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Research Article

Waste Heat as an Alternate Source for Electricity

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Abstract

Energy is an important unit for development. India is a developing country. Energy needs of various sectors has increased rapidly. In the present energy crisis scenario, many people think in terms of alternate energy sources and conservation methodologies. In the context of great uncertainty over future energy supplies, attention is being paid to conserve energy and use it as an alternate source.. Air conditioning units are designed to remove heat from interior spaces and reject it to the ambient air. While this heat is of low grade variety it still represents wasted energy. From an energy conservation point it would be desirable to reclaim this heat in a usable form. The best and most obvious form of heat recovery is for heating water. The main objective of this paper is experimental analysis of waste heat recovery system and utilization of the recovered heat as a source for generating hot water and thus saving electricity.

Keywords: *Energy needs, alternate source of energy, low-grade energy, high grade energy, payback period*

Introduction

In the present world energy scenario, energy management plays an important role. The research on alternate energy source is going on for the past few years. Under these circumstances, energy conservation is the technique to be adopted to face the energy crisis by which conserved energy can be used as an alternate source. Air conditioning units are designed to remove heat from interior spaces and reject it to the outside air. Heat rejection may occur directly to the air, as in the case of most conventional air source units or to water circulating from a cooling tower. The circulating water eventually rejects the heat to the ambient air in the cooling tower. While this heat is of low grade variety, it still represents wasted energy. From an energy conservation point of view, it would be desirable to reclaim this heat in a usable form. The best and most obvious form of heat recovery is for heating water. A one ton air conditioning unit running for twelve hours a day liberate around 6*105kj of heat /day. This heat which is normally discarded outside can be recaptured and can be utilized to provide free hot water.

Energy Conservation

Energy saved is energy produced. Energy conservation does not mean curtailment in energy use at the expense of industrial and economic growth; rather it means effective utilization of energy resources ensuring the same level of economic and industrial activity with lesser inputs of energy. Despite the fact there has been a phenomenal increase in energy production in the past four decades, energy shortage continued to exist. This is mainly because of

- Increasing demand
- Limited resources
- Rapid depletion
- Increasing cost of harnessing the resources. Hence it becomes imperative to attribute a special status to energy conservation in the world.

Waste Heat Recovery

Waste heat is defined as the heat which is rejected from a process at a temperature high enough, above the ambient temperature to permit the extraction of additional value from it. It is generally available in the form of waste steam, Flue gases form boilers and vapors hot condensate from refrigeration and air conditioners etc.

System Description

Vapor compression refrigeration is the primary method used to provide mechanical cooling .All vapor compression systems consist of four basic components: Evaporator, condenser, compressor and an expansion device (Fig 1). The evaporator and condenser are heat exchangers that evaporate and condense the

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refrigerant while absorbing and rejecting heat. The compressor takes the refrigerant vapors from the evaporator and raises the pressure sufficiently for the vapor to condense in the condenser. The expansion device controls the flow of condensed refrigerant at this low pressure back into the evaporator.

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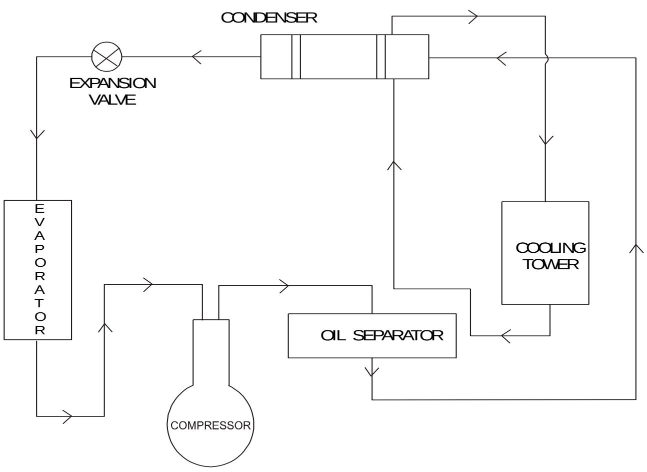

Fig.1 Principle of Vapour Compression System

Heat Available in an Air Conditioning Unit

The heat available for recovery is an air conditioning unit is the heat that is removed from the room or space plus the heat available due to compression of the refrigerant in the compressor. The actual amount of heat available varies as the load on the system changes. It is more difficult to predict the performance. The first thing is to estimate the heat of compression. It is always expressed in terms of rated capacity i.e., how many tons of compression heat is available /ton of cooling capacity. This value will vary, but using a figure of 1 ton of compression heat for every 6 tons of rated cooling capacity is conservative. The second step in estimating the heat available in an air conditioning unit is to take into account that, on the average ,the unit will only operate at 70-80% of it s full rated capacity. Taking the above two factors into account the total heat available in an air conditioning unit can be estimated.

Recoverable Heat

The amount of heat that can be recovered from the total heat available to provide hot water is further limited. In a typical application the refrigerant line leaving the compressor will be connected to a heat exchanger unit. In this way the hot refrigerant gases will flow from the compressor through the heat exchanger. (Fig 2) and then to the condenser. The heat exchanger has water circulating through it that is heated by the hot refrigerant gases i.e., heat is given by the hotter fluid to the colder water circulating through the heat exchanger. The heat exchanger effectiveness also plays an important role. It would take an extremely large heat exchanger to allow the water and refrigerant to achieve the same final temperature. A heat exchanger of this size would not be economical to produce. Heat exchanger effectiveness describes how closely a particular heat exchanger approaches the performance of one of extremely large size. Good heat exchangers have an effectiveness of the range 60-80%.This effectiveness has to be applied to the heat available for removal , to determine the heat actually transferred to water.

