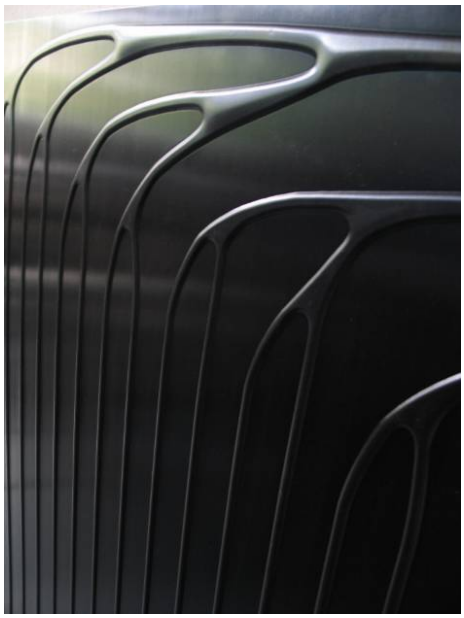
BIONICOL - DEVELOPMENT OF A BIONIC SOLAR COLLECTOR WITH ALUMINIUM ROLL-BOND ABSORBER

Project status after first year

Project aim



The aim of the project is to develop solar collectors with absorbers which feature bionic channel structures ("FracTherm®" structures), which are multiply branched in a fractal way in order to obtain a uniform flow distribution, a low pressure drop as well as a high thermal efficiency. The absorbers will be built of aluminium using the so-called roll-bond process. Small solar absorbers have already successfully been built in a previous research work. It is now necessary to develop collectors with typical dimensions needed for the market up to a prototype stage and demonstrate their efficiency and functionality as a basis for a following series production. It is expected that high-efficiency collectors at low costs can be obtained as a result of the project. The collectors are to be investigated for a wide temperature range in order to cover various applications. To reach the mentioned aims, the FracTherm® algorithm is to be developed further and the obtained designs have to be produced, evaluated and optimized. Moreover, the possibilities and constraints of the roll-bond production process have to be investigated in order to find out the best possibilities to produce a solar absorber with maximum efficiency and minimum costs. One of the very important tasks of the project will be the coating of the absorber after its channels are produced. Finally, the absorber has to be mounted into a collector casing and thus also has to fulfill a number of requirements. The target of a prototype and small-series production is to demonstrate the possibilities of manufacturing FracTherm® solar collectors with variations of the absorber. In order to prevent corrosion, it is necessary to work on appropriate heat transfer fluids. It is intended to build demonstration systems in various sites in Europe which are operated for more than one year within the project. The final objective is to evaluate the competitiveness of the developed solar collectors with state-of-the-art products.

Work done so far

During the first year of the BIONICOL project the consortium concentrated on basic investigations concerning roll-bond absorbers in general and issues related especially to a multiply branched FracTherm® channel design. It is important to know the possibilities and restrictions of roll-bond technology with respect to channel widths, channel heights and radii of curvature. The choice of channel cross sections has an influence on both pressure drop and resistance against internal pressure. The latter can cause deformation of the absorber panel or even cracking. Apart from the FracTherm® channels an important question is how the header channels of such absorbers should look like. Therefore some test samples with different bifurcation and header geometries were designed and produced (Figure 1). Afterwards they were used for pressure drop measurements and pressure resistance tests (Figure 2). It turned out that small channel widths perform better with regard to internal pressure (less deformation), however their pressure drop is of course higher. Therefore the correct dimensioning is a question of optimization. Concerning the pressure drop of roll-bond headers analytical calculations as well as pressure drop measurements showed that it is not possible to build roll-bond headers with reasonable width which lead to a pressure drop which is as low as in a conventional header tube with a diameter of 20 mm (Figure 3). In order to reach this it is necessary to develop completely new header concepts. Some suggestions were already sketched and assessed in the project. The next step is to find a realizable solution.

