Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 2): pp. 4063-4083
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.02.423

Comittee For Optimizing Thermal Efficiency For Feaanalysis

Sanjay Paliwal Department of Mechanical Engineering, R.D.Engineering College, Duhai,Gaziabad, Uttar Pradesh India-201206

Abstract
In right now, Refrigeration cycles are extremely fundamental in day to day existence, particularly being used for putting away food, wellness, and luxurylifestyle. Thisstudy'saim istoform someeffectivechanges withinthedesign ofa ordinary refrigerant framework in ordersothat theperformanceofthe evaporatorinsidethe compartmentmaybeoptimized. Thefreezer andrefrigerant compartments are read up for 3 setups to really look at the results of the conventional and punctured balance on therate and temperature circulation at various levels and the Examination of temperature profiles for different arrangements of the refrigerating compartment. As a result, the freezer and refrigerator maintain an average temperature of 273K and 286K, respectively. Inside Compartment 1) the temperature in without finned framework - 279.972K to 283.755K. 2) The temperature in with rectangular finned framework 277.563K to 283.1667K.
3) The temperature in with punctured finned framework - 277.362K to 282.335K. The design read up for this kind of fridge, the air temperature at the highest point of the cooler is around 5°C higher than the typical air temperature, and consequently it is critical to try not to put delicate items here. While punctured finned exhibited greatest Temperature circulations and giving a higher cooling impact.

Keywords: CFD, Refrigerator, Evaporator, Temperature

INTRODUCTION

In presenttimeRefrigeration cycles areveryessential in dailylife, especiallyin usefor storingfood, fitness,andfor luxurylifestyle. The essential component of a homegrown cooler is to keep up with low temperature for transient items, and this palatable depends upon on an excellent fridge performance,[1][2] that is shockingly connected to temperature circulation and the wind current inside the compartments.
For coolers upheld fume compression,manystudies are led, significantlythat have some expertise in the temperature and wind stream dispersion of the compartments. Inside the writing we could understand works related with thestudyoftheair speed usingtheParticleImageVelocimeter (PIV) techniquein mix with 3D numericsimulations byusing CFD programming framework [3].For model directed anumericstudyof wind stream and intensity move during a characteristic convection domesticrefrigerator .The upgrade of cooler model a for a free-ice fridge wherein they are expecting and by trial and error assess temperature profiles, getting an unequivocal disparity of their results. To fostered the temperature consistency and thus the wind stream for all wall through a characteristic convection refrigerator. The fact that the temperature dispersion dependentuponontheinternalgeometryoftherefrigerator,especiallywithintheareasbetwe entherefrigerator makes by exploratory it found shelves and therefore the liner lower wall [5]. The existing a numerical simulation of a pressured convection refrigerator remaining that the freezer and therefore the fresh meals compartment are observed in section (synchronized) with every different. By CFD simulation theresearchers projected a new internal design model [6].

Furthermore, some technologies have emerged in answer for the look for different refrigeration systems, among them those thermallyactivated (sun power, geothermal, residual heat, and so forth.) that emulate a decrease in greenhouse gases and zero contribution to global warming highly depend for the category of working fluids [7].
In thisarea, thediffusion-absorption refrigeration systems arehugeapplied in houseequipment's likehotelrooms as they're quiet and secure. Although these refrigerators will operate forever and ever for several hours, their utility is limited solely to refrigerators of little cooling capability. Study in the field of the diffusion-absorption era is highly dependent on comparing absolutely unique combinations, the applying of nano-refrigerants, the evaluation of configurations, and consequently the enlarged electricity performance, amongst opportunity matters [8]-[12].
There are following objective of this research work:

- To form some effective changes within the design of a conventional refrigerant system in order so that performance of the evaporator inside compartment may be optimized. Possible enhancements within the design plate evaporator that result are sufficient for increase in thermal behavior and successivelyrepresent a decreasein the manufacture costs as compare with conventional refrigerator system.
- An analysis of flow and temperature fields for known stagnation points where minimum and maximum temperatures within the refrigerator compartment are identified.
- Thefreezer andrefrigerant compartmentsisstudied for 3 configurations.Tocheck theconsequencesoftraditional and perforated fin on the rate and temperature distribution at different level.
- Comparison oftemperature profiles for various configurations ofrefrigerating compartment. toform comparative analysis between various cases of with and without fin refrigerating system.

RELATED WORK

J.M. Belman-Flores et al. [1] presented the study about the flow and thermal behavior inside compartment of domestic diffusion absorption refrigerator (DAR). Computational fluid dynamic (CFD) simulation used for find thermal and flow behavior inside DAR. Aim ofthispaper wastocomparethethermal behavior ofa plate-evaporator design withrectangular finned surface (reference fridge) and a plate-evaporator without finned surface (proposed design) and also in this paper coefficient of performance of each model calculated separately. Finally, this work shows that hownumerical simulation is important for us for development of new design inside refrigerator and if we consider manufacturer cost than proposed design is better than reference design .
Mustafa Ali Ersoz et al. [2] Analyzed the effect of three different heat inputs provided to generator on the energy performance of the diffusion absorption refrigeration (DAR) system. Three different heat inputs 62, 80 and 115 W is with electrical resistance as heat input. The energy losses to ambient and the energy gain by component of the system were investigated. The highest energy performance of 0.36 was given by DAR 62 W. The lowest energy performanc3e of 0.30 was given by DAR 115W.
Rami Mansouri et al.[3] studied about low capacity commercial diffusion absorption system which was in close condition. In this paper both experimental and numerical simulation was carried out. All tests were conducted under different heat inlet situation. Acc to experimental three generator heat input 46, 56 and 67Wwere considered, all experimental data were used for comparing model which was developed by commercial

flow-sheeting Aspen-Plussoftware for numerical simulation. And finally by comparing experimental and numerical simulation it was found that highest performance of the refrigerator is found with a generator heat input 46 W with generator temperature of 167°C. A highest machine COP was attained 0.159 under these conditions.

J.M.Belman-Flores et al. [4] have given an analytical model of the bubble pump for a diffusion absorption refrigerator. They found that diameter ratio of the bubble pump influences the cooling capacity, COP and heat input to the bubble pump. Cooling capacityand cop increases byabout 150% if the diameter ratio is extended up to 1.5.

Adnan Sozen et al. [5], have studied the heat performance of diffusion absorption coolers with ammonia/water coupled and alumina(Al2O3)Nano-sized particles. Nano-particles improve heat transfer capacity of the fluid due to increased surface area and heat capacity. Reduced operation time of the system was observed due to short periods of heat transfer.

J.L. Rodriguez-Munoz et al. [6], Diffusion absorption technology is viable for domestic applications because of their silent and safe operation thus finding refrigeration solutions for small plant. ammonia/water mixed with hydrogen or helium is the commercially accepted working fluid for diffusion absorption refrigeration system. From varios study it can be revived that this technologyis approximately40% less efficient as compared to conventional absorption system.

