A

Project Report On

"Experimental Analysis of Heat Pump using LabVIEW Simulation Software"

Submitted in partial fulfillment of Bachelor of Engineering - Mechanical Engineering, by Savitribai Phule Pune University

Submitted to

Savitribai Phule Pune University

By

Mr. Malve Utkarsh Narendra

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Mr. Sonawane Ankit Ramesh

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Under the guidance of

Prof. S. J. Suryawanshi

NBA & NAAC "A^{++}" ACCREDITED INSTITUTE

Department of Mechanical Engineering

Maratha Vidya Prasarak Samaj's Karmaveer Adv. Baburao Ganpatrao Thakare College of Engineering, Nashik- 422013

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C E R T I F I C A T E

This is to certify that ***Mr. Malve Utkarsh Narendra, Mr. Patil Gaurav Vijay, Mr. Sonawane Ankit Ramesh, Mr. Shende Rajatkumar Shyam,*** have successfully completed the Project Stage – II entitled "***Experimental Analysis of Heat Pump using LabVIEW Simulation Software***" under my supervision, in the partial fulfillment of Bachelor of Engineering - Mechanical Engineering of Savitribai Phule Pune University, Pune.

Date:
Place: Nashik

Prof. S. J. Suryawanshi Guide	**Internal Examiner**
Dr. A. B. Kakade Head of the Department	**Dr. S. R. Devane** Principal

External Examiner

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Heat pumps (HP) are well-known technology which provides heating and cooling in a friendly manner. It is a very efficient device for the purpose of providing thermal energy for residential buildings. A heat pump maybe air to air or air to water type depending upon the application. The heat pump used in this study is air to water type. The aim of this study is to investigate about heat pump control concepts, algorithm, system optimization, and heat storage to provide more freedom for HP applications. The main purpose of this work is the evaluate COP of heat pump experimentally using LabVIEW Simulation Software from Human Machine Interface. A heat pump (HP) system was installed and tested at his KBT Engineering Faculty HVAC&R lab, NDMVPS, Nashik, Maharashtra, India. Experimental test results are presented and described here. The HP system's coefficient of performance (COP sys) is determined from measured data. It is found that the actual COP determined with the help of experimental analysis is less than the theoretical COP of heat pump. The detailed step by step process for the determination of COP using LabVIEW Simulation software in the experimental analysis is explained in detail in this project work.

Sources

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*It gives us great pleasure in presenting the project stage-I report on "***Experimental analysis of Heat Pump Using LabVIEW Simulation Software***".*

We would like to take this opportunity to thank our internal guide ***Prof. S. J. Suryawanshi Sir*** *for giving us all the help and guidance we needed. We are really grateful to him for his kind support. His valuable suggestions were very helpful.*

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Mr. Malve Utkarsh Narendra

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(B.E. Mechanical Engineering)

ABSTRACT

Heat pumps (HP) are well-known technology which provides heating and cooling in a friendly manner. It is a very efficient device for the purpose of providing thermal energy for residential buildings. A heat pump maybe air to air or air to water type depending upon the application. The heat pump used in this study is air to water type. The aim of this study is to investigate about heat pump control concepts, algorithm, system optimization, and heat storage to provide more freedom for HP applications.

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It is found that the actual COP determined with the help of experimental analysis is less than the theoretical COP of heat pump. The detailed step by step process for the determination of COP using LabVIEW Simulation software in the experimental analysis is explained in detail in this project work.

International Societies & Abbreviations

ASHRAE→ American Society Of Refrigeration Air Conditioning Engineers
ISHRAE→ Indian Society of Heating Refrigeration Air Conditioning Engineers
ASTM→ American Society For Testing Of Materials
IAQ→ Indoor Air Quality
GSHP→ Ground Source Heat Pump
ASHP→ Air Source Heat Pump
AC→ Air conditioning
ACH →Air handling unit
BTU→ British thermal unit
CFM→ Cubic feet per minute
COP→ Coefficient of Performance
Cp→ Specific Heat of Water
DB→ Dry bulb
DP→ Dew point
FCU→ Fan coil unit
FPM→ Feet per minute
GPM→ Gallons per minute
HMI→ Human Machine Interface
HVAC&R→ Heating, Ventilation, Air Conditioning and Refrigeration
HPWH→ Heat Pump Water Heater
IEA→ International Energy Agency
LAT→ Leaving air temperature
MCB→ Miniature Circuit Breaker
LabVIEW→ Laboratory Virtual Instrumentation Engineering Workbench
EAT→ Entering air temperature
OA→ Outside air
OS X→ Operating Software
SA→ Supply air
VAV → Variable air volume
VD →Volume damper
WB→ Wet bulb

List of Figures

List of Tables

Certifications of Members:

ISHRAE

ISHRAE

(INDIAN SOCIETY OF HEATING REFRIGERATING & AIR CONDITIONING ENGINEERS)

Student Membership Certificate

This is to certify that

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of

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has been granted the grade of

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Table of Contents

Chapter: 1

1. Introduction

1.1 HVAC System:

H-Heating

V-ventilation

AC-Air conditioning

Heating – Designing the system in cold climate is known as Heating.

Heat - It is a form of energy that can be transfer from high body temperature to low body temperature.

Ventilation – It is the fresh air penetrated from outside.

- The process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide.
- Ventilation removes unpleasant smells and excessive moisture, introduces outside air, and keeps interior building air circulating.

Introduction to Heat Pump:

Heating accounts for the majority of energy consumption in the world's coldest countries. Due to the scarcity of fossil fuels, efforts are being made to find alternative energy sources. Heat pumps have been proposed as the answer to reduce energy consumption used in energy recovery systems and used to upgrade low grade energy in the area neighborhood.

A heat pump is basically a refrigeration unit that can extract heat from any low-level heat source. It heats the temperature of air, oceans, ground, etc. and improves the heat to a useful temperature. Heat pump is widely used in many industrial applications. The refrigerant circuit is only used for heating purposes when the ambient temperature is the required temperature.

Definition:

A heat pump is a device that provides heat energy from a source of heat to a destination called a "heat sink". Heat pumps are designed to move thermal energy opposite to the direction of spontaneous heat flow by absorbing heat from a cold space and releasing it to a warmer one. A heat pump uses some amount of external power to accomplish the work of transferring energy from the heat source to the heat sink. While air conditioners and freezers are familiar examples of heat pumps, the term "heat pump" is more general and applies to many HVAC devices used for space heating or space cooling.

Using a heat pump for heating it uses the same basic refrigeration circuit as air conditioners and refrigerators, Opposite direction - heat release to air-conditioned space instead of ambient neighborhood. In this application, heat pumps typically extract cooler outside air or floor. In heating mode, the heat pump is 3-4 times more efficient in power usage. It performs better than simple electric resistance heaters.

1.2 Problem statement:

In this project, the heat pump is analyzed by its various parameters, so that we can evaluate the coefficient of performance. For this we perform a test on the heat pump test equipment and with the observations we do the various calculations so that all efficiency factors are achieved.

1.3 Objectives of work:

- Optimization of heat pump systems
- Identify design or operational issues
- Validation of Numerical Models
- Optimization of heat pump systems

1.4 Scope:

A heat pump water heater does not create heat but instead uses electricity to absorb heat from the air to transfer it to the water. As it relies on this mechanism, it makes it 2-3 times more energy efficient than traditional water heaters. This also allows you to save up to 70% on electricity. What's an even more interesting is that heat pump water geyser have a tank capacity that is similar to traditional storage geysers so there is no compromise on the amount of hot water.

1.5 Methodology:

For this project first we studied basics of HVAC system and all small things required to examine a Heat pump system. We have also gone through various impacts of the HVAC industry on environment such as global warming, greenhouse effect, ozone layer depletion and many more. After that we decided to examine a Heat Pump test rig which is eco-friendly. For that we have gone through various research papers and analyzed them.

Methodology for this project involve below steps;

- **Chapter 1** includes, Introduction of heat pump system, Problem statement, Objectives of work, Scope of the work.
- **Chapter 2** includes, literature review, summary of various research papers that is further used in this report.
- **Chapter 3** includes Heat pump and its Components, Heat pump circuit, advantages, disadvantages and applications.
- **Chapter 4** includes, Experimental Analysis of Heat pump using LabView Simulation Software, Experimental setup, Software details, Technical specifications, Step By step procedure, Observations, Observation table and Calculations, Actual COP of heat pump And Theoretical COP of system.
- **Chapter 5** includes result and discussion.
- **Chapter 6** includes Conclusion of the work.

