Name of Scholar: Salma Khatoon **Notification No: 578/2022**

Name of Supervisor: Prof. Munawar Nawab Karimi **Date of Award:23-05-2023**

Name of Department: Mechanical Engineering

Topic of Research: Comparison of Fourth Generation Refrigerants By Second Law Efficiency and Exergy Destruction Analysis

Findings

Refrigeration and air conditioning systems are the most widely used systems. Their diverse usage covers all sectors, be it residential, industrial, commercial, or research. Single vapour compression refrigeration systems are utilized in domestic sectors and their demand is ever-increasing. Automobiles also have been using these systems for air-conditioning as they not only provide thermal comfort but also improve road safety with the comfort of the driver. However, now there is a rising demand for refrigerators also in automobiles. With automobile air-conditioners already wiping off around half of the engine power, the addition of refrigerators will add a huge overload. Hence, an efficient system is required and two-evaporator systems can be a way out. Many international regulations have been adopted to restrict the high global warming potential refrigerants such as HFC-134a. So, many low GWP refrigerants have been studied in different systems to observe the impact of these refrigerants on the system and the environment.

The first part mainly focuses on the effects of engine speed and ambient temperatures on thermodynamic performance and the emissions of the automobile air conditioning system (AAC) system. For this purpose, low GWP refrigerants R1234yf, R1243zf, R450A, R143m, and R161 are analysed. It is found that work consumption, total exergy destruction, and cooling capacity are positively correlated with speed. After R161, R134a indicates the highest input power, total exergy destruction, and cooling capacity in all the cases. R1243zf, R143m, and R450A show almost equivalent cooling capacity, and also R1243zf and R143m indicate similar input power with a difference of approximately 1.5% with the latter having the lowest work input. It is worth mentioning that indirect emissions are directly impacted by speed and high indirect emissions correlate to high fuel consumption. Furthermore, at idle speed, R134a indicates the highest total global warming emission of 7.65 tons co2 per year whereas, at normal and high speed, R161 shows the highest value of 12.38 and 17.33 tons co2 per year, respectively. R1243zf shows the lowest TEWI in all cases.

performance of the different generations of refrigerants in the cascade refrigeration system. The main aim of this comparative study is to present a comprehensive outlook on the environmental impact of refrigerants. A different perspective on refrigerant selection to reduce global warming is also discussed. R600a, R290, R12, R22, R134a, R152a, R245fa, R1234yf, and R1234ze are used in the high-temperature circuit, while R32 is used in the low-temperature circuit. Exergy and energy analyses are done for thermodynamic performance, and total equivalent warming impact (TEWI) assessment is carried out to show global warming produced. While the refrigerant couple R152a/R32 shows the best thermodynamic performance with maximum COP, minimum exergy destruction, and maximum second law efficiency, R1234yf/R32 displays the worst thermodynamic performance. R12/R32 shows maximum TEWI while R290/R32 shows minimum TEWI. The first-generation refrigerants are found to be most environmentally friendly followed by the third and fourth. It is concluded that thermodynamic performance plays a significant role in reducing TEWI as indirect emissions account for the major part of the TEWI, and therefore, the global warming potential cannot be the only basis for refrigerant selection. This study suggests that first-generation refrigerants and R152a can be better alternatives.

The third part evaluates a two-evaporator vapor compression system to eliminate the requirement for separate refrigeration and air conditioning units. Various refrigerants with low GWP such as R513A, HFO1336mzz(Z), R1234yf, and R450A are compared against high GWP R134a and R452A. The results reveal that maximum exergy efficiency and COP and lowest compressor power of 31.50%, 2.47, and 6.304 kW, respectively, are obtained with HFO1336mzz(Z). After HFO1336mzz(Z), R134a shows the highest exergy efficiency and COP of 30.56% and 2.41, respectively, and the lowest compressor power of 5.61kW. HFO1336mzz(Z) exhibits the optimum performance, whereas R452A shows the worst thermodynamic performance in the system. It is also found that the performance of R450 and R513A, R450A and R1234yf is approximately equivalent to each other. Moreover, component-wise exergy destruction analyses indicate that the efficiency of the compressor needs to be improved as the maximum destruction of 61.84-56.00% is found in the compressor alone while the minimum exergy destruction of 0.42-0.54% occurs in expansion valve. This study proposes the two-evaporator system for both refrigeration and air conditioning in automobiles. It also finds that R450A, R1234yf, R513A, and HFO1336mzz(Z) can be the potential alternative to
R134a.