Absorption heat transformer using adiabatic absorption for low grade heat recovery

An Absorption Heat Transformer (AHT) is a machine that consumes heat at a certain available temperature in order to produce higher temperature (upgraded) heat. Heat is the primary energy input to the AHT, minimal additional work is required for pumping. Under the Horizon 2020 framework of the European union, a consortium of 10 companies and universities was established on October 2015 to work on the Indus3Es project – development of an AHT for industrial heat recovery and manufacturing a demonstration pilot AHT to be installed and operated at the Tüpraş refineries in Turkey.

An AHT typically operates under two pressure levels, high and low. The high pressure level consists of an absorber and evaporator pair, and the low pressure level consists of a desorber and condenser pair. For this project, an aqueous LiBr-H_2O solution is used as the absorbent, and H_2O is the refrigerant. In the absorber, the refrigerant is absorbed in the solution. The heat released by this process is the desired heating effect which is the product of the AHT. The rest of the machine is dedicated to enabling this continuous absorption. This is accomplished by using the available heat to both evaporate the refrigerant at the evaporator at the high pressure, and to evaporate the refrigerant out of the hygroscopic solution at the desorber at the low pressure. Cooling (typically ambient) is required to condense the regenerated refrigerant at the low pressure before it is pumped to the high pressure evaporator. An additional pump is required to recirculate the regenerated solution from the desorber to the absorber.

Under the Indus3Es project, the Technion is tasked with developing the high pressure component of the AHT. This task (currently completed) includes simulation, design, manufacturing of a small scale (~10kW), measurements, and design of a larger scale (~50kW). The larger scale will be manufactured in Germany by BS Nova and installed for further analysis at the technical university TU Berlin (currently in progress).

A small scale AHT was manufactured and installed at the Technion laboratory. With a hot water source of 95°C and cooling water at 25-30°C, a temperature boost to about 135°C was demonstrated. Perhaps more importantly, a new technique was implemented in order to achieve adiabatic absorption (AA). AA is a process that enhances the performance of the AHT by allowing the initial absorption process to occur adiabatically in order to obtain the maximal temperature boost. To obtain AA, the solution must be allowed sufficient contact with the refrigerant. This can be achieved by either more time, or more surface area, for vapor-solution interaction. An innovative solution was implemented to obtain the latter. The adiabatic vapor-solution interface surface area was increased by injecting the solution to the absorber via atomizing spray nozzles. The atomization of the solution into small droplets greatly increases its surface area (adiabatically) and also serves as a liquid distribution system for the non-adiabatic absorption stage that immediately follows. The performance of this technique exceeded expectations and early measurements show complete AA.

This work has been developed under the project “Indus3Es: Industrial Energy and Environmental Efficiency” funded by the Horizon 2020 framework of the European Union, Project No. 680738. http://www.indus3es.eu