

ENSC 461 PROJECT: Next generation air conditioning systems for vehicles

Assigned date: Feb. 21, 2011

Due date: April 11, 2011

Introduction

Air conditioning is a critical system for hybrid electronic vehicles (HEVs), as it is the second most energy consuming system after the electric motor. Further, HVAC loads are the most significant auxiliary loads present in conventional ICE vehicles today. All current air conditioning systems used in the automotive industry are based on vapour-compression refrigeration cycle. A/C energy use outweighs the energy loss to rolling resistance, aerodynamic drag, or driveline losses for a typical vehicle. The U.S. alone consumes about 7 billion gallons of fuel a year for HVAC systems of light duty vehicles. An A/C compressor can add up to 5-6 kW peak power draw on a vehicle's engine, or battery pack in case of HEVs and EVs. This power draw is equivalent to a 1200-kg sedan driving steady-state down the road at 60 km/h. Significant opportunities for reducing the A/C power consumption lie in designing more efficient systems and intelligent control of various components in the cycle.

Devising efficient HVAC strategies in HEVs is of critical importance since adding any auxiliary load on the battery pack will affect fuel economy and driving range. For example, an increase in auxiliary load from 500 W to 3500 W (i.e. the A/C compressor load) leads to a 38% decrease in fuel economy. Based on a study in National Renewable Energy Lab (NREL), the A/C system can increase tailpipe emissions significantly, more than doubling the CO and NO_x depending on the engine.

Refrigerant type

In addition to significant power consumption of vapour-compression systems, finding a new "green" refrigerant is another major challenge facing the automotive industry. Currently, R-134a is being used, almost in all vehicles, as the refrigerant. R134a has a global warming potential (GWP) of 1300 times that of CO₂. The European Union is to ban R134a in 2011 and Canada and the US will follow suit soon after. Therefore, the industry has been searching for refrigerants with low GWP for automotive A/C systems. CO₂ and R152a have been proposed as potential alternatives to R134a. However, their effects on the thermal performance of the vapour-compression cycle are not clearly understood.

Your task

Your task is to design a vapour-compression system with a nominal capacity of 6 kW using both R-134a and CO₂. Design and comparison parameters that should be included in your work include, but not limited to: the system efficiency (COP), cost, weight, and environmental impacts of both systems. A software design tool should be developed to investigate and compare both systems under various driving and climate conditions.

The project report should also include: properly sized heat exchangers (evaporator, condenser, inter-cooler), valves, piping system, control system (optional), compressor, and other parts; a wealth of information can be found online and from suppliers. Preliminary engineering drawings will be considered extra.

Research proposal

As a first step, your group need to prepare a short research proposal. This short document should have three major sections:

1) Introduction (~ 1 page): describe the importance and challenges facing A/C in the automotive industry; this should include the environmental impacts, initial costs, maintenance, and performance. Perform a literature review and describe the state-of-the-art for A/C in automotive industry, for both conventional ICE and HEVs in the automotive industry. Other items include: recent activities in the area, environmental impacts/laws/regulations, emerging systems, new refrigerants; cite the references.

2) Objectives (a paragraph): mention what are the objectives and milestones of your proposed research activities, preferably in an itemized fashion.

3) Methodology (~1 page): Describe how you are going to achieve these goals. Examples of the proposed activities include: developing a design tool for modeling refrigeration cycle (thermodynamic and thermal models), impact of new refrigerant on Coefficient of Performance (COP), methods to enhance the COP, second law efficiency (exergy analysis), impact of new techniques on overall vehicle performance.

You need to provide a list of references that you used in preparation of the document (extra page).