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OPEN ABSORPTION SYSTEM FOR AIR CONDITIONING USING MEMBRANE CONTACTORS

PHASE II

Annual Report 2010

Autor und Koautoren	Dr Manuel Conde-Petit
beauftragte Institution	M. CONDE ENGINEERING
Adresse	Eugen Huber-Strasse 61, CH-8048 Zurich, Switzerland
Telefon, E-mail, Internetadresse	+41- 444 314 175, mconde.petit@mrc-eng.com
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SUMMARY

The results obtained in the course of the past six months concern work done to support decisions on the design, manufacturing techniques and selection of materials, and on the methodogy to assess the expected service life of the main components of the Air Handling Unit (AHU) being developed in the Project. The tests to select materials and manufacturing methods point clearly to concrete directions and choices.

Testing of two advanced polymer welding techniques yielded results that led to redesign of some components, while keeping the basic concept of functional modularity. These results are now supporting the design of a semi-automated manufacturing platform for polymeric heat and mass exchangers.

In the exploratory work on the methodology to assess the expected service life of polymeric parts, various techniques were tested, providing good discriminating power in most cases. Further refinements are required to enable the definition of a predicting method, however.

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, also contribute to attain a high performance in terms of the driving thermal energy. 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 starting date of the Project was June 14, 2010. In the past six months, the work effort has been concentrated along three main lines:

a) Refining the design and manufacturing techniques of the main components, in particular of the membrane contactors, polymeric heat exchangers, the general structure of the *AHU,* and the desiccant storage;

b) Testing techniques that shall permit the establishment of methods to estimate the expected service life of the polymeric components under the operating conditions of the *AHU;*

c) Defining the manufacturing platforms that shall permit a semi-automated production of the membrane contactors as well as of the polymeric heat exchangers of various types.

The main results obtained show that two competing polymer welding technologies can be used successfully in the manufacture of the various polymeric components, replacing with great advantages the adhesive bonding techniques used in Phase I of the Project. Furthermore, an improved design of the membrane contactors enables the manufacture of key parts by injection molding and extrusion, with a great potential to minimize manufacturing costs in the future, particularly considering the original modularity concept at the origin of the whole design. The tools required for injection molding and those for extrusion of parts have passed the first round of the development (construction design). Their final detailed dimensions hang now upon the decision on whether one welding technology is used or both. Evaluation of the two technologies tested is currently under way. On the general structure of the Air Handling Unit, a decision has been made to assemble it in several sections built from extruded aluminum profiles and high value panels, satisfying the highest standards in terms of thermal bridges and leakage losses. Two separate solution storage tanks, one for concentrated aqueous LiCl and the other for diluted aqueous LiCl, were designed, and are to be manufactured with working volumes of approximately 200 liters each.

Work on methods to estimate the expected service life of polymeric parts has been carried out, namely by testing various techniques to evaluate ageing effects on the main polymer used in the manufacture of the prototype components. These techniques include, besides microscopy (light, *AFM* and *REM*[1]), infrared *(IR)* transmission measurements, thermogravimetry analysis *(TGA),* and strain-stress analysis. Samples of polymeric parts were exposed for certain periods of time to various chemical substances, including aqueous LiCl, and then tested with these techniques. The results obtained show in most cases a good discriminating power in the identification of effects of that exposition. Further work

[1] *AFM* stands for atomic force microscope, and *REM* for raster electron microscope.

is still required to permit extrapolations, or even a decision on which extrapolation method shall be used in the estimation of the expected service life, which is the main aim of these studies.

The definition of the manufacturing platforms is as yet not fully accomplished. Their development, currently being done at *Soltherm,* is important for the course of the *MemProDEC Project,* though not full part of it. Since the platforms are essentially conceived to weld polymeric parts, they are the most relevant tool in the manufacture of the components for the prototype. Although a semi-automated solution is seen as the most promising at present, with (a) robotic arm(s) performing the most delicate operations, such as welding together the membrane contactor parts as well as the heat exchanger parts, the variety 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 2010 AND OUTLOOK 2011

The work carried out in the half year period since the Project start, is characterized by a search for and test of innovative manufacturing solutions, on one hand, and the establishment of the foundations for the assessment of the expected service life of polymeric components, on the other. The advances made in both endeavours can be rated as successful. Particularly, provisory results obtained with an advanced welding technique from a Swiss manufacturer are very encouraging. And, although this technique is not suitable for all welding operations required, it is the most adequate for the most sensible ones. A few, but essential welding operations, still require the involvement of a US provider of equipment. The design in detail of the components depends on the actual selection of welding techniques. It has now been done for using exclusively either one welding technique. The use of both requires reassessing and merging the two designs according to where each technique is adopted.

2011 shall see:

- further and decisive advances in the development of a methodology to assess the expected service life of polymeric parts;
- the approval of the definitive design after provisory testing;
- The final design of the *AHU* modular structure;
- The definition and implementation of the internal data acquisition system (not part of the control system and used exclusively for detailed process analysis);
- The definition and implementation of the control and regulation systems;
- The finalizing of the manufacturing platform;
- The manufacture of tools (injection molding and extrusion);
- The manufacture of the components for the prototype, with individual testing and assembly;
- The establishment of the component simulation tools, which has been going on as a background task during 2010;
- The preparation for testing the complete unit at the *"Prüfstelle HLK"* at the *Lucerne University of Applied Sciences & Arts.*

The Project work is on track.

REFERENCES

None.

ANNEX

None.