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Design and Fabrication of Seed Dryer using Waste Heat of VCR Cycle

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Abstract: This research paper presents vapor compression refrigeration (VCR) system for simultaneous heating and cooling utilities for the purpose of seed dryer. The main advantage of the simultaneous is to carry out heating and cooling in dual mode, by which fossil fuel can be saved by minimize the use of the energy due to simultaneous operation. And even due to simultaneous operation the requirement individual equipment is no more so it saved the first cost of equipment.
Keywords: Design of seed dryer, Heat Utilization, Seed dryer, VCR cycle, Waste heat utilization.

I. INTRODUCTION

In today's era, refrigeration industry is passing through evolutionary changes. Emphasis is given to save energy and to protect the environment. Refrigeration technology is expected to develop technologies which are cheap and using refrigerant other than CFC. Many food industries, textiles industries, hotels require both refrigeration and water heating. In case of textile mill, it requires central air conditioning plant which requires chilled water and hot water for steam generation and heating purpose, while in food industries, refrigeration required for product preservation and hot water required for cleaning, sterilization or process heating. It is common for the refrigeration and water heating systems to be separate and unconnected, and both consuming purchased energy. This approach wastes considerable energy, contributing to the depletion of fossil fuel reserves and the release of greenhouse gases. Even in large size VCR system required condenser and cooling tower for condensation process, while by simultaneous heating and cooling requirement of cooling tower is no more. So by the simultaneous heating and cooling by VCR system save the fossil fuel, energy and first cost of system/equipment by serving the both function of heating and cooling simultaneously. In addition, many refrigeration systems employ ozone depleting refrigerants. There are strong international moves to use naturally occurring and ecologically safe working fluids rather than harmful chemicals, in order to minimize the impact on the environment.

A. VCR cycle in brief

The compressor enhances the pressure of the refrigerant streaming from the evaporator i.e. pulling in low- pressure, low temp saturated vapour and supplying highly pressured and high temperatures towards the condenser.

The highly pressured, high-temperature vapour which goes in the condenser has heat taken out of it and consequently it is condensed back again into a liquid state. To lower pressure to the equal level as that of the evaporating pressure, a device has to be placed to undertake this procedure, referred to as throttling device or an expansion device.

Refrigerant in liquid state can absorb heat from the cold chamber leads to evaporate. The evaporator offers a heat transfer surface area through which heat may move from refrigerant space in to the vaporizing refrigerant. For research work water cooled condenser and evaporator is used.

B. Refrigerant - R134a

The refrigerant R134a or tetra-fluoro ethane composed of 2 atoms of carbon, 2 atoms of hydrogen and 4 atoms of fluorine. The molecular weight is 133.4 and its boiling point is 15.1-degree F. Its chemical formula is CF3 CH2 F.

Refrigerant R134a is a hydrofluorocarbon (HFC) which has no potential to influence the destruction of the ozone layer and have very little greenhouse effect. It is the non-flammable and nonexplosive, offers toxicity within boundaries and better chemical stability. It includes relatively great affinity for the moisture content.

Properties of R134a [1] [2]

Name	1,1,1,2-Tetrafluoroethane
Formula	CH_2FCF_3
Main Application Fields (With Force)	Domestic Refrigeration; Refrigerated Transport; Air Conditioning
Molar Mass	102.03 Kg/Kmol

Properties at 0ºC (At Saturation)		
	UNIT (SI)	LIQUID
Pressure	MPa	0.29
Volume mass	dm3/kg	0.77
Specific heat capacity • at constant pressure • at constant volume	kJ/(kg K) kJ/(kg K)	1.34 0.88
Thermal conductivity	10-6 Pa s	271.08

Thermo Physical Properties	
Normal boiling point (at 0.1013 MPa)	–26,1°C
Critical temperature	101.08°C
Critical pressure	4.06 MPa