Chapter: 2

2. LITERATURE REVIEW :

Nasratullah Mohseni [1] has studied heat pump supplying thermal energy to residential buildings. A heat pump receives heat from a heat source such as air, water or ground and heats/cools it by heating or condensing it. The purpose of this study is to explore heat pump control concepts, algorithms, system optimization and heat storage to provide more freedom for HP applications.

Dr. Jeoju M. Issac [2] has studied that heat pump assist dryers are one of the most efficient ways to save energy. It is widely used in many industries due to its ability to dry large quantities of products. This study describes the design of a heat pump assisted dryer. Drying kinetics of green peas were studied using fluid bed dryers with different configurations. Performance of all systems was evaluated and compared in terms of energy consumption, drying time and MER. The effect of temperature on drying parameters was analyzed for each configuration. Experimental results show that using heat pumps in the drying process of Greenpeace is beneficial mainly in terms of energy consumption, drying time and MER.

D.Carbonell [3] has studied that heat pumps are becoming an important technology in the renewable energy field. Studies of capabilities And limitations of existing models in order to choose appropriately which models to use for specific situations is considered to be of importance. Validation and analysis of an equation-fit and a refrigerant cycle based models for a brine to water heat pump in heating mode is provided in this paper. A very important feature that the models must full fill is that the necessary inputs are to be estimated only from Catalogue data typically provided by manufacturers.

Mustafa Inalli [4] have studied in his research that the evaluation of heat pump systems using the ground as the heat source. A ground source heat pump (GCHP) system was installed and tested in a test room at Firat University in Elazig, Turkey.

Results obtained during experimental testing are presented and described here. Coefficient of Performance (COP of system) determined from the measured data of the GCHP system. A numerical model of heat transfer in the ground was developed to determine the temperature distribution near the pipe. Finite difference approximations used for numerical analysis. It is observed that the numerical results agree with theexperimental results.

Kayla Lewry [5] has studied that due to environmental concerns about traditional refrigerants, carbon dioxide (CO2) are being considered as replacement refrigerants for HPWH. In this study, commercial trans critical CO2 HPWH was evaluated numerically and experimentally. This included developing a CO model2 HPWH and calibration with experimental data. This model was theoretically validated and used to predict compressor cycle pressure and isentropic efficiency. Although the predicted supply pressure was within the expected range, the large bias indicates that further work is needed to improve the accuracy of the model. A control system study also found that the water outlet temperature controls the water pump, the ambient temperature controls the compressor and evaporator fans, and the expansion valve controls the high side pressure. Finally, the performance data show that the HPWH performs best at ambient temperatures above 0°C and water inlet temperatures below 30°C.

Tina Fawcett [6] has concluded that the future role of heat pumps links demand and supply side issues. The benefits of heat pumps vary between countries, regions, individual households and also over time. This makes a policy promoting heat pumps different, and more complex, than policy supporting energy efficiency, which offers universal benefits. Heat pumps cannot lead us towards a lower carbon future. They can only be a following technology when other major energy and housing system changes have already been accomplished.

Chapter: 3

3. Heat Pump and its Circuit:

3.1 Heat Pump:

Heat pumps offer an energy efficient alternative to stoves and air conditioners in all climates like a refrigerator, a heat pump uses electricity to move heat from a cooler room to a warmer one, making a cooler room cooler and a warmer room warmer. During the heating season, heat pumps transfer heat from the cold outside to your warm home. During the cold season, heat pumps carry the heat of your home outside. Heat pumps effectively keep your home at a comfortable temperature by transferring heat instead of generating heat.

Thermal energy naturally moves from a warm place to a cold place. However, a heat pump can reverse this process, taking heat from a cold room and transferring it to a warm room. Heat is not conserved in this process and some external energy is required. In heating, ventilation, and air conditioning (HVAC) systems, the term heat pump usually refers to vapor compression refrigeration equipment optimized for high efficiency in both directions of heat energy transfer. These heat pumps are reversible and work in both directions to heat or cool the interior space. Heat pumps are used to transfer heat because less high quality energy is required than is released as heat. Most of the energy for heating comes from the outside environment, and only a small part comes from electricity (or other high-value energy sources needed to power the compressor). With an electric heat pump, the heat transferred is 3 or 4 times higher than the power consumed, and the system coefficient of performance (COP) is 3 or 4 times higher than the COP of 1 for traditional electric resistance heaters, where total heat is generated from supplied electrical energy.

Reversible heat pumps work in both directions to heat or cool the interior. A reverse valve is used to reverse the flow of refrigerant from the compressor through the condenser and evaporator coils.

In heating mode, the outdoor coil is the evaporator and the indoor coil is the condenser. The refrigerant exiting the evaporator (outer heat exchanger) carries heat energy inside from the outside air (or ground, or even flowing water). As the steam is compressed in the pump, the temperature rises. The indoor coil then transfers thermal energy (including energy from the compression) to the indoor air, which is then moved around the inside of the building by an air handler.

Alternatively, thermal energy is transferred to water, which is then used to heat the building via radiators or under floor heating. The heated water may also be used for domestic hot water consumption. The refrigerant is then allowed to expand, and hence cool, and absorb heat from the outdoor temperature in the outside evaporator, and the cycle repeats. This is a standard refrigeration cycle, save that the “cold” side of the Refrigerator (the evaporator coil) is positioned so it is outdoors where the environment is colder. During cold weather, the outdoor unit of an air source heat pump must be defrosted temporarily. This activates an auxiliary or emergency heating element (in the air handler). At the same time, the frost on the outdoor unit's register is quickly melted by the warm refrigerant. The condenser/evaporator fan will not operate during defrost mode.

In cooling mode the circuit is similar, but the outdoor coil becomes the condenser and the indoor coil (reaching low temperatures) becomes the evaporator. This is the well-known mode in which the air conditioner operates.

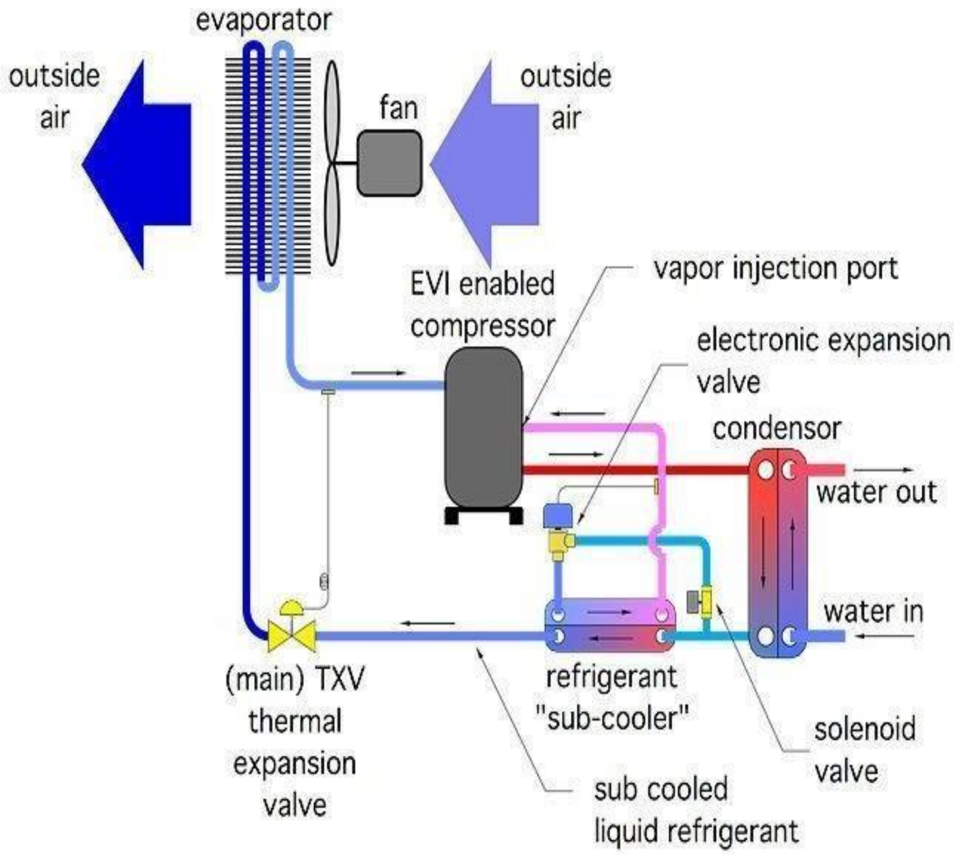


Fig. 3.1.1: HEAT PUMP

Heat pumps use a refrigerant as an intermediate liquid to absorb heat where it vaporizes in the evaporator and release heat where it condenses in the condenser. Refrigerant flows through an insulated tube between the evaporator and condenser, allowing efficient heat energy transfer over relatively long distances.

