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REVIEW ON WASTE HEAT RECOVERY TECHNIQUES FOR VARIOUS APPLICATIONS

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ABSTRACT

Worldwide there is fastest growth in industrial sector also it invites problem arising regarding the crisis of fossil fuels. Basically such fuels are employed as conversion of their chemical energy into the thermal energy and further to desired work. Approximately, there is only 30-50% heat supplied is converted into desired work and remaining heat is exhausted or rejected in atmosphere. These results in rise in atmospheric temperature i.e. problem of global warming may arise as well as this tends to create atmospheric pollution too as green house and harmful gases such as CO, CO_2, NO_X etc. are exhausted to surrounding atmosphere. So, it is necessary to utilize this waste exhaust. This tends conserve fossil or conventional fuels as well as to reduce the amount of waste exhaust heat. This also may help in reduction of atmospheric pollution. This paper is presented to present the possibility and availability to waste heat recovery in various applications such internal combustion engines (ICE), CHP cycles, heat pumps, gas turbines, renovated apartments etc. As this article draws conclusion such as waste heat recovery for various applications will be an arrowhead solution to reduce the fuel consumption in order to serve further industrial needs.

***Keywords*: Conventional Fuels, Global Warming, Waste Exhaust Heat, Waste Heat, Waste Heat Recovery.**

1. INTRODUCTION

The current scenario of worldwide consumption of fossil fuels i.e. conventional energy sources it has brought us to conclusion that in very few next years these sources will definitely diminish. As day by day the problem of energy crisis has become challenging one in front of community; so we should approach towards the better utilization of these sources for i.e. to use these sources efficiently. By employing some techniques such as reuse, reproduce and recovering the wastage into some better desired work or desired way. In this article we concentrated an approach towards the recovery i.e. recovery of waste heat. Approximately there is a 30-50% heat energy loss in the form of heat dissipation i.e. by cooling system and exhaust systems. This lost heat may contain heat energy and kinetic energy which could be further employed for some applications.

These waste heat recovery techniques would definitely reduce the power requirement for auxiliaries in some cases. Also the waste heat recovery would reduce the impact on environment by reducing emission which may helpful to control the global warming. In many applications these methods are employed for fuel saving. For example, in IC engines the waste heat recovery technique has proved useful for operating auxiliaries such as turbochargers, compressors, A/F mixing, valve mechanisms(specially time based) etc. In thermal power plants these methods are employed in the form of cogeneration to reuse waste heat.

1.1 Concept of waste heat recovery

Waste heat recovery means to utilize the heat energy in better desired which is expelled or which is exhausted to the atmosphere. This wasted heat energy can be recovered by coupling some secondary auxiliaries such as turbocharges in ICE (internal combustion engines), regenerators in gas turbines, secondary turbine in thermal power plants etc. This reduces wastage and improves efficient utilization of fuel i.e. resources. The lost heat may be utilized for further energy requirements.

