ENERGY RECYCLING UTILIZATION SYSTEM USING CHEMICAL HEAT PUMP CONTAINER

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Abstract: From the viewpoints of energy and resource problems, an effective energy utilization system for wide area energy management using chemical heat pump container (CHPC) is proposed. In this system, waste heat at factory area is stored as chemical energy in the CHPC. The stored heat is transported with almost no heat loss by the CHPC transportation using truck, train, ship etc. At heat supply area, the stored heat is upgraded to higher temperature heat for heating or lower temperature heat for cooling/refrigerating without adding extra energy by the chemical heat pump function. In this study, the simulation on local recycling energy system using CHPC for wide Tokyo area was performed and the efficiencies on energy, cost and CO_2 emission were shown. As a result, the system using CHPC was found to be more effective than similar transportation systems using latent heat storage container etc. Especially, the system using CHPC can supply hot-heat and cold-heat without adding extra energy at heat supply area effectively.

Key Words: chemical heat pumps, chemical heat storage, energy transportation

1 INTRODUCTION

From the viewpoints of energy and resource problems, an effective energy utilization system using chemical heat pump container (CHPC) as shown in Figure 1 was proposed and evaluated for wide area energy management.

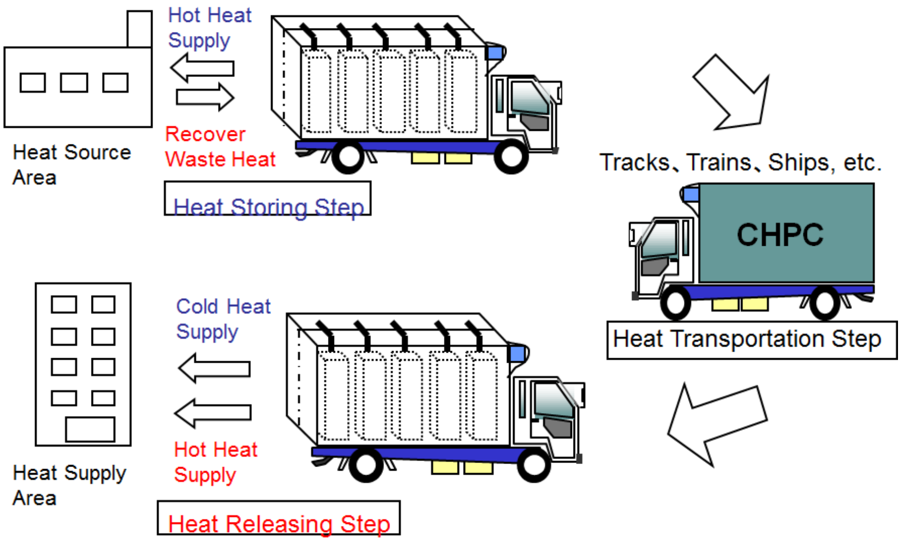

Figure 1: Proposed waste heat recycling system using Chemical Heat Pump Container

In this system, waste heat at factory area is stored as chemical energy in the CHPC. The stored heat is transported with almost no heat loss by the CHPC transportation using truck, train, ship etc. At heat supply area, the stored heat is upgraded to higher temperature heat for heating and/or lower temperature heat for cooling/ refrigerating without adding extra energy by the chemical heat pump function.

2 CHEMICAL HEAT PUMP CONTAINER (CHPC)

Chemical Heat Pump (CHP) can be a possible key technique for the effective energy recycling systems [3] as it has two important functions in both heat storage and heat pump technologies. The CHP can store thermal energy such as the waste heat from exhaust air, solar energy, geothermal energy, etc. and release the energy at various temperature levels on demand. The CHP has following advantages: long term thermal storage, high energy-storage density, no other energy sources, and large output temperature range.

