Insight into Research, Investigations and Surveys on Heat Pumps and Engines

Towards Efficiency and Cost Effectiveness

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***Abstract*— The reduction is energy consumption or energy efficient technologies are becoming need of modern day development. Waste heat recovery, cogeneration are important aspects of heat recovery and reuse. Use of nanoparticles increases the heat transfer and increases efficiency. Heat pumps are devices used in a mechanical-compression cycle refrigeration system. They can be used to either heat or cool a controlled space . Various investigators have tried different heating cooling mediums and modifications in typical heat pumps based on need and cost. Energy efficient operations and equipment not only enhances profit but also it is environment friendly. The work carried out by various researchers reveal that classical thermodynamic analysis based on thermodynamic equilibrium do not consider constraints such as irreversibilities originating from finite-time and finite-size constraints. Also investigators observed that irreversibilities originating from finite-time and finite-size constraints are important. Few studies indicated that Sterling-cycle machines offer an environmentally-friendly alternative to vapour-compression systems. The results of single pressure absorption system yielded positive results. The current review summarizes research; investigations are surveys on heat pumps.**

***Index Terms*— Energy, efficiency, absorption, Carnot, Rankin, cycle, power.**

I. INTRODUCTION

Energy efficient operations and equipments not only enhances profit but also are environment friendly. The reduction is energy consumption or energy efficient technologies are becoming need of modern day development. Various nonconventional energy sources are overtaking conventional sources. Fuel cells, tidal, solar energy sources are being explored for their use[1-6]. Process intensification is becoming very familiar and sought after method of reducing cost, space and increasing efficiency [7-9]. Pinch analysis and energy retrofit studies help in deciding optimum temperature and energy utilization [10-12]. Waste heat recovery, cogeneration are important aspects of heat recovery and reuse [13-15]. Use of nanoparticles increases the heat transfer and increases efficiency [16]. Heat pumps are devices used in a mechanical-compression cycle refrigeration system. They can be used to either heat or cool a controlled space. It extracts heat from one place and transfers it to another. The heat pump cycle is fully reversible. Three types of heat pumps are air-to-air, water source, and geothermal. The heat pumps operate on Carnot or Rankin cycles. Various investigators have tried different heating cooling mediums and modifications in typical heat pumps based on need and cost. The current review summarizes research; investigations are surveys on heat pumps.

II. RESEARCH, INVESTIGATIONS AND SURVEYS ON HEAT PUMPS

Kaneko has reported use of gas heat pump and its effects[17].He explained various facts related to gas heat pumps. First fact was, as it is driven by natural gas, there is savings in energy. Control of cooling and heating capacity provides efficiency during partial capacity. Analysis of single pressure absorption heat pump was carried out by Schaefer[18].Generally dual pressure cycle systems are used in the heat pumps. The need for a pump and any electrical power is removed in single pressure absorption heat pump. Due to this it becomes portable, inexpensive, reliable, and silent. Between the generator and the condenser/absorber, they added external heat exchanger. This helped improve heat recovery. Jordan et.al. explored use of heat pump for thermal power production in dairy farm[19].Normally Ohmic heating has been used in dairy farms. This increases energy cost. They proposed a water-water heat pumping for simultaneous cold and heat generations. They proved that it is feasible to use two thermal effects (cooling and heating) of a heat pump in a single device. Their work also explored the possibility of driving heat pumps with biogas from animal manure. Becker et.al. studied process integration to optimize the process[20].They worked towards decreasing energy demand and operating costs as well as reduction of pollutants emissions. They carried out pinch analysis to demonstrate the opportunity of integrating heat pumps in industrial processes. They found that an important energy saving potential can be realized by the combination of appropriate refrigeration and heat pump cycles. Distillation column analysis was incorporated with heat pump/heat engine principles by Olakunle et.al.[21].According to them, the plate-to-plate distillation operation was seen to be akin to the operation of a reverse absorption heat pump. They considered reboiler as generator in absorption system. According to them, absorption, condensation and evaporation can be considered akin to the working of enriching and stripping section. They concluded that a better understanding of the energy transformation processes within a distillation column can be obtained by extending the principles of heat engine and heat pump to distillation operation.