J.M. Belman-Flores et al. [7], employed CFD for modeling and simulation for the force convection domestic refrigerator sort with bottom mount configuration thus the temperature stratification in the freezer compartment was analyzed that modified design of shelves and wire shelves clearlyshow in temperature and velocitycontour, air flow does not block and flows more appropriately than original configuration.

Abdullah Yildiz et al. [8], Carried out experimental and theoretical energy and exergy analysis of diffusion absorption refrigeration cycle. Theexperimentalsetup is supplied with 25 -75 byvolumemixtureofammoniaandwater as working fluid, with the auxiliary inert gashelium at 12 bar pressure. for both the experimental and theoretical analysis, highest energy and exergy loss found to be in solution heat exchanger total energy loss of approximately 44% and total exergy loss of approximately 64% was found in both the experimental and theoretical analysis.

Acuna et al. [9], studied the diffusion absorption cooling system for different working fluids to determined best suitable fluid on the basis of operating condition and coefficient of performance(COP).NH3-LINO3,NH3-H2O,NH3- NASCN mixture were chosen for comparison. Mathematical model of the system was developed and compared to experimentalresults availableintheliterature.Best performanceis shown byNH3-LINO3-Hemixturewith aCOP of0.48. the mixture proved 46%extra efficient than NH3-NASCN-He mixture. NH3-LINO3-He was found 50 to 69% more efficient compared to NH3-LINO3-He mixture. Crystallization was observed with NH3-LINO3-He mixture at higher temperature.

METHODOLOGY

Inthisstudythefreezerandrefrigeratingcompartmentsisstudiedforthreedifferentconfigurations.Inthesethreestudies different models are used namely Plate-evaporator without finned, Plate-evaporator with rectangular finned surface and Plate-evaporator with perforated finned surface. For the modeling purpose CATIA V5 R20 is used for modeling the three designs of refrigerator. CATIA software provides the approaches for model generation like creating a solid model within the 3D work space. For theneed of CFD analysis ANSYS-Fluent software is used. ANSYS-Fluent software is basically a software program designed for solving computational fluid dynamics based problems. In our study

ANSYS-Fluentsoftware is used for the CFD simulation of the Refrigerator compartment. The SIMPLE algorithm is used to solve conservation equations to steady state for the coupling of pressure and velocity. Standard scheme was used for the pressure equation and a second order upwind scheme was considered for momentum and energy equations. The laminar regime was applied considering the Boussinesq´ s equation in the y-component of the momentum equation. 410, 360 and 530 iterations were carried out to achieve convergence for the plate evaporator with rectangular extended surfaces, the plate without extended surfaces and the plate with perforated surfaces respectively. The convergence criteria for the momentum and continuityequations were $10^{-3}$and $10^{-6}$for energyequation.

FORMULATION OF THE PROBLEM

Themathematicalstudyofthefluidflowoftheair isfocused on thecompartmentoftherefrigerator as outlinedabove.The main objective is to check the thermal behavior of the reference refrigerator (plate with rectangular surface) with the proposed refrigerator (plate with perforated surface) and also with refrigerator (plate having smooth surface). The subsequent assumptions were done for the mathematical model.

- Incompressibleflow
- Steadystateflow
- Boussinesq[1]model
- Withoutthermalloadinsidetherefrigerator
- Laminar flowregioninsidethecompartment

The density is calculated using the Boussinesq approximation in the momentum equation in y direction. The conservation equations are adapted to the model, considering constant properties and including the Boussinesq's equationin the y-component of the Navier-Stokes equation.

Governing Equations

All equation given below are taken which are applied in CFD simulation.

Continuity Equation

$$\rho\left(\frac{\partial u_x}{\partial x}+\frac{\partial u_y}{\partial y}+\frac{\partial u_z}{\partial z}\right)=0 \quad (1)$$

EnergyEquation

$$\rho c\left(u_x\frac{\partial u_x}{\partial x}+u_y\frac{\partial u_y}{\partial y}+u_z\frac{\partial u_z}{\partial z}\right)=k\left(\frac{\partial^2 u_x}{\partial x^2}+\frac{\partial^2 u_y}{\partial y^2}+\frac{\partial^2 u_z}{\partial z^2}\right) \quad (2)$$

DensityDifferenceEquation

$$\rho_\infty - \rho = \rho\beta(T - T_\infty) \quad (3)$$

In which the density difference is expressed in terms of the volumetric thermal expansion coefficient, b, and the temperature, T.

MomentumEquation

ComponentX

$$u_x\frac{\partial u_x}{\partial x} + u_y\frac{\partial u_y}{\partial y} + u_z\frac{\partial u_z}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \frac{\mu}{\rho}\left(\frac{\partial^2 u_x}{\partial x^2} + \frac{\partial^2 u_y}{\partial y^2} + \frac{\partial^2 u_z}{\partial z^2}\right) \quad (4)$$

ComponentY

$$u_x\frac{\partial u_x}{\partial x} + u_y\frac{\partial u_y}{\partial y} + u_z\frac{\partial u_z}{\partial z} = g\beta(T - T_\infty) + \frac{\mu}{\rho}\left(\frac{\partial^2 u_x}{\partial x^2} + \frac{\partial^2 u_y}{\partial y^2} + \frac{\partial^2 u_z}{\partial z^2}\right) \quad (5)$$

ComponentZ

$$u_x\frac{\partial u_x}{\partial x} + u_y\frac{\partial u_y}{\partial y} + u_z\frac{\partial u_z}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \frac{\mu}{\rho}\left(\frac{\partial^2 u_x}{\partial x^2} + \frac{\partial^2 u_y}{\partial y^2} + \frac{\partial^2 u_z}{\partial z^2}\right) \quad (6)$$

Geometrical Model

CATIA V5 R20 is used for modeling the three designs of refrigerator and its compartment, namely plate-evaporatorwithout finned surface, plate-evaporator with rectangular finned surface and plate-evaporator with perforated finned surface. CATIA software provides the approaches formodel generation like creating a solid model in the 3D work space.In this research work ANSYS-FLUENT 16 software is used for the CFD simulation of the all three refrigerator compartments. In meshing section of ANSYS-FLUENT 18.2 the mesh size of the compartment was found 4,78,747 hexahedralelementsfor therectangular finned plate-evaporator and 1,56,198hexahedral elementsfor thenon-finnedplate- evaporator and 18,48,509 hexahedral element for perforated-finned plate evaporator. The geometry of the refrigerator compartment considers the plate-evaporators, door, and walls withchannels to put the shelves, the bottom and the top of the compartment. In all three models, the structural mesh was obtained with good quality according to Equivalent Size Skew parameter,used todefinethedegree of deformation of theelements, where90% of theelements presenta valuenear to zero. Equivalent size orthogonal parameter is also used for defining the degree of deformation of the elements, where 90% of the elements present a value near to one.