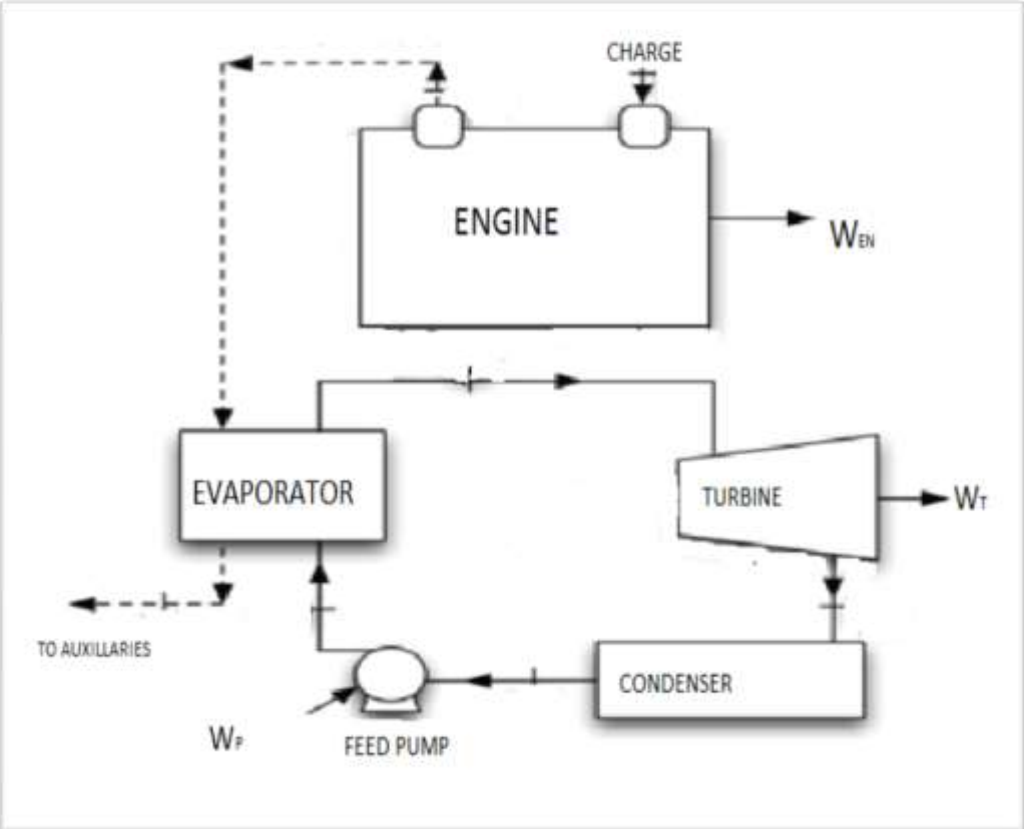

Fig 1.1 waste heat recovery system conceptual representation

1.2 Applications

- Heat recovery system for oven exhaust in paint shop.
- Waste heat recovery system in in IC engines.
- Regeneration in gas turbines.
- Cogeneration in refrigeration systems.
- Heat recovery system in CHP cycles.
- Ventilation system with heat recovery system in renovated apartment buildings.

II REVIEW OF SOME RESEARCHERS

2.1 Mr. SagarSubhashraoThakare et al [1]

Researchers proposed a heat recovery system unit for a paint shop top coat oven. Systematic arrangement of heat exchanger (shell and tube type heat exchanger) in heat recovery unit for generation of hot water through exchanging heat with hot waste gases from oven exhaust. Hot flue gases leaves at approximately 340^0 C and also exhaust energy is about 923 kW. By proposed experiment around 90% waste exhaust energy is recovered i.e. around 885 kW energy is utilized for generation of hot water. Hot water generated having temperature 110^0 C approximately. This generated hot water will further returned to pretreatment process as well as oil conservation process. This heating of water reduces the CNG consumption of the boiler to heat the water. During exhaust the temperature of gases reduces to 105^0 Cvia passing through heat recovery unit.

2.1.1 Components of system

- Shell and tube type heat exchanger
- Water feed pump
- Water conveying pipes.

2.1.2Result

1. About 90% waste heat is recovered.
2. Hot water at about 110^0 C is generated.
3. Consumption of CNG for heating the water is considerably reduced.

2.1.3 Experimental set-up

This set up consist of shell and tube type heat exchanger mounted before exhaust mouth, water carrying lines for conveying water through system, feed pump for circulation of water.

