
JAMI PAPARAO  
Research scholar  
Dept of Mechanical Engg, Aditya college of engineering and Technology, Surampalem, Andhra Pradesh, India.

Mr. K. VIJAY  
Asst Professor  
Dept of Mechanical Engg, Aditya college of engineering and Technology, Surampalem, Andhra Pradesh, India.

Abstract: This project deals with performance of vapor absorption refrigeration system is used to produce refrigeration effect by using the recovery of thermal energy available at exhaust gases of internal combustion engine. The Net heat transfer in the generator from hot flue gases to aqua ammonia strong solution is purely depends upon the heat transfer surface contact area, these surface contact areas basically depends upon the shape of the device.

The COP of the vapor absorption refrigeration system mainly depends upon the heat extracted at refrigeration cabin to the heat supplied at the generator. So if available heat from engine emissions is high in generator contact surfaces then the net heat supplied to the refrigerant will be more there by COP may increase.

I. INTRODUCTION

1.1 REFRIGERATION

It is a process of transferring thermal energy from one position to another in controlled conditions. The work of thermal energy transport is normally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means.

1.2 APPLICATIONS OF REFRIGERATION PROCESS

The best applications of refrigeration are for air conditioning of private homes and public buildings, and refrigerating foodstuffs in homes, restaurants and large storage warehouses. The use of refrigerators in kitchens for storing fruits and vegetables has allowed adding fresh salads to the modern diet year round, and storing fish and meats safely for long periods.

When transporting temperature-sensitive foodstuffs and other materials by trucks, trains, airplanes and seagoing vessels, refrigeration is a necessity.

Dairy products are constantly in need of refrigeration, and it was only discovered in the past few decades that eggs needed to be refrigerated during shipment rather than waiting to be refrigerated after arrival at the grocery store. Meats, poultry and fish all must be kept in climate-controlled environments before being sold.

This refrigeration process also used to liquefy the gases like oxygen, nitrogen, Propane and methane.

For example: In compressed air purification, it is used to condense water vapor from compressed air to reduce its moisture content. In oil refineries, chemical plants, and petrochemical plants, refrigeration is used to maintain certain processes at their needed low temperatures (for example, in alkylation of butanes and butane to produce a high octane gasoline component). Metal workers use refrigeration to temper steel and cutlery.

1.3 VAPOUR COMPRESSION REFRIGERATION SYSTEM

The Vapour Compression Refrigeration system plays an important role in all the applications of refrigeration and air-conditioning. The refrigeration & air conditioning is necessary due to uneven production of products. The air-conditioning is necessary due to advancement in human life and uneven weather conditions.

In Vapour Compression Refrigeration system the working substance is called as refrigerant. The refrigerant by absorbing heat from products or space then converts into vapour. This vapour refrigerant is compressed in compressor to the desired condenser pressure. This is the working principle of Vapour Compression Refrigeration system.

The compressor is a heart Vapour Compression Refrigeration system. To compress the vapour refrigerant to desired condenser of heat extracted or removed from space or product to produce cooling effect.

The performance of the system is defined in terms of coefficient of performance (C.O.P). It is the ratio between refrigeration effects to the work done in compressor. The COP of the system can be influence by evaporation and condenser pressure.

1.4 HISTORY

In 1922, two young engineers, Baltzar von Platen and Carl Munters from the Royal Institute of Technology in Stockholm, submitted a degree project that gained them much attention. It was a refrigeration machine that employed a simple
application of the absorption process to transform heat to cold. The heat source that initiated the process could be fueled by electricity, gas or kerosene, making the system extremely flexible. The two inventors needed money to develop and market their product, however. By 1923, they had come as far as establishing two companies, AB Arctic and Platen-Munters Refrigeration System. Refrigerator production got underway now, albeit on a small scale, at the new Arctic factory in Motala. The absorption refrigeration machine was far from fully developed when Wenner-Gren began to take an interest in it. It was, then, a bold move when he made an offer for the two companies, which meant Electrolux's future would depend on the success of the refrigerator. In 1925, Electrolux introduced its first refrigerators on the market. Intense efforts to develop refrigeration technology were underway at a refrigeration lab that had been set up in Stockholm. The primary goal was to develop an air-cooled system. Platen-Munters' first appliance was water-cooled an fairly impractical solution. This was one of the reasons for bringing physicist John Tandberg to the lab.

