Analysis of Airconditioning System Using Single-Rotor Wind Turbine Power, Dual Rotor Wind Turbine Power, and Ducted Dual Rotor Wind Turbine Power As Input to Compressor

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Abstract

As vapor compression refrigeration system is the best-suited system used in the present scenario due to its various advantages, in the present paper MATLAB analysis is done for the analysis of simple VCR to calculate COP and refrigeration effect.in the present paper R134a refrigerant is used as a refrigerant.as we know a certain amount of power is used to drive the compressor input in conventional VCR system uses electrical power to convert into mechanical shaft rotation with certain rotation, power and torque.in this paper specific power torque and rotation is given to the compressor without any electrical motor. the power obtains from an SRWT, DRWT, and DDRWT with specific torque power and rotation. then after analysis is carried out to get the COP and Refrigeration Effect.

1. Introduction

Simple VCR is the most appropriate refrigeration system used for producing refrigeration effect which can also be considered as an improved air refrigeration system in which instead of air the refrigerant is used, here R124a is used to carry out the analysis.

It consists of four basic components:

- Compressor
- Evaporator
- Condenser

Throttling or expansion valve.

a)-Compressor-Compressor is a mechanical device that compresses the vapor refrigerant from low pressure to high pressure and temperature. This is placed in between the evaporator and condenser. To run the compressor a certain amount of power is required in the form of an electric motor that runs the compressor at a certain power. But here in my study, the electricity is not used to run the compressor whereas direct dual ducted wind power is used to drive the compressor and to produce refrigeration effect.

b). Condensor-It is a mechanical device where refrigerants condensed at constant temperature in which a certain amount of heat is generated/rejected. It works under constant pressure and temperature. It is placed in between the compressor and the throttling valve. Thus here in the condenser vapor refrigerant is converted into liquid refrigerant which is allowed to pass through the throttling valve.

c). Throttling valve- This is the place where the pressure of the liquid refrigerant is reduced by the throttling process which is also known as the constant enthalpy process due to which low-pressure liquid refrigerant formed and which is allowed to pass through the evaporator. A throttling valve is placed in between the condenser and evaporator.

d). Evaporator-This is the place where the refrigeration effect is generated by vaporization of the liquid refrigerant at constant temperature and pressure due to which a certain amount of heat is absorbed from the space surrounding the evaporator thus producing a cooling effect at the desired space. Here in evaporator low pressure, liquid refrigerant converted into low-pressure low-temperature vapor refrigerant which is allowed to pass through compressor afterward. The amount of heat absorbed by the refrigerant in the evaporator is equaled to the latent heat of vaporization of the refrigerant.

The figure shows the arrangement of simple VCR whereas the ts and ph diagram shows how various parameters like temperature, entropy, pressure, and enthalpy change in the system corresponding to the flow of refrigerant.

Components are connected as shown in figure 1.

2. Literature Review

Several research has been carried out on the analysis of various related parameters for simple VCR on MATLAB simulation. Sharad Choudhary[2] observed and analyze the various refrigeration parameter successfully and calculated the parameters of mass flow rate, refrigeration effect (RE),

Compressor work, volumetric efficiency, and COP related to various input parameters. Baskaran et al. [3] analyze the various parameters of refrigeration on various refrigerants like R152a, R170, R600a, and R290. Alternative refrigerants except for R431a (which is the combination of R152a, R290 at 29% and 71%) can perform better than R134a at the condensation temperature at 50˚C and evaporator temperature between -30˚C and 10˚C. Dhumal [4] et al. analyze the expansion devices of various types used in VCR using R407C as a refrigerant. He also observed that a capillary tube with a diameter of 0.50" can give a 90% increase in compressor work with only a 50% increase in RE. Andrew Alleye [5] fabricated an experimental setup with various components along with a dual evaporator and R134a as a refrigerant.

3. Methodology

3.1 Analysis of Passive Air Conditioner

Compressor required a certain amount of power/torque her it is given by the dual ducted wind turbine directly without any electric motor so here the power or rotation is directly given by the wind turbine. The analysis is carried out from MATLAB after mathematical model development.

The refrigerant flows from compressor to condenser then expansion valve and then evaporator.