A heat pump is part of your heating and cooling system and is installed outside your home. Like an air conditioner like the Central Air, it can cool your home, but it can also provide heat. During the cold season, the heat pump extracts heat from the cold outside air and moves it indoors, and during the warm season, it extracts heat from the indoor air to cool the home. It is electrically operated and uses a refrigerant to transfer heat for year-round comfort. It provides both cooling and heating, so home owners may not need to install a separate system to heat their home.

3.2 Important Components of A Heat Pump System:

A heat pump consists of five main components: Compressor, condenser, expansion valve, evaporator and refrigerant. In refrigerators and air conditioners, the evaporator is responsible for cooling or freezing, while in heat pumps the condenser is responsible for heating. The refrigerant is the working medium for heating or cooling.

Compressor

An important part of the heat pump is the compressor. In the compressor, the refrigerant is compressed to a very high pressure and the temperature increases at the same time. When the refrigerant enters the compressor, it is in a low pressure and low temperature gas state and leaves the compressor in a high pressure and high temperature gas state.

Fig. 3.2.1: Compressor

Compressors can be divided into two types:

Reciprocating compressor and Rotary compressor:

A piston compressor, like a reciprocating engine, has a piston and a cylinder. A reciprocating engine uses fuel to generate electricity, while a reciprocating compressor uses electricity to provide compression. A reciprocating compressor can also be driven directly by a motor. Compression occurs as the piston moves back and forth in the cylinder. A rotary compressor has a rotating rotor that compresses a refrigerant within a closed chamber.

Electricity is required to operate the compressor. Rotary compressors consume less power than reciprocating compressors. Reciprocating compressors are noisier than rotary compressors. Also, reciprocating compressors require more maintenance than rotary compressors. Due to these factors, rotary compressors have rapidly replaced reciprocating compressors not only in heat pumps but also in air conditioning systems.

According to the second law of thermodynamics, heat flow occurs from a hot, hot source or reservoir to a cold, cold sink or reservoir. Heat must be transferred from the cold storage to the hot storage by external work. Heat pumps require an external power source because they move heat from the cold air to a hot space.

A heat pump requires electrical energy to operate a compressor supplied by external work. Compressors consume the most energy in heat pumps, refrigerators, freezers and air conditioning systems. This compressor performs the essential task of compressing the refrigerant to transfer heat from the cold storage tank to the hot storage tank.

Condenser

The next important component of the heat pump is the condenser. Heating is one of the functions of a heat pump, and condensers create this effect in a space. A refrigerator's main function is to cool a substance or material, and an evaporator produces this effect. The main component of a heat pump is the condenser, which produces heat, while the evaporator is the main component of a refrigerator, which produces cold air.

The air conditioner condenser is outside the room and is cooled, while the heat pump condenser is inside the room. As the refrigerant exits the compressor, it is at very high temperature and pressure. The refrigerant is then sent to the condenser. Capacitors usually consist of copper coils. Due to the high temperature of the refrigerant, the condenser coil also becomes very hot, generating heat in the room.

Fig.3.2.2: CONDENSER

A fan or blower behind the condenser coil forces air over the hot condenser coil. Heat is transferred to the air as it passes through the condenser coil, and the heated air is discharged into the room, heating it up. A fan draws in air while sending warm air into the room. The room is kept at a much higher temperature than the surrounding air. For the condenser coil he can use two types of fans.

The temperature of the condenser and the refrigerant it contains will drop as the air flows through it as it absorbs heat from the condenser. The refrigerant leaves the condenser in apart liquid, part gas state at high pressure and medium temperature. It then enters the expansion valve or capillary which plays a key role.

Expansion Valve

The expansion valve reduces pressure. The pressure and temperature of the high-pressure medium-temperature refrigerant that enters the expansion valve suddenly drops. Copper capillaries are the most common expansion valves in heat pumps. Expansion valves release refrigerant in a partially liquid and partially gaseous state at very low pressures and temperatures.

Fig.3.2.3: Expansion Valve

Evaporator

Air conditioners have their evaporators indoors, while heat pumps have their evaporators outdoors, exposed to the local atmosphere and very cold. Similar to a condenser, a copper spiral also forms an evaporator. By entering the evaporator coil at low pressure and temperature, the refrigerant significantly reduces the temperature of the coil to a level even below ambient temperature.

Fig.3.2.4: Evaporator

Due to the low temperature of the refrigerant in the evaporator, it tends to absorb heat from the environment. A blower or fan blows air onto the evaporator, releasing its heat to the refrigerant, which heats it up. The ability to absorb heat from the atmosphere increases the temperature of the refrigerant. But its pressure remains constant and becomes a gas.

Gaseous refrigerant is introduced into the compressor at low pressure and medium temperature. Compressors condense gaseous refrigerant to very high pressures and temperatures. The refrigerant is then fed to the heat pump condenser to heat the room air. So the cycle continues. In each cycle, the refrigerant continuously flows through a closed circuit, heating and cooling. Heat pumps and refrigerators use refrigerants that can change phases without causing a chemical change.

3.3 Heat Pump Circuit:

A heat pump is a refrigerant circuit that mainly uses a heat source such as air, sea or earth. The heat absorbed from this unusable heat source is fortified with the help of a compressor, and the heat-carrying fluid is discharged through the refrigeration system's condenser to the required point. The refrigerant come out of expansion valve absorb heat Q2 from atmosphere or low temperature reservoir(sink).

This absorbed heat by refrigerant is upgraded by addition the work through compressor and the total heat is dissipated in the room through condenser as shown below:

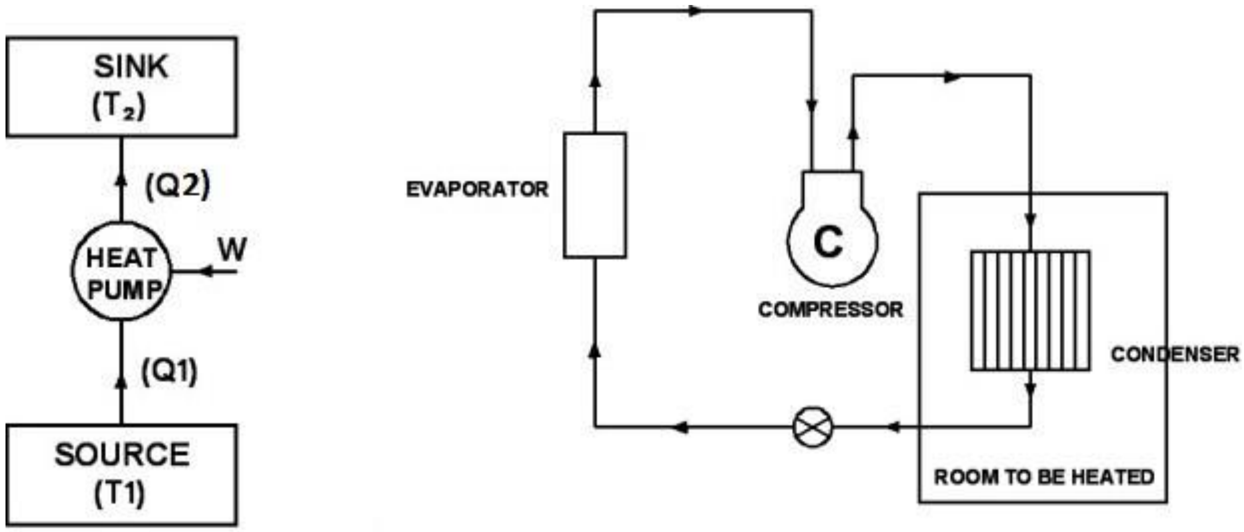


Fig. 3.3.1: Heat Pump Circuit

The performance of refrigeration cycle when used for heating purpose is given by ratio of heat delivered (desired effect) to work supplied.

C.O.P.Heat Pump = Desired Effect / Work done

Advantages of Heat pump

1. The system reduces carbon emissions and it has an efficient conversion rate of energy to heat.
2. Heat pump is pick up heat from air, water, west heat, geothermal heat for heating purpose
3. Simple in construction.

