Section A-Research paper
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Design of waste heat recovery refrigeration system

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ABSTRACT

Supply of continuous electricity is still not possible in several remote areas in our country. At such places, this proposed work will be helpful for refrigeration of food, medicines etc. This paper investigates the result of an experimental study carried out to determine the performance of domestic refrigerator when a liquefied petroleum gas . Which comprises of approximately 24% propane, 56% butane and 17% isobutene which is varied from company to company, used as a Refrigerant. The refrigerator used in the present study is designed to work on LPG. Experiment done at atmospheric condition and predict the optimum value of cooling effect with the suitable operating condition of regulating valve and capillary tube of the system. LPG is available in cylinders at high pressure. When high-pressure LPG use as refrigerant is passed through the capillary tube of very small internal diameter, the pressure of LPG gas is dropped due to expansion and phase change of LPG gas liquid to gas occurs in an isenthalpic process. Due to phase change from liquid stage to gas stage latent heat is gained by the liquid refrigerant and the temperature drops down. In this way LPG gas produce refrigerating effect with heating for a confined space.

1 Introduction

Due to the large demand of electricity all over the world, we should recover the energy which is waste but not being utilized further. Due to climatic change and global warming in earth demand accessible and affordable cooling systems in the form of refrigerators and air conditioners. In remote rural areas various purposes such as food cold storage or storing medical supplies may fulfill by low cost refrigeration system using LPG waste heat. The refrigeration effect means a continued extraction of heat from a body, whose temperature is already below the temperature of its surroundings. This refrigerating effect can be used for cooling purposes also. So this work provides refrigeration for remote area needs. High pressure LPG used in conventional VCR (Vapour Compression Refrigeration System) uses refrigerant and produced the refrigerating effect

passing through a capillary tube and expands. After expansion, the phase of LPG is changed and converted from liquid state to gas state and then it passes through the evaporator where it absorbs the heat and produces the refrigerating effect. After evaporator it passes through the gas burner where it burns.

2 Design of basic components of lpg refrigeration system

2.1 Design of capillary tube

The capillary tube is a fixed restriction-type device. It is a long and narrow tube connecting the condenser directly to the evaporator. The pressure drop through the capillary tube is due to friction, due to fluid viscosity, resulting in frictional pressure drop and acceleration, due to the flashing of the liquid refrigerant into vapour, resulting in momentum pressure drop. The capillary tube is the commonly used as throttling device in the domestic refrigeration system. The capillary tube is a copper tube of narrow passage i.e small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration applications varies from 0.45 to 2.18 mm . The capillary tube is shown in picture 1. The decrease in pressure of the refrigerant through the capillary depends on the length of capillary and diameter of capillary. Smaller is the diameter and more is the length of capillary more is the drop in pressure of the refrigerant as it passes through the capillary tube Design parameters for capillary tube are: Cylinder size = 13.8 kg, Dia. cylinder = 295 mm dia. capillary = 1.05mm

2.2 Design of evaporator

The evaporator is the component of a refrigeration system in which heat is removed from air, water or any other body required to be cooled by the evaporating refrigerant. In experimental setup plate and tube type evaporator has been study.

2.3 Types of refrigeration systems

Refrigeration may be defined as the process of maintaining a temperature below that of the surroundings, the aim being to cool space at required temperature. One of the most important applications of refrigeration has been the preservation food, thermal comfort to human. It is also refers as air Conditioning treat of air control its temperature, moisture content, cleanliness, odor and circulation, as required by occupants, All components are shown in fig.

Fig 1 Components of waste heat recovery refrigeration system

2.4 Evaporator

The evaporators through which the evaporators the cooling effect is produced in the refrigeration system. It is in the evaporators when the actual cooling effect takes place in the refrigeration systems. The evaporators are heat exchanger surface that transfer the heat from the substance to be cooled to the refrigerant, thus removing the heat from the substance. The evaporators are wide variety of shape, sizes and designs. Even after cooling the substance the temperature of the refrigerant leaving the evaporator is less than the substance. In the large refrigeration plants the evaporator is used for cold water.

2.5 Pressure gauge

Pressure gauges or vacuum gauges, Pressure gauge is range of high pressure pipes covers most application where there is a need to transfer gas at high pressure. They consist of a steel pipe with steel ball fitted to both ends. Two swiveling connection nipples press these balls against the seating of the connecting hole and thus sealing against gas leakage for improvement effectiveness of the unit. All pipes are pressure tested to 120 M Pa over recommended working pressure.

2.6 High Pressure Regulator:

High pressure regulator is used to send high pressure gas from the cylinders. These are mainly used in functions to stoves.

