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OPEN ABSORPTION SYSTEM FOR AIR CONDITIONING USING MEMBRANE CONTACTORS

PHASE II

Annual Report 2011

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SUMMARY

The results obtained in the course of the past year proceed from:

- experimental work on accelerated ageing of polymer parts, in particular of thin films as models for membranes;
- extended testing of welding polymer parts including the welding of thin films (membranes and fleece) to thicker plates;
- the design and manufacture by processes such as injection moulding, extrusion, and deep drawing;
- the development of mathematical models for computer-assisted simulation of components.

Progress has been made in all these areas, as presented recently at the 2nd Progress Meeting on the Project. On the design of a semi-automated manufacturing platform for polymeric heat exchangers, work is as yet not concluded. On the other hand, selection and acquisition of most sensors and of a dedicated data acquisition system has been fully accomplished.

Arrangements for performance testing the prototype Air Handling Unit *(AHU)* at a certified laboratory have been discussed with the laboratory concerned, and the laboratory's capabilities and needs clarified. An offer for the work and use of the laboratory facilities shall be available before year's end.

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 along the following main lines:

a) Further development of techniques designed to estimate the expected service life of polymeric parts;
b) Testing polymer welding processes, in particular Laser Transmission Welding *(LTW)* as applied to manufacture *AHU* components*;*
c) Development and manufacture of polymeric parts by injection moulding, extrusion and deep drawing ;
d) Selection and acquisition of sensors (temperature, humidity, pressure, level, electrical conductivity, flow of liquids and air, active electric power) and of a suitable data acquisition system;
e) Definition and establishment of the fundamentals of mathematical models for computer-assisted design of the components of the *AHU;*
f) Establishing the final design of the *AHU* modular structure;
g) Discussion of needs and evaluation of capabilities for testing the prototype *AHU* at the *HVAC Laboratory of the Lucerne University of Applied Sciences and Arts*[1]*;*
h) Further evaluations of the manufacturing platform for polymeric components, namely energy recovery heat exchangers, indirect evaporative cooler and membrane contactors (robot vs CNC table).

[1] HVAC Laboratory at the HSLU, in the following.

The main results obtained (presented at the 2nd Progress Meeting, held on November 7, 2011) show that:

1. On the very important issue of polymer ageing and expected service life, continued exposure during a period of ~3000 h, of membrane material to concentrated liquid desiccant at 80 °C, has produced no significant changes, as evaluated by Infrared Spectroscopy and by Tensile Testing;
2. *LTW* tests of twin-wall structured plates as used to manufacture heat exchangers, and of thin polymeric films to twin-wall structured plate frames, have proved their reliability and in the case of films that the welding seams are tight to liquids;
3. The polymeric parts manufactured by injection moulding, extrusion and deep drawing satisfy in general the specifications and the design, with small refinements still required in the cases of one extruded part to reduce warping, and of a deep drawn part where the punching operation is not satisfactory;
4. The sensors have been acquired, in particular those with special specifications required for use in contact with the very corrosive liquid desiccant. The same applies to the data acquisition system, which shall be independent of both the testing laboratory data acquisition and of the *AHU* own control system. This data acquisition system was designed to permit the evaluation of the individual components of the *AHU;*
5. The simulation platform and the fundamentals of the mathematical simulation models of the various components of the *AHU* are now in place;
6. The modular structure of the AHU has been defined, both dimensionally and in layout;
7. The discussions held with the *HVAC Laboratory of the HSLU* have shown this laboratory to satisfy the necessary conditions to carry out the performance tests required. During those tests the monitoring of the individual components of the *AHU* by a dedicated data acquisition system (see 4.) shall provided the data necessary to ascertain their performance and suitability for the purpose;
8. The manufacturing platforms to manufacture polymeric components by welding, both by *LTW* and induction, are as yet not definitely defined. Their development, currently being done by the partner *Soltherm AG,* is critical for the course of the *MemProDEC Project,* though not full part of it. Although semi-automated solutions continue to be seen as the most promising, with (a) robotic arm(s) performing the most delicate operations, such as welding together the membrane contactor parts as well as heat exchanger parts, the variety and complexity of components to be manufactured, also for applications beyond the *MemProDEC Project,* requires careful evaluation on one hand, and a progressive implementation on the other.

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 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.

ASSESSMENT 2011 AND OUTLOOK 2012

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

- Decisive advances 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 characterize the open absorption process as applied in the *AHU* prototype. This work has been done at the facilities of equipment suppliers;
- Definition of the simulation platform and fundamentals of the mathematical models of all components of the *AHU;*
- Progress in the design and manufacture of injection moulded, extruded, and deep drawn parts required to manufacture the membrane contactors, following the modular concept at the basis of all developments in the Project;
- The design of the data acquisition system, including the required sensors, in particular of those that are to operate in direct contact with the highly corrosive liquid desiccant;
- A positive assessment of the needs and capabilities of the *HVAC Laboratory at the HSLU,* and a preliminary decision to carry out the *AHU* performance tests there;
- Continued search for an adequate polymer welding platform at industrial scale;
- The selection and application of a suitable method to study the accelerated ageing of polymer parts, in particular of the membranes.

2012 shall see:

- Finishing, testing and use of the computer assisted design by simulation of all components of the *AHU;*
- An end to ageing tests and the proposal of a method to predict the expected service life of polymeric parts;
- An end to all pre-manufacture testing, including polymer welding in an industrial setting;
- 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.

The Project work is on track.

REFERENCES

None.

ANNEX

None.