In compressor refrigerant is in a gaseous state, in condenser refrigerant condensed from vapor to liquid state, then in expansion valve its pressure reduces and the refrigerant remains in the liquid state then it finally goes to the evaporator where refrigerant changes the state from liquid to vapor to extract a certain amount of heat from the space required for cooling which is absorbed to the refrigerant. Thus refrigeration effect is produced around the evaporator coil.

The compressor consumes power so that the work is done on the system to compress the refrigerant to raise its pressure and temperature, refrigerant is in vapor stage. Thus the work done is needed in compressor which is given by dual ducted wind turbine.

In a condenser, heat is rejected. In the expansion valve, a certain amount of pressure of the refrigerant is reduced.

In an evaporator, heat is absorbed by heat extraction from the space required for cooling

A mathematical model for simulation

Refrigeration effect at evaporator side=h1-h4=RE

Compressor power=h2-h1

Heat rejected in condenser =h2-h3=Q

COP of the refrigeration system=(h1-h4)/(h2-h1)

Where h1=386.66 KJ/kg enthalpy of wet vapor refrigerant at variable evaporator pressure p2, which varies as per given compressor power.

Mass flow rate of refrigerant=0.5 kg/min.

h2=enthalpy of the vapor refrigerant at condenser pressure p1 and variable condenser temperature.

h3=enthalpy of the liquid refrigerant after condensation at condenser pressure p1

h4=enthalpy of the refrigerant after throttling process which is isenthalpic so that h3=h4

Considering the following conditions in VCR

1-Refrigerant is dry saturated before compression at evaporator fixed pressure p2

2. Refrigerant is superheated after compression at a condenser pressure p1

3. Refrigerant is the saturated liquid after condensation

4. Mass flow rate of the refrigerant remains to consider to be constant equals0.5 kg/min

5. Compression is assumed to be isentropic.

6. Condensation is carried out at constant temperature and pressure.

7. Expansion or throttling process is carried out such that enthalpy remains constant.

8. Evaporation carried out at constant pressure and temperature.
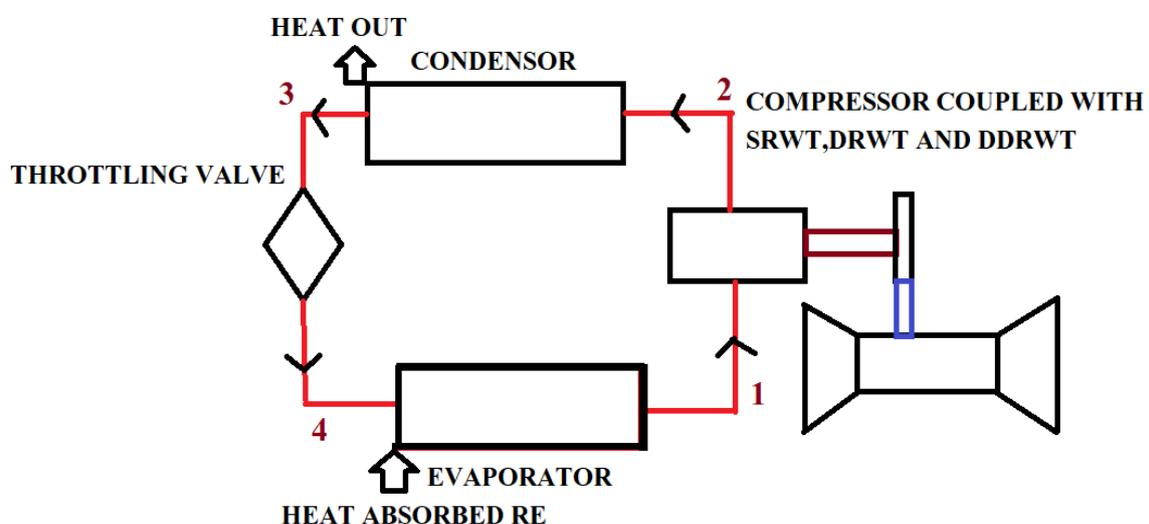
9. Losses are neglected.