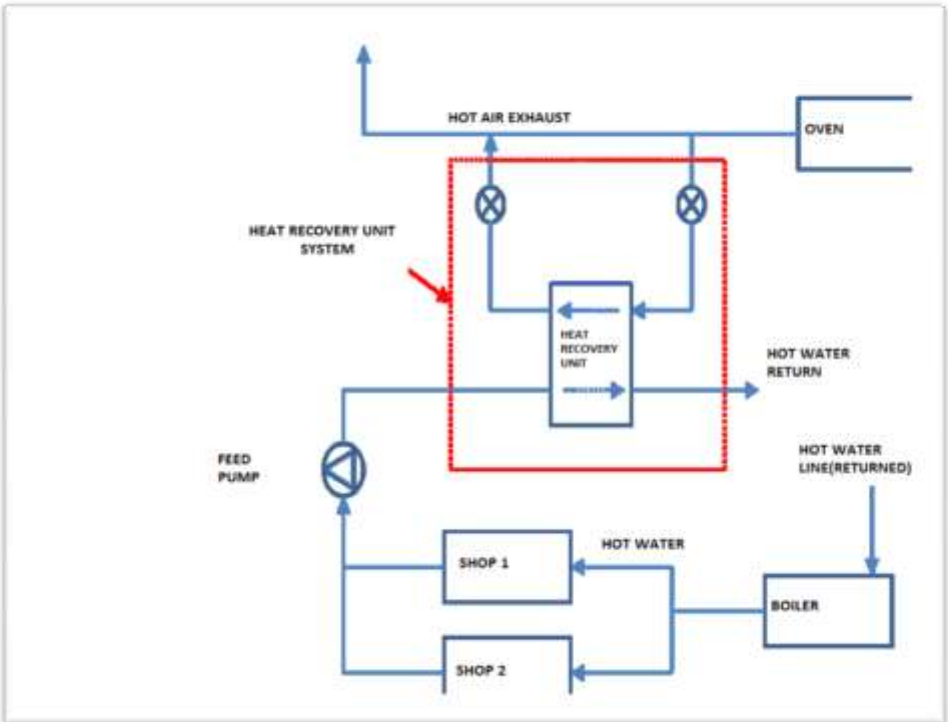

Fig 2.1 Experimental set-up of heat recovery system implementation in paint shop

2.1.4 Experimentation

During the set up in working, the waste exhaust flue gases through oven are made to flow through heat exchanger unit. Temperature of flue gases at exhaust is about 340^0C, and containing heat energy approximately 923 kW. Due to flow of hot gases through heat exchanger there is increase in temperature of water which is circulated from feed pump via heat exchanger to boiler. Water gets heated and gains temperature up to 110^0 C i.e. waste heat is recovered the flue gases gets exhaust at reduced temperature approximately at 110^0C. The temperature of exhaust gases is considerably reduced; this also helps to control global warming. Hot water generated is further passed towards the boiler; as water is preheated up to 95-110^0C there is considerable reduction in fuel i.e. CNG required to heat the water. This water is further used for pretreatment process and conservation of oil process in shops.

2.1.5 Conclusion

The waste heat energy of flue gases through oven can be recovered. This recovered heat can be utilized to generate i.e. to heat the water and this water can be further used for pretreatment and conservation of oil processes. Heat exchanger is acts as basic recovery device. In this application there is efficient utilization of heat i.e. heat recovery.

2.2Reza Soltani et al [2]

Researcher has proposed a multigenerational system which having one input i.e. fuel input (sawdust as s biofuel) and five outputs for wood factory. This multigenerational system is proved to satisfy the needs of wood factory. This system provides following outputs from waste.

1. Satisfying needs of dryer unit
2. Satisfying needs of steaming unit
3. Electricity generation
4. Hot tap water
5. Desired heat output for surrounding district and factory

In this system there are two main units; CHP unit and HRU unit. Amongst these CHP (combine heat and power) is the main part of proposed system. It consists of biomass combustor; biomass combustor uses sawdust as afuel. It also consist ORC (organic rankine cycle) for power generation, a turbine unit for power generation, steam generator for steaming unit, hot water heater for district. For ORC water is used as working fluid. The electricity produced by using biomass as a fuel in ORC is utilized by district or wood factory itself. Exhaust steam from turbine is supplied to steaming unit of wood factory. Also this CHP unit provides hot water as output. CHP unit provides input to HRU. HRU consist of heat exchanger and air/exhaust heat exchangers. Exhaust steam having temperature about 200^0C; the heat recovered from it is either utilized for hot water production or with other ORC with proper working fluid. The ORC of HRU generates superheated steam for deaerator. Turbine drives the compressor for further desuperheater of ORC. Air from heat exchanger at 100^0C is conveyed to pine timbers drying and ambient heated air at 50^0C is conveyed to dryer room. Moisture content in wood can be reduced at .15 kg water/ kg dry wood. At exit temperature is reduced at 80^0C.

2.2.1Components of system

- Heat exchangers

- Turbines, compressors for ORC
- Fluid conveying system
- Deaerator

2.2.3 Results and conclusions

1. Waste biomass as well as heat recovered efficiently
2. By single input five output in the form of input to dryer and steamer, power generation, hot tap water and desired heat for surrounding district or factory itself has obtained.
3. Due to reduced exhaust gas temperature it helps in lowering global warming.

2.3 Tushar S. Jadhav et al[3]

Researchers focuses on HPHX(heat pipe heat exchanger) for heat recovery in air conditioning system. This use of HPHX in clean room air conditioning there is considerable saving in energy. By implementing horizontal HPHXs in air conditioning it has proven advantageous for energy saving and improved effectiveness of conventional heat pipe and oscillating heat pipe. At DBT 21^0C it has proven advantageous in lowering temperature of air which enters in cooling coil after passing through HPHX. This has resulted in saving more in cooling coil capacity. At DBT 21^0C and 50% RH (relative humidity) at basic case condition at 2.6 TR (tonnes of refrigeration) there is increase in initial cooling capacity without HPHX. By using or implementing HPHX at same conditions there is saving in cooling capacity about 0.5 TR at this stage HPHX is with 16 rows. At 23^0C and 55% of RH with HPHX there is saving about 0.7 TR. This has resulted helpful in reducing initial and operating cost of cooling coil.

2.3.1 Components of system

- Air conditioning facility with area 590 m^2, height 3.6 m.
- Horizontal HPHX

2.3.2 Results and Conclusion

1. There is saving in overall cooling coil capacity of air conditioner by using HPHX.
2. As HPHX does not requires external power source it is beneficial.
3. Reduced energy consumption of air conditioner.

2.4 G.V. PradeepVarma et al [4]

Researchers proposed a cogeneration system for a cement factory; which results in waste heat recovery for power generation. It has been identified that cement factory has more potential than any other industry for generation of electric power. There are three waste heat rejection locations in cement factory which have two plants one, 1600 TPD and 5500 TPD. The total power produced from waste heat recovery is about 12.5 MW. Researcher has focused on cogeneration system for production of electric power from three heat rejection sources which are at 176^0C, 330^0 C and 420^oC respectively. But heat source at 176^0 C is unsuitable for generating steam at required pressure level. Hence there is provision of supplementary firing for rising temperature from 176^0C to 420^0C. After firing unit gas is mixed to reach at high temperature. After mixing there remaining two sources of 420^0C and 330^0C. Steam from four source lines is mixed and conveyed to turbine for power generation. Remaining layout is similar to somplerankine cycle.

2.4.1 Components of system

- Steam Turbine
- Feed pumps
- Steam conveying pipes
- Fluid conveying pipes
- Condenser
- Supplementary firing unit
- Air preheaters

2.4.2 Results and Conclusions

1. The proposed design of a power plant layout has analyzed and identified the potential in cement factory for generation of electric power.
2. It results in generation of about 12.5 MW of electrical power from recovery of waste heat.
3. There is also provision made to meet cement factory need of 15 MW i. e. for extra 2.5 MW.
4. This layout has increased EUF of the plant.

2.5 R. Saidur et al [5]

This paper presents an approach towards implementing waste heat recovery system in ICE (internal combustion engine). System can be implemented as a turbocharger for getting higher speeds and proper burning i.e. efficient burning of fuel. Turbocharger is driven by exhaust gases. As engines commonly produces higher amount of waste exhaust so turbocharger is an efficient and better way of heat recovery. Turbochargers basically consist of turbine, compressor, center housing and rotating assembly (CHRA), actuator, exhaust gate valve and shaft. Turbocharger functions to increase the air mass flow rate in combustion chamber which reduces particulates which are emitted or exhausted to atmosphere. It has been seen that the use of turbocharger can improve the fuel economy up to 30-50% for diesel engine vehicles and 5-20% for gasoline engine vehicles. The waste exhaust gases are passes through gas turbine which is mechanically coupled with compressor which compresses and pressurizes air and then introduces it in combustion chamber for better combustion of fuel. Turbocharger also reduces particulates emission like NO_x, SO_2etc. There are still modifications are going on in turbochargers for better improved performance and also for suitability with modern IC engines systems.

2.5.1 Components of system

- Gas turbine for rotating compressor shaft.
- Compressor for compressing and pressurizing air and delivering in combustion chamber.
- Exhaust gate valve
- Shaft for mechanical coupling.

2.5.2 Results and Conclusions

1. Large amount i.e. large potential of energy can be saved by using heat recovery arrangement in IC engines.
2. Turbocharger reduces hammering to atmosphere by reducing particulates emission.
3. Turbocharger has improved the fuel economy about 30-50% in diesel engines and 5-20% in gasoline engines.

4. It also improved overall performance of IC engines.

III CONCLUSION

The approach of review of this paper is towards the heat recovery techniques implementation for various systems in day to day life. These techniques have proven better, beneficial and also eco-friendly. Also an approach and hope towards energy saving.

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