Numerical Simulation

The ANSYS-FLUENT 18.2 software was used for the CFD simulation inside the compartment. For simulation purpose pressure based solver, absolute velocity and steady time is used. Energy model and laminar model were considered. Material considered were air as fluid and aluminium as solid. Table 1 shows the properties of air and aluminium.

The SIMPLE algorithm is used to solve conservation equations to steady state for the coupling of pressure and velocity. Standard scheme was used for the pressure equation and a second order upwind scheme was considered for momentum and energy equations. The laminar regime was applied considering the Boussinesq´ s equation in the y-component of the momentum equation. 410, 360 and 530 iterations were carried out to achieve convergence for the plate evaporator with rectangular extended surfaces, the plate without extended surfaces and the plate with perforated surfaces respectively. The convergence criteria for the momentum and continuityequations were $10^{-3}$and $10^{-6}$for energyequation.

BoundaryCondition

Experimental Data of J.M. Belman-Flores et al. [1] is applied for the numerical simulation in boundary condition withinthe compartment.acc to their experimental work considering an average temperature on cold wall and hot wall, here the plate-evaporator has the lower temperature because it directly contact with evaporator tube and andrefrigerator door have higher temperature acc to experimental result. No-slip condition was considered for all wall velocity no-slip condition. Temperature range considered was 273K to 286K for boundary conditions inside the compartment.

Table I shows the property of the dry air that was considered as fluid inside the compartment and aluminum as itis the material of fin plate that is taken into consideration.

- Fin
- Material-aluminum
- Coldwall
- Temperature-273K
- Hotwall
- Temperature-286K

Afterapplyingtheproperboundaryconditionthesimulationissettorun.Andtheresultswererecorded.

ExperimentationAlgorithm

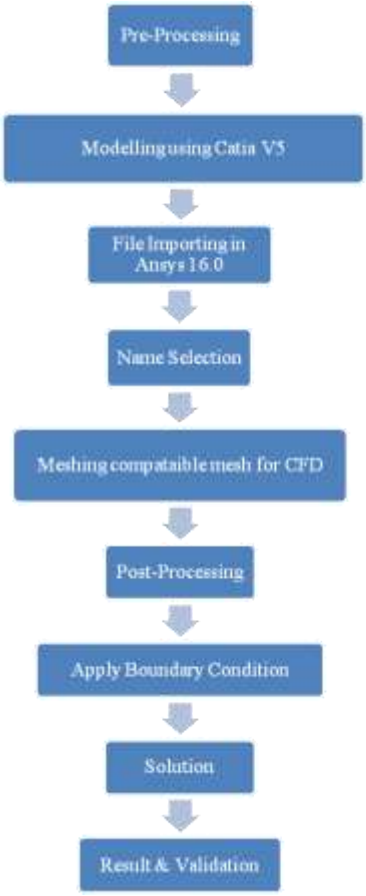

Figure1: Experimentation Algorithm

Air and Aluminum Properties

Properties of the air and aluminum inside of the compartment

Table1: PropertiesAirandAluminum

Property	Density [Kg/M^3]	SpecificHeat [J/ Kg K]	ThermalConductivity [W/M K]	Viscosity [Kg/M-S]
Air	1.22	1006.43	0.0242	1.78x10^{-5}
Al	2719	871	202.4	-

Experimentation

- CollectinginformationanddatarelatedtotheRefrigeratorsystem.
- AfullyparametricmodeloftheRefrigeratorsystemisgeneratedusingCatiaV5.
- ModelobtainedinStep2isanalyzedusingANSYS18.2(FLUENT).
- Finally, the results obtained from ANSYS are compared in the result section.

MethodofANSYSAnalysis Building the Model

The CATIA provides the following approaches for model generation: Creating a solid model within CATIA. The commercialrefrigerator used in this studywas ofsmallcapacity(0.03 m^3)as seen in Fig. 2. Theexternaldimensions ofthe experimentalrefrigerator were 0.4 mx 0.35 m x0.50 m (width x depth xheight)andthe wall thickness was approximately

0.037m. Inside the refrigerator there was an aluminum plate with rectangular fins, which was directly in contact with the evaporator tube, and bythis means, theheat transfer was achieved in the food compartment. The plate consisted of 19 fins and was 0.3mx 0.3 m. In caseofperforation plate,bymanyCFD analysis at different dimension takediameter ofthehole for perforation is 0.026m.

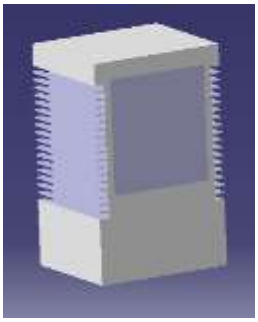

Figure 2: RefrigeratormodelinCATIAV5

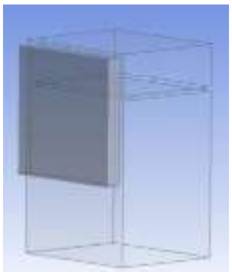

Figure3: Refrigerator Model Air Domain

Meshing
In ANSYS CFD works on finite element analysis (FEA).The basic idea of FEA is to make calculation at onlylimited(finite) no. of points and then interpolate the result for the entire domain(surface or volume).any object has infinite degree of freedom and it's just not possible to solve the problem in this format. The FEA reduces the degree of freedom from infinite to finite with the help of meshing or discretization. Meshing quality is measure by two parameter first isskewness(maximum element near to 0) and second is orthogonal(maximum element near to 1). In all three models, the structural mesh was obtained with good qualityaccording to Equivalent SizeSkew parameter, used to define thedegree of deformation oftheelements, where90% oftheelements presenta valuenear tozero. Equivalent sizeorthogonalparameter is alsoused for definingthe degree ofdeformation ofthe elements, where90%ofthe elementspresenta valuenear toone.
Case1-RectangularFinnedSurface

Themesh created in rectangular finned work is shown in Fig. 4.Thetotalnumber ofnode generated is 169407&Total No. of Elements is 156198 for Refrigerator with Rectangular fin.

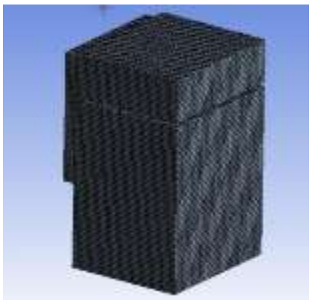

Figure 4: Meshing: Total No. of Nodes:169407&TotalNo.Elements: 156198

Case2-WithoutFinnedSurface

Themesh created in without finned work is shown in Fig.4.ThetotalNodeis generated102720&TotalNo. ofElementsis 478747 for Refrigerator without fin.