Performance analysis of a generalized radioactive heat engine was carried out by Maheshwari et.al.[22].In their work, they analyzed an internally and externally irreversible radioactive Carnot heat engine model. By using various criteria, they analyzed the advantages and disadvantages of a maximum efficient power (MEP) design. In a technical review of Mitsubishi Heavy Industries, Ltd., Yoshimura et.al. discussed high-performance gas heat pump ECO7[23].They discussed advantages such as the fact that the ECO7 includes a large-capacity outdoor combination series using two outdoor units. In one refrigerant system, it enable simultaneous cooling and heating. They concluded that objectives such as market needs for reduction of environmental impact, improved efficiency and increased capacity can be met with new heat pump. Experimental performance of an R134a automobile heat pump system coupled to the passenger compartment was analyzed by Direk et.al.[24]. For developing experimental set up, they used the components of the air conditioning system of a compact-size car. They tested the experimental set up by changing the engine speed, engine load and air temperatures entering the condenser and evaporator. They applied energy analysis to the system based on experimental data. They found for first five minutes, that automotive heat pump (AHP) system using engine coolant provides higher heating capacities and air temperatures. At steady state, the baseline heating system usually performs better than the AHP system. Weerasiri performed studies on the heat recovery from exhaust gas at the ACE Power Embilipitiya (Pvt) Ltd (APE) in Sri Lanka[25]. He conceptually proposed and evaluated heat recovery system. To avoid temperature cross situations, he selected 8 ^{0}C approach temperature. He used Engineering Equation Solver software for the purpose of optimization of the modeled HRSG.

Hendricks et.al. discussed cooling opportunities generated due to heat related procedures[26].According to them, it has potential to reduce the amount of fuel used today for air conditioning. For a typical car, according to them, the waste heat available is twice as much as the mechanical output of the engine. The coolant, exhaust gases, and engine compartment warm-up work as an output for remaining 70 percent heat. They proposed Hydride heat pumps. They use the fact that utilize the fact that when hydrogen is adsorbed by the metal heat is released in reaction. Input can be desorbing or releasing the hydrogen, which is endothermic.

Jinshah et.al. carried out investigation on standing wave thermo acoustic refrigerator[27]. For designing this, they used readily available materials. Their studies suggested that thermo acoustic technology was suited candidate for conventional vapour compression cooling system. In their work, they identified optimum operating conditions for the design, fabrication, and operation of a thermo acoustic refrigerator.Thermoacustic effect also includes temperature oscillations as a response to the pressure variations. Livingstone under a guidance of Doctor Nick Kelly carried out investigation on the suitability of air and ground source heat pumps[28]. His investigation was related to the UK environment with a swimming pool complex heat pump. He reported studies on the suitability of both GSHPs and ASHPs to the UK environment. ASHP systems were better in terms of space, time and expense of installation. In terms efficiency, operating cost, life and short term maintenance, GSHPs were better that ASHPs.In technical meeting on the user–vendor interface in cogeneration for electricity production and seawater desalination, Przybyszewska proposed waste heat from research reactor as a source for heat pump for low temperature cogeneration[29].

Momen et.al. carried out work aimed at a residential fuel fired heat pump design[30]. They prepared a report based on work sponsored by an agency of the United States Government. They, more importantly evaluated the commercial viability of a residential fuel fired multifunction heat pump. The design was optimized for the smallest possible footprint, the lowest possible electric consumption, and the best possible efficiency. Heywood et.al. explored possibility of use of low-cost Sterling-cycle machines with air as a refrigerant [31].In this article they outlined the working principles of Sterling-cycle heat-pumps and refrigerator. According to them, Sterling-cycle machines offer an environmentally-friendly alternative to vapour-compression systems. For a practical machine, they found the Sterling Cycle to be extremely difficult to optimize. Once optimized it provides as good performance as traditional vapour-compression systems. A low-cost mechanical design configuration, and manufacturing in sufficiently large volumes are two key attributes which can render feasibility to this system.

Finite-time thermodynamics and thermo-economics based optimization of thermal systems was studied by Durmayaz et.al.[32]. In the real thermal system optimization, according to them, irreversibilities originating from finite-time and finite-size constraints are important. The energy transfer between the system and its surroundings in the rate form was considered by them for analysis. According to their studies, classical thermodynamic analysis based on thermodynamic equilibrium do not consider constraints such as irreversibilities originating from finite-time and finite-size constraints.Teiniranta carried out work related to heating and cooling with a heat pump[33].He discussed different types of heat pumps. His emphasis was on vapour-compression heat pump.

III. CONCLUSION

Energy efficient operations and equipment not only enhances profit but also are environment friendly. The work by various researchers reveal that classical thermodynamic analysis based on thermodynamic equilibrium do not consider constraints such as irreversibilities originating from finite-time and finite-size constraints. Also investigators observed that irreversibilities originating from finite-time and finite-size constraints are important. Few studies indicated that Sterling-cycle machines offer an environmentally-friendly alternative to vapour-compression systems. The results of single pressure absorption system yielded positive results. As indicated in few studies, the need for a pump and any electrical power is removed in single pressure absorption heat pump.

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