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Review Article

A Review on Studies and Research on Heat Recovery, Regeneration and Cogeneration

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ABSTRACT

The growing human demands and urbanization along with rapid industrial development calls for efficient use of energy. The energy requirement is ever increasing. There is need to use the technologies and methods of heat exchange, manufacturing and chemical synthesis which consume minimum energy. The waste heat from flue gases and other hot streams can be utilized efficiently for preheating air or other process streams. The concept of regeneration and cogeneration can be applied to various refrigerator, heat exchanger and air conditioning system at domestic and industrial applications. The present review summarizes studies and research aimed at energy saving, recovery, cogeneration and regeneration.

Key words: energy, heat exchanger, area of heat transfer, recuperator, temperature.

INTRODUCTION

Energy and environment are two important aspects of engineering and technology which are gaining increasing importance. Both are important for sustainable growth of mankind. The effective and proper utilization of energy resources is key aspect of many process intensification studies such as hydrotropy, cavitation, reactive chromatography and reactive adsorption. [1-6] Also reduction of friction can lead to energy saving. [7,8] The concept of regeneration and co generation is very useful from energy conservation point of view. The waste gases and liquid streams need to be cooled before they are disposed and vented off from environmental considerations. These streams can be used to preheat air or other process streams. This can save the energy cost considerably. Different modifications of existing heat exchangers, boilers, refrigerating and air condition systems can bring about huge energy savings. [9,10] The current review summarizes research and studies on energy saving with cogeneration, regeneration and modification of existing facilities.

STUDIES AND RESEARCH ON ENERGY SAVING METHODS: A REVIEW

Murugesan and Balasubramani carried out investigation on enhanced heat transfer performance in plate type heat exchanger. [11] They investigated the effects of various operating and design parameters to enhance heat transfer performance in plate type heat exchanger. Their experimental setup consisted of plate type heat exchanger, rotameter, and thermocouples, pumps and tanks. According to them, compact heat exchangers have advantages over conventional heat exchangers. It was emphasized that the plate type heat exchangers have the advantages over the shell and tube heat exchanger for the heat recovery as large area can be provided in smaller space. They observed that the increase mass flow rate with subsequently increase in the flow velocity led to an increased overall heat transfer coefficient as well as individual heat transfer coefficient.

Jotanovia et.al. Carried out studies on heat recovery of waste heat from soda ash plant. [12] They proposed use of heat pump for this purpose. The authors have carried out investigation on the application of a high temperature heat pump in the industrial waste heat recovery. The heat recovery was carried out in two stages. The first stage of heat recovery involved adiabatic evaporation of the solution without introducing heat. They achieved adiabatic evaporation by lowering the pressure and, consequently, decreasing the boiling temperature of the solution. The second stage of heat recovery involved heating of water whose heat is used as a low-temperature source of high temperature heat pump.

A Review was carried out on waste heat recovery technologies in turbocharged automotive engine (TEG) by Noor et.al. [13] The main objective of their review was to assess each waste heat recovery technology based on current developments, research trends and its future in an automotive application. Dependency on thermal and electrical properties of material used is limitation for the TEGs. The interesting subjects for the researchers are factors such as expander efficiency, toxicity and stability of the working fluids. Saadatfdar carried out state of the art review on organic Rankine cycles in sustainable energy conversion. [14] According to them selection of the working fluid is important aspect. This working fluid has to complete several criteria's such as being economical, nontoxic, non-flammable, environmentally friendly etc. It is important that they have optimum thermodynamic properties at the lowest possible pressures and temperatures. Also according to these studies fluids with higher molecular weight have a positive impact on turbine efficiency and small number of stages. Ramesh and Kalyani used stirling engine for improving the efficiency of marine power plant for waste heat recovery systems. [15] According to these studies about 30% of the total energy converted in a diesel engine is rejected in the exhaust gas. They advocated the use of heat balance studies for improving the efficiency of the marine power plant. These this studies stressed the need to undertake such studies at the basic design stage for every ship to identify various losses so that improvements can be undertaken to minimize such losses.

Vijayraghavan and Shriram provided an insight into recovery and cogeneration of heat. [16] During their studies they found that for every power plant, the overall efficiency was much lesser than the percentage heat loss wasted into the atmosphere which may damage the surroundings. They discussed several applications of regeneration such as power plants, engine systems. Kotani et. al. used active magnetic regenerative (AMR) heat circulator for energy saving. [17] They explained working of AMR system. They observed that the AMR heat circulator is capable of circulating the process heat in the vicinity of the Curie temperature of a magnetocaloric material with small energy. Singh et.al. Investigated energy conservation in metal casting. [18] In their design, they used a special designed device called recuperator to make use of the waste heat exposed to atmosphere which eventually increased efficiency of furnace. The efficiency almost doubled with the application of recuperator. The fuel consumption reduced by almost 25 percent with recuperator. Stalin et. al. carried out studies in order to use the heat wasted by air conditioners. [19] They made an attempt to recover waste heat rejected by the 1 TR air conditioning systems. They were able to rescue 5040 units of electricity. According to these studies, by supplanting the normal air conditioner by this system one can save to rescue 4 numbers of LPG gas cylinders per year.