1.5 Components of Vapour Compression Refrigeration System

The major components of vapour compression refrigeration system are

- Compressor
- Condenser
- Expansion valve
- Evaporator

1.5.1. Compressor

A refrigerant compressor is a machine used to compress the vapour refrigerant from the evaporator and to raise its pressure, so that the corresponding saturation temperature is higher than that of the cooling medium.

It gives motive force to the whole refrigeration system since the compression of refrigerant requires some work to be done on it, therefore a compressor must be driven by some mover (i.e. motor).

Compressor may be called as a heart of any vapour compression system. The rapid development of refrigeration systems is made possible due to the developments in compressor technologies.

Classification of Compressors

The compressor may be classified in many ways, but the following are some important forms.

1. According to method of compression
   a. Reciprocating compressor
   b. Rotary compressor, and
   c. Centrifugal compressors

2. According to the no. of working strokes
   a. Single acting compressor, and
   b. Double acting compressor

3. According to no. of stages
   a. Stage (or single cylinder) compressors, and
   b. Multi stage (or multi cylinder) compressors

4. According to the method of drive employed
   a. Direct drive compressors, and
   b. Belt drive compressors

5. According to the location of the prime mover
   a. Semi hermetic compressor (direct drive, motor and compressor in separate housings), and
   b. Hermetic compressors (direct drive, motor and compressor in same housings)
   c. Open type compressor.

6. According to the pressure compressors
   a. Low pressure compressors
   b. Medium pressure compressors, and
   c. High pressure compressors.

Hermetic Sealed Compressor

Hermetic compressor as shown in Fig.1.1 is one which is enclosed in a welded shell along with its motor and totally sealed from the atmosphere. Low pressure refrigerant from the ion evaporator enters the casing through a section line. The rotor of the electric motor is press fitted on to the vertical crank shaft and its stator is secured in the casing. The motor windings are directly exposed to the cool vapour refrigerant entering the casing and after compression, the high pressure and temperature vapour refrigerant of leakage of refrigerant with less noisy.

II. Literature Review

Due to the world wide attempt to find energies which are alternative, vapour absorption refrigeration has become a major system for many refrigeration applications. In which thermal energy is available in the V.A.R system can very well substitute the V.C.R system. The fact of LC Engine is a high amount of thermal energy associated with the exhaust gases is wasted. An average energy balance of the energy available in the combustion of fuel in an automobile engine shows that 30% of available energy converted into break power, approximately 30% available energy lost at the radiator and around 30% of available energy is wasted as heat at the exhaust system and reaming energy unaccounted heat loss. Even for a relative small engine, 10 kW of heat energy can be utilized from the exhaust gas. This heat is enough to power an absorption refrigeration system to produce a refrigeration capacity of 4 kW. In this thesis, energy from the exhaust gas of an internal combustion engine is used to power an vapour absorption
refrigeration system. In this thesis an absorption refrigeration system is designed and part of the refrigeration system is analyzed. Modeling and analysis is done in ANSYS. Thermal analysis is done on generator [1].

In our day to day life fuel consumption increasing and environmental pollution is increasing there by global warming increasing. The V.A.R.S offers the possibility of using heat to provide refrigeration effect. For the refrigeration process the required heat input is collected from the exhaust gases of automobiles thereby we can minimize the global warming due to automobiles [2].

