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Evaluation of Low-Global Warming Potential Refrigerants in Vapor Compression Heat Pumps

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Abstract : Global warming presents an immense environmental risk, causing detrimental impacts on ecological systems and putting coastal areas at risk. Implementing efficient measures to minimize greenhouse gas emissions and the use of fossil fuels is essential to reducing global warming. Vapor compression heat pumps provide a practical method for harnessing energy from waste heat sources and reducing energy consumption. However, traditional working fluids used in these heat pumps generally contain a significant global warming potential (GWP), which might cause severe greenhouse effects if they are released. The goal of the emphasis on low-GWP (below 150) refrigerants is to further the vapor compression heat pumps. A classification system for vapor compression heat pumps is offered, with different boundaries based on the needed heat temperature and advancements in heat pump technology. A heat pump could be classified as a low temperature heat pump (LTHP), medium temperature heat pump (MTHP), high temperature heat pump (HTHP), or ultra-high temperature heat pump (UHTHP). The HTHP/UHTHP border is 160 °C, the MTHP/HTHP and LTHP/MTHP limits are 100 and 60 °C, respectively. The refrigerant is one of the most important parts of a vapor compression heat pump system. Presently, the main ways to choose a refrigerant are based on ozone depletion potential (ODP) and GWP, with GWP being the lowest possible value and ODP being zero. Pure low-GWP refrigerants, such as natural refrigerants (R718 and R744), hydrocarbons (R290, R600), hydrofluorocarbons (R152a and R161), hydrofluoroolefins (R1234yf, R1234ze(E)), and hydrochlorofluoroolefin (R1233zd(E)), were selected as candidates for vapor compression heat pump systems based on these selection principles. The performance, characteristics, and potential uses of these low-GWP refrigerants in heat pump systems are investigated in this paper. As vapor compression heat pumps with pure low-GWP refrigerants become more common, more and more low-grade heat can be recovered. This means that energy consumption would decrease. The research outputs showed that the refrigerants R718 for UHTHP application, R1233zd(E) for HTHP application, R600, R152a, R161, R1234ze(E) for MTHP, and R744, R290, and R1234yf for LTHP application are appropriate. The selection of an appropriate refrigerant should, in fact, take into consideration two different environmental and thermodynamic points of view. It might be argued that, depending on the situation, a trade-off between these two groups should constantly be considered. The environmental approach is now far stronger than it was previously, according to the European Union regulations. This will promote sustainable energy consumption and social development in addition to assisting in the reduction of greenhouse gas emissions and the management of global warming.

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