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Review on Condenser Heat Transfer of Computational Fluid-Dynamic System Using ANSYS

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***Abstract* – Condenser is a high pressure side heat exchanger in which heated vapor enters and gets converted into liquid form by condensation process. In the condenser coil, gaseous substance is condensed into liquid by transferring latent heat content present in it to the surrounding. In the whole process, mode of heat transfer is conduction in condenser coil and forced convection between refrigerant and condenser. Any refrigeration system's backbone is comprised of condensers. It aids in the transfer of heat from the refrigerant to the universal sink, which is the atmosphere. The latent heat of the refrigerant is lost in the condenser. At the entry of the condenser, vapours from the compressor enter, and during the length of the condenser, the vapours are converted to liquid form, resulting in refrigerant in the form of saturated or even sub-cooled liquid form at the condenser's exit. In several sectors of chemical and petroleum engineering, computational fluid dynamics (CFD) is a common tool for simulating flow systems. As a branch of fluid mechanics, computational fluid dynamics (CFD) is an appropriate tool for investigating and modelling the ANSYS Program. The applicability of CFD studies for simulating the ANSYS Program was reviewed in this work. Ansys CFD is one of the industry's most powerful simulation packages.**

***Keywords*—Condenser Heat Transfer, Refrigerant, Computational Fluid-Dynamic, ANSYS Programme.**

I. INTRODUCTION

A condenser is a heat transmission equipment used in a liquid condition to chill a gaseous component. As a consequence, the material discharges its latent heat to the condenser coolant. Condensers come in many different shapes and sizes, from small handheld units to enormous industrial devices used in plant processes. They include heat exchangers. For instance, a refrigerator uses a condenser to transmit heat from inside to outside the unit. Condensers are used for air conditioners and for industrial chemical processes. Examples include distillation, steam plants and other heat transfer systems. Cooling water or ambient air is employed as a refrigerant in many condensers. The principal purpose of a condenser is that steam from a steam motor or turbine is collected and condensed. The benefit is to make proper use of the energy that would otherwise be wasted.

A steam condenser drops the vapour pressure to below the pressure of the atmosphere. This allows for additional jobs by the turbine or engine. The vapour is also transformed into feed water and is subsequently transported by the condenser to the steam generator or boiler. The latent condensation heat is transmitted through the cooling tubes in the condenser to the coolant fluid. [1].

II. OVERVIEW OF CONDENSER

Condenser as the name suggests is used to condense vapours coming from compressors. The condensers are used for both domestic and commercial refrigeration as well as air conditioning units. The design of condenser resembles that of car radiator. The condensation (gaseous to liquid state) of refrigerants in condenser is achieved by cooling the refrigerants. During the process of condensation, the latent heat is dissipated to coolant used in condenser. Any refrigeration system's backbone is comprised of condensers. It aids in the transfer of heat from the refrigerant to the universal sink, which is the atmosphere. The latent heat of the refrigerant is lost in the condenser.

These condensers are used in distillation process employed in industrial chemical process and heat exchanger process. The majority of condensers use the surrounding air's cooling water as a coolant.

Figure 1: Condensers of refrigerators

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A refrigerant (also known as coolant) is an integral part of refrigeration and air conditioning units. A Refrigerant changes its state from liquid to vapour state and vice versa at appropriate temperature for the refrigeration cycle. The refrigerant then moves to the outdoor unit, where the heat is pushed outside once it has absorbed it. Once the heat has been released outside, the refrigerant reverts to a gaseous condition and returns within to restart the cycle.

Salient Features of Condensers

The salient features of condensers are as follows:

- The refrigerant under go to the phase change in condensers or evaporators.
- The heat from refrigerant is rejected to a heat sink as the refrigerant vapour condenses.
- In evaporator, the liquid evaporates refrigerant by heat extract from an external fluid (heat source of low temperature).

A. Thermodynamic analysis of system

- The circulating refrigerant enters the compressor in a state ['p'] at position (1) in the diagram.
- The coolant is isentropically compressed (i.e., compressed at constant entropy) and exits the compressor from point (1) to point in a superheated condition (2).
- The de-superheating method (2)-(3)' is a de-superheating procedure.
- The condensation process is Process (3)'-(3).
- Processes (3)-(4) are reasonable subcooling processes in which the refrigerant lowers the temperature.
- Process (4)-(5) is an isenthalpic flash adiabatic evaporation process.

