BUILD SIMUL (2012) 5: 219 – 232
DOI 10.1007/s12273-012-0089-0

Modelling and simulation of a heat pump for simultaneous heating and cooling

Paul Byrne (✉), Jacques Miriel, Yves Lénat

Equipe MTRhéo, Laboratoire LGCGM, INSA Rennes — Université de Rennes1, IUT Génie Civil, 3 rue du clos Courtel, BP 90422, 35704 Rennes Cedex 7, France

Abstract

The heat pump for simultaneous heating and cooling (HPS) carries out space heating, space cooling and hot water production for small office and residential buildings. It works under heating, cooling and simultaneous modes to produce hot and chilled water according to the thermal demand of the building. A subcooler connected to a water tank is placed after the condenser to recover some energy by subcooling of the refrigerant during a heating mode. The water loop at a higher temperature than ambient air is used subsequently as a source for a water evaporator. Average winter performance is improved compared to a standard reversible heat pump (HP). The air evaporator is defrosted by a two-phase thermosiphon without stopping the heat production. The operation of the HPS is modelled using TRNSYS software. The model is validated using results of an experimental study carried out on a HPS prototype working with R407C. Annual simulations of the HPS coupled to a hotel are run in order to evaluate annual performance and energy consumption of the system. The results are compared to the ones of a standard reversible HP. Depending on the scenario, savings in electric energy consumption and annual performance improvement can reach respectively 55% and 19%.

Keywords

heat pump,
simultaneous heating and cooling,
defrosting

Article History

Received: 6 July 2011
Revised: 7 December 2011
Accepted: 13 January 2012

1 Introduction

In developed countries, commercial and residential buildings account for around 40% of national energy consumption and 25% of greenhouse gas emissions. This is the sector in which savings have to be made in priority. Thermal performance of buildings is thus continuously improving thanks to thermal regulations. Besides, comfort requirements demand more and more energy. Whilst domestic hot water (DHW) demands increase continuously, a demand for cooling appears or rises to compensate internal heat gains caused by more and more household electrical equipment. A more insulated thermal envelope implies also that new buildings need less energy for heating and more for cooling. Therefore thermal needs of new buildings are more balanced between heating and cooling over the year.

During winter, energy is demanded exclusively for space heating and DHW production. Between winter and summer, some buildings can demand simultaneously cooling in rooms facing south and heating in rooms facing north. During summer, energy is needed for DHW production and space cooling at the same time. An answer to a dual energy demand is the heat pump, since it supplies simultaneously a heating capacity at the condenser and a cooling capacity at the evaporator. Annex 48 of the ECBCS programme (Energy Conservation in and Community Systems) of the IEA (International Energy Agency) deals with this topic (Stabat 2008). The annex first highlights that some buildings actually present simultaneous or slightly delayed heating and cooling needs and then proposes solutions to satisfy these needs using heat pumping technology.

This study presents the model of a heat pump that can satisfy fluctuating needs, simultaneous or not, in heating and cooling. This heat pump is named HPS (Heat Pump for Simultaneous heating and cooling) and can be installed in hotels where DHW demands are high and glass-fronted buildings where simultaneous needs in space heating and space cooling are more frequent. The first objective is to

E-mail: paul.byrne@univ-rennes1.fr