Design and Performance Analysis of VAR System using Exhaust Gases as Input Source of Energy in Diesel Genset

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Abstract - Depleting fossil fuels is a future challenge. Internal combustion engines are major consumer of fossil fuels. One third of heat energy generated by the automotive internal combustion engine is wasted in the exhaust system. Resulting in the rise of entropy and serious environmental pollution thus there is a demand to utilize the low-grade waste heat energy from exhaust gases. Now a day's diesel generators are having more demand for instantaneous electric energy .The major problem facing diesel gensets are giving lower efficiency due to overheating of genset.
Current project mainly focus on controlling the overheating of gensets to obtain better efficiency and increasing the durability of production of electricity by running refrigeration system using NH3-H2O vapor absorption refrigeration system and exhaust gases as input source of energy. Designing and performance analysis are to be done on the heat exchanger. The heat exchanger changes the phase of refrigerant from liquid to vapor which necessary for the refrigeration process by absorbing heat energy from exhaust gases.

Keywords - VARS, VCRS, COP.

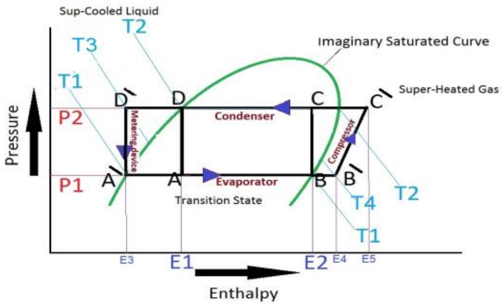
I. INTRODUCTION

A diesel generator is the collaboration of a diesel engine using a electric generator often called an alternator to generate energy. Diesel generating sets have been used in places without connection to the power grid as emergency power supply when the grid fails.
Generating sets are selected based on the electrical load they are intended to supply, the electrical load's characteristics such as kW, kVA, harmonic content, surge currents and non-linear loads. The expected duty as well as environmental conditions such as altitude, temperature and exhaust emissions regulations must also be considered. Set sizes range from 8 to 30 kW for homes, small shops and offices
With the larger industrial generators from 8 kW up to 2,000 kW used for large office complexes, factories.

Problems occurred in diesel generators

- Dry, cracking and otherwise bad belts
- Dead Batteries
- Block heater wear and tear
- Low coolant, no coolant or lack of oil, which causes overheating, over crank,cracked heads, broken pistons, catastrophic engine failure
- Lack of fuel, bad fuel, sludge in the fuel tank or lines
- Burnt components on the boards, electrical components, stepper motors, transfer coils, ice cube relays
- Damages caused by weather and pests

A. Refrigeration System - The refrigeration system is used to withdrawn heat from the lower temperature and sending it to the higher temperate by taking work input. The refrigeration system works on the reverse Carnot cycle. The capacity of refrigeration system indicated in terms of ton of refrigeration (TR). COP is used to indicate the performance of the refrigeration system. COP is the ratio of amount of heat taken to the amount of input work supplied. In case of refrigerator cop is always greater than 1.

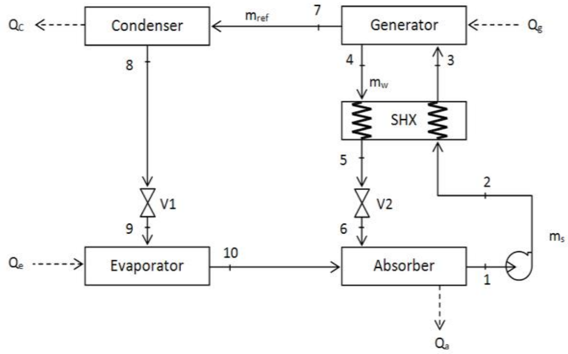


The refrigeration system mainly classified in to two types based upon the source of input energy. They are,

- Vapor compression refrigeration system
- Vapor absorption refrigeration system

Vapor compression refrigeration system requires mechanical energy as input energy to compress the refrigerant coming out of the evaporator. Vapor absorption refrigeration does not require any mechanical energy as input energy because of not present of any compressing device in absorption refrigeration system. Vapor absorption refrigeration system requires small amount of heat energy as input source.

B. Var System - The basic objective of developing a vapor absorption refrigerant system for diesel generator is to further lowering the temperature of a cooling water utilizing heat contained in exhaust gases from engine. In a Vapor Absorption Refrigerant System, the heat required for running the system can be obtained from that which is wasted into the atmosphere from diesel engine.



Hence to utilize the exhaust gases and waste heat from an engine the vapor absorption refrigerant system can be put into practice, which decreases the cooling water temperature. That leads to proper cooling of diesel engines walls there by increases the overall performance of diesel engine and also reduce the problem of leaking of cooling water which is caused by the over heating of engine parts.

Advantgaes -

- Circulation of refrigerant volume very low, which reduces the running cost.
- The performance of the system does not depend upon the load variation.
- COP is high.
- Compare to other system evaporator size is small in this system.

