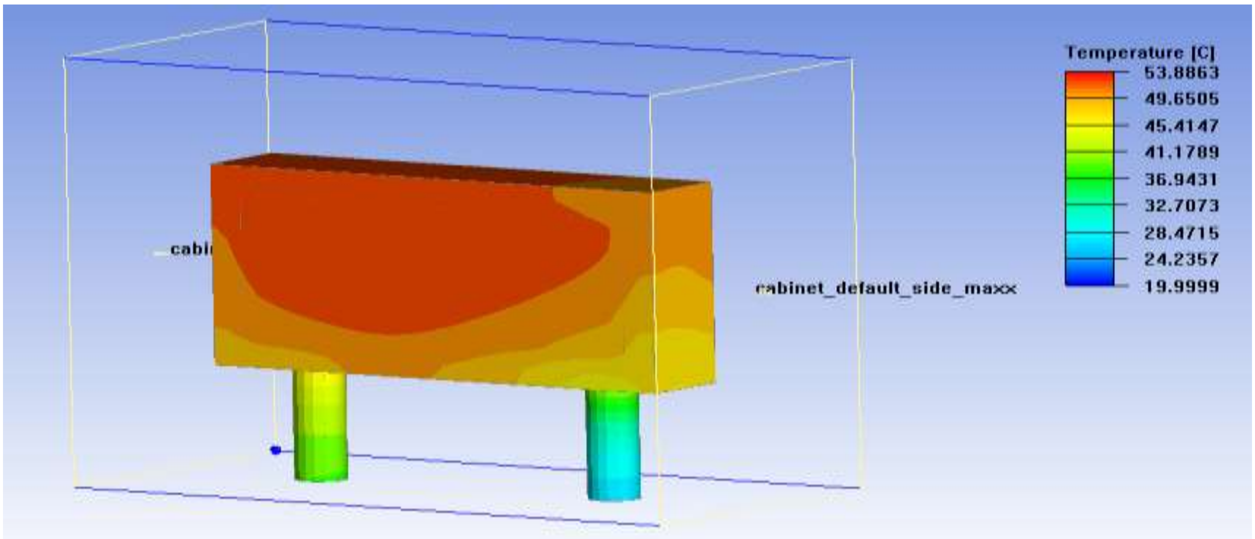

Fig 6 Temperature Profile

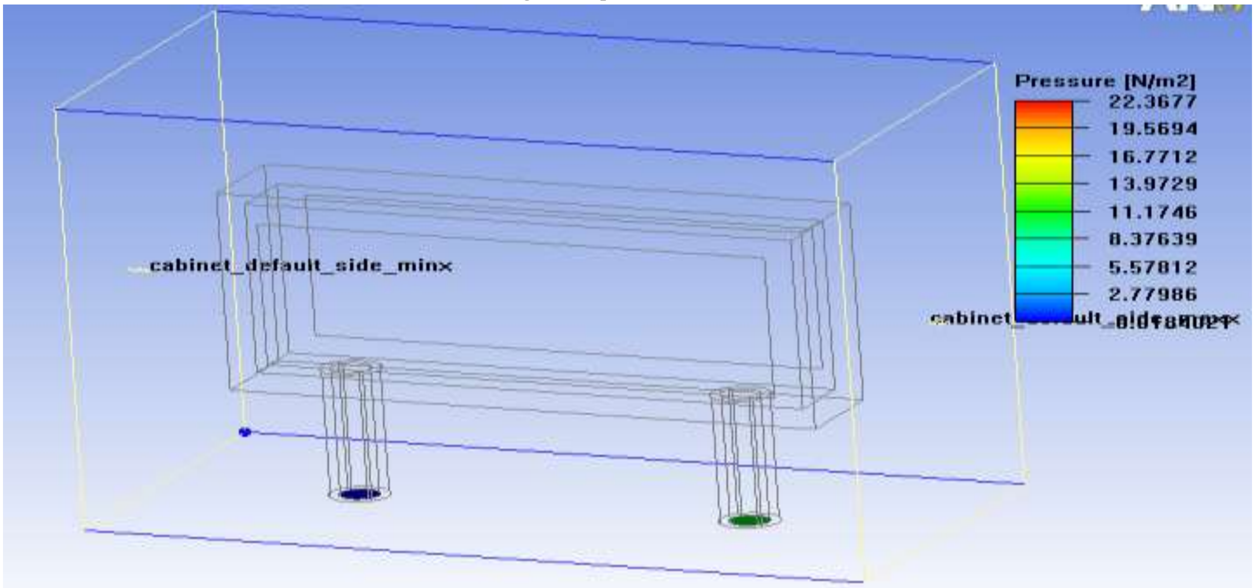

Fig 7 Pressure Profile

3.3) Third Case: Coolent 80% Ethylene Glycol in Water

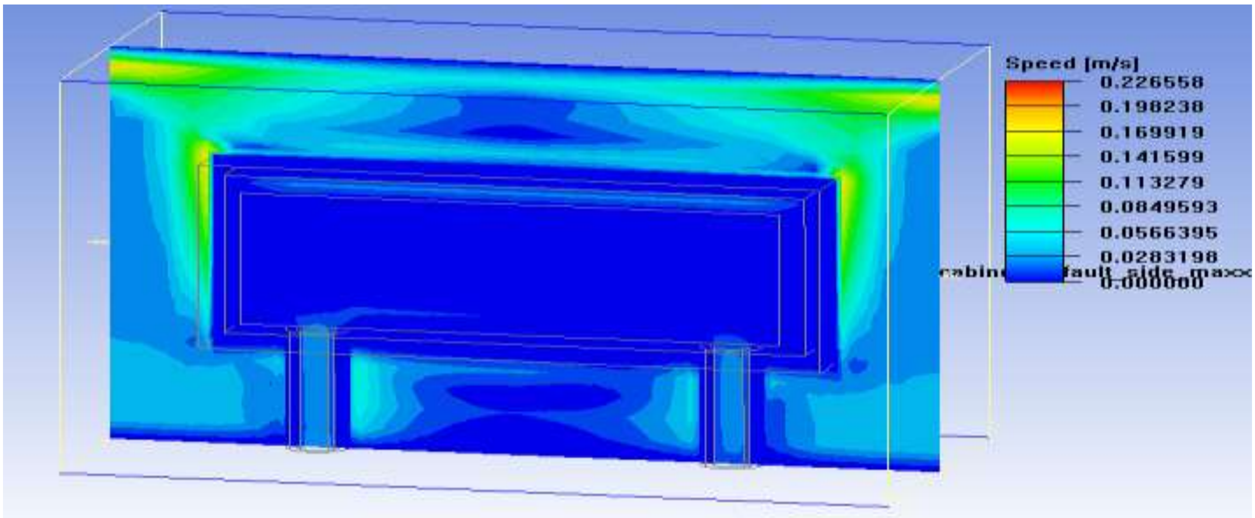

Fig 8 Velocity Profile

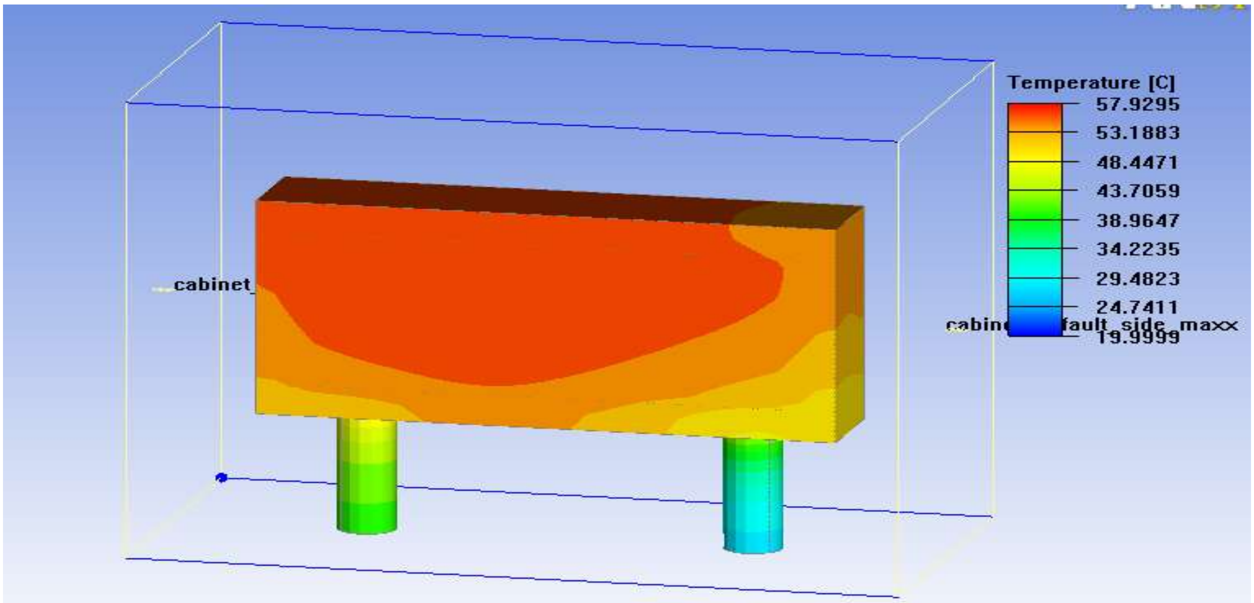

Fig 9 Temperature Profile

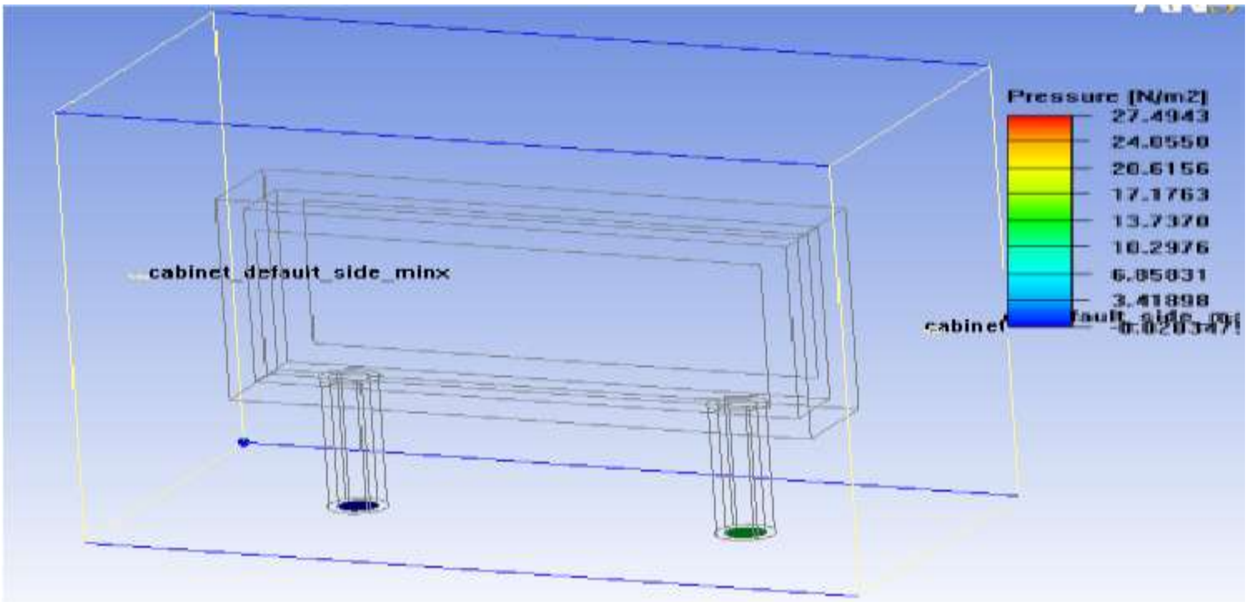

Fig 10 Pressure Profile

Case	FIrst Case: Coolent 20% Ethylene Glycol in Water	Second Case: Coolent 50% Ethylene Glycol in Water	Third Case: Coolent 80% Ethylene Glycol in Water
Inlet Velo. (m/s)	0.02	0.02	0.02
Cold Plate Temp. (^{0}C)	49.51	53.88	57.92
Pressure (N/m^2)	13.25	22.36	27.49
Inlet Temp. (^{0}C)	20	20	20
Outlet Temp. (^{0}C)	38.45	36.34	34.96

IV. CONCLUSION

As 20% to 80% ethylyne glycol solution is mixed with water in pipe of cold plate is increased, cold plate temperature increases from 49.51 ^{0}C to 57.92^{0}C which is not affecting much for life of cold plate but upto certain pressure. However As 20% to 80% ethylyne glycol solution is mixed with water in pipe of cold plate is increased, the outlet temperature decreses from 38.45 ^{0}C to 34.96 ^{0}C which means % increase in ethylenlene glycol solution in water is not heated to extreme value which is beneficial for life of cold plate.

Hence it concludes that % increase in ethylenlene glycol solution in water increses with constant inlet velcity of coolent, cold plate temperature increases but outlet temperature decreases.

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