Dadi et.al. proposed a gamma type stirling engine for efficient recovery of heat. [20] According to them, thermal limit of the operation of the stirling engine depends on the material used for construction. Wang presented several novel ideas to use heat pipes in adsorption water chiller or ice maker. [21] They achieved a cooling COP of 0.4 for a small scale silica gel-water adsorption water chiller with cooling power rated as 10 kW, and driven by 85°C hot water. For, a silica gel-water adsorption room air conditioner powered by 80 °C hot water, a COP of 0.3 was achieved. Dubey et. al. presented review on waste energy recovery systems. [22] According to this review the use of Rankine cycles with low-grade thermal sources offers significant potential for energy productivity. Also Rankine cycles are viable technology for our energy future. Also they highlighted the fact that heat pump technologies are widely used for upgrading ambient heat from sustainable sources, such as air, water, the ground and waste heat, to heating temperatures.

Fukushima et. al. carried out studies on eco-friendly regenerative burner heating system technology application. [23] They observed that use of a ceramic honeycomb regenerator brings the temperature of preheated air to a level close to the temperature of furnace gases. This brings about extremely efficient recovery of the heat compared to conventional heat exchanger. The regenerative efficiency was observed in the rage 70 to 90 percent by them. The existing heat exchanger system has efficiency 40 to 50 percent. Sabek et. al. carried out studies on an analytical solution of heat and mass transfer processes in regenerator and air conditioning system (ACS)cores of a heat recovery/desiccant cooling system (HRDCS). [24] The results indicated improvement in the coefficient of performance of system when they used the renewable energy for heating and cooling. Tahani et. al. carried out comprehensive studies on waste heat recovery from internal combustion engines using organic Rankine cycle. [25] They tried to maximize the power generation and cycle thermal efficiency. They used two different configurations of organic Rankine cycle. They considered expander inlet pressure and preheating temperature as design parameters. They observed that the best performance in both configurations was obtained using R-123 as the working fluid.

Analysis of the use of waste heat in an oxy-combustion power plant to replace steam cycle heat regeneration was carried out by Job et.al. [26] They analyzed a supercritical oxycombustion coal-fired power plant. They presented the results of thermodynamic analysis for different cases of compression installations organization extracted from individual blocks of the oxy-combustion unit. Their analysis proved that division of compressors into intercooled sections allows for significant reduction of the compressors electricity consumption. Studies carried out by Kic and Zajicek were focused on the computational fluid dynamics (CFD) modeling of regenerative heat exchanger suitable for animal houses. [27] They used CFD modeling to calculate main parameters of a special heat exchanger. They observed that the limiting factor for the structure of the heat exchanger was the absorption of the heat from the air flow. Thu et.al. presented the performance of a heat-driven adsorption (AD) chiller. [28] This chiller utilized a low temperature hot water which can be extracted from either an exhaust of processes or the solar thermal energy. The AD system had advantages like no moving parts, low maintenance and environment friendly operation. These studies indicated that the overall heat transfer coefficients of the processes have a direct linear relation with the hot water inlet temperatures.

Rey-Chein and Wen-Chiang carried out studies on high temperature air combustion fired heavy oil. [29] They observed that NOx level was controlled below the regulation by staged fuel combustion. Also stabilized flames are continuously maintained. Kumar and Krishna carried out an investigation on evaporation and condensation processes using vapour adsorption technique. [30] The absorption refrigeration works on principle of the evaporation and condensation of a refrigerant combined with adsorption or chemical reaction. They highlighted advantages of this method such as environmental friendliness and suitability for numerous other applications such as air-conditioning and cooling food storage units. Saidur et.al carried out studies on the latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE). [31] The heat can be saved by different ways. The heat can either be ’reused’ within the same process or transferred to another thermal, electrical, or mechanical process. They highlighted the concept of exergy efficiency. This concept helps to show the environmental impact by numbers. Elsner et. al. presented the analysis of operating conditions of a modern supercritical power plant. [32] They demonstrated the role of supercritical parameters in enhancing the efficiency of the thermodynamic process. They observed almost 3-4% rise in efficiency in case of super–critical concept than the critical steam cycles.

CONCLUSION

Selection of the working fluid is important aspect in refrigeration and cooling application. The AD system had advantages like no moving parts, low maintenance and environment friendly operation. Environmental friendliness and suitability are additional advantages of absorption refrigeration. Various investigators have observed that minor modification carried out after proper analysis of the system has led to energy saving ranging from 25 to 40 percent. The concepts of cogeneration and regeneration have yielded very high energy saving possibilities when applied to various heat engines and refrigeration cycles.

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