Efficiency Enhancement and Low Temperature Regeneration for Liquid Desiccant Air Conditioning Systems (LDAC)

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I. Motivation

Especially in humid climates vapor-compression cycles (VC) for air conditioning have several disadvantages like high energy consumption for condensation of the air contained humidity, wet surfaces due to this condensation and thus problems with bacterial growth. Furthermore, to reach comfortable air conditions the supply air has to be heated up again after condensing the moisture.

Liquid desiccant air conditioning systems (LDAC) try to avoid the dehumidification of the air through subcooling and condensation. Therefore, hygroscopic liquid desiccants like aqueous salt solutions are used to absorb the moisture from the air. While dehumidifying the air, the desiccant solution is diluted and has to be regenerated again.

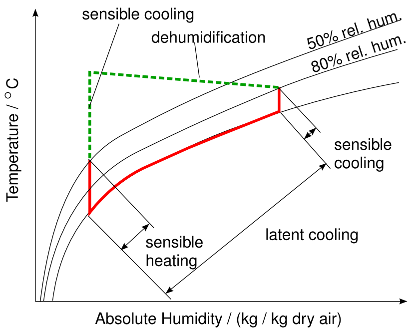

Figure 1: Mollier diagram of vapor-compression cycle (red) in comparison with LDAC (dehumidification and sensible cooling, green)

Currently available systems mainly use direct contact air-desiccant heat and mass exchangers for both dehumidification and regeneration process with Lithium Chloride solutions. These systems have several severe disadvantages:

- The direct contact heat exchangers allow good heat and mass transfer rates, but lead to carry-over of desiccant solution and desiccant aerosols into both, room air and exhaust air from the regenerator. This leads to losses of the expensive desiccant as well as to corrosion problems in all downstream components.
- For the regeneration of the desiccant, open air systems are used, producing a waste air flow without recuperation of the latent energy contained in this flow.
- High temperatures are needed for regeneration of the desiccant, which increases corrosion and causes higher costs for heat supply and operation.

The aim of this project is to combine a LDAC system with a low temperature desiccant regenerator that is able to use low grade heat sources like from solar thermal collectors or waste heat and tackle above mentioned disadvantages of VC as well as direct contact LDAC systems.

Figure 2 shows the proposed LDAC system. The concentrated liquid desiccant (LD) is used to dry the hot and humid air stream. The desiccant absorbs the moisture from the air, is diluted and has to be regenerated by removing a part of the contained water. This is done in the regenerator, which is heated with low grade waste heat or for example by solar thermal collectors.

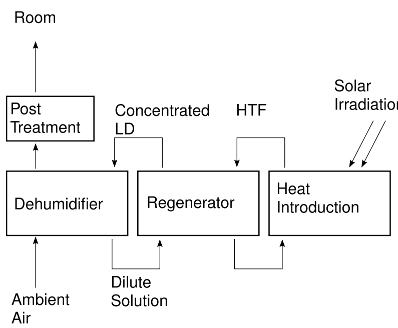

Figure 2: Sketch of the LDAC System

II. Numerical and Experimental Investigations

The whole system is designed and optimized for a hotel resort in Djerba (Tunisia), where a pilot plant will be installed. The system design contains numerical simulation of all components and experiments on the dehumidifier and the regenerator. Besides the optimization of the dehumidifier and chiller unit, the interaction of this part with the regenerator has to be optimized. For the regeneration of the liquid desiccant methods known from seawater desalination are used that have to be optimized for handling the highly concentrated desiccant solutions.

Together with the Tunesian project partner from the National Engineering School of Tunis (ENIT) different desiccant solutions are evaluated as well as membrane tests for the membrane distillation unit and the dehumidifier are examined. Furthermore, with memsys® and W. A. Gore & Associates, two well-known companies in the sector of membrane distillation and membrane manufacturing, participate in the project.

The final aim of the project is to build a pilot plant in Tunisia to conduct measurements and to gather data for model validation and further improvement of the system.

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