II. LITERATURE REVIEW

A. Elumalai P., Vijayan R., Ramasamy K.K. And Premkumar M., Experimental Study on Energy Recovery from Condenser Unit of Small Capacity Domestic Refrigerator, Middle-East Journal of Scientific Research 23 (3), 2015, 417-420

Elumalai et al. [3] have studied about heat retrieval from the condenser in the Vapour Compression Refrigeration (VCR) system by using oven and heating unit that could be installed between compressor and condenser parts. The existence of oven enables us to retrieve the superheat from the discharge vapour and put it to use for raising the temperature of the space inside hot oven and raise the temperature of the fluids in the heater. The effectiveness of the chiller with varying operating time has were studied. The result of operating temperature inside the oven and heating unit for changing working time of a refrigeration device have been analysed and possible heat recovery had been determined.

B. Walawade S.C., Barve B.R. And Kulkarni P.R. Design and Development of Waste Heat Recovery System for Domestic Refrigerator, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN: 2278-1684, 28-32

Walawade et al. [4] have studied "Waste heat recuperation framework for residential refrigerator". For small price range, this framework is much valuable for residential reason. An endeavor has been discovered from condenser of refrigerator to retrieve the heat. This heat can be used for number of home and industry purposes. It is important option way to deal with enhance general effectiveness and reuse the waste heat. The review has demonstrated that such a framework is in fact technically and economically feasible.

C. Ambarita Himsar, Nasution Abdul Halim, Siahaan Nelson M. And Kawai Hideki, Performance of a Clothes Drying Cabinet by Utilizing Waste Heat from a Split-Type Residential Air Conditioner, Case Studies in Thermal Engineering, 2016, 105-114

Ambarita et al. [5] have discussed on the general performance of clothes drying chamber with the use of waste heat out of a split-type residential air-conditioner (RAC) have been performed. A drying chamber having a volume of 1m3 had been built and fabricated. The waste heat from condenser of the RAC with power of 800W was used as a heat source.

D. Momin G.G., Deshmukh S.R., Deshmukh M.T., Chavan P.T., Choudhari P.P., COP Enhancement of Domestic Refrigerator by Recovering Heat from the Condenser, International Journal of Research in Advent Technology, Vol.2, No.5, 2014, 402-406

Momin et al. [6] have retrieved waste heat coming from condenser unit of the home refrigerator to enhance the overall performance of the system. Retrieval of heat is from the home refrigerator is by thermos siphon. From the experimentation, it had been noted that after heat retrieving process from the condenser of the home refrigerator its overall COP got raised when compared to conventional refrigerator.

E. Varghese Reny, Raju Nithin, M. Rohit, Antony Roshan Thomas, Mathew Tom, Heat Recovery System in Domestic Refrigerator, International Journal for Research & Development in Technology, Volume 2, Issue 2, 2014, 16-20

Varghese et al. [7] have illustrated the practical feasibility of the heat recovery system to extract heat which is waste from the condenser exit of the refrigerator and use it for heating. The shown work, attempted to retrieve the waste heat out of a 210 L refrigerator, intended for residential requirements. The top chamber of the refrigerator was made as a hot chamber, by extension of the condenser coils, and the connection of the top section, towards top surface of the lower chamber of the refrigerator. Hot chamber and the cold chamber had temperature difference inside hence, was analysed considering the different variables considering the aspects of time, capacity of chamber and load. From the outcomes, it had been founded that the mentioned technique of heat recovery, could be engineered and developed for each and every domestic refrigerator, with the nominal cost. Thus, the reuse of waste heat provided method for optimum energy conservation. This kind of work could be improved by providing better insulation which in turn reduces the heat loss and increases the performance of the system.

F. Soni Lakshya, Kumar Pawan, Goyal Rahul, Waste Heat Recovery System from Domestic Refrigerator for Water and Air Heating, International Journal of Engineering Sciences & Research Technology, 2016, 500-507

Soni [8] have developed ways to use waste heat coming from condenser of refrigerator. This kind of heat can be employed for number of residential and commercial reasons. In minimal constructional and service cost this method is considerably useful for residential motive. It could be beneficial alternative solution to increase functionality and reuse the waste product which is in heat form. The study has unveiled that such process is practically feasible and financially feasible. This system discarded less heat to the natural environment therefore it is safer in environmental attributes.