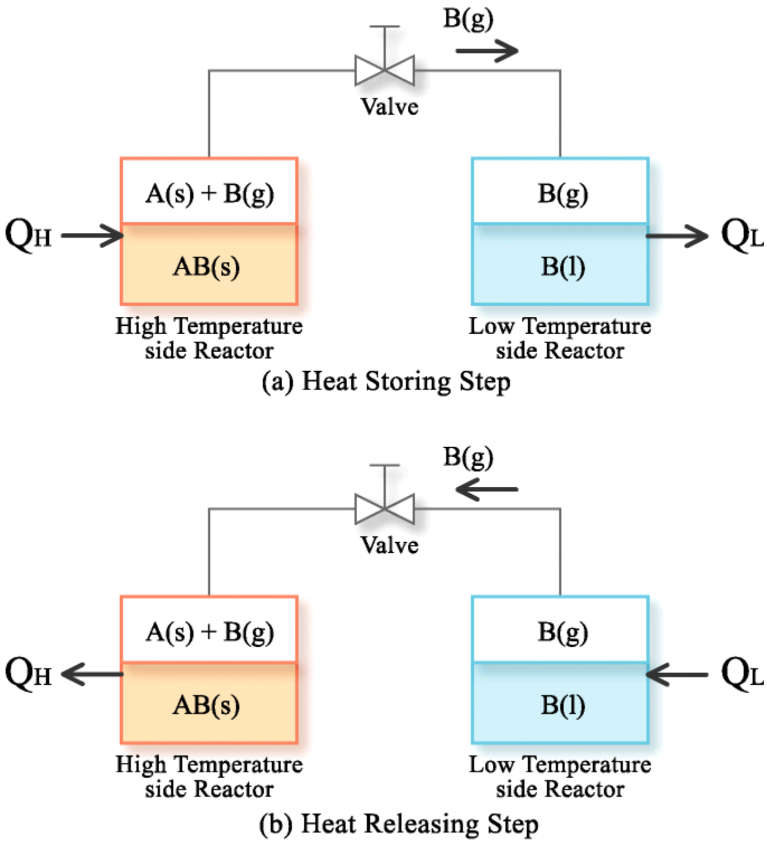

Figure 2: Typical gas-sold Chemical Heat Pump

Figure 2 shows a typical gas-solid CHP configuration. The CHP is a closed system of coupled low and high temperature reactors connected to each other. The heat storage and release reactions occur at different pressure levels. The low temperature side reactor has a higher reaction equilibrium pressure line. The CHP, as studied earlier, operates as a batch system with a heat storing step and a heat releasing step [2].
In this study, the following reaction system was applied for the local recycling energy system using Chemical Heat Pump Container (CHPC).

$$CaSO_4 1/2H_2O(s)+16.8KJ/mol \leftrightarrow CaSO4+1/2H_2O(g) \quad (1)$$

$$1/2H_2O(g) \leftrightarrow 1/2H_2O(l)+20.9KJ/mol \quad (2)$$

The CHPC is assumed to be 21m^3 and divided two spaces at 16:1 for the above two CHP reactors. One is for $CaSO_4$ reaction and the other is for evaporation/condensation of water. Spherical capsules (6.00*10^{-2}mφ) are loaded onto the spaces by the closest packing as the small reactors and the evaporators/ condensers. The volume and the surface area of capsule are 15.5m^3, 783m^2.

3 SIMURATION

The unsteady heat and mass transfer analysis of the container by forward difference method was performed as shown in our previous study[1]. The stored/released amount to/from the reactors were simulated and the simulation on local recycling energy system using CHPC for wide Tokyo area was performed. Finally, the efficiencies on energy, cost and CO_2 emission were shown.

4 RESULTS AND DISCUSSION

As example of results, the changes of temperature profile and stored/released heat amount to/from the container are shown in Figures 3-6.