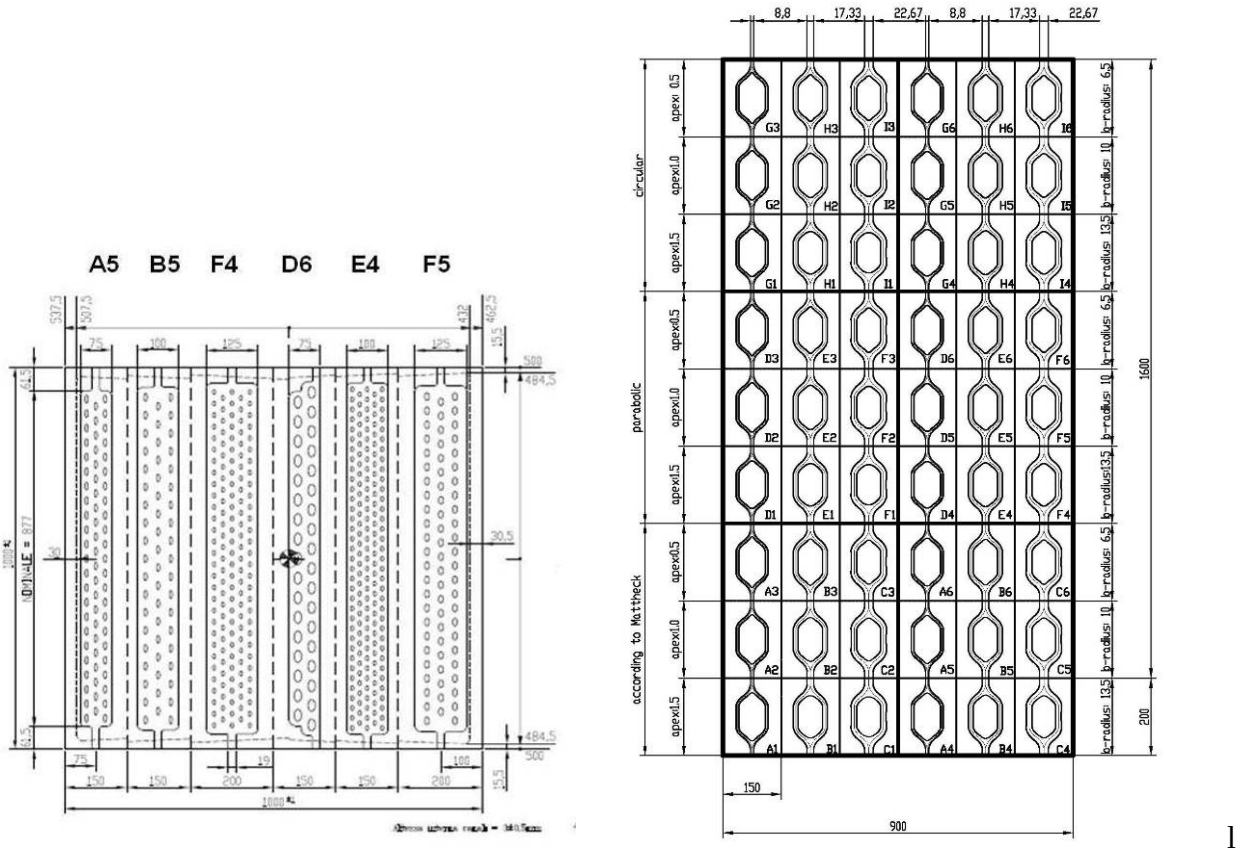


Figure 1: Roll-bond samples with different header (left) and bifurcation (right) geometries

