ISSN(Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Eco-Friendly Electricity Production from the Waste Heat of Air Conditioners

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ABSTRACT: This is a new innovation that can be developed. Here I am going to use the waste heat of air conditioner so as to produce the electricity by using the Stirling engine because this waste heat creates the thermal pollution in the environment. The waste heat from the air conditioners has caused a temperature rise of 1°–2°C or more on weekdays in the Tokyo office areas. This heating promotes the heat-island phenomenon in Tokyo on weekdays.
Now these air conditioners creates the thermal pollution in the environment and hence rising the temperature of the environment .Air conditioner generally emit the waste heat air whose temperature is about 50°c which heat the environment. Today the demand of energy is increasing tremendously, but available energy lacks in supply. Hence, there is no option for proper and efficient utilization and conservation of energy. In this paper the main stress is given on energy conservation by using technique of utilizing waste heat from Air-conditioning system. Actually the focus is on the use of the waste heat rather than improving the COP of the air- conditioners; if also we improve the COP of air conditioners gradually it would emit some waste heat so I want that waste heat to be used up. As I have used air conditioner's waste heat to produce electricity so similarly there are various other appliances which emit the waste heat in the surrounding so here also we could use the Stirling engines and Geothermal heat pump concept to produce the electricity and hence can reduce the thermal pollution in the environment.

KEYWORDS: Stirling engine, Geothermal heat pumps

I. INTRODUCTION

The Stirling Engine relies on the property of gases that they expand when heated and contract when cooled (Charles' Law). If the gas is contained within a fixed volume, its pressure will increase on heating and decrease on cooling. If the gas is held in a variable volume container, constructed from a movable piston in a cylinder closed at one end, the pressure increases and decreases will cause the piston to move out and in. Repeated heating and cooling will cause a reciprocating movement of the piston which can be converted to rotary motion using a conventional connecting rod and a crankshaft with a flywheel.

Unfortunately the rate at which the temperature of the gas can be varied by heating and cooling the cylinder is limited by the large thermal capacity of practical pistons and cylinders. This problem however can be overcome by maintaining one end of the cylinder at a constant high temperature and the other end at a constant cold temperature and moving the gas from one end of the cylinder to the other. This is accomplished by means of a loose fitting piston, known as the displacer, which moves back and forth inside the cylinder, thus shuttling the gas from one end to the other. As the displacer moves, the gas leaks around the gap between the displacer and the cylinder wall. The displacer produces no power itself and only uses enough energy to circulate the gas within the cylinder. Power is extracted from the thermal system by using the volume/pressure variations of the gas at the cold end of the cylinder to push a separate "power piston" back and forth. Alpha Configuration- A fixed amount of air, or other working fluid, is enclosed within two cylinders, one hot and one cold, and shuttles forwards and backwards between the two. The air is heated and expands in the hot cylinder and is cooled in the cold cylinder where it contracts, giving up its energy to perform mechanical work in the process.

Note: The two pistons are connected to a crankshaft but their motions are 90 degrees out of phase with each other. This means that when one piston is at the top or the bottom of its stroke, the other will be half way between the top and the bottom. Many ingenious mechanisms have been developed to provide the delayed motion between the pistons. For the

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sake of simplicity only simple crankshafts are shown in fig.1, fig.2, fig.3, fig.4.

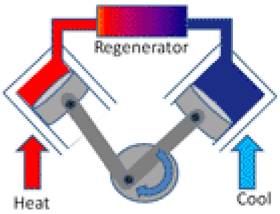

Fig. 1

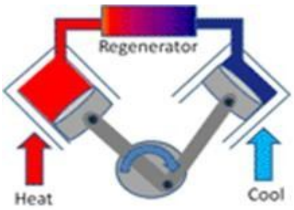

Fig. 2

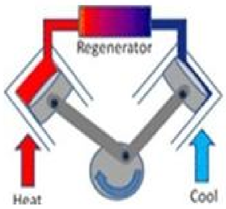

Fig. 3

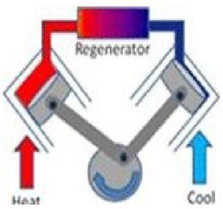

Fig. 4

1.1 The working fluid (gas) is heated and expands pushing the hot piston to the bottom of the cylinder, turning the crank shaft, thus extracting work from the hot gas. Expansion continues causing the gas to flow towards the cold cylinder. The piston in the cold cylinder which is 90 degrees (a quarter revolutions) behind the hot piston in its cycle is also pushed downwards extracting more work from the hot gas.