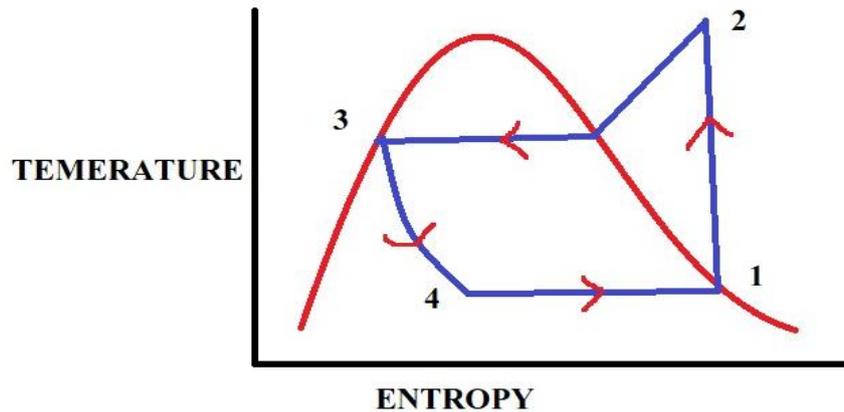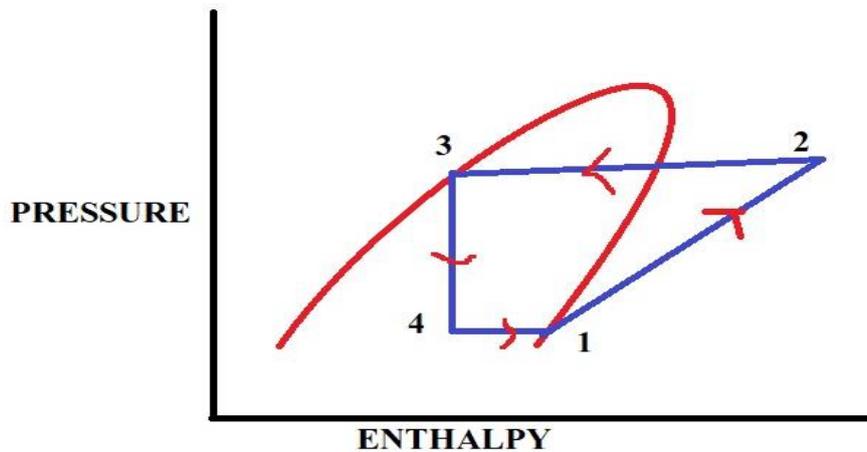Figure 1 - Simple VCR

Figure 2 - TS Graph for Simple VCR

Figure 3 - PH Graph for Simple VCR

4. Result and Discussion

4.1 Analysis of COP and RE using SRWT, DRWT, and DDRWT as an input to the compressor. For the analysis considering fixed evaporator temperature -20 c as, with saturation pressure of p2=1.3286 bar, condenser pressure varies as the compressor power given to the compressor varies with different wind turbine power.

We have three types of wind turbine single-rotor wind turbine, dual rotor wind turbine, and ducted dual rotor wind turbine.in which Compressor power is given from dual ducted wind turbine as it produces more power.

Table 1 - Represents the Power Obtained from a Single Rotor, Dual Rotor, and Ducted Dual Rotor Wind Turbine Power Used as an Input to a Compressor to Operate it to Produce RE

S.NO	(SRWT) Single Rotor Shaft Power (Watt)	(SRWT) Dual Rotor Shaft Power (Watt)	(DDWT) Dual Ducted Rotor Shaft Power (Watt)
1	51.61	61.04	87.56
2	63.47	76.15	97.42
3	80.48	95.74	115.70
4	94.22	132.69	139.52
5	107.82	157.73	164.41
6	134.11	184.82	200.73
7	180.3	240.88	266.32
8	249.59	344.12	410.14
9	281.61	484.35	578.10

Graph 1 Shows the data obtain from analysis of some previous work on wind turbines this shows the variation of wind power obtained from SRWT, DRWT and DDRWT at various wind speeds.