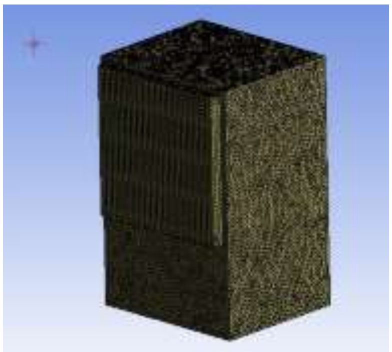

Figure5: Meshing: Total No. Of Nodes:102720&TotalNo. of Elements Is 478747

Case3-PerforatedFinnedSurface
The mesh created in perforated finned work is shown in Fig.5. The total Node is generated 366357 & Total No. of Elements is 1848509for Refrigerator with perforation.

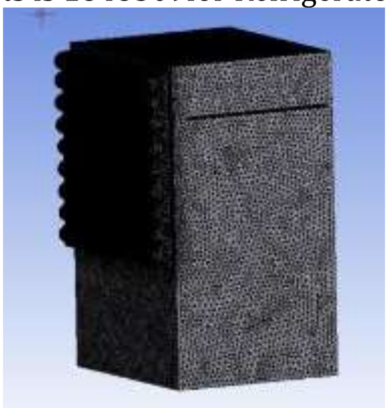

Figure6: Meshing:TotalNo. ofNodes: 366357&TotalNo.Elements:1848509.

Defining Name Selection
InnameselectionfirstselectthecoldsurfaceinallthreecasesfromFig.6.

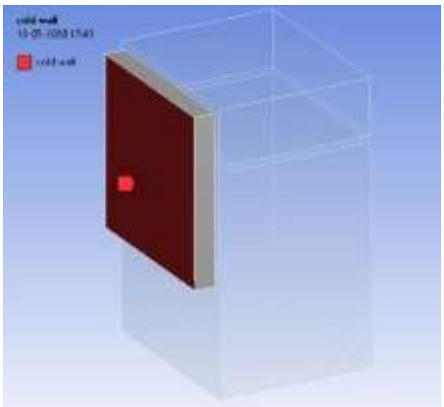

Figure7:ColdWall Selection

Seconddefineair-domaininallthreecasesfromFig. 7.

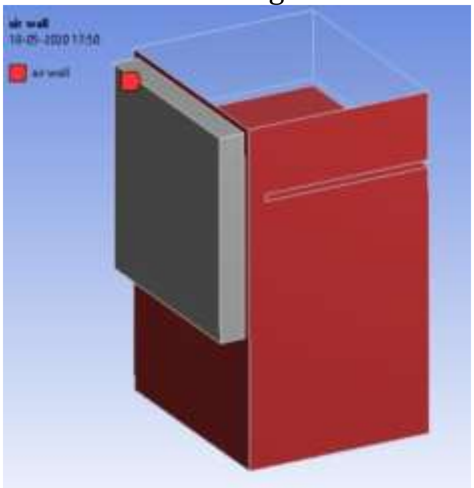

Figure 8: Air Domain Selection

ThirddefinehotwallnameselectioninallthreecasesfromFig.9

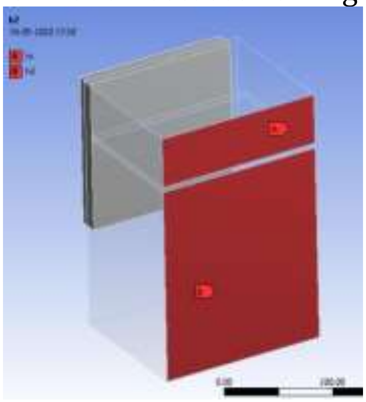

Figure 9: Hot Wall Selection

Defining Material Properties

For any kind of analysis material property are the main things which mustbedefined beforemovingfurtheranalysis. There arethousandsofmaterialsavailablein theANSYS environmentandifrequired libraryis notavailablein ANSYS directory the new material directory can be created as per requirement. For present work aluminum is used as a material of fin. The material propertiesofthepresent caseareas: Density: 2719kg/m^3,thermal conductivity: 202.4 W/m-K,SpecificHeat: 871 J/kg-K(from table no 4.1)

CFDAnalysis

CFD analysis may use to determine temperature distribution and other thermal capacity that may vary over the time. Variousheattransfer application,heattreatmentproblems, Condenser coilsinvolveCFDanalysis. Itisthefunction tool for defining the equation or describing the curves and then applying the function for boundaryconditions.

CFDSimulationofthe Compartment

Steady heat transfer in time also requires the Aluminum and Air properties as described in Table 4.1: Properties of Aluminum and Air.

The study was carried out using ANSYSFLUENT tool. The steps for he analysis are shown below

- Import the stp. File in the ANSYSFLUENT module.

- After importing the stp. File in ANSYS, open design modular of the ANSYSFLUENT and created the named selection of the parts refrigerator.
- Preparingthematerialsforanalysis.
- Assigningthematerialproperties.
- Definingthecellzoneconditions.
- Settingtheiterationsforthecalculation ofresults.
- EvaluatingtheresultsinCFDPost.

PointsTakenforCalculationAverageTemperature,Velocity&COPforCFDSimulationInsidet he Compartment

Table 2: PositionofPointsForCFDSimulation

	Minimum Temperature	**Maximum Temperature**	**Middle Compartment**	**Horizontal-Plane (Ta)**	**Plate Temperature (TP)**
T1 V1(X,Y,Z,)	0.50, -0.099 0.020	0.50 0.099 0.25	0.50 0.099 0.110	0.350 0.060 0.110	0.35 0.060 0.001
T2,V2(X,Y,Z,)	0.25 0.099 0.020	0.25 0.099 0.25	0.25 0.099 0.110	0.350\0.25 0.110	0.35 0.025 0.001
T3,V3(X,Y,Z,)	0.10 0.099 0.020	0.10 0.099 0.25	0.10 0.099 0.110	0.350 0.10 0.110	0.35 0.10 0.001

CalculationforCOP

From below calculation, 1 is taken for without fin plate evaporator,2 is taken for rectangular fin evaporator and 3 is taken for perforated fin plate evaporator.

Cp=871j/kgk(foraluminum) m=4.96x10^{-3}kg/s

Qbp=65w T_{air1}=281.91k T_{air2}=278.09k T_{air3}=277.73k T_{P1}=280.454 T_{P2}=280.11 T_{P3}=280.04

$Q=mC_p(T_{air}-T_P)$

(7)

NowbyusingaboveequationwefoundQafter calculationfor differentconfigurations Q_1=6.29 W (without finned plate evaporator)

Q_2=8.727W(withrectangular finnedplateevaporator) Q_3=9.98 W (with perforated finned plate evaporator)

$COP=Q_{evap}/Q_{bp}$

(8)

NowbyusingaboveequationwefoundCOPafter calculationfor differentconfigurations $(COP)_1$=0.09677 (without finned plate evaporator)

$(COP)_2$=0.13426(withrectangularfinnedplateevaporator) $(COP)_3$=0.1535 (with perforated finned plate evaporator)

RESULTANALYSIS

Case1-WithoutFinnedSurface

CFDSimulationofPlate-evaporatorwithoutfinnedsurface.