The source of power for producing refrigeration effect is heat energy from exhaust gases of internal combustion engine. These hot flue gases heat energy used to run the aqua ammonia vapour absorption refrigeration system which is used to run air conditioning system there by fuel consumption as well as running cost of moving vehicle will reduces [3].

The aqua ammonia V.A.R.system is an economically attractive concept due to the usage of exhaust waste heat energy which is coming from the I.C engines of automobiles, and hot flue gases which is moving through chimney of boiler in steam power plant [4].

By using low grade thermal energy which is coming from I.C engine exhaust gases are used to run the vapour absorption refrigeration system there by atmospheric pollution, global warming gets reduced [5].

A detailed experimental work was carried out to validate the results in real engine operation. Theoretical results show how the absorption refrigeration system decreases the intake air flow temperature down to Temperature around 5 °C and even lower by using the bottoming waste heat energy available in the exhaust gases in a wide range of engine operating conditions. In addition, the theoretical analysis estimates the potential of the strategy for increasing the engine indicated efficiency in levels up to 4% also at the operating conditions under evaluation. Finally, this predicted benefit in engine indicated efficiency has been experimentally confirmed by direct testing [6].

Energy efficiency has been a major topic of discussions on natural resources preservation and costs reduction. Based on estimates of energy resources reduction at medium and long terms, it is vital to develop more efficient processes from energy and exergy standpoints. Environment preservation must also be considered through energy optimization studies. An important point to mention absorption refrigeration systems is the continuing substitution of chlorinated fluorocarbons (CFCs) by alternative refrigerants, according to the Montreal Protocol, signed in 1987 by 46 countries and revised in 1990 to protect the ozone layer. Other motivating factors are the continuous optimization of the performance of internal combustion engines and the increasing utilization of air-conditioning engines, as it reaches the status of essential need for modern life. Internal combustion engines are potential energy sources for absorption refrigeration systems, as about one third of the energy availability in the combustion process is wasted through the exhaust gas. Thus, use of the exhaust gas in an absorption refrigeration system can increase the overall system efficiency. [7] a lot of low grade heat goes waste along with the exhaust gases. Absorption refrigeration systems always attract the users to utilize the low grade waste heat wherever it is available Therefore, in this work, a simulation model of an Indian combined cycle power plant coupled with exhaust heat operated ammonia-water absorption refrigeration system has been developed to investigate the performance of the combined system according to Indian atmospheric conditions which vary throughout the year. Energy and exergy analysis reveals that by having this arrangement, in summer season but, in winter the variation of plant performance with the variation of ammonia condenser temperature has also been studied. [8]. Absorption refrigeration system is appropriate for waste heat utilization of the exhaust for freezing applications. However, it should be noted that the exhaust condition of the diesel engine is not stable because the power output of the diesel engine varies along with the electrical load. The exhaust condition, for instance, might be at non-steady state due to the rapid changes of electrical power output, probably leads to unstable operation of the absorption refrigeration unit. Even worse, the unit might be shut down because of insufficient removal of the rectification heat. Although the power can be always produced at its possible highest capacity in some cogeneration systems because it can be integrated with the electrical grid, the power output of the generator always Changes according to the power demand for an islanding energy system. [9].

The basic objective of developing a vapour absorption refrigerant system for cars is to cool the space inside the car by utilizing waste heat and exhaust gases from engine. The air conditioning system of cars in today’s world uses “Vapour Compression Refrigerant System” (VCRS) which absorbs and removes heat from the interior of the car which is the space to be cooled and further rejects the heat to be elsewhere. Now to increase an efficiency of car beyond a certain limit vapour compression refrigerant system resists as it cannot make use of the exhaust gases from the engine. In vapour compression refrigerant system, the system utilizes power from engine shaft as the input power to drive the compressor of the refrigerant system,
hence the engine has to produce extra work to run the compressor of the refrigeration system utilizing extra amount of fuel [10].