Disadvantages of Heat pump

1. Initial costs are higher than other water heaters or system.
2. Sizes of heat pump could be big.

Applications of Heat pump-

1. Heat pump issued for space heating.
2. Heat pump is used for water heating.
3. Heat pumps can be used for dehumidification applications, such as in swimming pools or other humid environments.
4. Heat pumps can be used in various industrial processes, such as in the chemical, food processing, and pharmaceutical industries.

Chapter: 4

4. Experimental analysis of heat pump using LabView

4.1 Experimental set-up:-

The equipment consists of a hermetically sealed compressor, water cooled condenser, drier -filter, expansion device, and forced convection air cooled evaporator. Hot vapors from the evaporator in the tank are sucked by the compressor, are compressed & sent to the heat rejection chamber. Liquid emerging out from the heat rejection chamber passes through the expansion device; it is throttled to low pressure & temperature & sent to evaporator where it boils. A drier filter is in the way to throttling device.

Separate pressure gauges are provided to measure heat absorption device & heat rejection device Pressures at various locations. Energy meter is provided to measure energy consumed by compressor. Digital temperature indicator displays temperatures at various locations as per the selection viz. temperature before & after compressor and before &after expansion.

Fig. 4.1.1: Heat Pump test rig

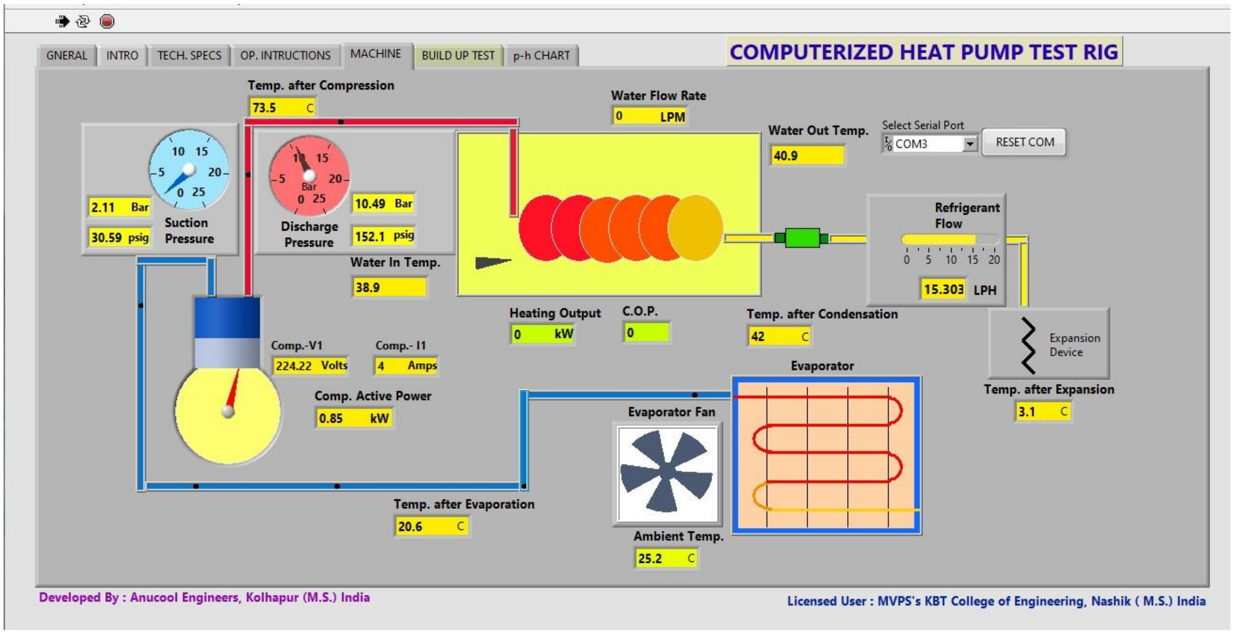


Fig.4.1.2: Schematic diagram of Computerized Heat Pump test Rig

4.2 LabView Simulation Software:-

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of Linux, and Mac OS X.

LabVIEW Control Design and Simulation Module:-

With LabVIEW Control Design and Simulation Module you can construct plant and control models using transfer function, or zero-pole-gain. Simulate linear, nonlinear, and discrete systems with a wide option of solvers. With the NI LabVIEW Control Design and Simulation Module, you can analyze open-loop model behavior, design closed-loop controllers, simulate online and offline systems, and conduct physical implementations.

4.3 Technical Specifications:

Heating Capacity In Kw	3.0kW@Rated test conditions *
Heating Capacity In Liters/Hr	100 Liters /hr
Max. Temperature Attained	55degC
Input Power In Kw	1.01kW
Compressor Make	Emerson Climate Technology Ltd.
Compressor Type	Reciprocating, Hermetically sealed
Refrigerant	R134a
Condenser	TUBE IN TUBE type, Co-axial condenser
Expansion Device	Capillary tube
Evaporator	Forced convection air cooled. Copper tubes, Al fins
Evaporator Fan	VBM/HICOOL make Axial flow
Temperature Control	SUBZER make-Automatic, digital
Hp Cut Out	Danfoss make Provided
Pressure Gauge	Wika make, Provided
Electrical Switchgear	Schnider make, MCB, Power contactor
Indications	Temperature in deg C, mains on
Fault Indications	HP fault. Low flow
Supply	230 V,50 Hz,1ph,AC
Construction	Sheet metal:1.2mmCRCA, Powder coat
Circulation Pump	Kirloskar /Crompton Make provided

Table no. 4.3.1: Technical Specifications

4.4 Experiment Procedure:

1. Maintain constant water supply in heat receiving tank as well as heat absorbing tank with the help of Rota-meter and valve provided.
2. Note down water temperature (Inlet water temperature) which is supplied to tank.
3. Start compressor.
4. Note down the starting time and initial energy meter reading.
5. Temperature of water in condenser tank is increases while temperature in heat absorption tank starts falling.
6. Within half an hour steady state will occur.
7. Note down the final energy meter reading.

Stepwise Procedure for LabView Simulation software :-

Step 1:- Start the Software Window. and switch on the circulating pump.

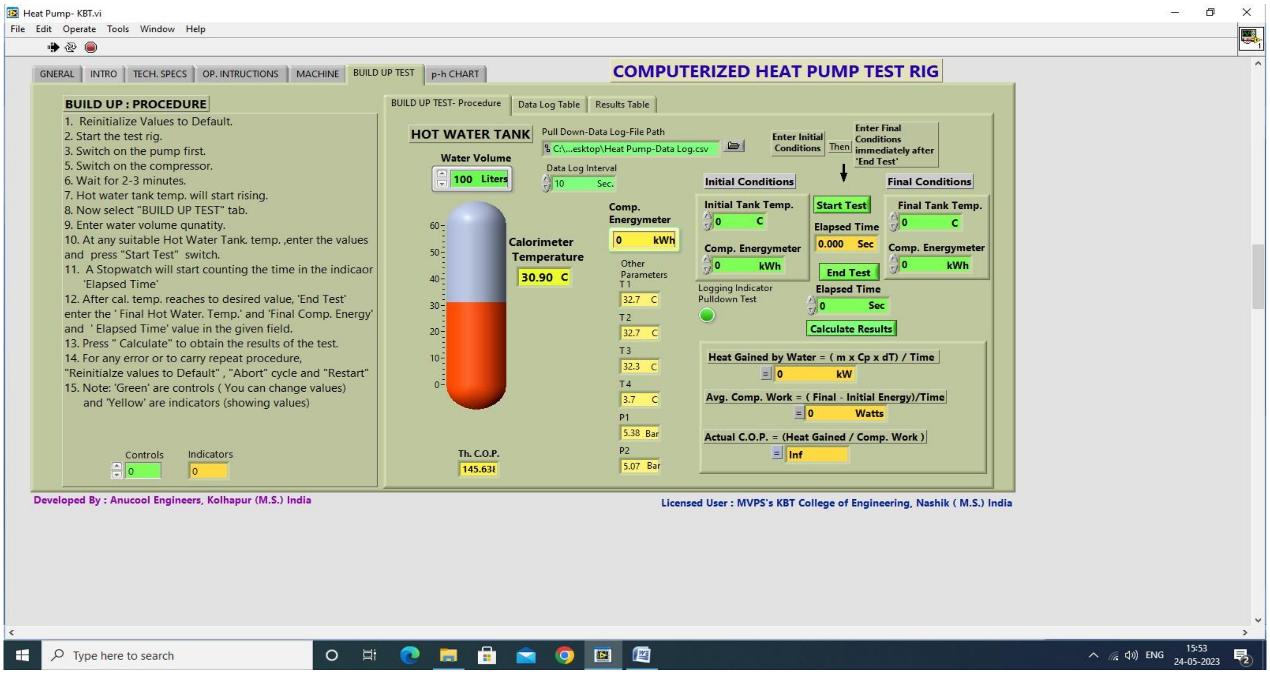


Fig.no. 4.4.1

Step 2:- Select the path for saving the data log and result file.

