Thermal Power Plant Generation from Waste Sources

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ABSTRACT: Pollution, population, electricity, transportation these are some words everyone talk about this every day that he is facing this problem or other but one we must know problems are create by us. In recent years, an increasing concern of environmental issues of emissions, in particular global warming and the limits of energy resources has resulted in extensive research into novel technologies of producing electrical power. Thermoelectric power generators have emerged as a promising alternative green technology due to their distinct advantages like environmentally friendly, lower production cost etc. Thermoelectric power generation offer a potential application in the direct change of waste-heat energy into electrical power where it is unnecessary to consider the cost of the thermal energy. The application of this alternative green technology in converting waste-heat energy directly into electrical power can also improve the overall efficiencies of energy conversion systems. In this paper, the basic ideas of thermoelectricity including their importance and relevant applications to waste-heat energy, noise/vibration is discussed.

KEYWORDS: Thermal power plant, Rankine cycle, Thermoelectric, Vibration, Waste-heat recovery, Environmental issue.

I. INTRODUCTION

Thermoelectric power generation (also known as Thermoelectricity) offers a promising technology in the direct change of low-grade thermal energy, such as waste-heat energy, into electrical power. Thermoelectric power generation offer a potential application in the direct change of waste-heat energy into electrical power. When “electrons” are in motion, we have an electrical current (i.e., charge per unit time per unit area), Electrical voltage (“pressure”) usually is the driving force. But, other forces like temperature difference and therefore flow of thermal energy or heat can drive the electrons! See beck (1822) discovered this. N-type is phosphorous doped silicon (creates extra loose electrons). P-type is Boron doped silicon (creates extra loose holes) Thermoelectric power generation (TEG) typically uses special semiconductor materials which are optimized for the See beck effect. Current thermo electric conversion efficiency is too low to compete with dynamic technologies for stand-alone. But TE technology has valuable features.

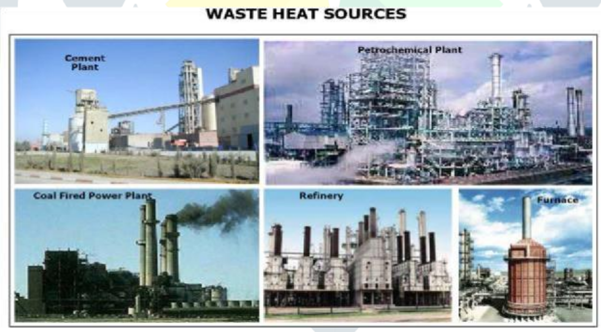

Figure 1- Waste heat sources

Technologies for Waste Heat Recovery Power generation: -

- ➢ Commercial Technologies
  – Single Fluid Rankin Cycle
  - Steam cycle
  - Hydrocarbons
  - Ammonia
  – Binary/Mixed Fluid Cycle
  - Ammonia/water absorption cycle
  - Mixed-hydrocarbon cycle
- ➢ Emerging Technologies
  - Supercritical CO_2 Brayton Cycle
  - Thermoelectric energy conversion
- ➢ Combined Cycles

II. ENVIRONMENTAL ISSUES

Environmental issues in thermal power plant mainly include the following:

- Air emissions
- Energy efficiency and Greenhouse Gas emissions
- Water consumption and aquatic habitat alteration
- Effluents

- Solid wastes
- Hazardous materials and oil
- Noise

Thermal Discharges**-** Thermal power plants consist of steam-powered generators and once-through cooling systems use significant volume of water to cool and condense the steam for return to the boiler. The heated water is normally discharged back to the source water (i.e., river, lake, or the ocean) or the nearest surface water body. In general, thermal discharge should be designed to ensure that discharge water temperature does not result in exceeding relevant ambient water quality temperature standards outside a scientifically established mixing zone. The mixing zone is typically defined as the zone where initial dilution of a discharge takes place within which relevant water quality temperature standards are allowed to exceed and takes into account cumulative impact of seasonal variations, ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations.

Noise**-** Principal sources of noise in thermal power plants include the turbine generators and auxiliaries; boilers and auxiliaries, such as coal pulverizers; reciprocating engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. Thermal power plants used for base load operation may operate continually while smaller plants may operate less frequently but still pose a significant source of noise if located in urban areas.
It is not possible to reduce much amount of the noise but these noises create vibration and can be used in power generation using piezoelectric generation technology. Piezoelectric generators work because of the piezoelectric effect.