G. Sreejith K., T.R. Sreesastha Ram, Mossas V.J., Nidhin M.J., Nithil E.S., Sushmitha S., Experimental Investigation of Waste Heat Recovery System for Household Refrigerator, International Journal of Engineering and Science, Vol.6, Issue 4, 2016, 19-23

Sreejith K. et al. [9] have designed, constructed and experimentally analysed a waste heat retrieval model for residential refrigerator. They'd analysed the system at several load conditions (No load, 40 W load and 100W load). They even performed the techno-economic evaluation by comparing the waste heat recovery system along with the standard geyser. From gathered testing outcomes, they determined that waste heat recovery system works very well with the home refrigerator. Hot water of moderate temperature can be acquired from it. This kind of changes made residential refrigerator to get work as simultaneously refrigerator and water heater. Considerable amount of hot water during an appreciable temperature could be obtained from the waste heat recovery system.

H. Agarwal Tarang, Kumar Manoj, Gautam Praveen Kumar, Cost-Effective COP Enhancement of a Domestic Air Cooled Refrigertor Using R-134a Refrigerant, International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 11, 2014, 300-305

Agarwal, et al. [10] have given economical approach to raise the COP and utility of the residential refrigerator working with R-134a refrigerant. A cabin was installed on the top of a residential refrigerator with the condenser coils of refrigerator providing as heating coils inside cabin. Known amount of water was heated by condenser coils (as a result of convection currents) thus elevating the overall COP of the refrigerator. Additionally, the utility was improved as it can certainly fulfil the objective of cooking (oven), geysers and so on. Besides, refrigerator can be used as standard refrigerator keeping the cabin door open in the instance of absence of heat sink. It was determined that it is possible to improve the COP up to 11% simply by utilizing a cabin on the top of the refrigerator system. Additional rise in COP is achievable; even so improvements will involve excessive costs.

I. Krishna A. Vamshi, Reddy M. Venkateshwara, Gowd A.E. Rana, Experimental Investigation on Recovery of Waste Heat from Window Air Conditioner, International Journal of Core Engineering & Management, 2017, 218-233

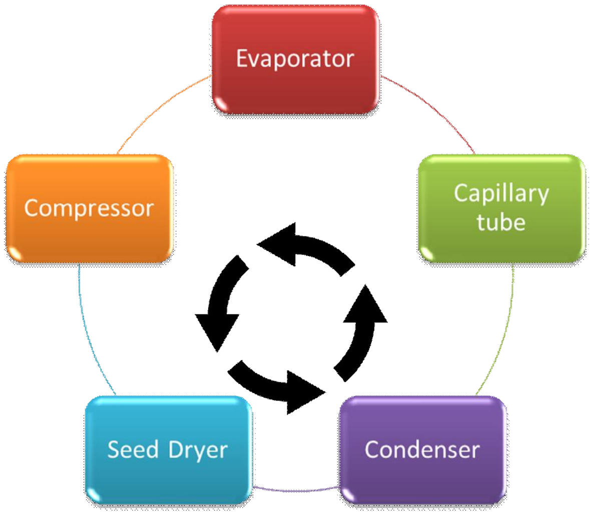
Krishna, [11] have discussed condenser of the air conditioning unit which is attached with a co-axial copper pipe by means of a spiral coil and is linked to water tank via the pipes to heat up the water to be employed for residential purposes. The outcomes demonstrated for AC (air conditioner) of 1.5 TR are; temperature of the water in the heating tank could be increased via preliminary temperature of the water 28°C to 57°C within 15 to16 minutes, the temperature from the evaporator could be reduced below within short while. By using this kind of heat recovery units, compressor performance could be increased and also, hot water intended for residential purposes could be constantly acquired. The outcome is quicker cooling and long-term compressor life as well as the AC system was determined to be higher COP when compared to those of conventional AC. This system is quite simple and cheap and capable to save the water heating cost and also, safe in environmental aspects.