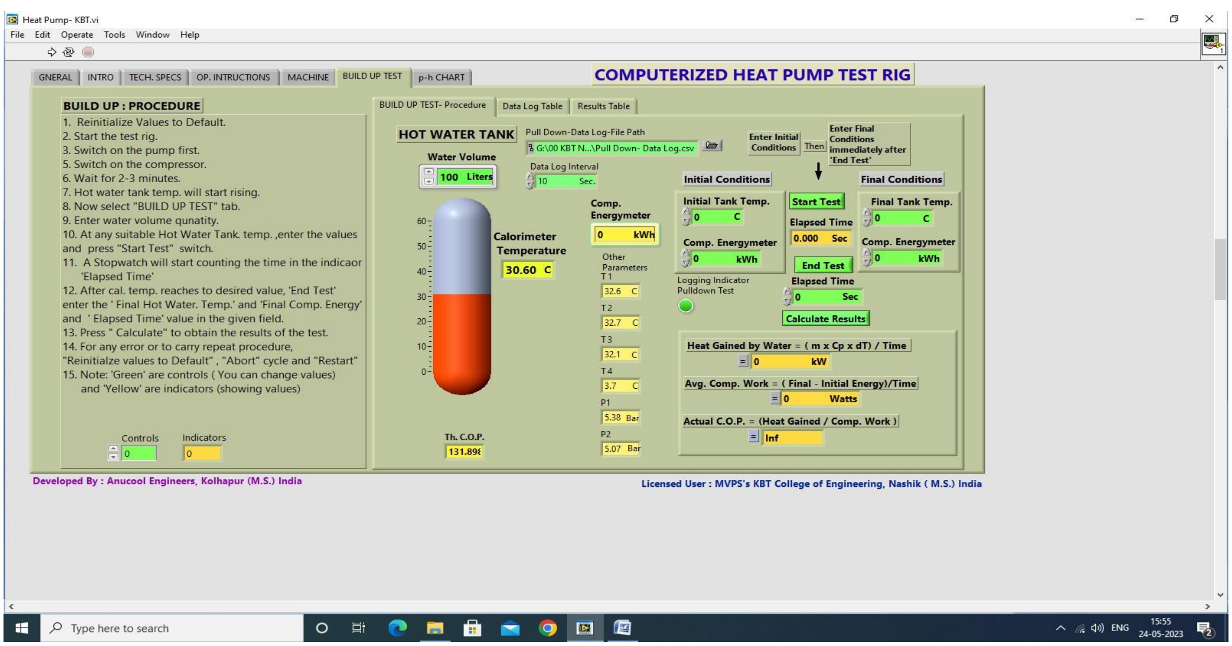


Fig.no. 4.4.1

Step 3:- Select the path for saving the result file.

Fig.no. 4.4.3

Step 4:- Start the Circulating pump.

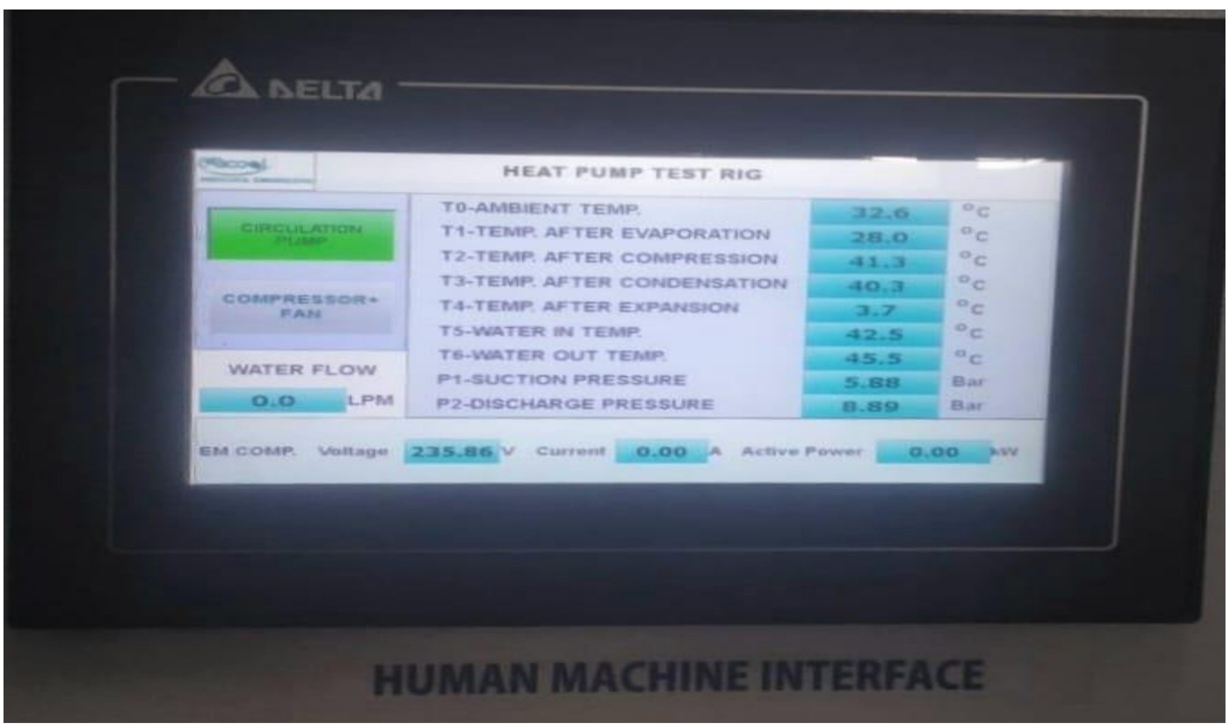


Fig.no. 4.4.4

Step 5:- Start the Compressor fan.

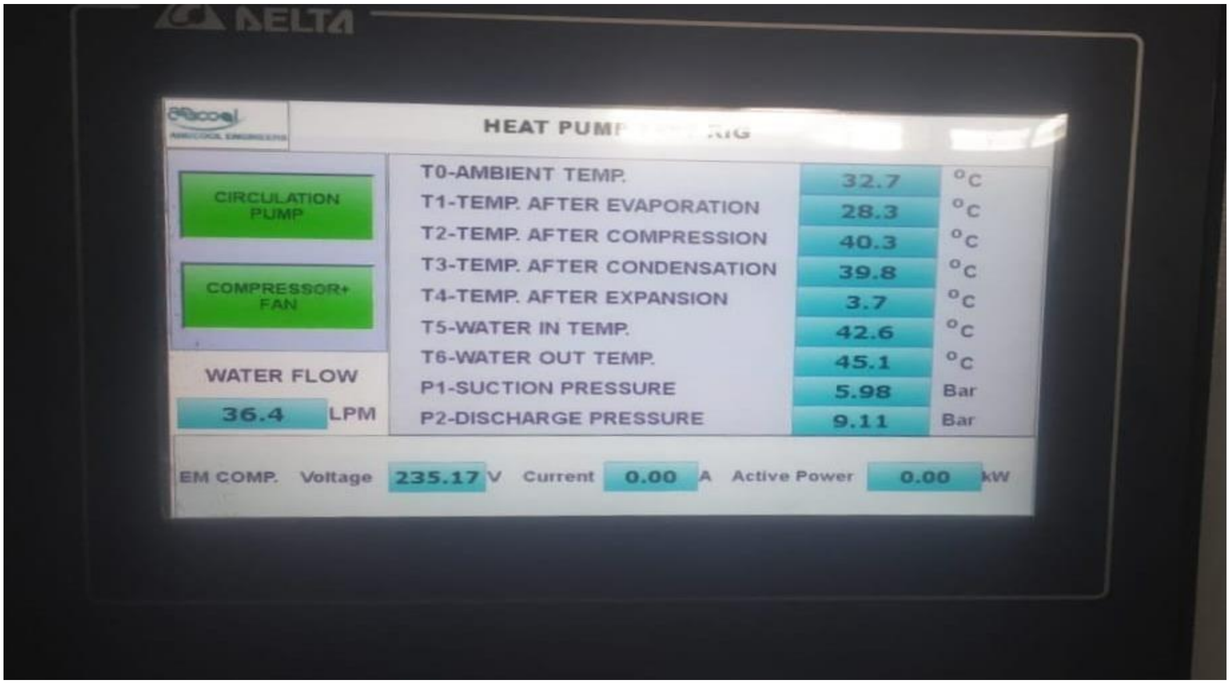


Fig.no. 4.4.5

Step 6:- Give the input parameters viz. Data log interval, Initial tank temperature, water volume and Press the **Start test button.**