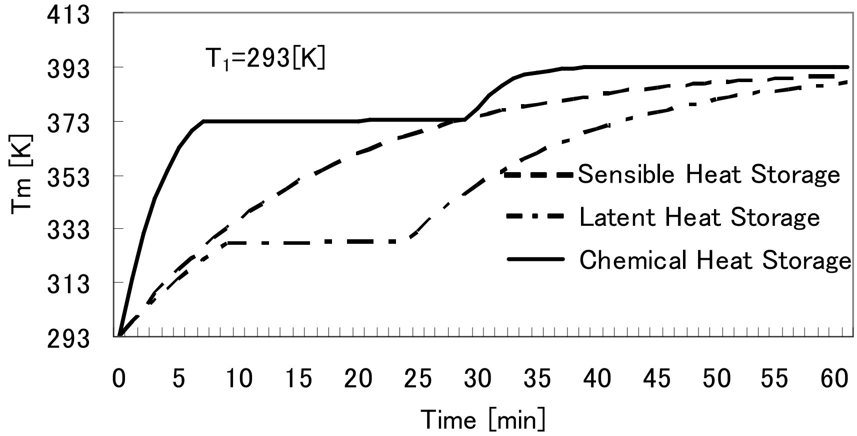

Figure 3: Temperature changes of heat storage material in 120℃ containers

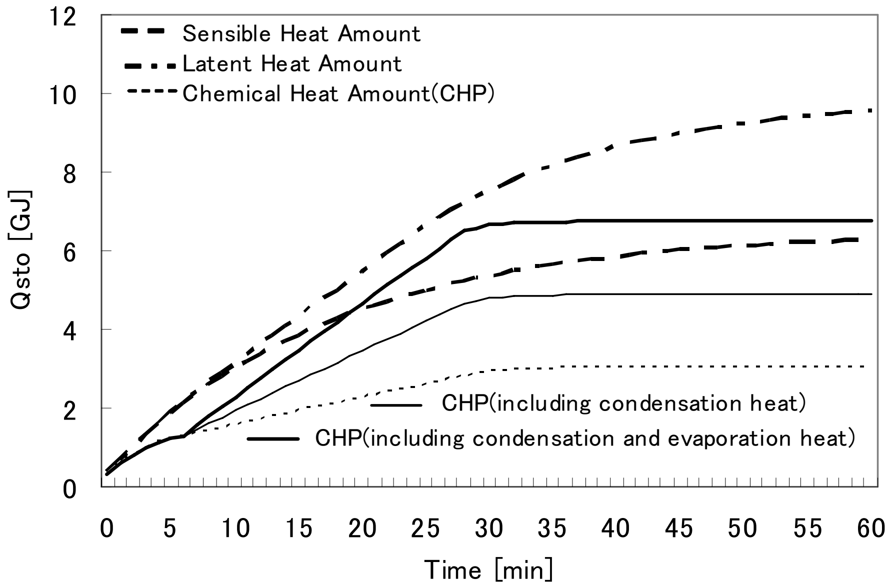

Figure 4: Stored heat changes of heat storage material in 120℃ containers

Figure3, CHPC and LHSC have flat term because of the reaction and the phase change.
It can be seen from Figure 4, the system using CHPC stores heat less than similar transportation systems using sensible or latent heat storage container. However, the CHPC can release more energy than the others by releasing hot and cold heat caused by heat pump function.

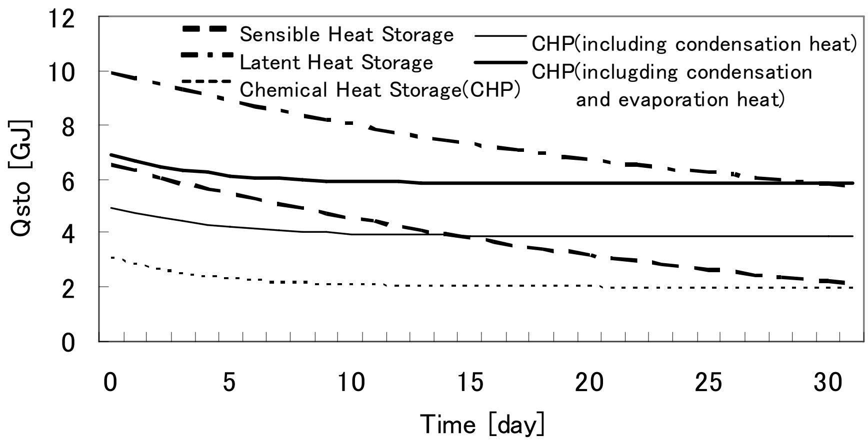

Figure 5: Stored heat changes of heat storage material in 120℃ containers

Figure 5 shows that the heat loss of CHPC is much less than similar transportation systems using sensible or latent heat storage container.

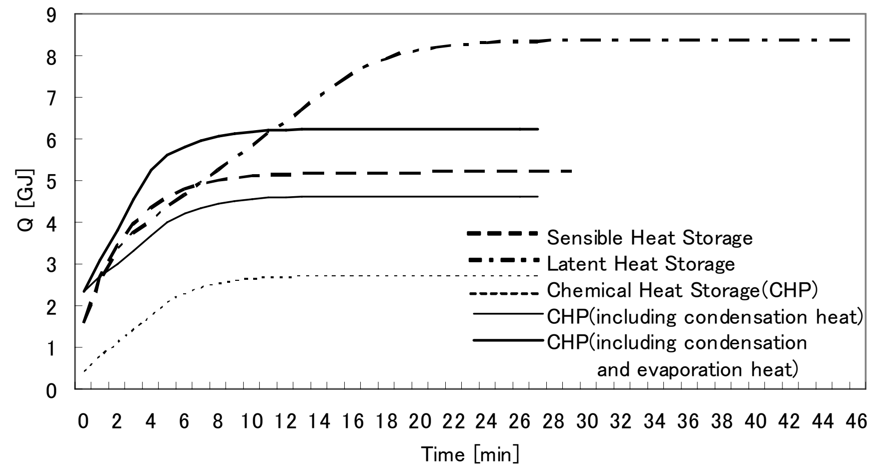

Figure 6: Released heat changes of heat storage material in 120℃ containers (no heat loss)

From Figure 6, the stored heat is found to be released effectively from the containers. In this case, the heat loss in the heat transportation term is not considered. Nevertheless, the system using CHPC can supply hot-heat and cold-heat without using any mechanical heat pumps etc.

5 CONCLUSION

The system using CHPC was found to be more effective than similar transportation systems using latent heat storage container etc. Especially, the system using Chemical Heat Pump Container (CHPC) can supply hot-heat and cold-heat without adding extra energy at heat supply area effectively.

6 REFERENCES

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