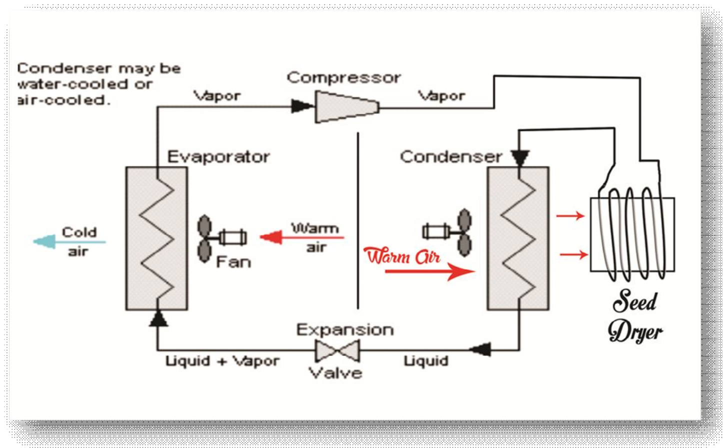
III. DESIGN METHODOLY

The vapour refrigerants that compressed to high temperature & high pressure conditions in the compressor.

Then this refrigerant will pass through seed dryer, so heat will utilize to dry seeds.

Also fan attached with condenser will help in removing humidity from container of seed by passing hot air toward seed container.





Modified VCR Cycle Line Diagram

A. Function and Specification of Parts

1) Compressor: compresses the vapor refrigerant sucked from the evaporator and discharges it to condenser.

Compressors Model: THK 1330 YCF
Number of Cylinders: 1
Displacement per rev (cc): 3.14 CC
Cooling capacity (Btu/Hr): 282 Btu/hr
Rated conditions Current (amps): 0.70 Amps
Power (watts): 80 Watts
Weight: 7.3 Kgs.

2) Heat Box: Charges the compressed vapor refrigerant into the liquid refrigerant by cooling.

3) Fan: Removes moisture and dirt inside pipes

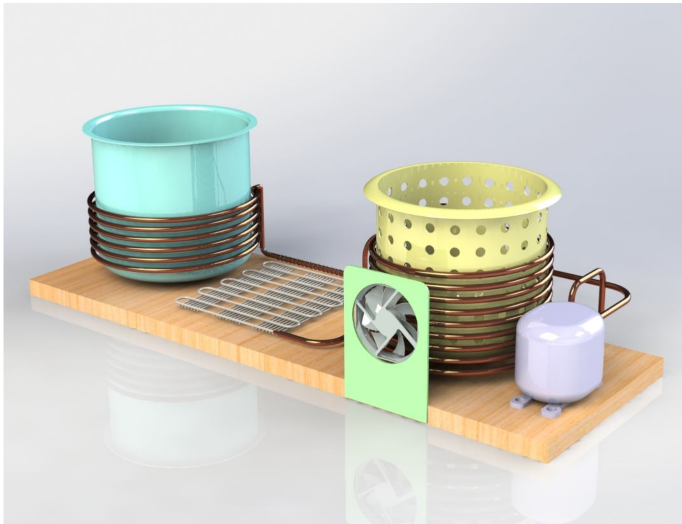
4) Condenser: Condenses vapor refrigerant in liquid state.

5) Capillary tube: Reduces the pressure of liquid refrigerant and evaporates it in the evaporator under constant pressure

6) Cold drum: Absorbs the surrounding heats while evaporating the liquid refrigerant, cools down water inside of cold water tank.

7) Over load protector: Protects the compressor and operates when rising up to abnormal temperature or energizing over current.

8) Starter relay: It starts up the motor of compress.