Disadvantages

- For given load it will take more time compared to vapor compression refrigeration system.
- Lower efficiency of system.
- Capital cost of system is high.

C. Parts Of Vars - The following are the main parts of vapor absorption refrigeration system

1. Generator
2. Absorber
3. Condenser
4. Evaporator
5. Separator
6. Pump

II. LITERATURE SURVEY

Arun Bangotra(2017) conducted a experiment on Design - Analysis of Generator of Vapor Absorption Refrigeration System for Automotive Air- Conditioning . The project states that diesel engines can be considered as a potential energy sources for absorption refrigeration systems, because of the energy wasted through the exhaust gas. The absorption refrigeration system may be able to take advantage of the exhaust gas power availability and provide the cooling capacity required for automotive air conditioning. The waste heat energy available in exhaust gas is directly proportional to the engine speed and exhaust gas flow rates.

Satish K. Maurya (2014) conducted a experiment on Cooling System for an Automobile Based on Vapor Absorption Refrigeration Cycle Using Waste Heat of an Engine .the project stated that It is possible to design an automobile air conditioning system using engine heat based on Vapor Absorption Refrigeration System. Also from the Environmental point of view this system is Eco-friendly as it involves the use of Ammonia as a refrigerant, which is a natural gas and is not responsible for ozone layer depletion.

III. OBJECTIVES OF PROJECT

The objective of the project is divided in to the following phases,

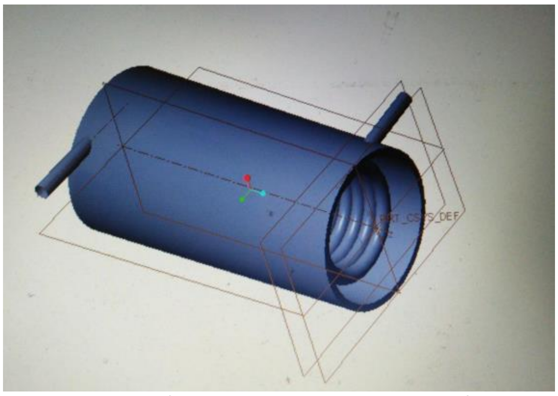
- Theoretical calculations should be done for proper specifications for the design of the generator.
- Fabrications of prototype for vapor absorption refrigeration system evaluating the results and apply for the diesel gensets.

IV. DESIGN OF THE GENERATOR

The numerical calculations done for the specifications for generator. The helical coiled generator is designed for the purpose of separating the ammonia from the NH_3+H_2O by exacting the heat from the exhaust gases.

Specifications of generator for 3KW of heat extraction.

Length = 1.2 m
Diameter of external tube = 0.3 m
Thickness of tube = 0.005 m
Thickness of insulation = 0.010 m
Number of coils = 12
Diameter of coiling = 0.26 m
Diameter of coil = 0.05 m
Thickness of coil = 0.010 m
Mass flow rate of refrigerant =2.058 gr/sec
Mass flow rate of water = 28.82gr/sec
Material of the tube =Mild Steel
Material of the coil = Copper



The exhaust gases from the diesel engine are flow through the tube over the helical coil pipe. The refrigerate flow through the helical coil. Copper having high thermal conductivity used as the material of helical coil. The exchange of heat energy takes place between the exhaust gases and the refrigerant, which is flowing through the helical coil. The higher temperature refrigerate pumped to the chamber where separation of ammonia takes place from the NH3+H2O.The weak mixture from the chamber again sent to the absorber.

V. EXPERIMENTAL SET-UP

Experimental setup used in the present study is consists of an evaporator, Generator, condenser, refrigerant receiver (absorber), capillary tube and measuring equipment along with necessary valve systems. Typical photographic view of experimental setup is shown in figure. The exhaust gases from the engine is sent into the generator where a fine turnings of copper is placed into the filled solution of refrigerant for regeneration of refrigerant vapor that has been adsorbed during earlier cycle. The copper turning has a inlet and an outlet port through which the exhaust gases enters and exits from the inlet and outlet respectively. The heat from the exhaust gases is absorbed by the refrigerant solution (ammonia-water) and gets converted into saturated vapors. The vapors are then condensed in a fin type heat exchanger and the cycle continues.

VI. INSTRUMENTATION

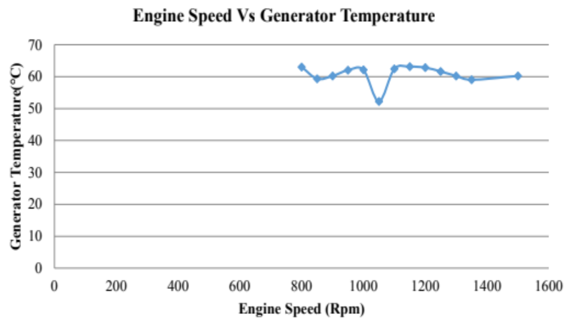
The performance of the VARS during the trails is evaluated based on the derived data from the tests. In experimentation the temperature, pressure and volume flow rate were considered as the main parameters for measuring. A set of calibrated K-type thermocouples were used and connected to a digital temperature indicator for recording temperatures (resolution 1ºC and accuracy ±0.5ºC). In addition, pressure at salient locations is measured in terms of mm of Hg in the experiment for selected refrigeration system. A flow-metering device installed after condenser was used to determine flow rate of refrigerant through the system.