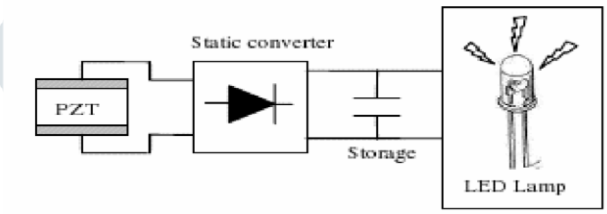

Figure 2- Circuit arrangement for piezoelectric

This is the ability of certain materials to create electric potential when responding to mechanical changes. To put it more simply, when compressed or expanded or changing shape a piezoelectric material, will some voltage.

III. THERMOELECTRIC POWER GENERATION MATERIALS

To make a good thermoelectric it is required that

$$ZT = \frac{\alpha^2}{\rho\lambda} * T \quad \text{.... (1)}$$

Where, α = see beck coefficient –large
ρ = Resistivity –small
λ = Thermal conductivity – small

Conflicting needs are development of novel materials, material tailoring-crystal chemistry and composites-microstructure, nanostructure. In thermoelectric up-to-date best bulks are Bi2Te3/Sb2Te3, PbTe, Si-Ge and new bulk materials are Skutterudites, Heusslen alloys, Complex Chalcogenides, oxides.

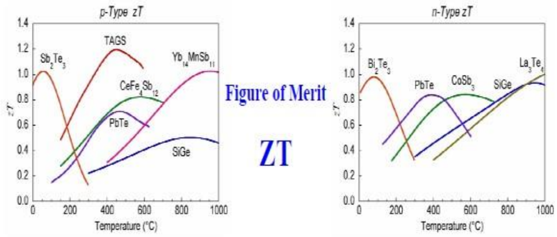

Figure 3- Figure of merit ZT

Some special and interesting materials which are related to power factor to highly doped semiconductors. For almost all typical thermoelectric materials, namely low gap semiconductors, if doping is increase, the electrical conductivity increment but the see beck coefficient is reduce.

$$Pf = \frac{\alpha^2}{\rho} \quad \text{...... (2)}$$

Nanotechnology in thermoelectricity:-
(2D quantum wells, 1D nano wires, 0D quantum dots)

$$ZT = \frac{S\ \ \sigma T}{K}{}_2 \quad \text{...... (3)}$$

ZT ~ 3 for desired goal
Where, S = see beck coefficient
σ = Conductivity

T = Temperature
K = Thermal conductivity

A limit to *Z* is rapidly obtained in conventional materials So far, best bulk material (Bi0.5Sb1.5Te3) has *ZT* ~ 1 at 300 K

Low dimensional physics gives extra control:
(1) Increased density of states due to quantum confinement effects
⇒ Increase *S* without reducing s
(2) Boundary scattering at interfaces can reduce k > s.
(3) Possibility of materials engineering to further improve *ZT*

Low dimensionality- impact on thermo power, thermo conductivity:

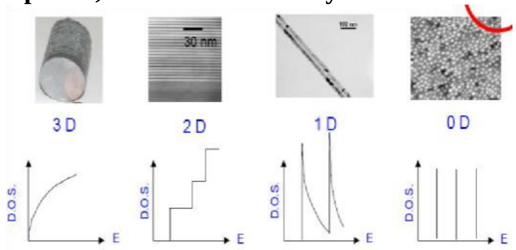

Figure 4- Dimensional view of material

- (D.O.S.) more favourable (stronger dependence of DOS on E) increase of a without increasing ρ
- Additional degree of freedom (size) for tailoring of the transport
- Possibility to explore the anisotropy of transport properties
- Chance to decrease lattice due to phonon scattering on interfaces
- ZT0D > ZT1D > ZT2D > ZT3D