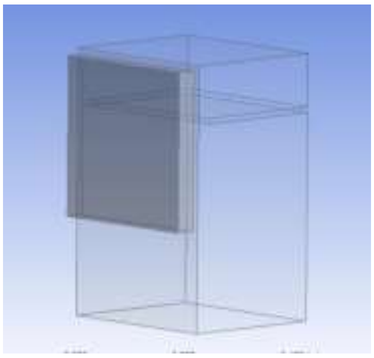

Figure 10:WithoutFinnedSurface

ContourofWithoutFinRefrigerationSystemforTemperature-Distribution

Below images shows the result of CFD analysis of without fin refrigerator. The contour in Fig. 11 shows the temperature distribution insidethe compartment of refrigerator. The bottom region of therefrigerator low temperature as compare with upper region of the refrigerator which is higher temperature insidecompartment. From fig.5.2the Plate-evaporator without finned surface not increases well the temperature distribution inside the compartment. In this case, it can be seen that the temperature distribution change significantly by showing in vertical direction a cooler zone in the bottom of 280.634 K(green colour zone) and an upper region with a higher temperature of 281.928 K(yellow colour zone). In fig.3 yellow colour zone (at middle of the compartmentobtained by CFD simulation) represents relatively high temperature.The average temperature of the yellow and green colour zone is obtained as 281.24 K.

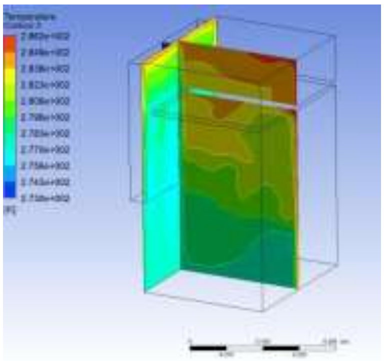

Figure11:Temperature-ContourforPlate- Evaporator without Finned Surface

Contour of Without Fin Refrigeration System for Velocity-Distribution

Another part of the analysis in the compartment is the velocity distribution generated by the temperature gradient. Fig. 12 show the velocity contour for the same cases mentioned above. The higher density of air is seen on the side walls and the bottom ofthecompartment, which includeareasoftheextended surface.Theposition oftheshelfinfluencestheflowfield, principallybecause the shelf in thelower position causes an upstreamretention (for instance, thered and yellow ones near the door), supporting the uniformityof temperature in this space of the compartment. For this case, theaverage velocity at the middle plane is 0.00747102 m/s and 0.015645 m/s forthe lowerand the uppershelves,and the average velocity at the middleplaneis0.0077m/s.

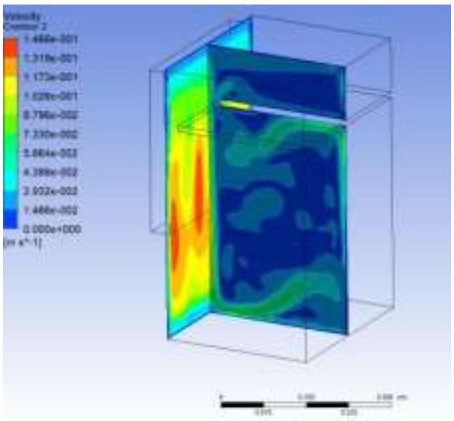

Figure12:Velocity-ContourforPlate- Evaporator Without Finned Surface

Case2-WithRectangularFinnedSurface
CFDSimulationofPlate-evaporatorwithrectangularfinnedsurface

ContourofPlate-EvaporatorwithFinnedSurfaceforTemperature-Distribution
Below images shows the result of CFD analysis on rectangular fin refrigerator. The contour in Fig. 13 shows the temperaturedistribution inside the compartment of refrigerator. The bottom area of therefrigerator is low temperatureand the upper area of the refrigerator is higher temperature in compartment.In this case, it can be seenthat theWith rectangular finned plate surface evaporator, the temperature distribution is varying from the bottom as 275.23 K (blue colour zone) to a higher temperature of 284.41 K (orange colour zone) at upper region. Slight fall in temperature (blue colour zone) is observed at the middle of the compartment which is not observed in temperature contour in without finned plate evaporator. The average temperature at middle of the compartment obtained is 278.77 K.

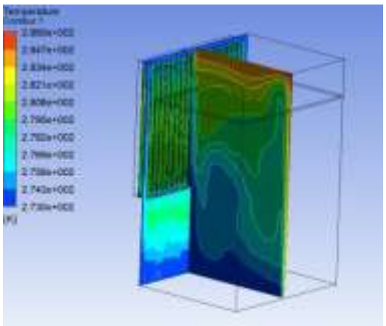

Figure13:Temperature-Contourfor Plate-Evaporator with Finned Surface

ContourofPlate-EvaporatorWithFinnedSurfaceforVelocity-Distribution
Another part of the analysis in the compartment is the velocity distribution generated by the temperature gradient. Fig. 14 show the velocity contour for the same cases mentioned above. For this case, the average velocity at the middle plane is 0.008432 m/s and 0.01523 m/s for the lower and the upper shelves, respectively and average velocity at middle plane is 0.00788m/s.