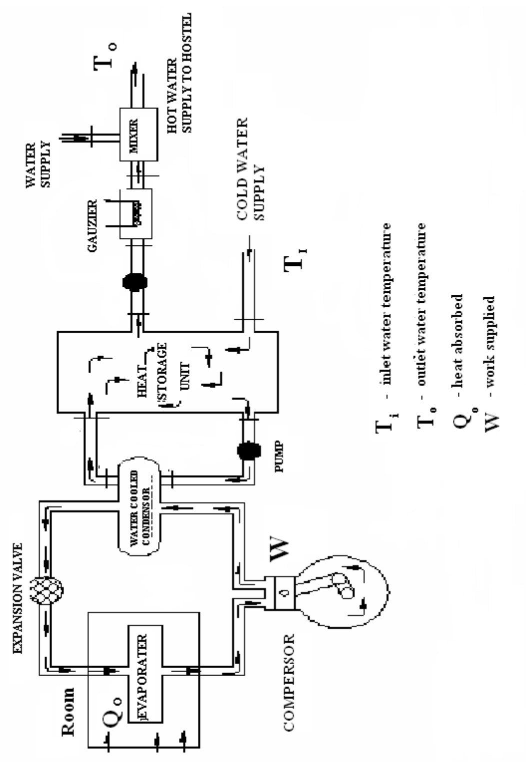

Fig.1 Recoverable Heat

Analysis of Waste Heat Recovery System

The analysis is carried on a Waste heat recovery system for a 16 ton Air-conditioning unit operating for 8 hrs a day .the air conditioning unit is assumed to operate at 75% load capacity. the heat exchanger effectiveness is assumed as 70%.The thermostat is set at 45 C on the hot water side and the entering cold water is taken as 30 C.

16 Ton A/C System Capacities

Refrigeration system capacity
Q c = 16TR
= 16*3.5 = 56 kW
A.C assumed to operate at 75% load
Q 0 = 56*0.75
= 42 KW
For 6 ton of refrigeration 1 ton of work is required
Q t = Q 0 + W
= Q 0+ (Q 0 / COP)
= 42 + 42*1\6 KW
= 49 KW (OR) KJ\S
The efficiency of the heat exchanger is assumed to be 70%
Q k = 49*0.70 KW
= 34.7 KW
Hours of Operation of Refrigeration System
Daily heat available = Qk *3600
=34.7*3600
=123x103kJ/hour
Every liter of water requires 4.184kJ of heat to raise its temperature through one degree centigrade.
The energy required /liter to heat the water to 45 ºC (Q S) = 1*4.184*(45-30)
=62.76kJ/litre
Litres of hot water that can be produced
using this heat recovery system = Q k/ Q S
= 123*103/62.76 =1900 liters/hour

If the air conditioning unit is operated 8 hours a day,
Liters of hot water that can be produced = 1900*8
=15195 liters/day

Economic Analysis

Hot water utilization
Quantity of hot water required for an individual for bathing = 30 liters
Quantity of hot water available = 15195 liters/day
No of individuals who can utilize hot water =15195/30
= 506 individuals
If Electric power is used
Total heat required= 15195*4.184(45-30)
= 954*10 3 Kj/day
No of Electric units consumed
= 954*10 3/3600
= 265units/day
Cost incurred for electricity /day
= 265*3
= Rs795/day
Annual cost incurred = 795*30*6[Considering hot water requirement for 6 month period]
= Rs 143100
Additional to be incurred for Waste heat recovery system
Heat exchanger
= Rs150000
5 H.P Motor with pump for pumping hot water = Rs 20000
Water tank (10*10*10) for storing hot water = Rs200000

Total cost = Rs 3.7 lakhs

If the hot water is to be sent to the place of requirement it may involve additional cost for pipe line and insulation.
Simple Payback period (N) = 3.7lakhs/1.43lakhs =2.6Years

Significance of Undertaking this as a Project in the Context of Current Status

- In India being a developing country faces many problems in providing electricity to the 100 crore population.
- Understanding the requirement, the AICTE New Delhi has recently sent a notification to various educational and R & D Institutions to start energy related courses.
- Having the present average short fall in electricity supply to demand as 10 % and peak supply demand short fall about 39%, conservation of electricity usage gets highest priority.

Executing this as a project will conserve about 47,700 units of electricity per year.

- Engineering Educational Institutions.

No of Colleges in Tamilnadu: 250
Possible electricity savings: 47700 *250units/year (For KEC)
: 1192500units/year

Limitations of the System

- High initial investment is needed for this system for commercialization.
- Design of heat storage device is a tedious process
- The heat can be removed only when the chiller is operating
- Heating to higher temperature results in lower output.

Conclusion

By implementing waste heat recovery system for a 16ton air conditioning unit it is possible to supply around 15000 liters of hot water which can be utilized for 500 individuals.. This system can be effectively implemented in educational institutions, hotels and residential complexes having central air conditioning facilities. In educational institutions it can be utilized for supplying hot water for student's hostel and thus the recovered heat acts an an alternate source and thus huge amount of electicity can be saved . Heat recovery system can be installed for air conditioning units as small as 2 tons to very large chillers. By adding heat recovery unit, the capacity of the air conditioning unit can be slightly improved Heat recovery units also has certain limitations. The limitations can be over come by making some changes in the current design but are possible with the existing knowledge. Last but not the least -Problems are the root of progress and are bread and butter to the engineer

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