1.2 The gas is now at its maximum volume. The momentum of a flywheel on the crankshaft now pushes the piston in the hot cylinder towards the top of its stroke forcing most of the gas into the cold cylinder pushing the cold piston downwards. In the cold cylinder the gas cools and its pressure drops.

1.3 As the hot piston reaches the top of its stroke almost all the gas has now transferred to the cold cylinder where cooling continues and the gas contracts reducing the pressure even more. The reduced pressure allows the cold piston to rise. The power of the flywheel momentum, compresses the gas and forces it back towards the hot cylinder.

1.4 The gas reaches its minimum volume and forced into the hot cylinder where it starts to push the hot piston downwards. The gas is heated once more in the hot cylinder where its pressure increases and it expands pushing the hot piston downwards in its power stroke and the cycle starts again.

II. REGENERATOR

The regenerator located in the air passage between the two pistons is not strictly necessary but serves to improve the efficiency of the engine. It is typically a metal or ceramic matrix with a large surface area capable of absorbing or giving upheat. As the gas cycles from the hot cylinder to the cold cylinder, some of its heat is transferred to the regenerator thus helping to cool the gas. As the cold gas returns to the hot cylinder it picks up heat from the regenerator on the way back. This reduces both the amount of heat which must be put into the gas by the heat source and also the amount of waste heat which must be removed from the gas by the cooling system. It thus reduces the fuel consumption and improves the overall working cycle efficiency. The gas transfer passage between the two cylinders is essentially dead space and in most designs this kept as short as possible.

The working fluid may simply be air but other gases such as Hydrogen, Helium and Nitrogen may be used to increase

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the specific power. The Stirling Engine (Gamma Configuration) The Stirling gamma configuration is simply a Stirling beta engine in which the power piston is not mounted coaxially with the displacer piston but in a separate cylinder. This avoids the complications of the of the displacer piston linkage passing through the power piston.

III. STIRLING ENGINE GAMMA CYCLE

A fixed amount of working fluid (gas) is maintained within the cylinders by the pistons which form a gas tight seal with the cylinder walls. The displacer is a loose fit within the hot cylinder, allowing the gas to pass down the sides as it moves up and down. As with other Stirling engines, the gas is alternately heated and cooled causing it to expand and contract as it shuttles between the hot and cold cylinders transferring its energy to the power piston in the cold cylinder.

IV. COMBINED HEAT AND POWER

The Stirling engine is ideal for use in small Combined Heat and Power installations for capturing waste heat. Stirling engine generators with electrical power outputs between 1 kW and 10 kW are available for domestic applications with the waste heat being used by the central heating boiler. Overall thermal efficiencies of these installations can be as high as 80%.

V. GEOTHERMAL HEAT PUMPS

Geothermal heat pumps (GHPs), sometimes referred to as Geo Exchange, earth-coupled, ground-source, or water-source heat pumps, have been in use since the late 1940s. They use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This allows the system to reach fairly high efficiencies (300% to 600%) on the coldest winter nights, compared to 175% to 250% for air-source heat pumps on cool days.

Although many parts of the country experience seasonal temperature extremes -- from scorching heat in the summer to sub-zero cold in the winter—a few feet below the earth's surface the ground remains at a relatively constant temperature. Depending on latitude, ground temperatures range from 45°F (7°C) to 75°F (21°C). Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger.

