Mechanical Engineering Doctoral Defense

Liquid-Phase Thermochemical Reactions For Thermal Energy Transport and Storage

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Abstract

District heating plays an important role in improving energy efficiency and providing thermal heat to buildings. Instead of using water as an energy carrier to transport sensible heat, this dissertation explores the use of liquid-phase thermochemical reactions for district heating as well as thermal storage. Chapters 2 and 3 present thermodynamic and design analyses for the proposed district heating system. Chapter 4 models the use of liquid-phase thermochemical reactions for on-site solar thermal storage.

In brief, the proposed district heating system uses liquid-phase thermochemical reactions to transport energy from a heat source to a heat sink. The separation ensures that the stored thermochemical heat can be stored indefinitely. The reactant molecules are then pumped to the heat sink, where they are combined in an exothermic reaction to provide heat. The product is then pumped back to the heat source for re-use. The key evaluation parameter is the system efficiency.

The results demonstrate that with heat recovery, the system efficiency can be up to 77% when the sink temperature equals 25 □C. The results also indicate that the appropriate chemical reaction candidates should have large reaction enthalpy and small reaction entropy. Further, the design analyses of two district heating systems, Direct District Heating (DDH) system and Indirect District Heating (IDH) system using the solvated case shows when the distance is shorter than 106m, the factors related to the chemical reaction at the user side and factors related to the separation process are important for the DDH system. When the distance is longer than 106m, the factors related to the fluid mechanic become more important. Because the substation of the IDH system degrades the quality of the energy, when the distance is shorter than 106m, the efficiency of the substation is significant. Lastly, I create models for on-site solar thermal storage systems using liquid-phase thermochemical reactions and hot water. The analysis shows that the thermochemical reaction is more competitive for long-duration storage applications. However, the heat recovery added to the thermochemical thermal storage system cannot help improving solar radiation absorption with high inlet temperature of the solar panel.

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