III. DESIGN AND ANALYSIS OF GENERATOR

Specification of practical generator from base paper

Volume of generator $V = 2.9941$ m$^3$
Length of generator $L = 0.85$m
Diameter of generator $d = 0.021$m

Rectangular type generator specifications

Volume of generator $V = 2.9941$ m$^3$
Thickness of generator $T = 0.001$m
Length of generator $L = 0.85$m
Height of generator $H = 0.346$m

Hemispherical type generator specifications

Length of generator $L = 0.85$m
Height of generator $H = 0.6799$m
Thickness of generator $T = 0.001$m
Volume of generator $V = 2.9941$ m$^3$

IV. INTRODUCTION TO ANSYS

ANSYS is an American Computer-aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, United States. Ansys publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer.

ANSYS Fluent, CFD, CFX, FENSAP-ICE

ANSYS Fluent, CFD, CFX, FENSAP-ICE and related software are Computational Fluid Dynamics software tools used by engineers for design and analysis.[12] These tools can simulate fluid flows in a virtual environment — for example, the fluid dynamics of ship hulls; gas turbine engines (including the compressors, combustion chamber, turbines and afterburners); aircraft aerodynamics; pumps, fans, HVAC systems, mixing vessels, hydrocyclones, vacuum cleaners, etc.

ANSYS MECHANICAL

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

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BASIC PROCESS IN ANSYS

1. PRE PROCESSING: Creation of geometry, meshing, defining problem
2. PROCESSING: solving the problem
3. POST PROCESSING: Result.

STEPS FOLLOWED TO DESIGN AND ANALYSIS ON THE TWO DIMENSIONAL GENERATOR

1. CREATION OF GEOMETRY
2. MESHING
3. PROBLAM ASSIGNING (SETUP)
4. SOLUTATION
5. RESULT

CREATION OF GEOMETRY

- Open the ansys work bench.
- Select fluid flow (fluent)
- Select the geometry
Select 2D type analysis
Open geometry window
Select the units in mm
Sketch the 2D view in XY plane and give the dimensions as shown in fig 4.1.4.2

**Fig 4.1 REC.GENERATOR**

- Create the surface from sketches
- Close the geometry window

**MESHING**
- Open mesh window
- Create default mesh for the 2D geometry
- Give the names as inlet, outlet1, outlet2, wall, and heating zone
- Update mesh

**PROBLEM ASSIGNING**
- Open setup window and assign the boundary conditions as mass flow rate Inlet
- Outlet as pressure out let
- Wall as wall
- Heating zone as wall and assign the temperature as 70°C
- Select model as
- Energy: on
- Viscous from laminar to K-E (2equation)
- Multiphase: on
- Assign materials water phase-1 and ammonia phase-2
- Adding from materials library

**SOLUTION**
Assign hybrid initialization
Calculate for 100 iterations for steady state analysis

**RESULT**
Take the results from
Contours for turbulence, pressure.
Vectors for turbulence, pressure
XY plots for turbulence, pressure.

**V. RESULTS AND DISCUSSIONS**

**5.1 EXPERIMENTAL RESULTS**

<table>
<thead>
<tr>
<th>S.N O</th>
<th>LOAD METER READING IN KG</th>
<th>EXHAUST GAS TEMPERATURE</th>
<th>HEAT ENERGY AVAILABLE AT EXHUSAT GASES IN WATTS</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2</td>
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<td>259</td>
<td>2083.2</td>
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</table>

**GRAPH 5.1 FOR LOAD vs. EXHAUST GAS TEMPERATURE OF 5HP 4STROKE SINGLE CYLINDER DIESEL ENGINE**
The exhaust gas temperature gradually increases with respect increase in load due high combustion

**GRAPH 5.2 FOR LOAD VS HEAT ENERGY AVAILABLE AT EXHUSAT GASES OF 5HP 4STROKE SINGLE CYLINDER DIESEL ENGINE**
The exhaust gas available heat energy gradually increase with respect to increase in load due to gradually increase in fuel consumption.