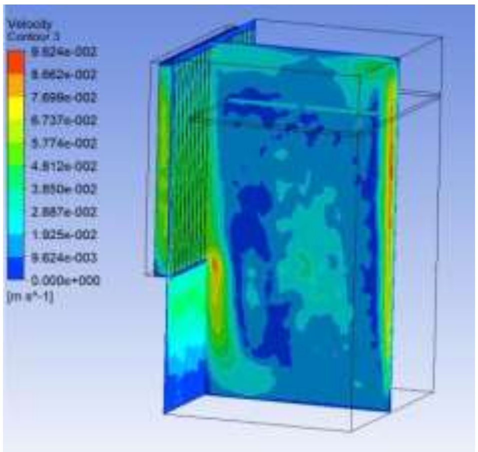

Figure14:Velocity-ContourforPlate- Evaporator with Finned Surface

Case3-WithPerforatedFinnedSurface

CFDSimulationofPlate-evaporatorwithperforatedfinnedsurface

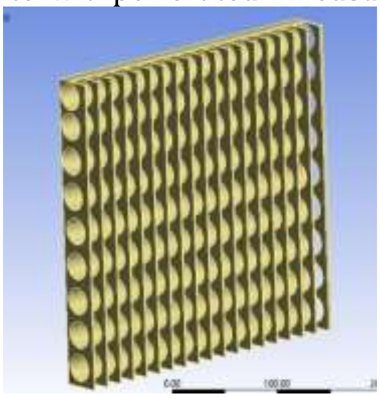

Figure15:Plate-Evaporatorwith Perforated Finned Surface

ContourofPlate-EvaporatorwithPerforatedFinnedSurfaceforTemperature-Distribution

Below images shows the result of CFD analysis on with perforated fin refrigerator. The contour in Fig. 16 shows the temperature distribution inside the refrigerator compartment. The bottom region of the refrigerator is at low temperature compare with upper region of the refrigerator is at higher temperature in compartment. In this case Plate-evaporator with perforated finned surface is used. In this case, it can be seen that Wide cooled region (blue colour zone) is obtained with perforated finned platesurfaceevaporator in comparison ofabovetwomodels; the temperaturedistribution isvaryingfrom bottom as274.476 K(blue colour zone) to ahigher temperatureof 283.273 K(yellowcolour zone) at upper region. Dueto increase in area of contact of air in perforated fin plate evaporator rate of cooling are also increases so in temperature contour it is found that temperaturedistribution of coolingregion (blue colour zone) increases. Theaveragetemperatureat middle of the compartment obtained is 277.99 K.

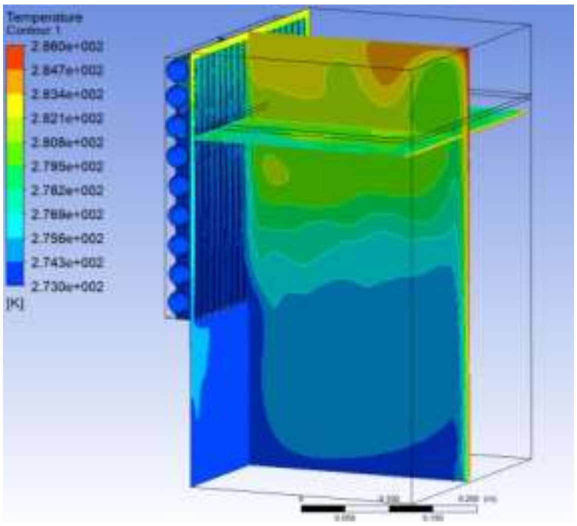

Figure16: Temperature-Contour For Plate Evaporator With Perforated Finned Surface

Contours of Plate-Evaporator with Perforated Finned Surface for Velocity-Distribution

Another part of the analysis in the compartment is the velocity distribution generated by the temperature gradient. The higher speed is located on the side walls and the bottom of the compartment, which include areas of the extended surface. The position of the shelf influences the flow field, principally because the shelf in the lower position causes an upstream retention, supportingthe uniformityoftemperaturein this spaceofthecompartment. For this case, from Fig.17theaverage velocityat themiddle planeis 0.009205 m/s and 0.01516m/s for thelower and theupper shelves, respectivelyand average velocity at middle plane is 0.00812m/s.

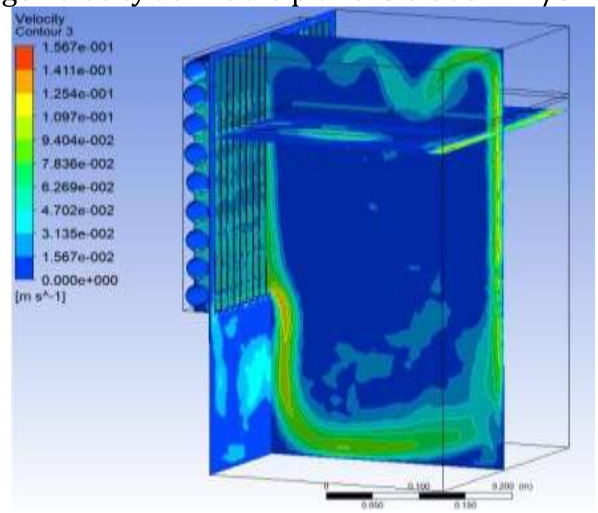

Figure17: Velocity-ContourforPlate-Evaporatorwith Perforated Finned Surface

Temperature-Analysis

Results were obtained in order to study the temperature and velocity distributions inside the domestic frost-freerefrigerator. Drop in maximumandminimumtemperature (Table III) isobserved in perforated fin refrigerator.The drop in temperatureisduetoincrementinthesurfaceareawhichinturnincreasestheheattransferrates.

Table3: Maximum-MinimumTemperature

Refrigerator	Withfin	Withoutfin	Perforatedfin
Minimum Temperature(PlateSide Temperature	277.56K	279.972K	277.41K
Middleof the compartmenttemperature	278.77K	281.24K	277.99K
Maximum Temperature(DoorSide Temperature)	283.16K	283.75K	282.34K

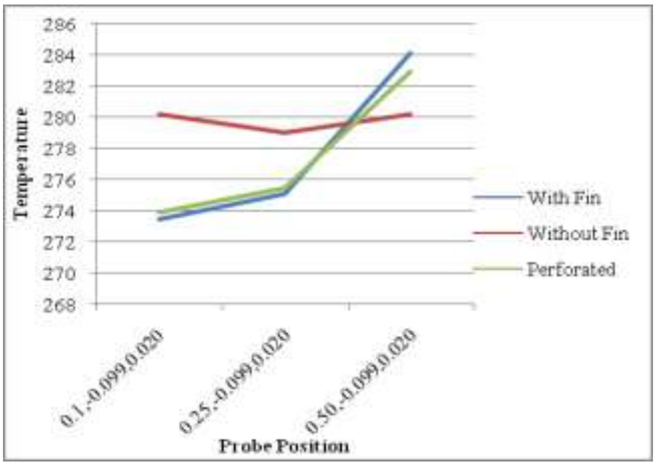

Figure18: MinimumTemperatureGraph

The above fig shows theminimum temperature (plate side) in therefrigerator compartment in three cases at three different points, which show that plate with perforated fin surface, has slightly minimum temperature 273.87 K than other two plate evaporator model.

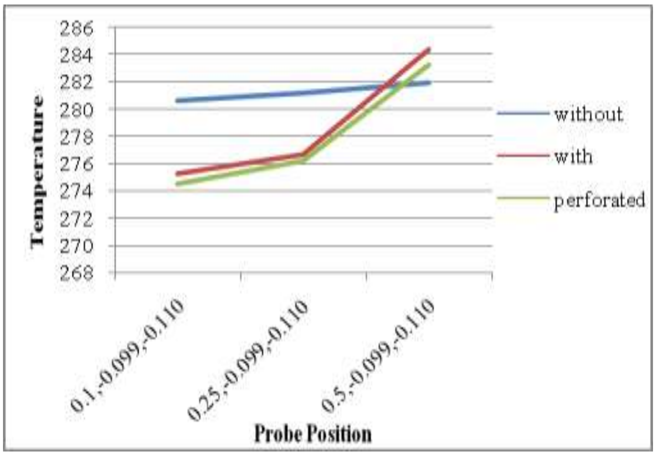

Figure19:MiddleCompartmentGraph

Theabove fig shows themiddle compartment temperature (at center line) in therefrigerator compartment in three cases at three different points, which show that plate with perforated fin surface, has slightly minimum temperature than other two plate evaporator model.