3D Model

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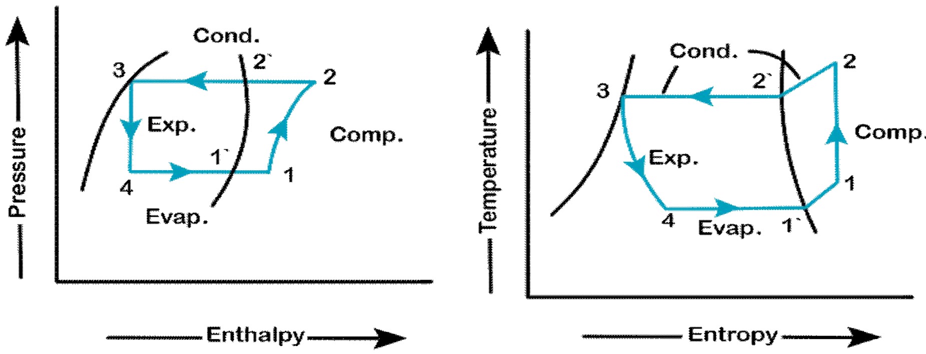
IV. COP CALCULATION

A. Calculation of theoretical COP

Suction pressure = 40 psi = 0.2756 Mpa
Compressor output pressure = 240 psi = 1.6536 Mpa
Compressor output temperature = 36°C
Evaporator output temperature = 1°C
Here According to R134a property table,
at 0.2756 Mpa pressure the saturation temperature is 2°C &
at 1.6536 Mpa pressure saturation temperature is 59°C.
So, we will get dry superheated refrigerant at both the places
Degree of superheat after evaporator = 3°C
Degree of superheat after compressor = 4°C.



From R134a Property table

Temp	H_f	H_g	C_p (Liquid)	C_p (gas)
-2°C	197.32	397.43	1.336	0.886
59°C	286.1	426.3	1.645	1.369

$$C.O.P = \frac{Refrigeration\ effect\ produced\ in\ evaporator}{Compressor\ work}$$

$$C.O.P = \frac{h_1 - h_4}{h_2 - h_1}$$

1) *Enthalpy at Point 1*

$h_1 = h_{g1} + C_{p1}.\Delta T_1$
$= 397.43 + 0.888\ (3)$
$= 400.094$ KJ/Kg

2) *Enthalpy at Point 2*

$h_2 = h_{g2} + C_{p2}.\Delta T_2$
$= 426.3 + 1.369\ (4)$
$= 431.77$ KJ/Kg

$h_3 = h_{f3} = 286.1$ KJ/Kg
$h_4 = h3 = 286.1$ KJ/Kg

So,

$$C.O.P = \frac{h_1 - h_4}{h_2 - h_1}$$

$$C.O.P = \frac{400.094 - 286.1}{431.77 - 400.094}$$

C.O.P = 3.69

B. Calculation of actual COP

$$\text{Actual C.O.P} = \frac{\text{Refrigeration effect produced in evaporator}}{\text{Compressor work}}$$

C. Calculation for refrigeration effect

Temperature of refrigeration at evaporator inlet = -2°C
RE = latent heat absorbed by refrigerant + Sensible heat absorbed by refrigerant
At evaporation pressure saturation temperature for refrigeration = -2°C

D. From R134a property table

Latent heat absorbed = (200.11) $\dot{m}$
Where, $\dot{m}$ = mass flow rate
Sensible heat absorbed = $\dot{m}C_p\,\Delta T$
= $\dot{m}$*(0.888)*3

E. Total refrigeration effect produced

= 200.11 $\dot{m}$ + $\dot{m}$ (0.888) 3
= $\dot{m}$ (200.11 + 0.888 (3))
= 202.774 $\dot{m}$