Figure 4 - Compare Power Produced by SRWT, DRWT, and DDRWT
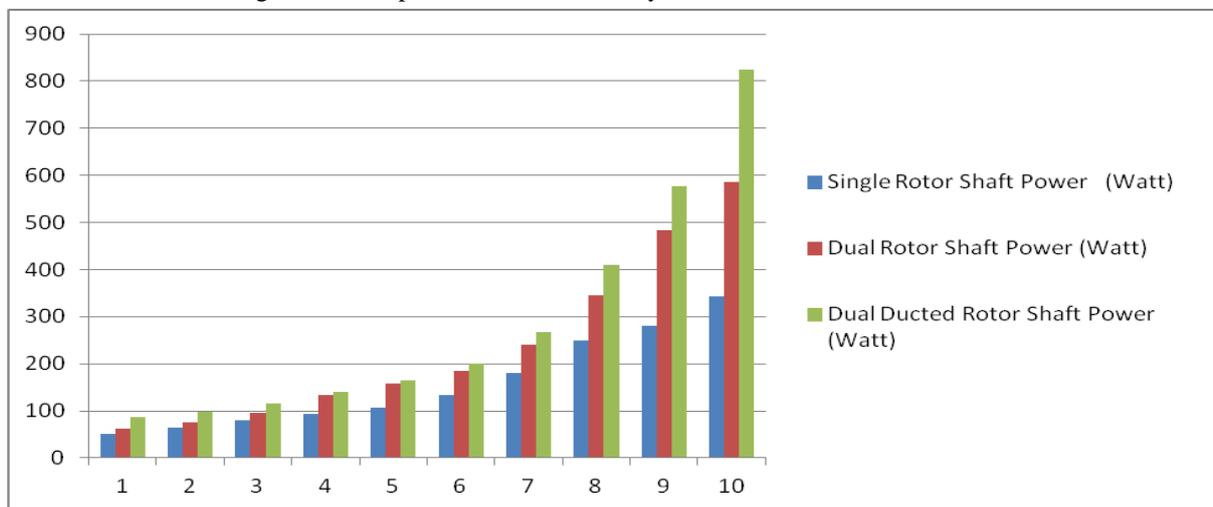
For the analysis considering dual ducted wind turbine power is transmitted to the compressor to operate the system and to produce refrigeration effect. Analysis can also be make considering SRWT and DRWT power input to the compressor.
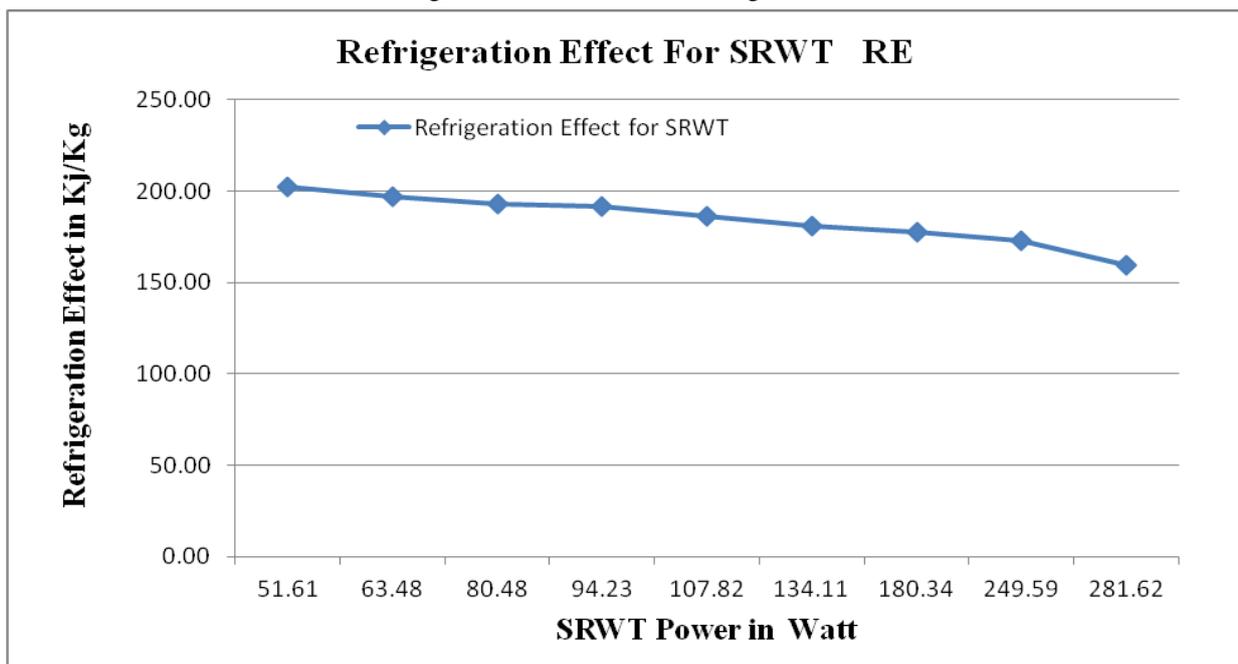
4.1.1 Analysis of COP and RE Using SRWT as an Input to the Compressor

Analysis has been carried on MAT LAB the results are plotted on a graph which has been discussed as follows.