As with any heat pump, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

A dual-source heat pump combines an air-source heat pump with a geothermal heat pump. These appliances combine the best of both systems. Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units. The main advantage of dual-source systems is that they cost much less to install than a single geothermal unit, and work almost as well.
Even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the additional costs are returned to you in energy savings in 5 to 10 years. System life is estimated at 25 years for the inside components and 50+ years for the ground loop. There are approximately 50,000 geothermal heat pumps installed in the United States each year. For more information, go to:

5.1 TYPES OF GEOTHERMAL HEAT PUMP SYSTEMS

There are four basic types of ground loop systems. Three of these -- horizontal, vertical, and pond/lake -- are closed-loop systems. The fourth type of system is the open-loop option. Which one of these is best depends on the climate, soil conditions, available land, and local installation costs at the site. All of these approaches can be used for residential and commercial building applications.

The loop can be in a horizontal, vertical, or pond/lake configuration. One variant of this approach, called direct

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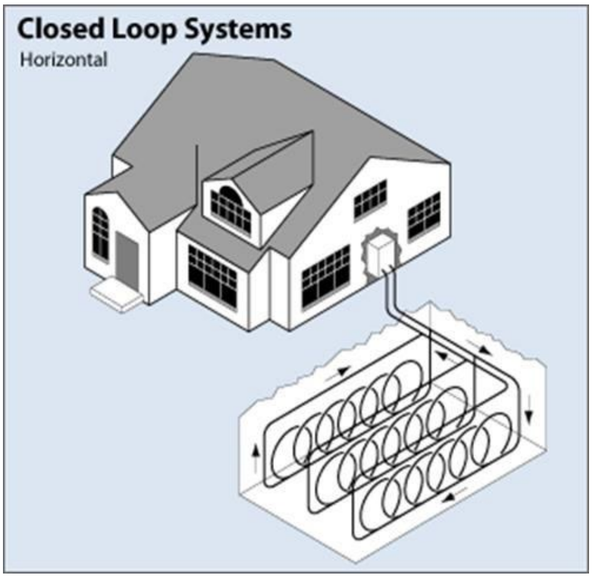
exchange, does not use a heat exchanger and instead pumps the refrigerant through copper tubing that is buried in the ground in a horizontal or vertical configuration. Direct exchange systems require a larger compressor and work best in moist soils (sometimes requiring additional irrigation to keep the soil moist), but you should avoid installing in soils corrosive to the copper tubing. Because these systems circulate refrigerant through the ground, local environmental regulations may prohibit their use in some locations.

HORIZONTAL SYSTEM

This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two- foot wide trench. The Slinky method of looping pipe allows more pipe in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications



VERTICAL

Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100 to 400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.

POND/LAKE

If the site has an adequate water body, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.

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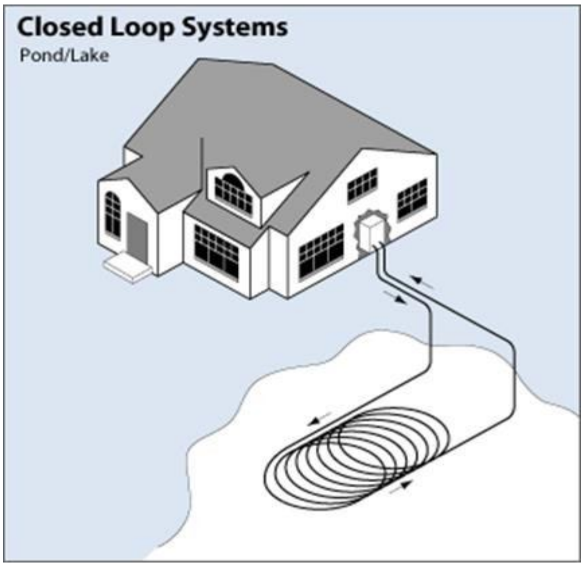
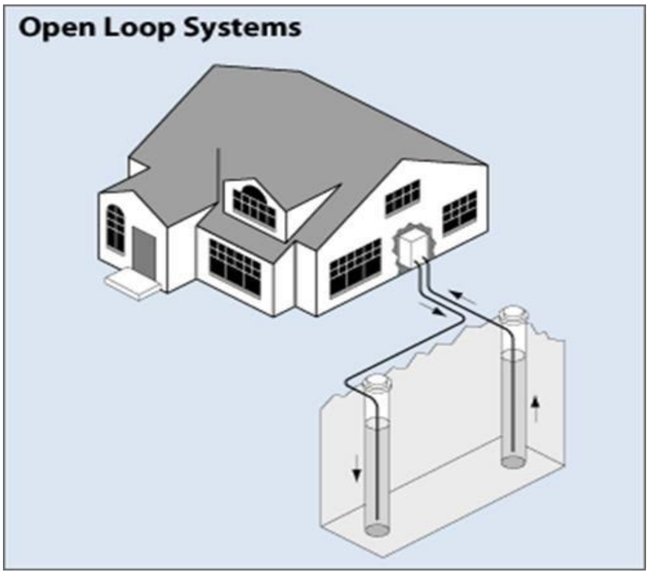