**GRAPH 5.3 FOR LOAD vs. EXHAUST GAS TEMPERATURE OF THE HM-50 MPFI VERSION 4-STROKE 4-CYLINDER PETROL ENGINE**

The exhaust gas temperature gradually increases with respect to increase in load due high combustion.

**GRAPH 5.4 FOR LOAD vs. HEAT ENERGY AVAILABLE AT EXHAUST GASES OF THE HM-50 MPFI VERSION 4-STROKE 4-CYLINDER PETROL ENGINE**

The exhaust gas available heat energy randomly increase with respect to increase in load due to increase in fuel consumption.

**COMPERISION BETWEEN PETROL AND DIESEL ENGINE EXHUST GAS TEMPERATURE AT DIFFERENT LOADS**

**GRAPH 5.5 FOR COMPERISION BETWEEN PETROL AND DIESEL ENGINE EXHUST GAS TEMPERATURE**

**COMPERISION BETWEEN PETROL AND DIESEL ENGINE EXHUST GAS HEAT ENERGY AT DIFFERENT LOADS**

**GRAPH 5.6 FOR COMPERISION BETWEEN PETROL AND DIESEL ENGINE EXHUST GAS HEAT ENERGY**

**Fig 5.2 CONTOURS OF VELOCITY**

**Fig 5.3 VELOCITY VECTORS COLORED BY STATIC PRESSURE**
Hemispherical type generator better than rectangular type generator based on the Efficiency so C.O.P of V.A.R.S will be higher by using hemispherical type generator

VI. CONCLUSION

- The exhaust gases heat energy for 4-Stroke single cylinder 5HP diesel engine at 16 Kg load is 2083.2 Watts which is sufficient to operate 0.1984 Ton vapour absorption refrigeration system.
- The exhaust gases heat energy for HM-50 MPFI version 4-Stroke 4-cylinder petrol engine is 6672.8 Watts which is sufficient to operate 0.635 Ton vapour absorption refrigeration system.
- Out of the selected petrol, diesel engines exhaust gas temperature is high for petrol engine so these petrol engine exhaust gas temperature is used as input to the generator.
- We know from the empirical relations of vapour absorption refrigeration system the cop is function of $T_g T_c T_e$ by keeping $T_c T_e$ as constant., the C.O.P of vapour absorption system proportional to $T_e$

- So in petrol engine exhaust gas temperature is high there by generator temperature will be high then C.O.P of V.A.R.S will be more
- The Net heat energy transfer from hot flue gases to ammonia vapor is for rectangular shape generator is 480.0 Watts.
- The Net heat energy transfer from hot flue gases to ammonia vapor is for hemispherical shaped edge is 570.0 watts.
- From the results Net heat transfer in generator is high for hemispherical shaped heating zone as compared to rectangular shaped heating zone.
- Hemispherical type generator Efficiency 18.59% which is better than rectangular type generator Efficiency 15.75%.
- By the efficient heat transfer in hemispherical shaped heating zone then generator performance is increased then C.O.P of V.A.R.S is improved.

VII. REFERENCES


Automobile Ac by Utilizing Waste Heat and Gases


BIOGRAPHY OF AUTHOR

JAMI PAPARAO was born in Narava (Vill), Gantyada (man) vizianagaram (distict), India, in 1992. He received the B.Tech. degree in Mechanical engineering from the GMR institute of technology (rajam) under jntu Kakinada, India, in 2014, and Pursuing M. Tech from Aditya college of engineering technology (jntu Kakinada) In 2015 August.

KOTAMARTHI VIJAY was born in Rajahmundry, East Godavari District, ANDHRA PRADESH India, in 1990. He received the M. Tech degree in thermal engineering from Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India, in 2014. He is working as an assistant professor in Aditya college of Engineering & Technology, Surampalem, Andhra Pradesh, India.