Graph 2

Explanation of Graph –The graph is plotted for the SRWT after the result obtained after analysis on MAT LAB, it shows the variation of RE wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator temperature of -20 C. The graph shows that at the given above condition the RE is 202.53 KJ/kg at 51.61 W and that of 159.26 KJ/kg at 281.62 W of SRWT power. The graph shows that the RE decreases as the power input of SRWT increases.
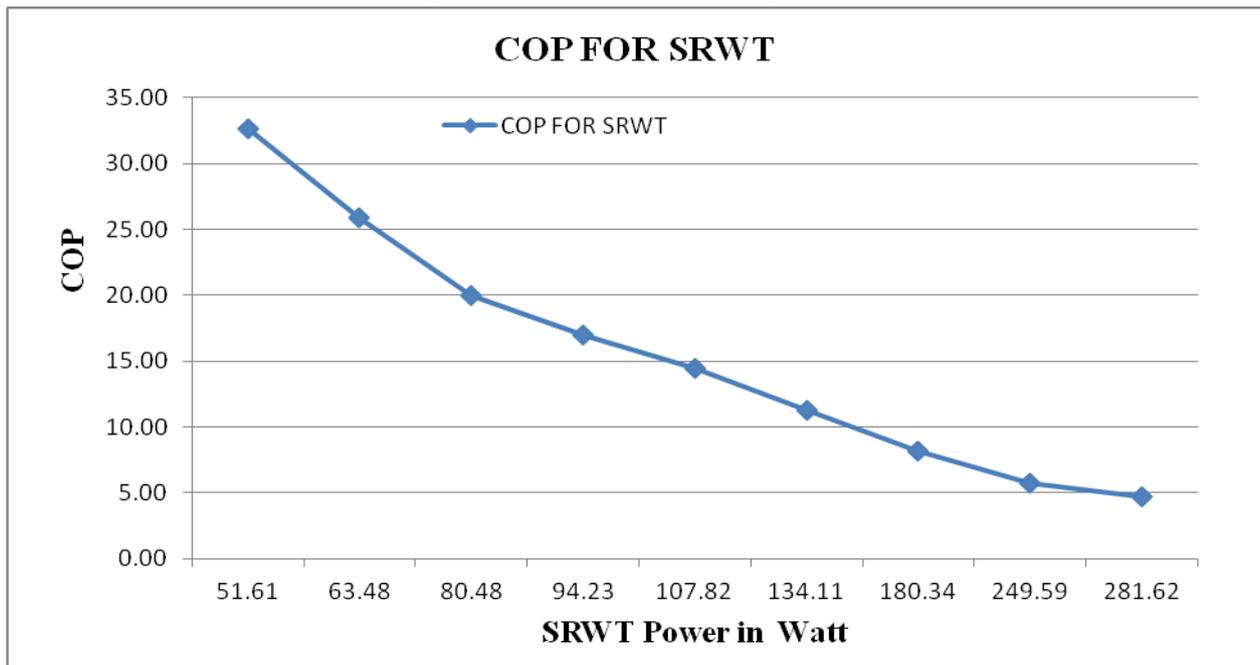
Figure 5 - Variation of RE Using SRWT