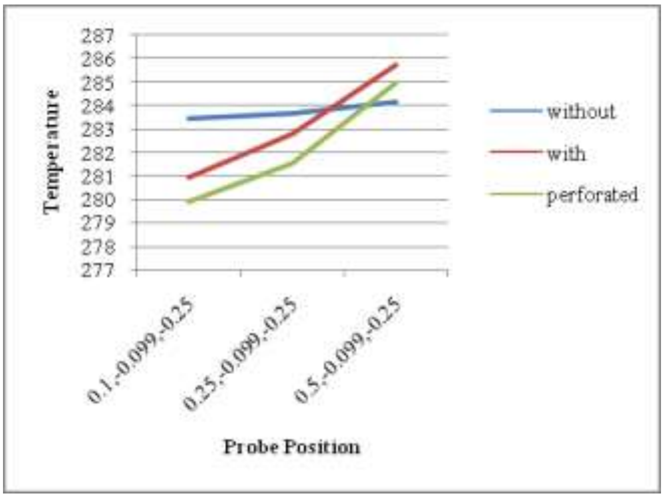

Figure20:MaximumTemperatureGraph

The above figshows the maximum temperature (Door side) in therefrigerator compartment in three cases at three different points, which show that plate with perforated fin surface, has lowest maximum temperature other than two cases rectangular fin and without fin.

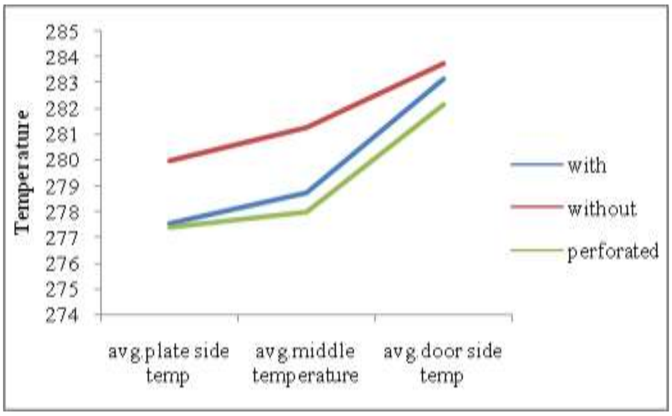

Figure21:AverageTemperatureGraph

The above figshows the average plate side temperature (minimum temperature), average middle temperature, average door side temperature (maximum temperature) inside the compartment. Average value for all side calculated with thehelp of three points which is taken in the compartment. From above graph it has seen that perforated has lowest for all average temperature value in comparison of other two models.

Temperature-DistributioninHorizontalPlanefordifferentCases

The temperature distribution on the horizontal plane of the compartment is related to the natural movement due to the density difference caused by the temperature gradient. Temperature distribution for a without finned plate, rectangular finned plate and perforated finned plate on a horizontal plane placed at the center of the compartment. The average temperature in the horizontal plane is 281.915 K for without finned plate, 278.114 K for rectangular finned plate and 277.734 for perforated finned plate.

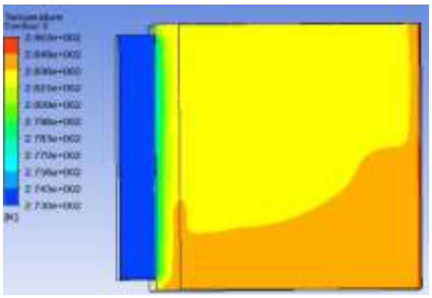

Figure22:WithoutFinnedPlate

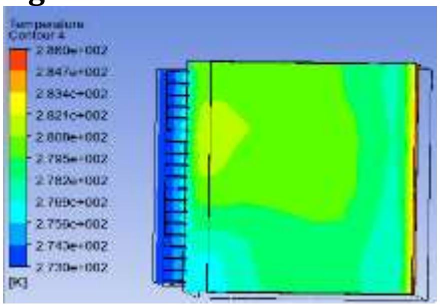

Figure23:WithRectangularFinned Plate

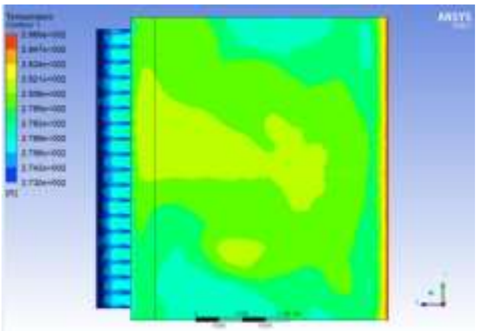

Figure24:WithPerforatedFinned Plate

PerformanceAnalysis

Performance analysis (table-II) for different refrigerator model, in this studyall calculation were done on horizontal plane (fig.22,fig.23,fig.24) by using below COP equation which is based on diffusion absorption cycleand after calculation we found that perforated finned evaporator plate has highest COP among other finned plate evaporator.

COP=$\frac{Qevap}{Qbp}$ (9)

Here Qevapis cooling capacity which directly depends on design of plate evaporator temperature, TPand Qbp(thermal capacity of bubble pump, which depends up on electrical resistance attached with bubble pump). This section compares the coefficient of performance for all three design of plate evaporator. The calculation for thermal capacity of bubble pump for all three refrigerator is considered as 65 W based on the work of Bellman-Flores [1][4]. The average temperature of plate evaporator (TP) is considered on the plane which is close to plate evaporator and average temperature ofair (Tair) isconsidered on theplanenear tomiddleofcompartment. Performanceanalysisfor differentrefrigerator model is shown in table-IV.Perforated finned surface found with highest cooling capacity and COP among other model of plate evaporator.

Table4:ComparisonofCOPforDifferentRefrigeratorModel

Refrigerator	Tp[K]	Tairc[K]	Qevop[W]	COP
Withoutfinned	280.454	281.91	6.29	0.09677
With finned	280.11	278.14	8.727	0.13426
Perforatedfinned	280.04	277.73	9.98	0.1535

CONCLUSIONS

CFD simulation of air flow and heat transfer is carried out within the refrigerating compartment of a domestic frost-free refrigerator. Three configurations are studied in the compartments with rectangular finned and without finned and perforated finned. Temperature distributions inthe freezer model confirm the theory that there is stratification, a warmzone (higher temperature) at the top and a cold zone at the bottom.