B. Analysis Of Condensers

The analysis of condenser is done using heat rejection value i.e. Q_c The total rejection of heat in the condenser, Q_c is given by $Q_c = m(h_2 - h_4) = m_{ext}C_{p,ext} (T_{ext,0} - T_{ext,i})$
Where

- m is the refrigerant's mass flow rate;
- h2, h4 are the refrigerant's inlet and exit enthalpies
- mext represents the external fluid's mass flow rate.
- The external average fluid of heat is denoted by Cp, ext.
- The temperatures of the external fluid's entrance and exit are Text,o and Text,i.
- The overall heat transfer coefficient is U.
- A represents the condenser's heat transfer surface.
- Tm represents the average temperature differential between the refrigerant and the external fluid. The heat rejection ratio of a condenser can be calculated as follows:

$$HRR = \frac{Q_c}{Qe} = \frac{Q_e + w_c}{Q_e} = 1 + \frac{w_c}{Q_e}$$

For a steady condenser temperature, the COP decreases as the evaporator temperature decreases, and the heat refusal ratio rises. As condenser temperatures rise, the COP decreases and the heat rejection ratio rises at a constant evaporator temperature.

III. Concept Of The Computational Fluid-Dynamic

CFD has been an invaluable tool in the research of industrial combustion systems. CFD simulations solve all volumes of interest (pressure, speed, temperature, etc.) rather than simply at a few tested locations like an experimental device. In addition to this, CFD may imitate full-scale equipment, whereas pilot or laboratory-scale modelling testing can be carried out only [39]. This is used to check that the heater functions well with a given burner and brûler combination.

CFD is an approach for finding a discrete solution to real-world fluid flow problems that involves achieving a discrete solution at a finites collections of space point & at discreted time level.The process is as figure 2.

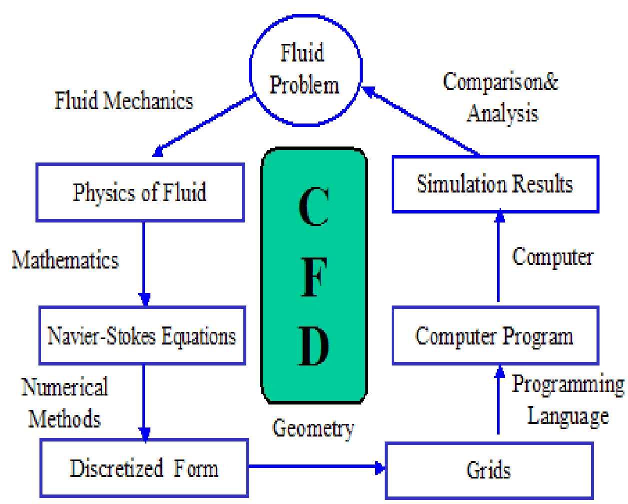

Figure 2: Process of Computational Fluid Dynamics

Firstly, we have a fluid issue to deal with. To resolve this issue, the physical characteristics of fluid mechanisms must first be understood. In order to reflect these physical properties we can then utilise numerical terms.

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This is the CFD administration and the Navier-Stokes Equation. Since the Equation for Navier-Stokes is explainable, anyone can understand it and describe it on paper. But if this condition needs to be understood using a PC, we need to transform it into a discrete structure. Numerical discretization systems such as finite difference, finites and finite volumes are the interpreters. In consequence we must divide the whole problem area into multiple little parts because we depend on them for discretion. We can build projects to deal with them at that point. Fortran and C are the most common dialects. Typically, projects are running on desktops or on supercomputers. We will finish by having our findings on reintroduction. The results, tests and underlying problem can be compared and compared. If the findings are not enoughfor problem solving, the approach has to be repeated until the solution is satisfactory. This is the CFD process.

A. Importances of the ComputationFluid,s Dynamic

The study of fluid has three methods: theory analysis, experimentation and simulation (CFD). In comparison to experiments CFD is a novel way of doing so.

Table 1 Comparisons of Simulation & Experiment

	Simulation (CFD)	Experiment
Cost	Cheap	Expensive
Time	Short	Long
Scale	Any	Small/Middle
Information	All	Measured Point
Repeatable	Yes	Some
Safety	Yes	Some Dangerous

B. Application of CFD

Because CFD offers so many advantages it is already widely utilised in the aerospace, motor vehicle, biomedical, chemical processing, hydraulic, electric generating, sports and shipping industry etc.

C. Grids

Frameworks are classified into three types: organised networks, unstructured lattices, and square organised matrices. The ordered lattice is the simplest (fig 3). In this type of matrix, each hub has a same amount of components surrounding it. We can effectively represent and store them. This type of network, on the other hand, is only for the basic space.

If we have an unpredictably shaped area, we can use an unstructured matrix. Figure 4, for example, is an air foil. The structure of an airfoil is exceedingly complicated. The stream near the item is significant and intricate; we require a good matrix in this district. The stream is equivalently basic far away from the airfoil, thus we can use a coarse matrix. In general for all geometries, unstructured lattice applies. It's quite famous in CFD. The downside of this is that it is becoming increasingly hard to express and retain the information structure as it is incessant. The network of square structures is a compromise between organised and unstructured matrices. The aim is to split the space in a few places right away and then utilise different frameworks in different parts.

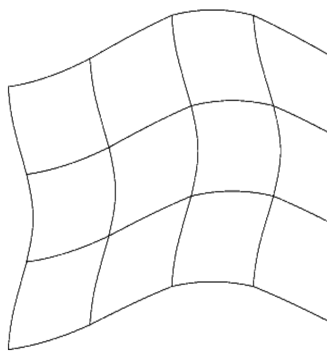

Figure 3: Structured Grids

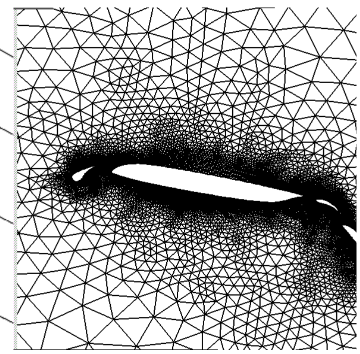

Figure 4: Unstructured Grids

IV. ANSYS SYSTEM

The ANSYS programme is a large-scale finite element multifunctional tool that may be used to tackle various technical problems. Continuing state and transient issues, mode recurrence and sealing of self-esteem, statics or time varying attractive exams and different sorts of field and combined field applications are included in ANSYS's testing skills. This Program contains a range of special features, for example pliability, huge strain, hyperversatility, creeping, growth, huge transfers, contacts, stress, solidifying, temperature reliability, material anisotropy and radiation, that allow for non-linearities or auxiliary effects to be incorporated into the scheme. The curriculum, in the way it was built, has also included other outstanding capacities, like sub-order, sub-showing, irregular vibrations, kineto-statutory techniques, kinetodynamics, free liquid-convection testing, sound, appealing piezo electrics. These features lead to ANSYS's status as a multipurpose examination tool for several construction disciplines.

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Examination of any issue in ANSYS needs to experience three principle steps. They are

- Preprocessor
- Solution
- Postprocessor

A. Analysis

The various analyses that can support by ANSYS are

- Static
- Modal
- Harmonic
- Transient
- Spectrum
- Eigen buckling
- Sub structuring

V. Literature Review

D. A.Luhrs and W.E.Dunn [2] Presents Microcontroller Tube Experimental Facilities Design and Construction. A testing centre has been set up to carry out warmth tests on heat exchangers in the microchip. The inspections will cover the accumulation of coolant 134a in the upgraded cylinders, although no results of accumulation in this archive are provided. With a representation of all elements and their capability in the stand the structure and design of the trial office is definitive. The office's activities have been assessed using a vitality balance study and the results are presented. The temperature of the coolant and the air side is ±3% within the high wind rate, however this bug is dropped at lower rates. Similarly, along with the hypothesis for future link enhancement, a discussion on the approach for determining refrigerant and air protection for the cylinder is presented. At long last, future alterations to the stand are proposed so as to address any issues with it, improving the capacity of the remain to deliver precise, dependable warmth move execution information.

Clark et al. [3] completed 18 ft3domestic fridge experimental. The condenser was cooled with water and the air condenser was cooled in the usual air. The results of this examination are as follows: I the cooling water temperature increases to 350C for 100 hours, (ii) the investment funds for heated water 18%, 20% and (iii) the refrigerant execution is not weakened.

Yilmaz [4] did experimentation on cool-unit. For warmth recovery, heat exchanger type concentrate cylinder was used. He noticed that the cooling unit's capability is increased when entering the water temperature which does not perfectly include the air temperature.

Stinson et al. [5] research on milk cooling by recovering condenser warmth. They found that the use of the COP condenser water-cooled in the framework was increased by 10% to 18%. They also observed that condenser weight expansion reduces COP, and the addition of a warmth heat exchanger decreases head misery.

Alex et al. [6] arranged an explanatory model of a private desuperheater. They found that the consequences of scientific model and aftereffects of exploratory arrangement change inside 12%.

Rane et al. [7] created reasonable warmth recuperation unit and did tests. The recouped waste heat is used for the warming of water. Its findings are as follows: I a 30 per cent increase in the chill cooling limit and COP 20 per cent; (ii) announced HSD 81 litres per day fuel savings; Rs 10 lakh/year reserve annual reserve funds; (iii) 450 tonne CO2 emission decreasing within four years; and (iv) a 3 to half year basic compensation.

J. Khedari et al. [8] explores the presentation of another half breed residential high temp water framework that joins sun based vitality with waste warmth from a thermoelectric (TE) climate control system. Thirty TE modules Models TEC1-12704 (modular specification: 40 = 40 mm, maximum operational tension, current: 13,5 VDC, 4,4 amps) were used in this respect. For the authority/piling tank a limit of 120 litres has been specified. The volume of test space for cooling was 2.5 m3. The tests were conducted with the heat transmitters 10, 15 l/min and 2,5 m/s, by adjoining theroelectric voltage (50 VDC, 100 VDC, 150 VDC) and water mass flow rate and air velocity. This frame has been tested to warm 120 litres to 50°C within 2 hours. The cooling limit was 176 watts. The cooling limit was reduced as a result of the tank's water temperature expansion, and the TE water / strong heat exchange rounded it down. The optimal settings for the high-temperature generation and cooling also include 100 VDC, a water stream of 15 l/min and a speed of 2.5 m/s under structural considerations used to carry out this exam. The comparing most astounding coefficient of execution of the half and half framework is about 3.12.

Jie Ji et al.[9] The innovation for 50 years has been the use of a warm syphon for room moulding and high-temperature residential warming in living environments. Previous syphons from air to water warmth and hot water syphons have had such shortcomings as a surprise, unreliable activity and firm applications. They were not too much in the market for customer attraction. This work adds a new cooling element that improves the execution of vitality, which can reach numerous skills.

Important plan standards are being introduced as well as laboratory test findings. Results reveal a huge boost in vitality by adding a water radiator to the outside unit of the forced air system, which may cool areas and heat water.

S. C. Walawade [10] vitality sparing is one of the important issues from view purpose of fuel utilization and for the insurance of worldwide condition. So it is essential that a critical and solid exertion ought to be made for moderating vitality through waste warmth recuperation as well. The fundamental goal of this paper is to think about "Squander Heat recuperation framework for household cooler". An effort was made to utilise waste warmth from the refrigerator condenser. This warmth can be used in many households and for current applications. This framework is very helpful for local reasons in the least constructive, maintenance and operating costs. It is an optional approach to increase efficiency in general and to reuse waste warmth. The review showed that such a framework is actually viable and financially reasonable.

Y.A.Patil and H.M.Dange [11] fridge has turned into a fundamental product instead of extravagance thing. The heat used in cooled rooms and the blower added to the coolant, through a condenser, are overly rejected. It's our goal to recover waste warmth from a family fridge's condenser unit to boost the frame display. Thermo syphon is the warmth of recovery from the familial fridge. From experiments it was found that its presentation improves over conventional cold in the aftermath of the heat recovered from the condenser of the usual cooler. The maximum temperature is 45oC with total stress in tanks with 100 litres of water. The tub is heated to a temperature of 45°C in 5 to 6 hours if the tub contains 50 litres of water.The framework will be diminished after this presentation. Therefore this boiling water needs normal use.

VI. CONCLUSION

The modern era is the period of science and technology, and things are changing at a breakneck speed. Things have progressed thanks to modern technologies. It has made things easier for people and provided them with a sense of security. The condenser is a device that transfers heat. It's used to take the heat out of a heated refrigerant vapour. The condenser converts vapour to liquid via some form of cooling.The condenser is an essential component of the refrigeration system of domestic refrigerator. The purpose of the condenser is to remove heat from the refrigeration cycle and dissipate that heat into the atmosphere.

To serve that purpose very efficiently and effectively, the fins are used over the condenser. The primary goal of fins is to improve the condenser's heat transfer surface area and thus the heat transfer rate. The use of simulation techniques such as computational fluid dynamics approaches has become possible for researchers due to advancements in computer equipment. The expenses and risks associated with experimental investigations are reduced when these methods are used.

REFERENCES

[1] Manish Baweja," A Review on Performance Analysis of Air-Cooled Condenser under Various Atmospheric Conditions", International Journal of Modern Engineering Research (IJMER), Vol.3, Issue.1, Jan-Feb. 2013 pp-411-414

[2] D. A. Luhrs anD W. E. Dunn, Design anDConsTrucTion of a Microchannel ConDenser Tube ExperimenTalFaciliTy. Air ConDiTioninganDRefrigeraTionCenTerUniversiTy of Illinois Mechanical &InDusTrial Engineering DepT., ACRC TR – 65, July 1994

[3] RoberT A. Clark, RicharD N. SmiTh, anD Michael K. Jensen, "An experimenTalsTuDy of wasTeheaT Recovery From a resiDenTialrefrigeraTor", 0-7803-3547-3-711 6 $4.00 0 1996 IEEE

[4] Dr. Emin Yilmaz, "Air conDiTioningwasTeheaT To DomesTichoTwaTer – a sTuDy Design reporT", ProceeDings of IMECE 2007, ASME InTernaTional Mechanical Engineering Congress anDExposiTion, November 10-15, SeaTTle, WashingTon, USA

[5] G. E. STinson, C. J. STuman, D. J. WarburTon, " A Dairy refrigeraTionheaT recovery uniTanDiTseffecTs on refrigeraTionoperaTion" , J. agric. Engng Res. (1987) 36, 275-285

[6] Alex H. W. Lee anD J. W. Jones, "AnalyTicalMoDel of a ResiDenTial De-superheaTer", ApplieD Energy vol. 57, No. 4, pp271-185, 1997.

[7] MilinD V. Rane, MaDhukar S. TanDale, "BenefiTs of superheaT recovery on chillers case sTuDy for a hoTelinsTallaTion", InTernaTional Congress of RefrigeraTion 2003, WashingTon, D.C

[8] J. KheDari, S. Maneewan, N. PraTinThong, W. Chimchavee& Dr. J. Hirunlabh, " DomesTichoTwaTersysTem combining solar anDwasTeheaT from ThermoelecTric air-conDiTioner", InTernaTional Journal of AmbienT Energy, Volume 22, Issue 1,2001.

[9] Jie Ji, Tin-Tai Chow, Gang Pei, Jun Dong, Wei He," DomesTicairconDiTioneranDinTegraTeDwaTerheaTer for subTropicalclimaTe", ApplieD Thermal Engineering Vol. 23, p. no. 581–592, 2003.

[10] S. C. WalawaDe, B. R. Barve, P. R. Kulkarni," Design anDDevelopmenT ofWasTeHeaT Recovery SysTem for DomesTicRefrigeraTor" IOSR Journal of Mechanical anD Civil Engineering, PP: 28-32, 2012.

[11] Y. A. PaTil1, H. M. Dange2," Improving The Performance of HouseholDRefrigeraTor by Recovering HeaT from The ConDenser", InTernaTional Journal of Science anD Research, Volume 2 Issue 6, June