Graph 3

Explanation of Graph –The graph is plotted for the SRWT after the result obtained after analysis on MAT LAB, it shows the variation of COP wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator temperature of -20 C. The graph shows that at the given above condition the COP is 32.69 at 51.61 W and that of 4.71 at 281.62 W of SRWT power. The graph shows that the COP decreases as the power input of SRWT increases.
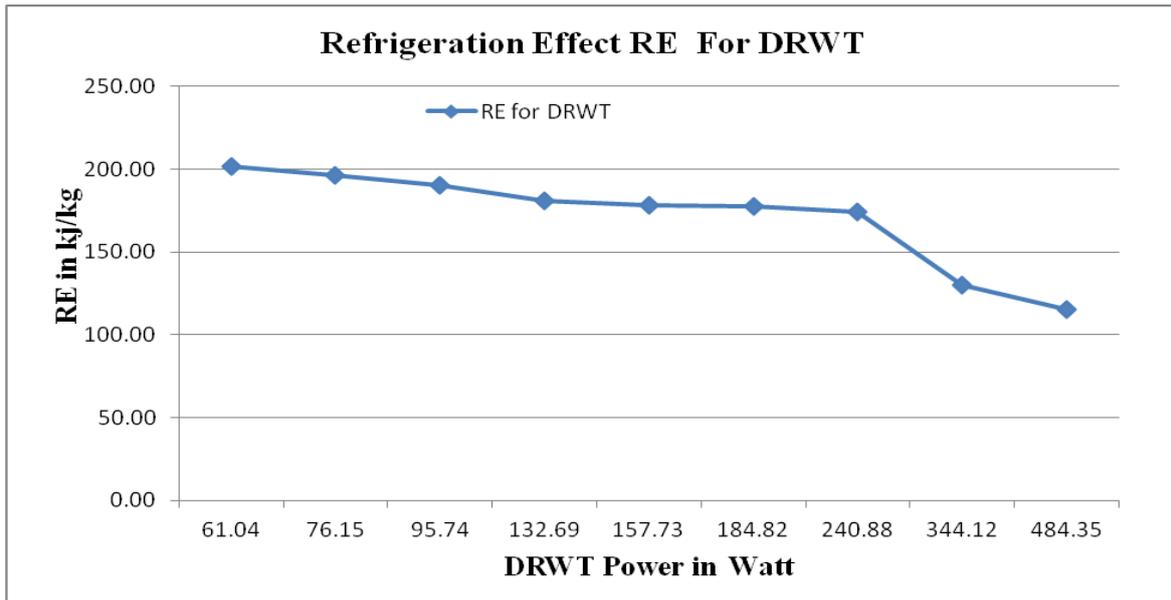
Figure 6 - Variation of COP Using SRWT

COP FOR SRWT

4.1.2 Analysis of COP Using DRWT as an Input to the Compressor

Analysis has been carried on MAT LAB the results are plotted on a graph which has been discussed as follows.

Graph 4

Explanation of Graph – The graph is plotted for the DRWT after the result obtained after analysis on MAT LAB, it shows the variation of RE wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator temperature of -20 C. The graph shows that at the given above condition the RE is 201.45 KJ/kg at 61.04 W and that of 115.07 KJ/kg at 484.35 W of DRWT power. The graph shows that the RE decreases as the power input of DRWT increases.
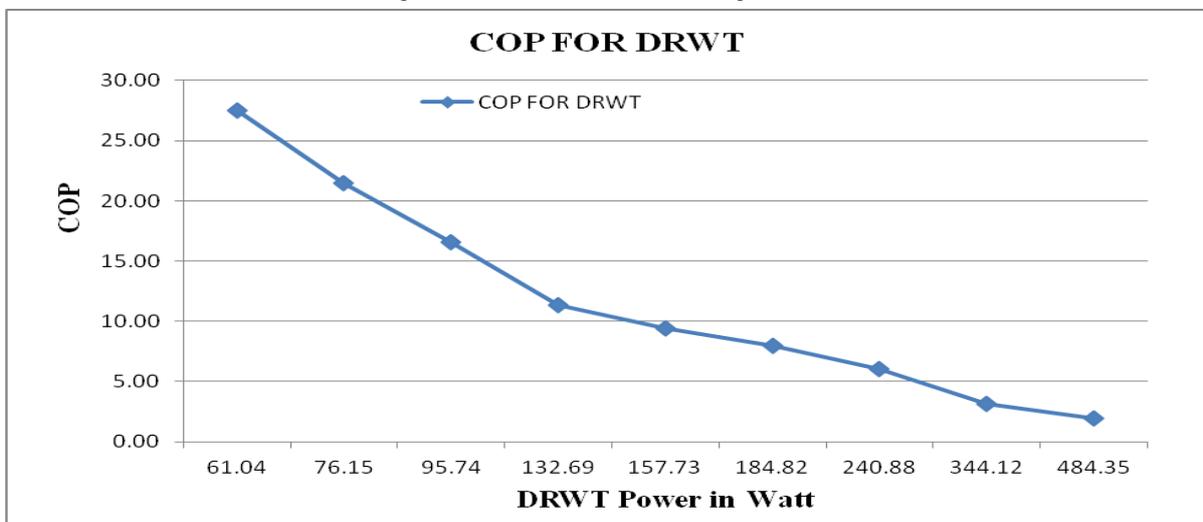
Figure 7 - Variation of RE Using DRWT

