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Waste Heat Recovery System (WHR)

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ABSTRACT

Waste heat recovery is that the process of warmth integration that's reusing heat that might rather be disposed of or just released into the atmosphere. By recovering waste heat, plants can reduces energy cost & CO2 emission, while simultaneously increasing energy efficiency. Waste heat found in the exhaust gas of various processes or even from the exhaust stream of a conditioning unit is often wont to preheat the incoming gas. This is one among the essential methods for recovery of waste heat. Many steel making plants use this process as an economic method to extend the assembly of the plant with lower fuel demand. There are many various commercial recovery units for the transferring of energy from hot medium space to lower one.

1. INTRODUCTION

Waste heat recovery (WHR) is essential for increasing energy efficiency in the chemical process industry (CPI). Presently, there are many WHR method & technologies at various stages of implementation in petrol refineries, petrochemical, chemical & other sectors. Increasing energy costs & environmental concerns provide strong motivation for implementation more & newer methods & technologies for WHR. Waste heat is energy rejected to the environment. It arises from equipment & operating inefficiencies, as well as from Thermodynamic limitation on equipment & processes. Often, a part of waste heat could potentially be used for a few useful purposes. At present, about 20 to 50 you look after energy utilized in industry is rejected as waste heat. A significance part of wasted energy is low-temperature heat that is send to the atmosphere mainly from cooling water, fin-fan coolers & flue gases. WHR are often defined because the process of capturing some portion of the warmth that normally would be wasted, & delivering it to a tool or process where it can be used as an effective, economical & environmentally friendly way to save energy.WHR has the potential to minimize those costs, & to reduce environmental impact along with several other benefits.

Typical example of waste heat recovery Several common consumer items recover waste for example, consider turbocharged cars, which are provided by multiple car manufacturers. In regular, non-turbocharged cars, the internal combustion gasoline engine expels hot gas through the cars exhaust after its fuel is burned. That gas contains both heat & kinetics energy, A portion of which can be recovered. Turbocharged engines divert the hot gas to a turbine, which is used to spin air in compressor. The compressed air is routed to the engine’s combustion chamber with the Vaporized gasoline, resulting in a more efficient ignition & grater power made with lower fuel consumption.

1.1 Advanced WHR technology

Various methods have recently been adopted in internal combustion engines (ICE) to meet increasingly emission regulations, such as diesel particulate filters, three-way catalytic converters, & selective catalytic reduction. The different advanced method are listed & discussed below.

- Hydrogen generation by using exhaust gas waste heat.
- Thermoelectric generators.
- Thermodynamic cycle of organic Rankine cycle.
- Hybrid pneumatic power system (HPPS)
- Electric turbo compounding (ETC) systems.

1.2 Hydrogen generation by using exhaust gas waste heat

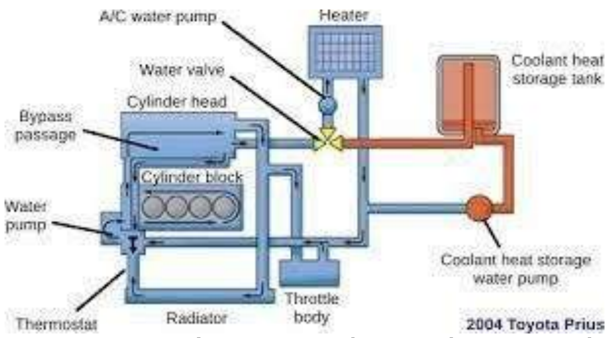

Fig. Hydrogen generation by using exhaust gas waste heat

Engine exhaust heat energy has been used to heat & decompose methanol & other auxiliary fuels into hydrogen to improve the original heat value of fuels, increase combustion rate & reduce emission. For example, hydrogen can be used for homogeneous charge compression ignition (HCCI) combustion. Because ignition timing control is crucial in the application of of HCCI combustion in engine, ignition timing control can be addressed by adjusting the proportion of dimethly ether & hydrogen gas waste energy can be used for hydrogen production without any changes in operating condition.

1.3 Thermoelectric generators

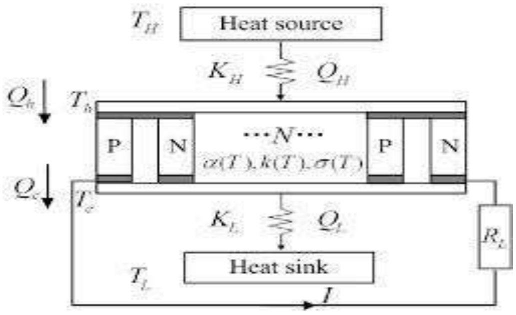

Fig.Thermoelectric generators

Thermoelectric materials are semiconductor materials that enable the conversion between heat energy & electric energy based on the Thermoelectric effect. The Thermoelectric effects refers to a phenomenon where by a temperature difference create an electrical potential or an electric potential creates a temperature difference, including the Seebeck effect, the Peltier effect & the Thomson effect. A schematics setup of Thermoelectric generators is shown in above figure.