- The average temperature maintained in the freezer and refrigerating compartment is about 273K and 286K respectively.
- InsidetheCompartment
- Temperatureinwithoutfinnedsystem –279.972Kto283.755K
- Temperatureinwithrectangularfinnedsystem–277.563Kto283.1667K
- Temperatureinwithperforatedfinnedsystem –277.362Kto282.335K
- Whatever the configuration studied (empty with/without shelves, loaded with products) for this type of refrigerator, theair temperatureat the top of therefrigerator is about 5°Chigher than theaverageair temperature, and therefore it is important to avoid placing sensitive products in this position.
- WhileperforatedfinneddemonstratedmaximumTemperaturedistributionsandprovidinghighercoolingeffect.
- Finally, the analysis and modeling through CFD for refrigerators based on diffusion-absorption is presented as a feasible tool for the purpose of evaluating proposals in the internal design of the refrigerator. The present study considers that significant improvements can be achieved on the thermal profiles, by researching an optimal geometric plate-evaporator, in which theair flowis included asa parameter of great importance in theoperability of the refrigerator and for the preservation of food supplies.

The present work concerned just the upgrade of Fins of evaporator plate from the purpose of High temperature distribution. There are some possible proposals which might be feasible for response in future.

- In future work maybe done on material of plateevaporator.In thisresearch paper we used aluminumas material. So, in future temperature distribution inside compartment may will be increase by change in plate evaporator material.
- The speed of air change in keeping with change in thermal profile because of these changes providing sensible cooling result within the refrigerator therefore in future it's will going to be possible enhancements may be achieved on the thermal profiles, byresearching on optimal geometric dimension of plate evaporator.
- The impact of different fin design of plate evaporator (as area of surface increases heat transfer also increases) providing good result for future purpose.
- TheCFD simulation performed in thisresearch work can beused in futureasa tool in order tostudytheinfluence of operating conditions on the temperature and velocity fields such as change in evaporator temperature, change dimensions of the evaporator and the change percentage of product-occupied volume inside the refrigerating compartment.

REFERENCES

1. J.M. Belman-Flores, A. Gallegos-Munoz, "Analysisof theflowandtemperaturedistributioninsidethecompartment of asmall refrigerator", Applied Thermal Engineering, vol. 106(2016) 743–752.
2. MustafaAli Ersoz,"InvestigationtheEffects of Different HeatInputsSuppliedtotheGenerator ontheEnergyPerformancein Diffusion Absorption Refrigeration Systems", International Journal of Refrigeration, vol.S0140-7007(2015) 00045-6.
3. Rami Mansouri, Mahmoud Bourouis, Ahmed Bellagi "Steady state investigations of a commercial diffusion absorption refrigerator: experimental study and numerical simulation", Applied Thermal Engineering, vol-16(2017)34487-8.
4. J.M. Belman-Flores, J.L. Rodriguez-Munoz, Rubio-Maya, J.J. Ramirez-Minguela, V. Perez-Garcia, "Energetic analysis of a diffusion absorption system: A bubble pump under geometrical and operational conditions effects", Applied Thermal Engineering vol.71(2014)1-10.
5. Adnan sozen, EnginOzbas, Tayfun Menlik, M.TarikCakir, Metin Guru, KurtulusBoran, "Improving the Thermal Performance of Diffusion Absorption Refrigeration System with Alumina Nanofluids: An Experimental Study", International Journal of Refrigeration, vol.S0140-7007(2014) 00094-2.
6. J.L. Rodriguez-Munoz, J.M. Belman-Flores, "Review of diffusion–absorption refrigeration technologies", Renewable and Sustainable Energy Reviews,vol. 30(2014) 145–153.
7. J.M. Belman-Flores, A. Gallegos-Munoz,A. Puente-Delgado, "Analysis of the temperature stratification of a no-frostdomestic refrigerator with bottom mount configuration", Applied Thermal Engineering, vol. 65(2014) 299-307.
8. Abdullah Yildiz, Mustafa Ali Ersoz, "Energy and Exergy Analyses of the Diffusion Absorption Refrigeration System", Energy (2013) 1-9.
9. A. Acuna, N. Velazquez, J. Cerezo, "Energy analysis of a diffusion absorption cooling system using lithium nitrate, sodium thiocyanateand water as absorbentsubstances and ammoniaastherefrigerant", Applied ThermalEngineering,vol. 51(2013) 1273-1281.
10. Ozgur Bayer, RuknettinOskay, Akin Paksoy, Selin Aradag, "CFD simulations and reduced order modeling of a refrigerator compartment including radiation effects", Energy Conversion and Management, vol. 69(2013)68–76.

11. Adnan Sozena, Tayfun Menlika, EnginOzbas, “The effect of ejector on the performance of diffusion absorption refrigeration systems: An experimental study”, Applied Thermal Engineering, vol.33-34(2012) 44-53.
12. RadhouaneBen Jemaa, RamiMansouri,Ismail Boukholda,AhmedBellagi “Experimentalinvestigation and exergy analysisof a triple fluid vapor absorption refrigerator”, Energy Conversion and Management, vol. 124(2016) 84-91.
13. Chaudhari, S. C., C. O. Yadav, and A. B. Damor. "A comparative study of mix flow pump impeller cfd analysis and experimentaldata of submersiblepump." InternationalJournal ofResearch inEngineering &Technology(IJRET) 1.3 (2013): 57-64.
14. KUMAR,AMARESH,ATMANANDANIKIVI,andSHRIDHARDESHPANDE."FEAANALYSIS ANDOPTIMIZATIONOF
15. TWO-WHEELERBIKEMONOSUSPENSIONSYSTEM."InternationalJournalofMechanicalandProductionEngineering
a. ResearchandDevelopment(IJMPERD)9.2(2019):111-122.
16. Krishnaveni,J.,G.Sowmya,andU.Sudhakar."ThermalAnalysisOfCylinderHeadByUsing FiniteElement Analysis." International Journal of Mechanical Engineering (IJME) 3.6 (2014): 11-20.
17. Arora, Rahul, and S. S. Dhami. "Finite Element Analysis and Multibody Dynamics of 6-DOF Industrial Robot."World Academy ofScience, EngineeringandTechnology,InternationalJournalofMechanical andProductionEngineeringResearch and Development (IJMPERD) 7.5 (2017): 1-12.

18. **Dharamveer, Samsher, Singh DB, Singh AK,Kumar N.** Solar Distiller Unit Loaded with Nanofluid-A Short Review. 2019;241-247. Lecture Notes in Mechanical Engineering, Advances in Interdisciplinary Engineering Springer Singapore. https://doi.org/10.1007/978-981-13-6577-5_24.
19. **Dharamveer, Samsher.** Comparative analyses energy matrices and enviro-economics for active and passive solar still. materialstoday:proceedings. 2020.https://doi.org/10.1016/j.matpr.2020.10.001.