Refrigeration Effect RE For DRWT

Graph 5

Explanation of Graph –The graph is plotted for the DRWT after the result obtained after analysis on MAT LAB, it shows the variation of COP wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator temperature of -20 C. The graph shows that at the given above condition the COP is 27.49 at 61.04 W and that of 1.98 at 484.35 W of DRWT power. The graph shows that the COP decreases as the power input of DRWT increases.

Figure 8 - Variation of COP Using DRWT


COP FOR DRWT

4.1.3 Analysis of COP Using DDRWT as an Input to the Compressor

Analysis has been carried on MAT LAB the results are plotted on a graph which has been discussed as follows.

Graph 6

Explanation of Graph –The graph is plotted for the DDRWT after the result obtained after analysis on MAT LAB, it shows the variation of RE wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator temperature of -20 C. The graph shows that at the given above condition the RE is 191.98 KJ/kg at 87.56 W and that of 85.82 KJ/kg at 578.1 W of DDRWT power. The graph shows that the RE decreases as the power input of DDRWT increases.

Figure 9 - Variation of RE Using DDRWT
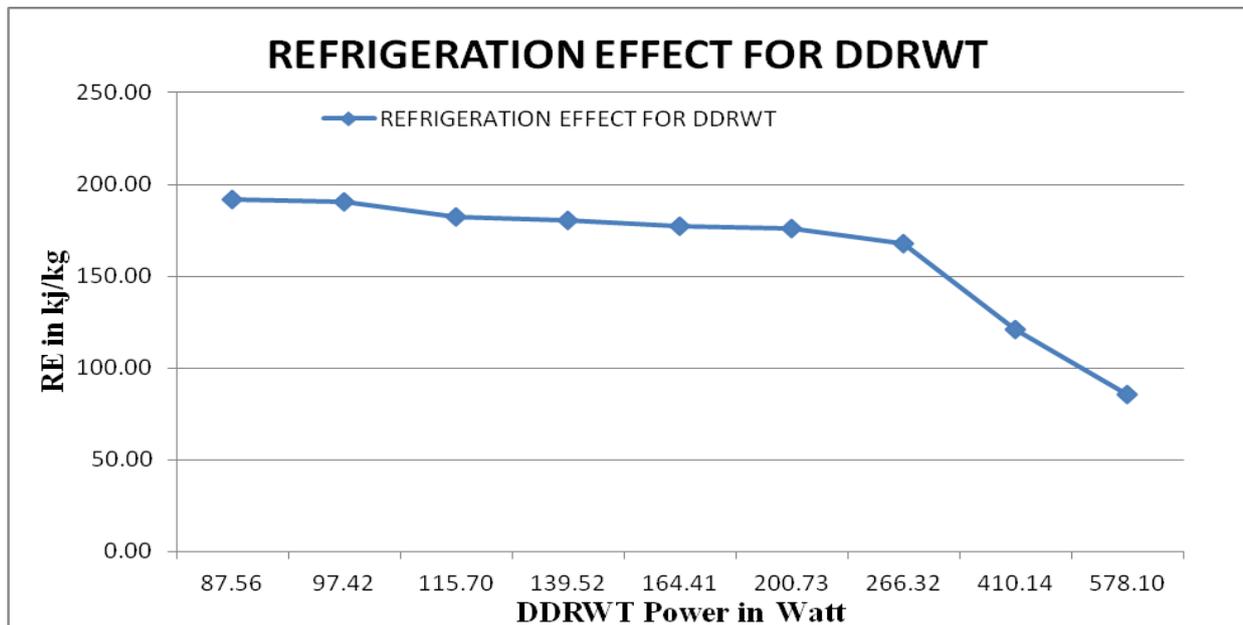
Graph 7

Explanation of Graph –The graph is plotted for the DDRWT after the result obtained after analysis on MAT LAB, it shows the variation of COP wrt power obtain at different wind speeds which is input to the compressor of the VCR air conditioning system to obtain fixed evaporator

temperature of -20 C. The graph shows that at the given above condition the COP is 18.26 at 87.56 W and that of 1.24 at 578.10 W of DDRWT power. The graph shows that the COP decreases as the power input of DDRWT increases.