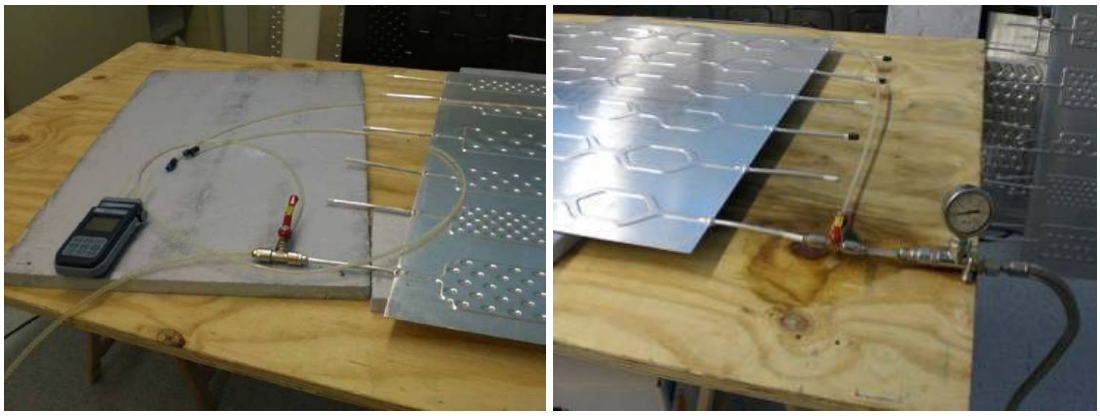


Figure 2: Pressure drop test of roll-bond samples

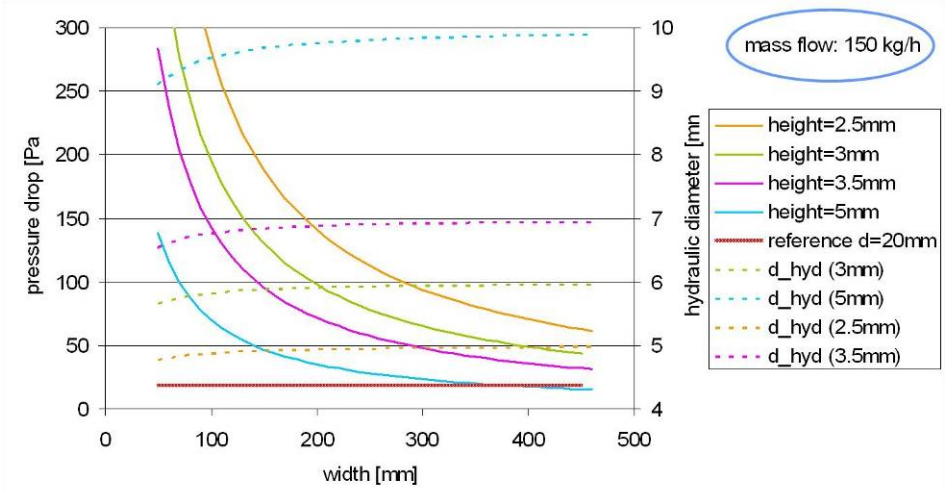


Figure 3: Pressure drop of rectangular headers in comparison with 20 mm tube

In order to better understand fluid flow phenomena in FracTherm® channels, three-dimensional CFD simulations were carried out (Figure 4) at Fraunhofer ISE. Moreover, a fluid dynamics test facility was planned (Figure 5). This test facility will be used for both pressure drop measurements and flow visualization of original absorbers and scaled models. Theoretical and practical results will allow a characterization of FracTherm® structures and thus an adaptation of the FracTherm® algorithm and finally a thermo-hydraulic optimization.

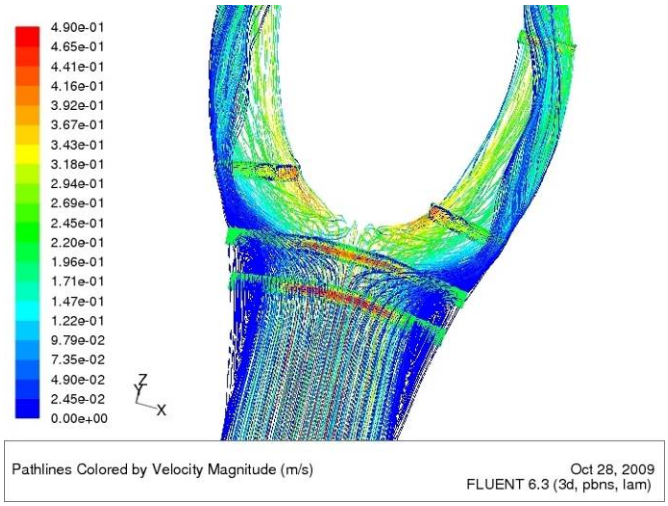


Figure 4: Streamlines of fluid flowing around a FracTherm® bifurcation (3D CFD simulation)

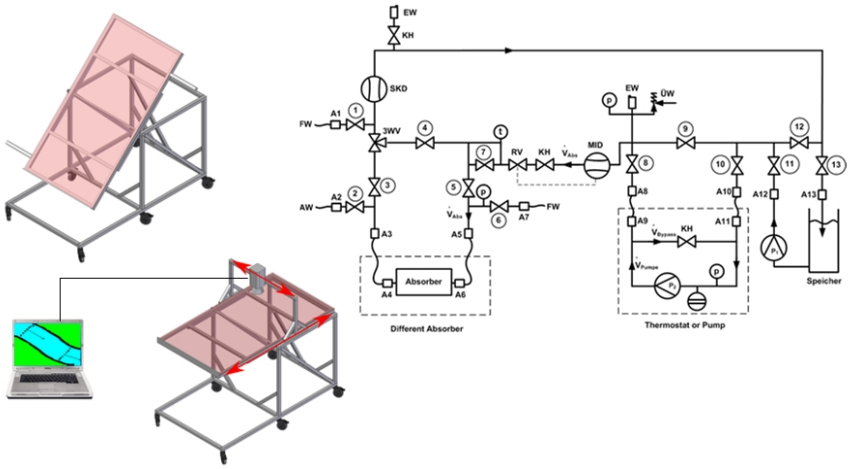


Figure 5: Draft and hydraulic scheme of the fluid dynamics test facility

One of the most important issues of aluminium roll-bond absorbers is corrosion prevention. Within the project ASTM D 1384 tests were successfully carried out with different heat transfer fluids by TYFOROP. According to the tests state-of-the-art TYFOCOR® L proved to be a suitable fluid. Further corrosion tests carried out at CGA also showed that corrosion in aluminium roll-bond channels can be avoided at medium temperatures. In order to carry out corrosion tests under stagnation conditions, a complete test loop with a collector containing an aluminium roll-bond absorber and various connections made of other metals was set up at TISUN. In a first test the solar fluid was erroneous diluted; therefore the corrosion prevention cannot be ensured anymore. Nevertheless the test serves as a worst-case scenario. The fluid of an ongoing second test without dilution will be analyzed soon.