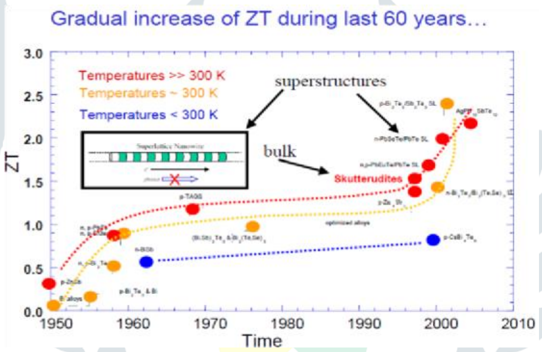

Figure 5- Graph of increment in ZT

IV. THERMOELECTRIC EFFECT IN POWER GENERATION

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

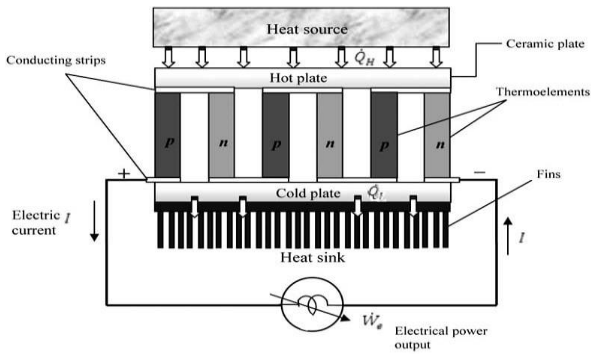

Figure 6- Thermoelectric effect

V. THERMOELECTRIC POWER GENERATOR

The basic principle of thermoelectric works is related to see beck effect. The See beck Effect describes a thermoelectric phenomenon by which temperature differences between two dissimilar metals in a circuit converts into an electric current. Discovered in 1821, the See beck Effect is one of three reversible phenomena describing similar processes relating to thermoelectricity, conductivity and temperature. The Peltier Effect was first observed in 1834 and the Thomson Effect was first explained in 1851.The Seebeck Effect is named for East Prussian scientist Thomas Johann Seebeck (1770-1831). In 1821, Seebeck discovered that a circuit made of two dissimilar metals conducts electricity if the two places where the metals connect are held at different temperatures. Seebeck placed a compass near the circuit he built and noticed that the needle deflected. He discovered that the deflection's magnitude increased proportionally as the temperature difference increased. His experiments also noted that the temperature distribution along the metal conductors did not affect the compass. However, changing the types of metals he used did change the magnitude that the needle deflected. The Seebeck Coefficient is a number describing the voltage produced between two points on a conductor, where a uniform temperature difference of 1 degree Kelvin exists between the points. The metals in See beck's experiments were reacting to the temperatures, creating a current loop in the circuit and a magnetic field.

The basic theory and operation of thermoelectric based systems have been developed for many years. Thermoelectric power generation is based on a phenomenon called "See beck effect". When a temperature difference is established between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, i.e., Seebeck voltage. In fact, this phenomenon is applied to thermocouples that are extensively used for temperature measurements. Based on this See beck effect, thermoelectric devices can act as electrical power generators. A schematic diagram of a simple thermoelectric power generator operating based on See beck effect. Heat is transferred at a rate of H from a high temperature heat source maintained at TH to the hot junction, and it is rejected at a rate of L Q to a low-temperature sink maintained at TL from the cold junction. Based on See beck effect, the heat supplied at the hot junction causes an electric current to flow in the circuit and electrical power is produced. Using the first-law of thermodynamics (energy conservation principle) the difference between H and L Q is the electrical power output e W. It should be noted that this power cycle intimately resembles the power cycle of a heat engine (Carnot engine), thus in this respect a thermoelectric power generator can be considered as a unique heat engine.

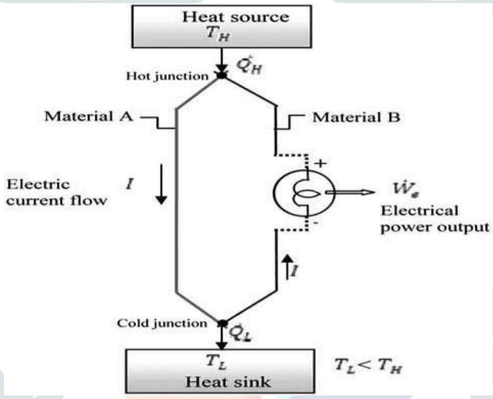

Figure 7- Circuitry of thermoelectric power

VI. ADVANTAGES AND DISADVANTAGE OF THERMOELECTRIC POWER

Advantages:

1) Environmentally friendly
2) Recycles wasted heat energy
3) Scalability, meaning that the device can be applied to any size heat source from a water heater to a manufacturer's equipment
4) Reliable source of energy
5) Lowers production cost

Disadvantages:

1) Low energy conversion efficiency rate
2) Slow technology Progression
3) Limited Applications
4) Requires relatively constant heat source
5) Lack of customer/industry education about thermoelectric generators

VII. CONCLUSION

In the thermal plant environmental issues are increasing everyday and now the requirement is to reduce that while utilizing that waste source like the noise of the various machines which produces vibration also so, these vibration can be use to generate the power if we see the other side there is wastage of heat in the thermal power plant so this waste heat can also be used for the generation of power. Thermo electric technology is very suitable and better option for generation of power using these sources. When these sources are moved in the direction of consumption then the environmental issues will decrease and the impact of these on the human health will decrease continuously in some amount. In other hand power generation will also increase so; supply demand curve will go near to meet each other.

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