Figure 10 - Variation of COP Using DDRWT
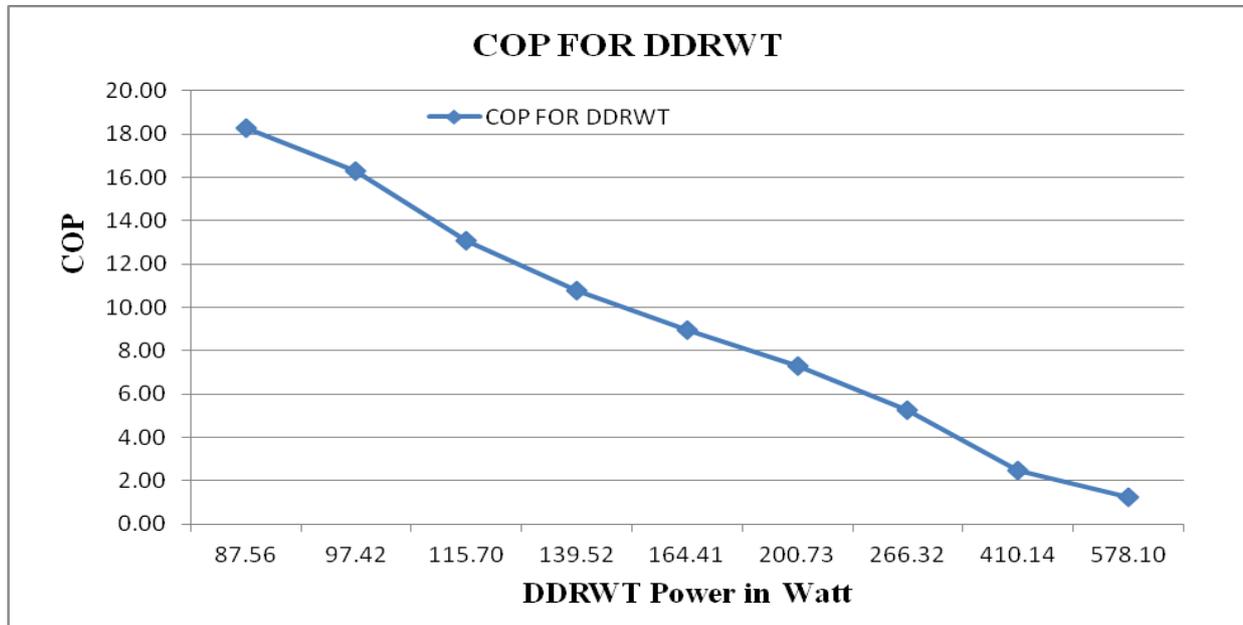
5. Conclusion

After analysis on MAT LAB, it shows the variation of condenser temperature wrt power obtains at different wind speeds which is input to the compressor of VCR air conditioning system to obtain fixed evaporator temperature of -20 C. It is concluded that at the given condition the. RE for SRWT is 202.53 KJ/kg at 51.61 W and that of 159.26 KJ/kg at 281.62 W of SRWT power.COP is 32.69 at 51.61 W and that of 4.71 at 281.62 W of SRWT power.

For DRWT RE is 201.45 KJ/kg at 61.04 W and that of 115.07 KJ/kg at 484.35 W of DRWT power. COP is 27.49 at 61.04 W and that of 1.98 at 484.35 W of DRWT power.

For DDRWT the. RE is 191.98 KJ/kg at 87.56 W and that of 85.82 KJ/kg at 578.1 W of DDRWT power. COP is 18.26 at 87.56 W and that of 1.24 at 578.10 W of DDRWT power. Thus for DDRWT more practical RE, Condensor Temperature, as well as COP, is achieved as compared to SRWT and DRWT.

Further, if we calculate for constant RE for Constant COP then we find that DDRWT can produce more RE as compare to SRWT and DRWT.

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