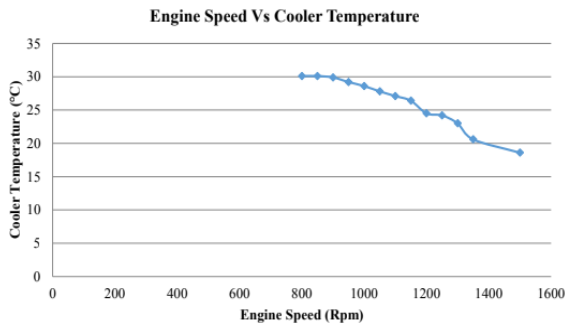
Measurement of temperature The temperature measurement at designated locations was made in the system. The measurements made are namely; i) refrigerant entry to absorber, ii) refrigerant exit to condenser or entry to evaporator, iii) refrigerant exit of absorber and iv) refrigerant entry to evaporator after expansion device thermocouples were employed in the temperature measurements.. Before connecting the thermocouple to digital temperature indicator, the EMF developed by each thermocouple was checked using a high sensitivity data acquisition system, having a sensitivity/resolution of 0.001 millivolts (at ice point and boiling point of water).

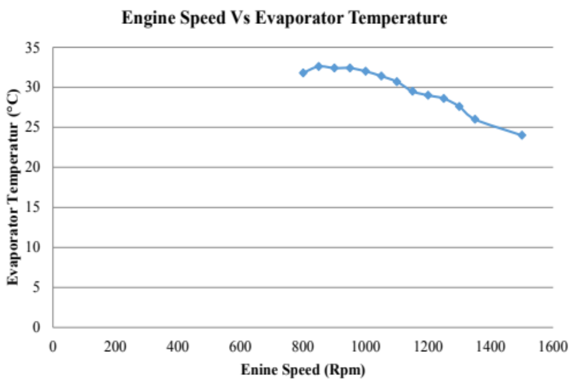
Measurement of flow The measurement of flow through the refrigeration system is measured using a Rota meter consisting of a tapered glass tube with a float. Since the float is a cone shaped weight is pushed up by drag force of the flow against gravity. The graduated scale position corresponding to top surface of the float indicates the volumetric flow rate of refrigerant.

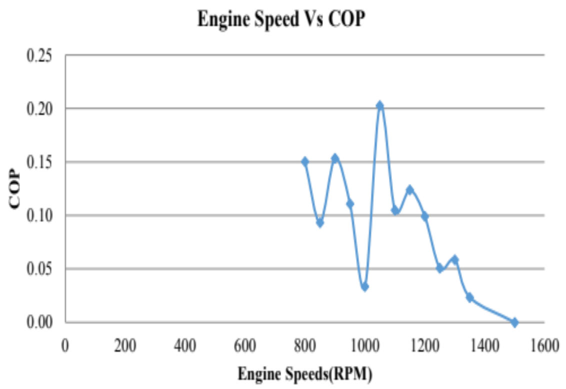
VII. RESULTS AND DISCUSSION

The vapor absorption test is carried out with Ammonia-Water with using the exhaust gases and the parameters which are evaporator temperature, coefficient of performance, power consumption, refrigerating effects is obtained. The parameters are taken by varying speeds of the diesel engine and the performance is evaluated. Below are the results obtained at different speeds with effect to the components.









VIII. CONCLUSION

The exhaust gases based vapor absorption systems have been analyzed using Experimental analysis. The statistical approach used to evaluate the performance of exhaust gases based single- effect Ammonia water vapor absorption system.

The conclusions drawn from the analysis of absorption refrigeration system are as:

1. To recover Energy from engine exhaust gases set was developed

2. The analysis of exhaust gases based vapor absorption refrigeration system revealed thatCOP for cooling lie in the range of 0.012-0.1.2 with generator temperature variation in the range of 45°C-70°C.

3. The analysis of exhaustgases operated vapor absorption refrigeration system revealed that cooling as well as heating coefficient of performance lies in the range of 0.159-0.33 and 1.16-1.332 respectively with generator temperature variation in the range of 50-70°C. The energy efficiency of the system also found to lie in the range of 0.29-0.80.

4. The results obtained for both analyzed systems revealed that irreversibility rate in generator is found to be the highest while it is found to be the lowest in case of condenser.

5. The outcomes of exhaust gases based system revealed that COP for heating applications shows a decreasing trend with an increase in absorber as well as condenser temperature.

6. It also becomes evident that the highest value of non-dimensional physical and chemical energy loss is found to be in generator. The second worst component from non-dimensional rate of physical and chemical irreversibility viewpoint is absorber, followed by solution heat exchanger, evaporator and condenser.

IX. REFERENCE

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