3 Construction of LPG Refrigerator

The LPG refrigerator is shown in the figure 1. Here one box of the Thermo-coal sheet is making. The thermo-coal sheet size is 15mm used for the LPG refrigerator. The size of the evaporator is 355*254*152 mm^3. Kept the thermo-coal sheet because the cold air cannot transfer from inside to outside of refrigerator. Evaporator is covered with aluminum sheet. The schematically diagram of the LPG refrigeration system is shown fig. The gas cylinder is connected to high pressure regulator, which is connected to high pressure pipes, on the other end of the high pressure pipes pressure guage is connected and another end a copper tube is connected which is connected to the capillary tube. The capillary tube is fitted with evaporator. The evaporator coil end is connected to the stove by another side of high pressure pipe. One pressure guage is put between capillary tube and cylinder and another is put at the end of the evaporator.

4 working principle of lpg refrigerator

The main idea behind LPG refrigerator is to use the LPG as refrigerant to absorb heat. The simple mechanism of the LPG refrigeration working as LPG is stored in the LPG cylinder under high pressure. When the gas tank of regulators is opened then high pressure LPG passes through the high pressure pipe. This LPG is going by high pressure gas pipe to capillary tube. High pressure LPG is converted in low pressure at capillary tube with enthalpy remains constant. After capillary tube, low pressure LPG is passed through the evaporator. LPG is converted into low pressure and temperature vapor from and passes the evaporator which absorbs heat from the chamber. Thus the chamber becomes cool down. Thus we can achieve cooling effect in refrigerator. After passing through the evaporator low pressure LPG is passed through the pipe to burner. And we can use the low pressure of LPG in burning processes.

The LPG Refrigerator is work on the simple Vapour Compression Refrigeration system. The working of VCR system is as, when the compressor is started, it draws the low pressure vapour from the evaporator compresses it isentropically to sufficiently high pressure. Since in

compression work is done on the vapors, its temp also increases and hence it is converted into low pressure adiabatically i.e. enthalpy remains constant. After capillary tube, this low pressure LPG is passed through evaporator. In the evaporator LPG is converted into low pressure and temperature form which it absorbs the heat from the cooling chamber. Thus the cooling chamber cools down.
Hot vapour in compressor under pressure is discharged into the condenser. Taken water or air as cooling medium for condenser, air is absorb the heat from hot vapour. This converts the hot vapour into liquid and the liquid is collected in liquid receiver. Finally the liquid from the liquid receiver at high pressure is then piped to a refrigerant control valve which regulates the flow of liquid into the evaporator. This control valve, while restricting the flow, also reduces the pressure of the liquid with the result the liquid change into vapour of low dryness fraction represented by initial state. During this process the temperature of the refrigerant decreases corresponding to its pressure. Finally, the low pressure and low temperature refrigerant passes through the evaporator coil, where it absorb and its latent heat from the cold chamber or from brine solution at constant pressure and converts into vapour.

The working principal of LPG refrigeration is to absorb heat from surrounding by using the evaporation of a LPG. The pressure of LPG cylinder which is stored liquid LPG is at about 80 psi. We are lowering this pressure of LPG up to pressure 15 psi by using capillary and so that cooling is done on surrounding by absorbing heat isentropically. LPG pressure in cylinder is high, when the regulator of gas tank is opened then high pressure LPG passes through gas pipe. After that this high pressure LPG goes in the capillary tube from high pressure pipe. In the capillary tube this high pressure LPG is converted into low pressure and hence low temperature because of expansion of LPG gas in capillary tube. Thus we can get refrigerating effect in refrigerator. After that the low pressure LPG from evaporator is passed to the burner through high pressure pipe and we can use this low pressure LPG for burning for further application. In this experiment, here use recompressed LPG cylinder instead of compressor. In this way we can achieve refrigerating effect from this system. The experimental setup of LPG refrigeration system is shown in the figure 1.
Use of LPG as a refrigerant also improves the overall efficiency of by 11 to 25%. The ozone depletion potential (ODP) of LPG is almost negligible and low Global warming potential (GWP). The parts are effectively silent in operation with running at zero cost.
It can be useful in remotes area where Electricity is not available. Cooling and storage of essentials in remote areas and in emergency vehicles, such as storage of essential bio-chemicals, injections, etc in an ambulance, is easily possible. It can be used for zero cost air-conditioning of spaces like,restaurants, railways statio, airports, shopping malls, etc which have their own gas turbine power-plants.

5 Conclusions and Result

LPG use as refrigerant and utilizing the energy of the high pressure in the cylinder for producing the refrigerating effect with the help of capillary tube.LPG gas stove, the pressure of LPG after the expansion device and before the burner would be different. COP of the LPG refrigerator is 5.85 and it is greater than the domestic refrigerator. Also, this system is cheaper at initial as well as running time. It does not require an external energy sources. As increase in capillary inner diameter and mass flow rate COP of system increases.

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