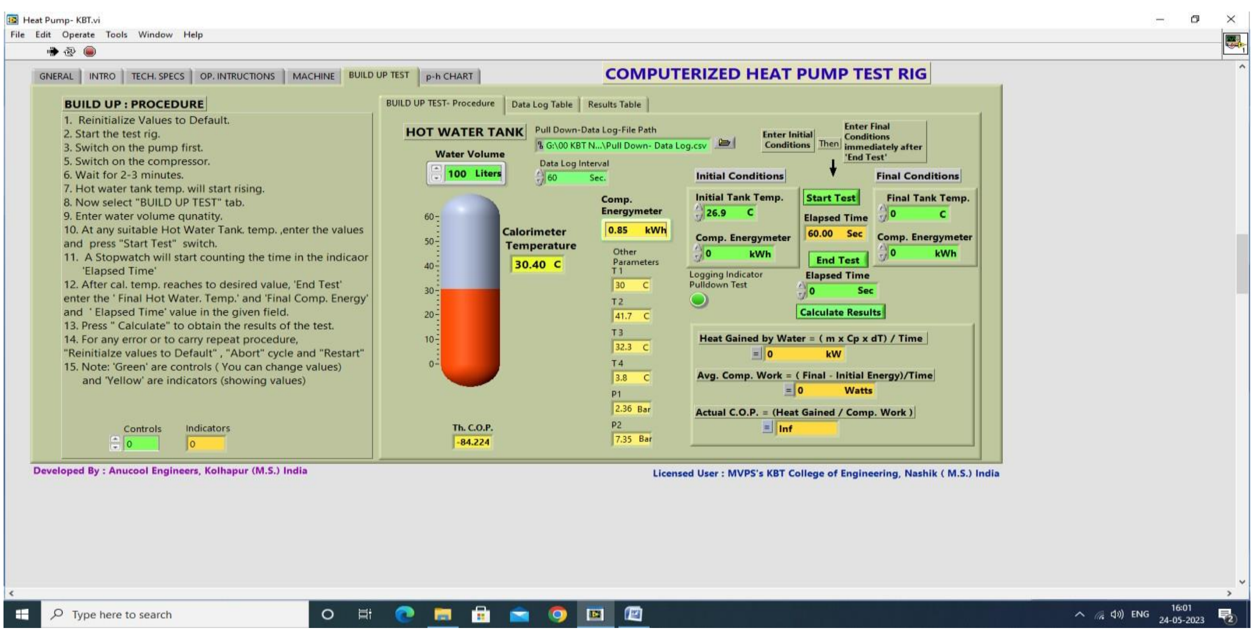


Fig.no. 4.4.6

Step 7:- Give the output parameters viz. Final tank temperature, Press the **End test button.**

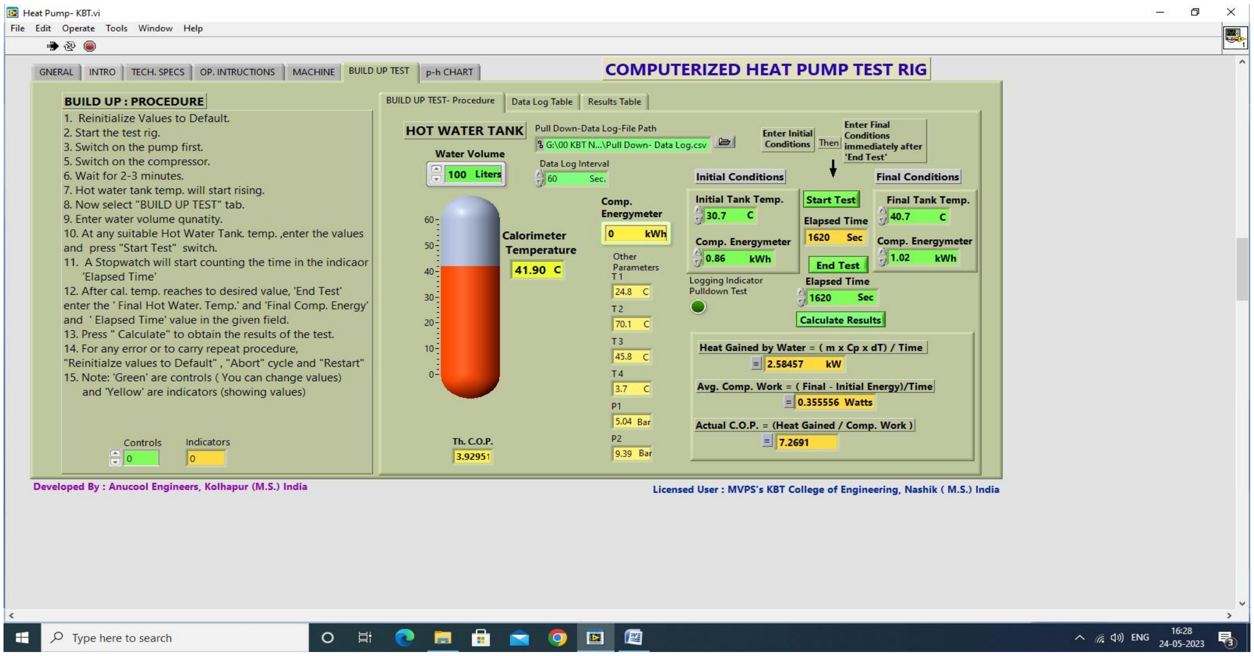


Fig.no. 4.4.7

Step 8:- Stop the **Compressor fan** and **Circulating pump.**

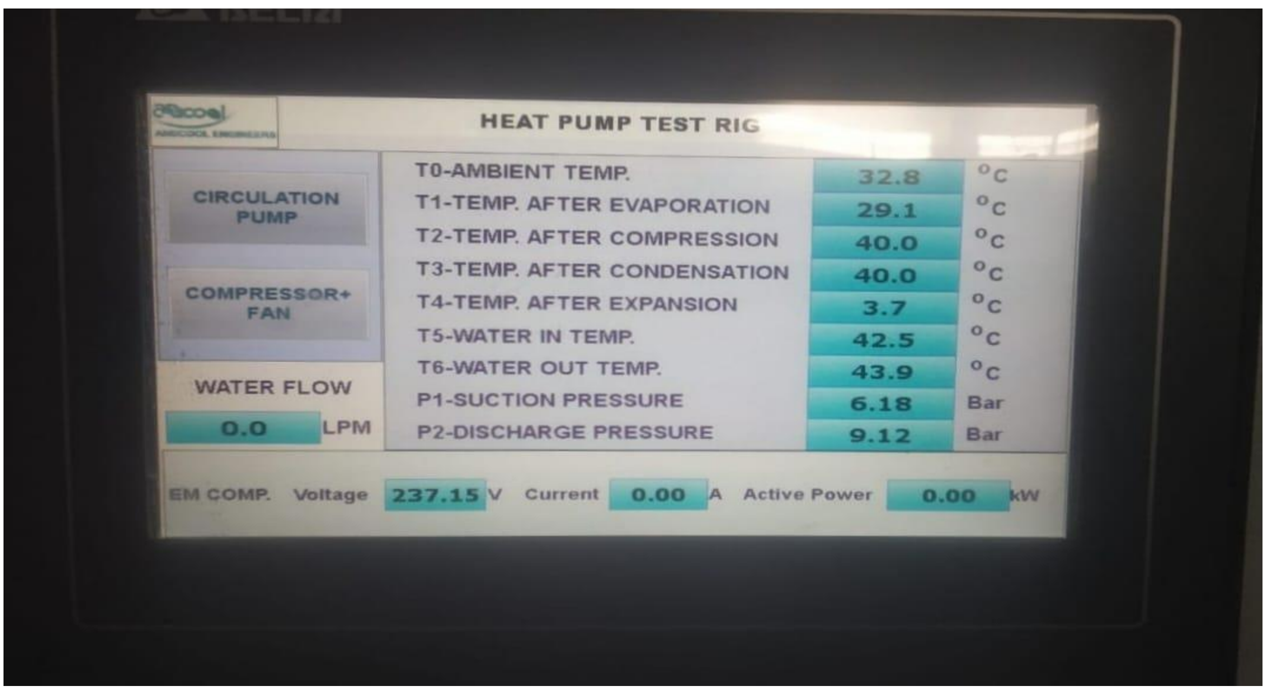


Fig.no. 4.4.