F. Mass flow rate

For given capacity of compressor mass flow rate

$$= 3\ \frac{\text{Litre}}{\text{Hour}}$$

Where, 1 litre = 10^{-3} m^3
3 litre/hour = 8.33 * 10^{-7} m^3/s
From R134a Property table at -2°C
8.33 * 10^{-7} m^3/s = 1.0845* 10^{-3} kg.
$\dot{m}$ = 1.0845 * 10^{-3} Kg/s
Refrigeration effect =
= 202.774 $\dot{m}$
= 202.774 (1.0845)(10^{-3})
= 0.219.90 KJ/s
= 219.9 J/s
= 219.9 Watt

G. Compressor work

Rated compressor work = 82 Kw

$$\text{C.O.P} = \frac{\text{Refrigeration effect produced in evaporator}}{\text{Compressor work}}$$

$$= \frac{219.9}{82}$$

= 2.68

H. Calculation of heat transfer rate in seed dryer chamber:

Inlet temperature of refrigerator : 63°C
Outlet temperature of refrigerant : 48°C
Here for experiment 200 gm of wheat at 25°C is taken.
At given pressure saturation temperature of refrigerant is 59°C. So, refrigerant will loose sensible heat and latent heat after conversion of refrigerant into liquid phase it will also loose sensible heat

Heat transfer rate in chamber
= Heat lost by refrigerant in chamber

Heat lost by refrigerant in chamber
= Sensible heat up to 59°C
+ latent heat of condensation
+ sensible heat up to 48°C

$= (63\text{-}59)\ C_p\dot{m} + \dot{m}\ (\text{latent heat}) + (59\text{-}48)C_p\dot{m}$
$= 4\ (1.369)\dot{m} + \dot{m}(141.07) + 11(1.5)\dot{m}$
$= \dot{m}\ [\ 5.476 + 141.07 + 16.5]$
$= 163.046(\dot{m})$
$= 163.046\ (1.0845)*10^{-3}$ KJ/s
$=163.046\ (1.845)(10^{-3})(10^{-3})$ J/s
=176.82 J/s
=176.82 watt

V. CONCLUSION

By considering above data here we can conclude that theoretical COP of VCR cycle is 3.69 where as actual COP is 2.68. Here the rate of heat transfer in seed dryer chamber is sufficient to dry the seeds for small amount of seeds.