1.4 Thermodynamic cycle of organic Rankine cycle.

Because of low temperature of engine exhaust gas, the traditional Rankine cycle using the water as the working fluid cannot obtain ideal working performance. So, organic Rankine cycle has become very popular method to improve the performance WHR because it works well with low-grade energy at a low flow rate.

1.5 Hybrid pneumatic power system (HPPS)

HPPS generally consists of an ICE, an air compressor , a pressure tank , & a high efficiency turbine. The main working principle of pneumatic hybridization engines is to recover a energy from a braking phase or form a combustion phase by pumping the exhaust gas or the pressurerized air into the air tank, then the air tank can then be restored to start the engine or change the engine during the strong transient accelerations or short-term high-power output period. An advantages of the pneumatic hybridization engine is that the pressurized air can pumped into the combustion chamber to overcome the turbo-lag problem during the speedup period of the turbocharge, which can maximize the performance of the turbocharge. Pneumatic hybridization engine also offer improve fuel economy & reduced emissions.

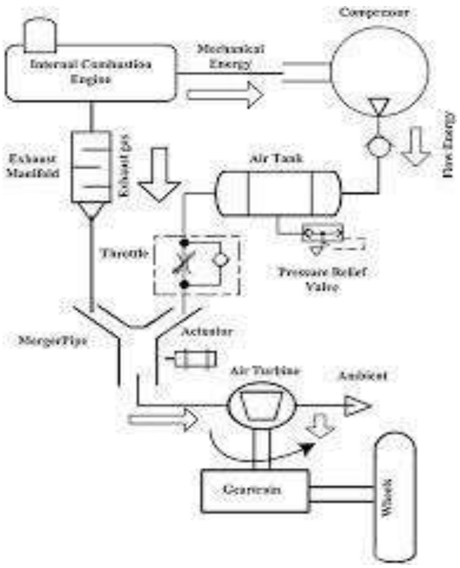

Fig. Concept setup of hybrid pneumatic power system.

1.6 Electric turbo compounding (ETC) system

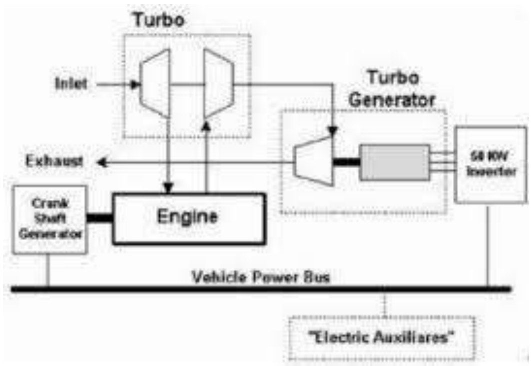

Fig.Electro turbo compounding (ETC)

System. Considering the high temperature, relatively high pressure, & kinetic energy of exhaust gas, we classify waste energy of exhaust gas as a thermal energy, pressure energy, & kinetic energy , with pressure energy accounting for the main part of the waste energy. ETC systems, which are mainly based on the Brayton cycle, are a very useful way to recover waste pressure energy. The figure present the setup of ETC system. The compound turbine mechanical driven energy recovery prototype was originally proposed by the Volvo Corporation

2. LITERATURE REVIEW

Condensate is pure water, returning more condensate to the feed-tank reduces the need of for blow- down & thus reduces the energy lost from the boilers.

2.1. Flash steam separator as WHR unit:-

The steam used in the process plant at various pressures depending upon the temperature requirement The condensate recovery pump from the high pressure steam when comes to low pressure, some parts of the condensate get evaporated which is called flash steam. Recovering the utmost possible flash steam back to the feed cistern reduces the fuel consumption of boiler . Flash steam has substantial amount of heat which is ignored & vented o atmosphere in most of the process plants.

2.2 Heat recovery steam generation (HRSG) :-

A heat recovery steam generator (HRSG) is a solution, when it is necessary recover heat from a hot gas steam. Once can produce steam that can be used in process (cogeneration) or wont to drive a turbine (combined cycle). The HRSG boilers are manufactured either in horizontal or vertical type. The vertical boilers is more compact in structure & can be fit in smaller plants& even indoor facilities. The horizontal boilers is used mainly in longer plant. Supplementary firing can be added to both boilers types so that the required energy volume can be produced with gas turbine running on partial loads.