OPEN-LOOP SYSTEM

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.



Geothermal Cooling

During the summer, Climate Master geothermal heating and cooling systems absorb heat from your home and transfers it to the underground loop where it is then absorbed by the cooler earth. The geothermal heat pump uses the cool water returning from the earth to create cool, dehumidified air for your home.

When you need cooling the most, the outside air is hottest. A traditional air source heat pump must work hard to force the heat from your home into the already heat saturated air. In contrast, a geothermal heat pump consumes less energy

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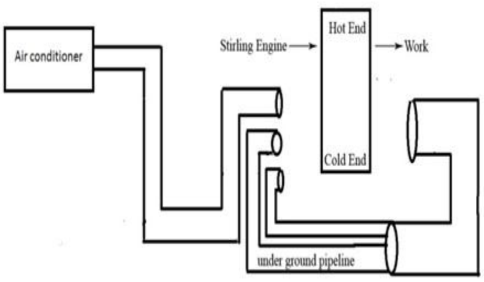
as it easily rejects heat into the cool earth, making geothermal cooling significantly more energy efficient.

Methodology- As we know that air conditioners emit hot air as waste heat which cause thermal pollution in the environment; so here is the method or the idea to use this waste heat as well as reduce the thermal pollution.
Geothermal heat pumps are the device which cools the hot air during summer and heats the cold air in winters these are assembled underground. During summers ACs are used by multinational company and common people; so I thought to use a pipe which takes or sucks the hot air of AC with the help of a fan and then takes it to the geothermal pump assembly which cools the hot air and lowers its temperature now this air is subjected to Stirling engine this cool air lowers the temperature of one end of the Stirling engine as a result of which compression of gas inside the Stirling engine takes place while the other end of the engine is subjected to the hot temperature of the summer; as a result of which rise in temperature causes the expansion of the gases and hence in this way the piston due to compression and expansion of the gases reciprocates; and hence we could convert this reciprocating motion into rotatory motion which is necessary for the production of electricity. In this way we are using the engine which work on temperature difference and no fuel is required.

Another aspect is that air conditioners are used to maintain the temperature of the room during winters; and they also emit hot air waste. Now as we know that a geothermal heat pump heats the cold air during winter; now if we introduce a pipe at the end of AC which intakes or sucks the hot air to the geothermal heat pump; this geothermal heat pump further heats the hot air of the AC. Now this hot air is subjected to one end of the Stirling engine. As a result of which gases in the Stirling engine expands. The other end of the Stirling engine is subjected to the atmospheric winter temperature (cold reservoir) As a result of which compression of the gas takes place; this compression and expansion simultaneously causes the reciprocating motion of the pistons. And hence this reciprocating motion can be converted into rotatory motion for the production of the electricity.

Important aspects-We know that Stirling engine works on temperature difference so greater the temperature difference more is the work which we get as output. So it is necessary to maintain a big temperature difference. So to maintain temperature difference we have used the geothermal heat pumps. So our temperature difference establishments depends more on the type of geothermal pumps we use. And work output depends on type of Stirling engines we use and temperature difference. Block diagram of our Methodology



GEO THERMAL ASSEMBLY

Equations
Conversion Efficiency:-
The theoretical efficiency η of the Stirling engine is given by
Carnot's Law thus:

$\eta = (T_h - T_c)/T_h$ or $\eta = 1 - T_c/T_h$

Where T_c is the temperature of the gas when it is cold and T_h is the temperature of the gas when it is hot.

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