R1234yf/R134a Based Refrigerant Mixture for Automobile Air Conditioning Systems: A Thermodynamic Approach

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Abstract. The environmental protocols lead to analysing various refrigerants minimum global warming potential (GWP) to substitute high GWP R134a in an automobile air conditioning (AAC) system. The present study deals with the thermodynamic analysis of the AAC unit using R1234yf/R134a refrigerant mixtures under three-vehicle speed conditions such as idling (L-900 rpm), city limit (M-1800 rpm), and high speed (H-2700 rpm). The mass fractions of R1234yf/R134a such as 0:1, 1:0, 0.9:0.1, 0.8:0.2, 0.7:0.3, 0.6:0.4 and 0.5:0.5 were considered in this analysis. The cooling capacity and coefficient of performance (COP) of R1234yf were observed to be poorer than that of the existing R134a by up to 10.4% and 8.3%. The addition of R134a in R1234yf reduced the performance gap between the existing R134a system under all the speed conditions. There was an increase cooling capacity and COP of the AAC by up to 6.4% and 4.9% was found with the addition of 0.5 mass fraction of R134a in R1234yf. However, the GWP of the refrigerant mixture was increased with rise in R134a mass fraction of which causes more direct CO2 emission from the AAC system. This study prevailed that the use of R1234yf/R134a mixture (0.5:0.5 by a mass fraction) performed very much similar to that of R134a in the AAC unit. Further, the R1234yf/R134a mixture (0.9:0.1 by a mass fraction) is suggested to use in the AAC system to satisfy the environmental protocols (GWP < 150).

1. Introduction

The use of refrigerants with high global warming potential (GWP) needs to be replaced soon because of the environmental protocols [1]. In this context, many researchers were trying to replace the existing R134a because of its GWP as 1430 in automobile air conditioning (AAC) systems [2]. The AAC system played a crucial role in fuel consumption also because it used 12 – 20% of engine power for running its compressor [3]. It is very important to consider thermo-physical, environmental, toxicity, and flammability properties for the selection of new refrigerant to replace R134a [4]. The properties of thermo-physical namely, latent heat of condensation and evaporation, thermal conductivity, viscosity, density, and pressure-temperature characteristics are played a significant role in the refrigerant performance [4]. Many refrigerants such as R152a, R1234ze(E), R1234yf, R744, R290, R600a, R430A, R444A, and R445A, etc were used in the AAC system for R134a replacement [5 – 11]. Out which, R1234yf attracts many researchers because of its comparable pressure-