4.5 Observations :

Observed Readings:

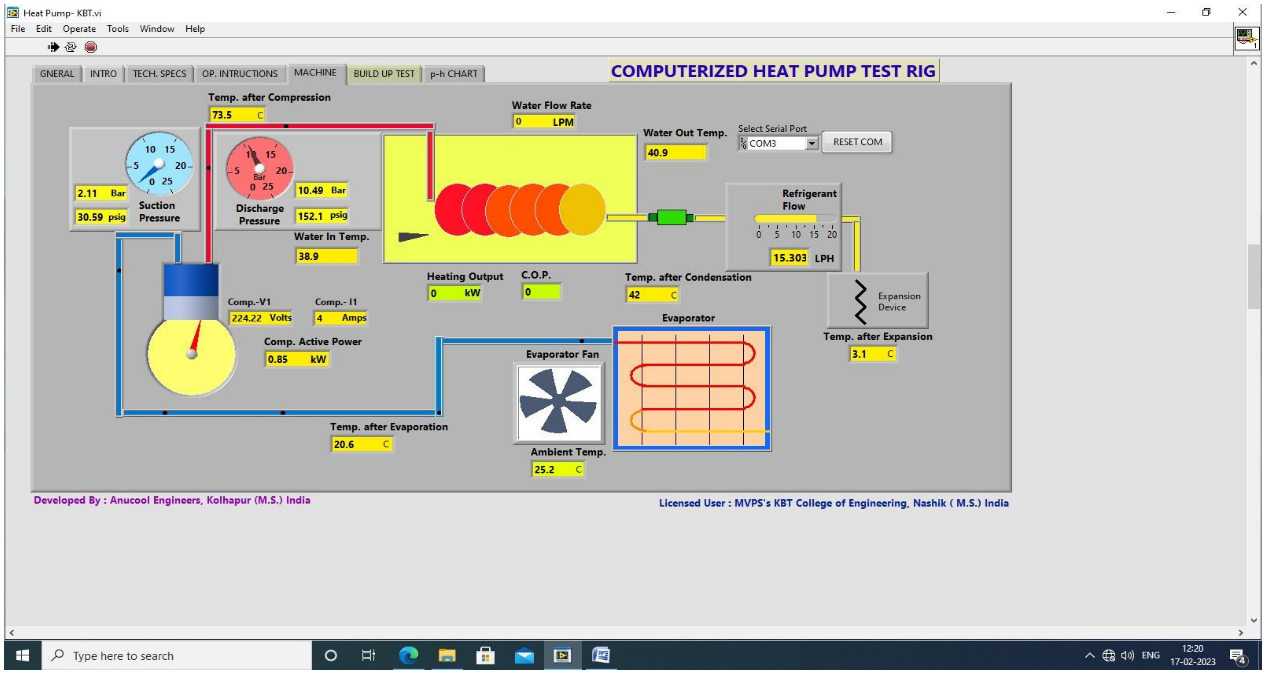


Fig. no. 4.5.1: Computerized Heat Pump Test Rig

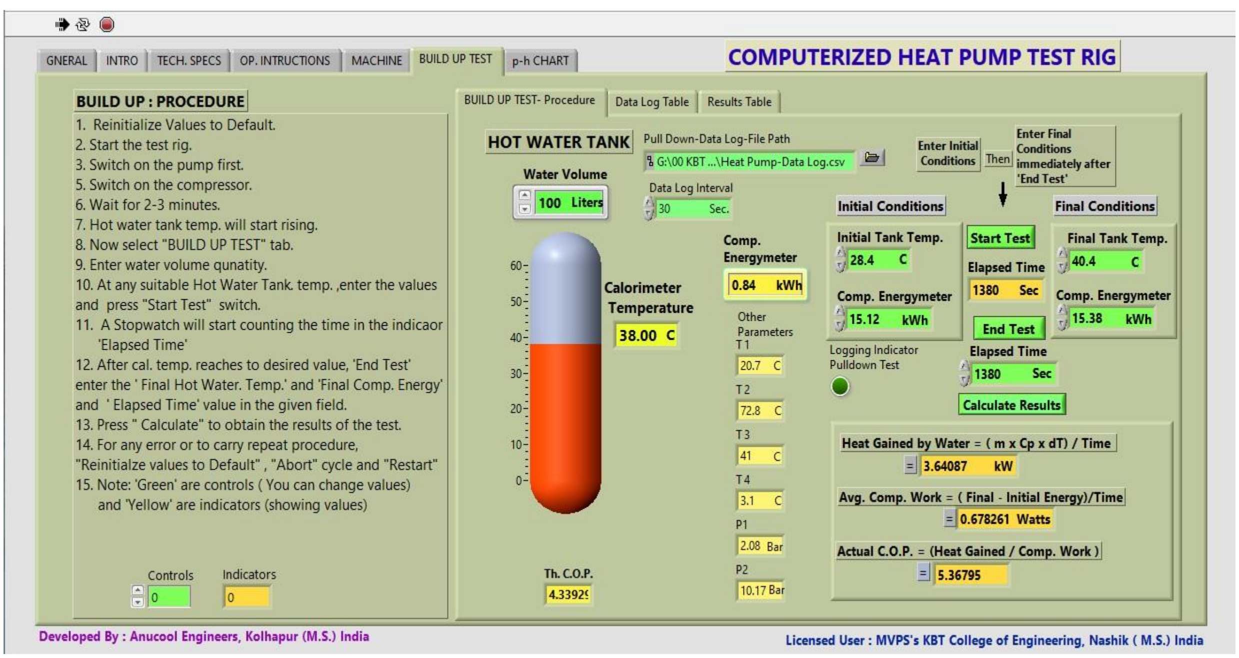


Fig. no.4.5.2: Build Up test

4.6 Observation Table:

Sr. No.	Parameter	Readings	
1)	Tank Water in Liters	100	
2)	Condensing pressure (kg/cm^2)	5.58	
3)	Refrigerant flow rate (LPH)	15.303	
4)	Ti = Inlet water temperature (ºC)	28.4	
5)	T1 = Temperature of refrigerant after compressor(ºC)	20.7	
6)	T2 =Temperature of refrigerant after condenser (ºC).	72.8	
7)	T3 =Temperature of refrigerant after expansion device (ºC).	41	
8)	T4 =Temperature of refrigerant after evaporator(C).	3.1	
9)	T5 =Temperature of water at condenser outlet(C).	40.4	
10)	Energy Meter Reading (kW-Hr)	Starting	Ending
		15.12	15.18
11)	Time	11.55	12.17

Table no.4.6.1: Observation table

4.7 Data Log:

Date	Time	Ambient Temp.	Calorimeter Temp.	Temp. after Compressor	Temp. After Condenser	Temp. after Expansion	Suction pressure	Discharge Pressure	Refrigerants Flow	Compressor Work	Actual COP
2/23	11:55:04	26.3	28.2	28.9	25.2	3.2	5.58	5.92	32.31	1.49	60.01
2/23	12:00:04	25.8	30.8	61.1	32.5	3.1	1.63	7.81	12.95	0.75	6.31
2/23	12:05:04	25.6	32.7	66.2	34.8	3.1	1.78	8.45	13.69	0.78	5.18
2/23	12:10:04	25.5	34.7	69.3	37.2	3.1	1.91	9.1	14.32	0.8	4.8
2/23	12:15:04	25.4	36.7	71.6	39.6	3.1	2	9.76	14.76	0.82	4.49
2/23	12:17:04	25.2	37.6	72.4	40.4	3.1	2.05	10.04	15.01	0.84	4.39

Table no. 4.6.2: Data log (Interval Time of 300 Sec)

4.7 Actual Calculations:

1. Work done: (Compressor Work)

Final Energy meter reading =15.38 kW-Hr

Initial Energy meter reading =15.12kW-H

Compressor Work = Final Energy meter reading - Initial Energy meter Reading

Compressor Work = 0.26 kW-hr

$$\textbf{Compressor work (kW)} = \frac{\text{Compressor Work}}{(\text{Ending time} - \text{Starting time})}$$

$$= (0.26)\ /\ (0.33)\ \text{kW}$$

Compressor work = 0.6782 kW

2. Heating Effect at Condenser side (Q1):

Q1 = m*(Cp) *(ΔT)