2.3 Saving calculation:-

1000kg/hr condensate recovered can save Rs 45, 00,000/- per year as fuel considering 20hrs a day & 300 days a year operational. 1000kg/hr condensate recovered can save Rs 7, 00,000/- per year on coal as fuel considering 20hrs a day & 300 days a year operational. The payback for the entire system comes bent be but 6 months.

2.4 Engine waste heat recovery technology:-

Rising fuel prices and the increasing demand for high fuel economy make the improvement of the working efficiency of engine become necessary, thus resulting in the application of waste heat recovery (WHR) technologies. For light duty passenger vehicles, tight packaging constraints
& The relatively low duty cycle of combustion engine make waste energy recovery difficult. Thus, the most promising WHR technology application lies in engine that operate steadily at high load for sustained periods, such as that Among the various types of waste heat, the heat contained in exhaust gas & coolant is generally the most promising for recovery. WHR technologies can be classified into

- Electro turbo-compounding (ETC) system
- Thermodynamic organic Rankine cycle (ORC)
- Hydrogen generation (HG) by using exhaust gas heat energy.
- Hybrid pneumatic power system (HPPS)
- Thermodynamic generators (TEG)

2.5 Waste heat boiler (WHB) :-

Using a principle similar to economizers, waste heat boiler recover heat generated in furnaces or exothermic chemical reaction at industrial plants. Those location may contain significant energy that should not be wasted up a stack. Instead, this energy are often captured to get low-to-medium pressure steam during a waste heat boiler (WHB). A WHB can also be used to remove the heat from a process fluids that need to be cooled for either transport of storage, & generate steam from that heat. The steam is generated in WHB may be used for heating application, or to drive turbines that generate electricity, compress vapors, or pump liquids. WHB steam may contain significant wetness, so it recommended that a high efficiency separator
& steam trap combustion is installed to make sure that the WHB delivers optimal quality steam to the recipient process.

2.6 Development of an optimum WHR system depend on following factors

- Quantity & temperature of waste heat
- Uses of recovered waste heat
- Cost of energy
- Availability of space
- Minimum allowable temperature of waste heat fluid.
- Minimum & maximum temperature of the process fluid.
- Chemical composition of waste heat process fluids.
- Facility’s heat-to-power ratio

2.7 Features of condensate recovery pump

- Uses inexpensive steam, air or gas to pump the condensate
- Negligible steam consumption
- Zero maintenance, no cavitation, no leaking seals, impeller wear or motor problems.
- Only one moving part (SS float) increases reliability.
- Superior build quality & rugged construction.
- Pre-wired, pre-piped packaged skid mounted for easy installation.
- Widest range of steam operated pump
- Skid mounted unit which is easy to install.

2.8 Advantages of condensate recovery pump

- Reduction in fuel bill.
- Reduction in water charges.
- Reduction in Exhaust treat plant (ETP) load
- Maximizing in blow down loss.

2.9 Benefits of waste heat recovery

Benefits of waste heat recovery can be broadly classified into two categories:-

- Direct Benefits
- Indirect Benefits

- Direct Benefits: - Recovery of waste heat has a direct effect on the efficiency of the process this is reflected by reduction in the utility consumption & costs, & process cost.
- Indirect Benefits :-
  - Reduction in pollution.
  - Reduction in equipment size. c. Reduction in auxiliary energy consumption.

3. OBSERVATION

Sr.No.	Source	Quality
1.	Heat in some gases	The higher the temperature, the greater the potential value for Heat recovery.
2.	Heat in vapor streams	As above but when condensed, heat of transformation also Recoverable.
3.	Convective & radiant heat equivalent t	Low grade – if collected could also because for space heating or air lost from exterior of preheats.
4.	Heat losses in cooling water	Low grade- useful gains if heat is Exchanged with incoming water.
5.	Heat losses in providing chilled water or in disposal of chilled water.	High grade if it are often utilized to reduced demand for refrigeration. Chilled water or within the Low grade if refrigeration unit used as a form of warmth pump. Disposal of Chilled water..
6.	Heat stored in products leaving the method .	Quality depend on temperature leaving the method .
7.	Heat in gaseous & liquid effluents leaving process	Poor if heavily contaminated & thus requiring alloy device

4.CONCLUSION

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- Reduction in water charges.
- Reduction in Exhaust treat plant (ETP) load
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- Thermodynamic generators (TEG)

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