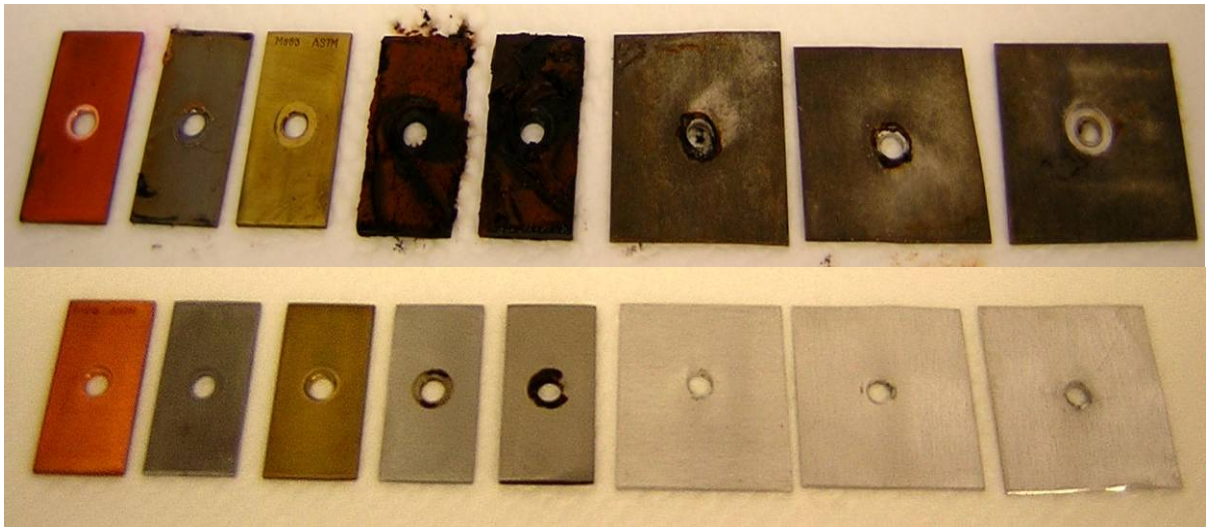


Figure 6: Appearance of metal specimens after ASTM D1384 before cleaning / weighing (top: fluid without corrosion inhibitors, bottom: fluid with corrosion inhibitors)

A second important issue concerning roll-bond absorbers is selective coating, since pre-coated aluminium sheets cannot be used in the production process. Therefore the roll-bond panels have to be coated after they are produced. This is intended to be done by INTERPANE in an adapted coating plant which is usually used for glass coating. An overview of the necessary changes is already given in the project. Further investigations

are carried out in order to ensure an appropriate surface quality for the application of the selective coating.
Apart from conventional rectangular collectors FracTherm® absorbers can also be generated with non-rectangular shapes. Figure 7 shows some examples of possible collector shapes which could feature FracTherm® channel designs. The shapes were proposed by TISUN.

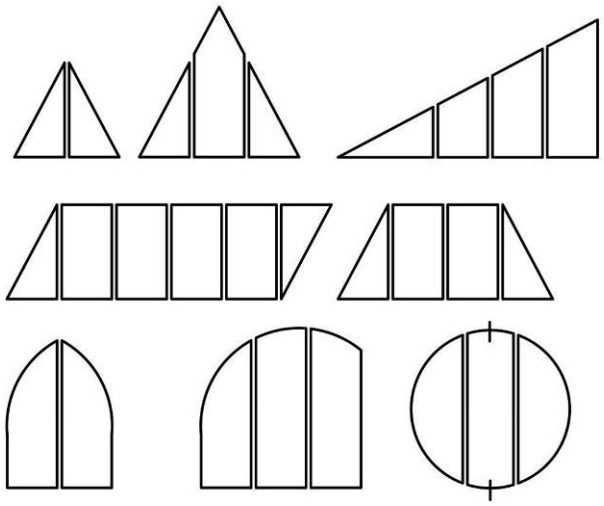


Figure 7: Possible non-rectangular collector shapes

Project data

Project duration: 1.9.2008-31.8.2011

Project consortium:

Fraunhofer Institute for Solar Energy Systems, Germany **(coordinator)**

TiSUN GmbH, Austria

CGA Technologies S.p.A., Italy

INTERPANE Entwicklungs- und Beratungsgesellschaft mbH & Co KG, Germany

Tyforop Chemie GmbH, Germany

Website: www.bionicol.eu

Contact

Dr.-Ing. Michael Hermann
Fraunhofer Institute for Solar Energy Systems ISE
Heidenhofstraße 2
79110 Freiburg
Germany

Phone: +49 (0) 7 61/ 45 88-54 09
michael.hermann@ise.fraunhofer.de