Where ;

m=mass flow rate of water(kg/sec)

Cp=specific heat of water=4.187(kJ/kgK)

Δ**T=**temperature difference (K)

= Outlet water temperature from condenser (T5) – Inlet water temperature to condenser (Ti)

= 40.4 – 28.4 = **12K**

M = Mass flow rate of water = 100LPM = 100/(23*60)

M = 0.07246 LPS

= **0.07246 kg/sec**

Q1= (0.07246)*(4.187)*(12)

Q1 = 3.6406kW

3. C.O.P. of Heat Pump:

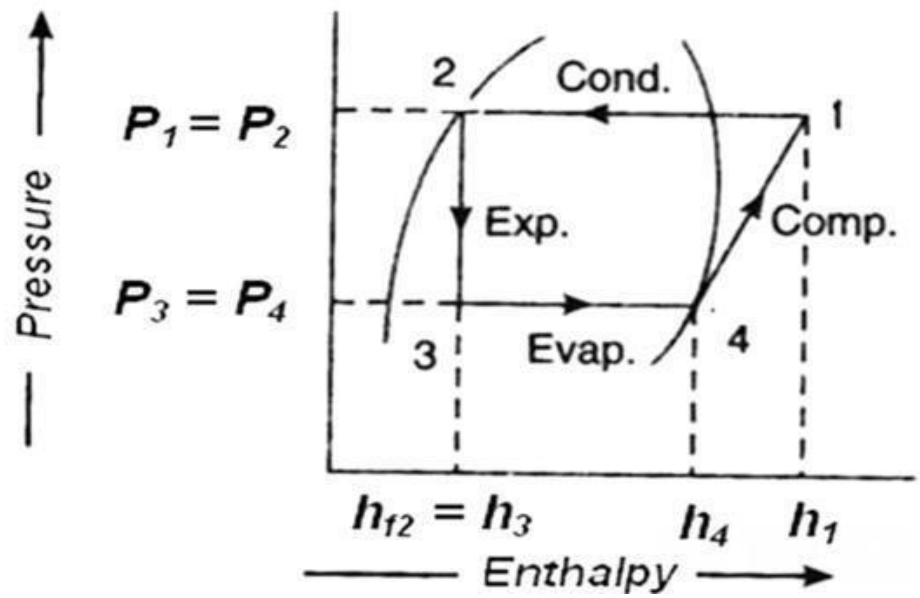
Coefficient of performance = Heating Effect / work done

C. O. P. Heat Pump = [(Q1) / (W)]

$C.O.P.\ HeatPump$ = [(3.6406) / (0.6782)]

Actual C.O.P. of Heat Pump = 5.3680

4.8 Theoretical C.O.P. of Heat pump:



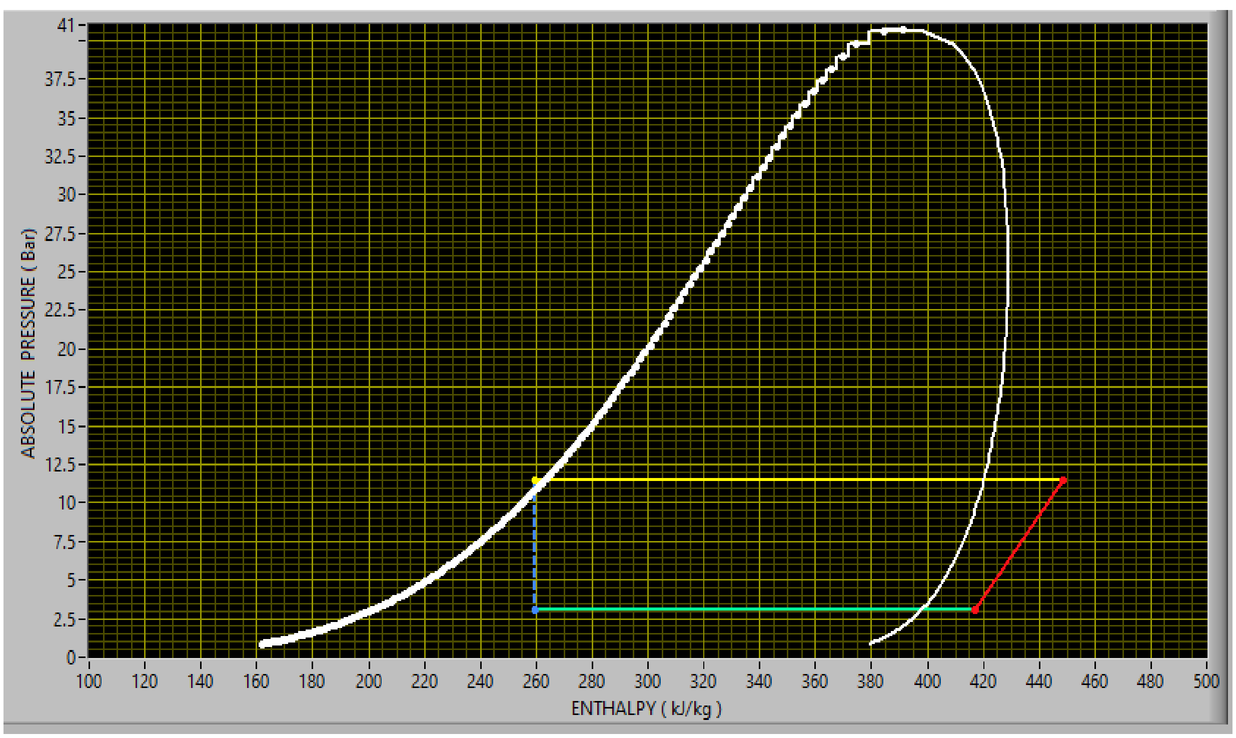


Fig.4.7.1: P-H Chart

From P-hchart;

$h1=430$kJ/kg

$hf2 = h3 = 230$ kJ/kg

$h4 = 400$kJ/kg

C. O. P. of Heat Pump = Heating Effect / Work done

$$= (h1-h2) / (h1-h4)$$

$$= (h1-hf2) / (h1-h4)$$

$C.O.P.Heatpump$ = (430−230) / (430−400=6.67

Theoretical C.O.P. Heat Pump = 6.67

Chapter 5:

5. Results and Discussion:

5.1 Results:

1. Actual C. O. P. of Heat Pump = 5.3680

2. Theoretical C. O. P. of Heat Pump = 6.67

5.2 Discussion:

The actual cycle deviates slightly due to pressure drop caused by friction in piping and valves. In addition to this there will be heat loss or gain depending on the temperature difference between the refrigerant and the surrounding. Further compression will be polytropic due to friction and heat transfer instead of isentropic. It is clear from the both actual and theoretical cycles that little pressure drop takes place when refrigerant pass through the Condenser.

- The operating cycle deviates as discussed above however, the saturated cycle is used to determine the COP of the cycle for all practical purpose. It is well observed that the pressure drop in the condenser due to frictional pressure drop and momentum pressure drop is larger than that of the evaporator.
- The COP of **HEAT Pump** varies from 0.5 to 1.5 depending on the operating conditions of the heat pump.

Chapter: 6

6. Conclusion and Future Scope:

6.1 Conclusion:

Theoretical COP is higher than actual COP; the reason of deviation is that the compression, condensation and evaporation processes are assumed to be reversible in calculation of theoretical COP.

6.2 Future Scope:

The key technology in the global shift to safe and sustainable heating is heat pumps, which are driven by low-emission energy. A special research from the IEA's World Energy prognosis series, The Future of Heat Pumps, offers a prognosis for heat pumps and identifies important potential to hasten their adoption. The article addresses the effects of a rapid adoption of heat pumps on energy security, consumer energy costs, employment, and efforts to combat climate change, as well as highlighting the main obstacles and legislative options.

- Heat pumps provided 10% of the world's space heating needs in 2021, however the rate of installation is accelerating and sales are at historic highs.
- However, consumers would need assistance from government policy to get over the higher initial expenses of heat pumps compared to alternatives. Incentives for heat pumps are now in place in more than 30 nations, which together meet more than 70% of the world's current demand for heating.
- According to the IEA, heat pumps have the potential to cut carbon dioxide (CO2) emissions worldwide by at least 500 million tonnes by 2030.

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United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002. (Chapter 5 page no. 101)

Photographs: