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Review Article

An Overview of Studies and Research on Waste Heat Recovery with Emphasis on Hot Gases

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ABSTRACT

Efficient use of energy resources is one of the most sought after area of studies and research among energy and environment fields. The natural resources of fuel are depleting day by day. The use of renewable resources is considered as promising option. The recovery of waste heat from different thermal units such as boilers, internal combustion units, air conditioners etc. can save considerable amount of energy. Also it reduces thermal pollution. Various investigators have carried out investigation on the use of various waste heat recovery methods. Current review summarizes research and studies on regeneration and recovery of waste heat.

Key words: heat pumps exhaust gases, heat pipes, Rankine cycle, and combustion engines.

INTRODUCTION

Waste heat recovery is one of the solutions for increasing energy demand. The growth of the country, both economical and social, depends on the amount of energy consumed and available. In many developing countries, energy availability is becoming problem. The emission of flue gases after combustion is also nuisance to the ecology and environment. [1-3] The gases like hydrogen sulphide, carbon dioxide and oxides of nitrogen can be controlled by various physical, chemical and biological methods. [4-6] The nonconventional energy sources like solar energy, tidal energy, and wind energy are being explored. [7,8] The use of pinch technology, fuel cells and heat regeneration are attractive methods for reducing energy consumption. [9,10] The waste gases from boilers, internal combustion engines, air conditioners etc. causes thermal pollution. These hot gases can be passed through heat exchangers for recovering their heat. Various investigators have carried out studies and research on direct and indirect use of energy from hot flue gases. The current review summarizes research and studies on waste heat recovery from hot gases.

AN OVERVIEW OF STUDIES AND RESEARCH ON WASTE HEAT RECOVERY FROM HOT GASES

Jotanovia et al. carried out an investigation on heat recovery in the process of soda ash formation. [11] They used high temperature heat pump in their experiments. A review was carried out by Noor et al. on waste heat recovery technologies in turbocharged automotive engine. [12] They analyzed each process to assess each waste heat recovery technology based on current developments, research trends and its future in an automotive application. According to them the waste heat from internal combustion engines can be utilized thermally, mechanically or electrically and it can be turned into useful form of energy. If adopted by the automotive manufacturers, these green technologies can reduce energy consumption and global warming. Saadatfdar et al. carried out review on organic Rankine cycle (ORC) for waste heat recovery. [13] They presented an analysis of physical and chemical properties of fluids and different applications of ORC. Vijayraghavan and Shriram carried out studies on heat recovery and cogeneration. [14] They emphasized that a lot of energy can be saved by using the waste heat by coupling the heat power plant or boiler to a gas turbine-generator. They tested a two phase cooling system for a waste heat recovery system. They concluded that the power output may be increased and a surplus amount of work can be produced by the heat recovery. Stalin et al. carried out an investigation on use of heat from air conditioner for production of hot water and reduction of LPG gas. [15] According to these studies, if the heat from the air conditioner is used for hot water generation and other LPG applications, minimum 4 cynlider LPG per year can be saved. By using this simple initiative, it is possible to reduce the thermal pollution. Gamma type Stirling engine was applied for heat recovery by Dadi et.al. [16] According to them, it is one of the most efficient methods to recover waste heat. They discussed advantages of Stirling engine. The thermal efficiency of this cycle is equal to Carnot cycle. Also the reasonable amount of work is obtained by this cycle at low swept volume and low pressure. In Gamma type Stirling engine, is connected to the same flywheel but the power piston mounted in a separate cylinder alongside the displacer piston cylinder. Dubey et al. carried out a review on waste heat recovery system. [17] According to their review, the research on waste heat recovery is focused on utilization of heat pipes, Rankine cycle and heat pumps. Low grade thermal sources, with Rankine cycles offer significant potential for energy productivity. Heat pump technology can be applied for upgrading the ambient heat from sustainable sources. Saidur et al. studied methods to recover exhaust heat from internal combustion engines. [18] They identified potential devices which can be incorporated to have maximum energy recovery. Engine efficiency and net power can be improved by maximizing the potential energy of exhaust gases. Job et al. carried out an investigation on the use of waste heat in an oxy-combustion power plant. [19] They carried out thermodynamic analysis for different cases of compression installations organization. They identified potential for reducing energy consumption in the compression process. For this purpose, they studied heat recovered in cooling and condensation in the individual sub-processes. This energy can replace low-pressure regeneration. Computational fluid dynamics (CFD) modeling of regenerative heat exchanger was studied by Kic and Zajicek. [20] They carried out studies on heat exchangers suitable for animal houses. The heat generated by presence of animals necessitates proper ventilation. The energy recovery approach can be recuperative and regenerative. The presence of the high dust concentration presents difficulty in operation of regeneration equipments and heat exchangers. They used fluent software for airflow and heat exchange simulations. The factors such as thickness of plate, air stream temperature, heating/cooling period or material properties need to be optimized for efficient waste heat recovery.

Albert carried out studies on heat recovery in aluminum cast house. [21] According to him solid aluminum can work as an energy bank. They identified cooling water section as the one with maximum potential for waste energy recovery possibilities. Flue gases from furnace had maximum energy generation potential. Jadhao and Thombare carried out an investigation on internal combustion gases for recovery potential. [22] According to them only 30 to 40 percent heats is actually converted into useful work. Remaining heat is lost to environment, which may lead to increase in entropy and pollution. The recovery of heat from I.C. engines thus not only reduces pollution but also maximizes energy efficiency. Sajan et al. carried out investigation on flue gas heat recovery for air conditioning. [23] They placed multipass heat exchanger between the space between boiler and chimney. They used the extracted energy in vapour absorption refrigeration system. The corrosive nature of flue gases limited the recovery to the acid dew point temperature of the flue gas. Mikielewicz carried out an investigation on organic Rankine cycle (ORC) recovery of waste flue gases from coal fired power plant for heat recovery. [24] Initially they supplied the ORC evaporator with hot water at 80 ^{0}C. According to these studies, the upper temperature of ORC can be increased by incorporation of absorption heat pumps or solar collectors in the cycle. Srinivasa et al. carried out an investigation on use of electro turbo generation for energy recovery. [25] They explored various heat recovery possibilities in two wheelers and four wheelers. The waste heat energy can be used to burn additional amount of energy. In the second stage the thermoelectric generator was used to utilize waste energy. Compressor and alternator were used in a third stage recovery.

CONCLUSION

The need of clean energy is increasing day by day. The combustion gases and many other gases from process industries many times carry considerable amount of energy and are at high temperature. On one hand, it causes thermal pollution and on the other hand lot of energy is wasted. The extraction of the heat from these gases serves twin purpose of energy and environment. The selection of proper equipment and material for heat transfer is major factor in waste heat recovery from gases.

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