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OPEN ABSORPTION SYSTEM FOR AIR CONDITIONING USING MEMBRANE CONTACTORS

PHASE II

Annual Report 2012

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SUMMARY

The results obtained during the past year proceed from:

- experimental work on accelerated ageing of polymer parts, in particular of thin films as models for membranes;
- final testing on welding polymeric parts by laser transmission *(LTW)* and by electromagnetic bonding *(EMB);*
- development work on mathematical models for computer-assisted simulation of components for open-absorption and indirect evaporative cooling processes;
- development work on the regulation and control system for open absorption-based air handling units;
- implementation of manufacturing processes for the various components of *ALDACS* (Advanced Liquid Desiccant-based Air Conditioning Systems).

Progress has been made in all these areas, although the long maturing periods of decisions on the manufacturing platforms has made necessary a request to extend the duration of the Project for another eight months, to the end of June 2013.

PROJECT OBJECTIVES

The objectives of Phase II of the *MemProDEC Project* are to demonstrate that an open absorption system combined with indirect evaporative cooling and limited chemical storage, can be advantageously operated as an autonomous Air Handling Unit *(AHU),* without the need for any other refrigeration system. Since an open absorption system can be driven at temperatures that won't exceed 80 °C, various sources of (thermal) energy can be considered, namely, solar thermal collectors, district heating networks, or any thermal effluents whose temperature satisfies the said condition. By developing, building and testing an industrial grade prototype, all necessary components of an autonomous *AHU,* including control and regulation, as well as industry standard manufacturing procedures and quality control, shall be applied. In this endeavour new manufacturing technologies shall be applied, that can be fully, or at least partially, automated in the near future. An important aspect of the application of new manufacturing technologies is putting to use solutions developed and made in Switzerland. Of overriding importance, and leitmotif of the whole project, is the expected drastic reduction of the electric energy required to drive air conditioning systems. Chemical energy storage combined with internal energy recovery shall, on the other hand, contribute to attain a high performance in terms of the driving thermal energy as well. As most *AHU* components are manufactured from polymeric materials, it is of utmost relevance to establish practical methods to estimate the expected service life of such components under the operating conditions of the unit. Ageing of the structure of the polymers, in particular, with the concurrent eventual development of brittleness, is studied in the project in view of establishing such methods.

WORK PERFORMED AND RESULTS

The work performed in the past year concentrated on:

a) Closing the development of techniques to estimate the expected service life of polymeric parts under the operating conditions of *ALDCS*;
b) Closing the testing phase on Laser Transmission Welding *(LTW)* as applied to manufacture *AHU* components*;*
c) Closing the testing phase on Electromagnetic Bonding *(EMB)* of thermoplastics, as used in the manufacture of *AHU* components ;
d) Ordering and commissioning at the manufacturer's facilities (before shipping to Switzerland) of *EMB* equipment, ordered for the industry partner in the Project;
e) Selecting and contracting a capable firm where to outsource all LTW operations required in the manufacture of membrane contactor elements for the absorber and regenerator of the prototype *AHU;*
f) Implementation into computer code of the mathematical simulation models for the main components of the *AHU*;
g) Establishing a detailed welding sequence for all parts of the membrane contactor elements to guide LTW and EMB operations, as well as designing the necessary auxiliary tools*;*
h) Detailed specification of the desiccant, water and air circuits in the modules (conditioner and regenerator) of the prototype *AHU;*
i) Written opposition, via prior art provisions, in collaboration with others, before the *WIPO* (World Intellectual Property Organization) against a World Patent *(WO)* applied for by an US Consortium. That patent application, if a patent would be issued, might eventually affect the prospects of a future commercialization of the technology we have been developing. That *WO* patent application presented a total of 546 highly interconnected claims. It still remains to be decided by the *WIPO* whether the prior art introduced in the application process,

as a third party observation, will lead to changes, or even refusal of the application;

j) Submission of prior art documents to oppose an US Patent family (seven patents) application by the same consortium as above. The prior art consists of publications (articles and reports) written within the framework of the MemProDEC Project. The opposition rests on the same grounds as for the *WIPO* case, while using US Patent Office *(USPO)* specific procedures;

k) Development, as yet unfinished, of the control and regulation system for the prototype *AHU.*

The main results obtained show that:

1. Exposure of polymeric parts, in particular thin films (e.g. membranes) to aqueous LiCl 42 % (mass), in the presence of oxygen, at temperatures up to 80 °C, for ~ 1500 hours, did not produce results significantly different from those obtained on samples exposed to water under equal conditions, as evaluated by Infrared Spectroscopy and Tensile Testing. This final conclusion from the work of IMPE-ZHAW, leaves some uncertainty in regard to longer exposition periods;
2. *LTW* and *EMB* techniques were demonstrated to be the most adequate to weld together the various parts of the membrane contactor elements: While *LTW* is used for the long seams, including those binding the membrane to the frames, *EMB* is restricted to welding the headers to the feeders/collectors, as the headers geometry and function would not allow using *LTW;*
3. *LTW* operations have been outsourced to a German company. Work is here in its starting phase;
4. *EMB* operations are to be carried out in house at Soltherm AG, the industry partner in the Project. They are however the last step in the manufacture of the membrane contactor elements
5. A request to extend the Project duration by eight months, to the end of June 2013, was presented, and accepted. That request was made necessary due to the long time necessary to establish a decision and to find a reliable partner where to outsource the LTW operations.

COOPERATION AT THE NATIONAL LEVEL

This Project is being carried out jointly by *M. Conde Engineering, Soltherm AG,* and the *Institute of Materials and Process Engineering of the Zurich University of Applied Sciences* in Winterthur. *EMPA Dubendorf* and the *Swiss District Heating Association* operate as accompanying group.

INTERNATIONAL COOPERATION

There is no formal international cooperation in this Phase of the Project in terms of Project work. We are however bound to work together with suppliers of both services and materials, particularly in the USA and Germany. The informal collaboration with other developers and researchers, working on the same technology, can strengthen and extend our own arguments, and amplify the prior art base through multiple third party observations to *WIPO* Patent Applications, on one hand, and force a drastic invalidation, or even elimination of Patent Application Claims, on the other, when opposing patent applications that might endanger the future commercialization of the technology we have been developing.

ASSESSMENT 2012 AND OUTLOOK 2013

The work carried out in the past twelve months is characterized by:

- Final steps in the refinement of the welding techniques as they are required in the manufacture of all polymeric components, in particular of the membrane contactors, that belong to the open absorption process as applied in the *AHU* prototype. This work has been done at the facilities of equipment suppliers;
- Implementation into computer code of the mathematical simulation models of most components of the *AHU;*
- Opposing eight (one *WIPO* and seven *USPO*) patent applications that, if they would result in patents being issued, might endanger the future commercialization of the technology we have been developing in the framework of this Project;
- Establishment of the final manufacturing platforms for the membrane contactor elements through acquisition of *EMB* equipment on one hand, and outsourcing the *LTW* operations on the other.

2013 shall see:

- Finishing, testing and use of the computer assisted design by simulation of all components of the *AHU;*
- The manufacture and assembling of all *AHU* modules, including the whole instrumentation, and control & regulation systems;
- Preliminary functional testing of the *AHU* at the manufacturer's facilities;
- Testing for performance at the ***HSLU's HVAC Laboratory;***
- Analysis of experimental data on *AHU's* performance, and on the performance of every individual component;
- Reporting and publication & dissemination of the results, and assessment of the commercial potential on the basis of these results.

REFERENCES

None.

ANNEX

None.