REFRENCE

[1] https://www.chemours.com/Refrigerants/en_US/assets/downloads/freon-134a-thermodynamic-properties-eng-units.pdf
[2] https://www.egr.msu.edu/classes/me417/somerton/R134a%20Tables.pdf
[3] Elumalai P., Vijayan R., Ramasamy K.K. And Premkumar M., Experimental Study on Energy Recovery from Condenser Unit of Small Capacity Domestic Refrigerator, Middle-East Journal of Scientific Research 23 (3), 2015, 417-420
[4] Walawade S.C., Barve B.R. And Kulkarni P.R. Design and Development of Waste Heat Recovery System for Domestic Refrigerator, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN: 2278-1684, 28-32
[5] Ambarita Himsar, Nasution Abdul Halim, Siahaan Nelson M. And Kawai Hideki, Performance of a Clothes Drying Cabinet by Utilizing Waste Heat from a Split-Type Residential Air Conditioner, Case Studies in Thermal Engineering, 2016, 105-114
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[7] Varghese Reny, Raju Nithin, M. Rohit, Antony Roshan Thomas, Mathew Tom, Heat Recovery System in Domestic Refrigerator, International Journal for Research & Development in Technology, Volume 2, Issue 2, 2014, 16-20
[8] Soni Lakshya, Kumar Pawan, Goyal Rahul, Waste Heat Recovery System from Domestic Refrigerator for Water and Air Heating, International Journal of Engineering Sciences & Research Technology, 2016, 500-507
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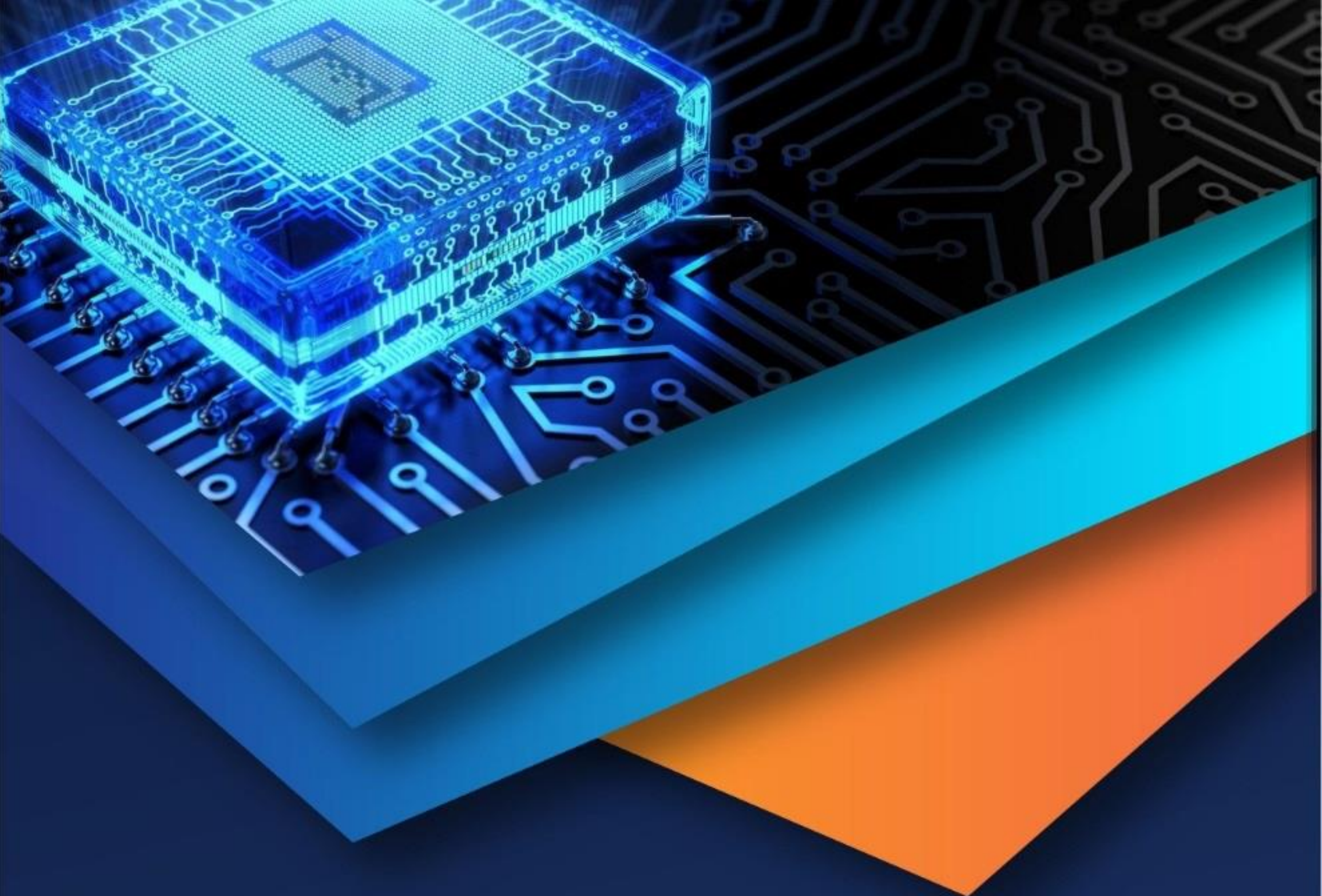
[11]Krishna A. Vamshi, Reddy M. Venkateshwara, Gowd A.E. Rana, Experimental Investigation on Recovery of Waste Heat from Window Air Conditioner, International Journal of Core Engineering & Management, 2017, 218-233

Reference Books
1) Refrigeration and air conditioning by R S khurmi
2) Basic Refrigeration and Air Conditioning by Ananthanarayanan



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