GEOHEX

GEOHEXPROJECT.EU

ANTI-CORROSION AND ANTI-SCALING OF GEOTHERMAL HEAT EXCHANGERS

Bhamji, Imran [1]; Mittal, Garima [2]; Taddei Pardelli, Paolo [3]; Ingvi Snorrason, Davíð [4]; Csaki, Ioana [12]; Ingi Ólafsson, Dagur [5]; Anxionnaz-Minvielle, Zoe [6]; Pálsson, Halldór [7]; Ragna Ragnarsdóttir, Kolbrún [8]; Kjellgren, Per [9]; Chowdhury, Fahim [10]; Defensor, John [11]; Khan, Raja [1]; Martelo, David [1]; Paul, Shiladitya [2]; Ósk Haraldsdóttir, Helen [8]; Karlsdóttir, Sigrún Nanna [7]; Cormorant, Guillaume [13]; Kale, Namrata [1]

Organization(s): 1: TWI Ltd, United Kingdom; 2: University of Leicester; 3: Spike Renewables; 4: Grein Research; 5: NMI; 6: CEA; 7: University of Iceland; 8: ON Power; 9: FlowPhys; 10: Technovative Solutions; 11: QLM; 12: University POLITEHNICA of Bucharest; 13: Enogia

ABSTRACT

Low temperature geothermal resources are abundant in many regions world-wide and hold a large amount of thermal energy that can be utilised directly for district heating. These can also be utilised for electricity generation through Organic Rankine Cycle (ORC) power plants. The ORC utilises an organic, usually high molecular weight, working fluid with a much lower boiling point than water, which is vaporised using the heat from the geothermal resource, in the process developing sufficient pressure to drive a turbine. Once past the turbine, the working fluid is cooled to a liquid state in a condenser before the cycle repeats. Heat exchangers in ORC plants, including preheaters, evaporators, superheaters and condensers account for a significant proportion of the plant total capital costs, and therefore reductions in cost related to these components will have a huge impact on plant profitability and could potentially mean that unviable resources become viable.

The GeoHex project considers the feasibility of applying coatings onto heat exchanger components to enhance corrosion, scaling and heat transfer performance. The scope of GeoHex is very broad, encompassing preheaters, evaporators, superheaters and condensers and a number of materials used for heat exchanger manufacture, including carbon steel, stainless steel, aluminium and copper. Various coatings for the brine and working fluid facing sides of the heat exchanger were developed, including fluorinated hydrophobic coatings, electroless nickel coatings and amorphous metal coatings. Performance testing of the coatings was completed in mock up heat exchangers, and specific testing was also completed to determine mechanical and hydrophobic properties. This paper presents selected highlights from the project, and demonstrates that coated heat exchanger components show considerable promise to reduce cost and increase performance of geothermal heat exchangers.

INTRODUCTION

As a part of its plan to combat the climate change, the European commission has established a long term goal of net-zero emission by 2050. Alternatives energies are integral to achieve this target, among these, geothermal energy highlights due its seasonal independent reliability, among other benefits. Heat exchanger (HXs) are the most critical component of a geothermal power plant.

The conditions of the brine reservoir (chemistry, temperature, pressure, etc.) will define the type of geothermal power plant i.e. dry-steam, single flash, basic binary. And depending on the type of geothermal power plant, different designs of HXs can be used. Typically, corrosion resistant alloys (CRA) are used as a base for the components of the HX due to nature of the geothermal brine i.e. containing aqueous silica, carbon dioxide, hydrogen sulfide among other compounds.

In this poster, an innovative test rig for performing heat transfer tests to simulate the HX condenser of an ORC is presented, and some results of preliminary tests are shown.

COATING TECHNOLOGY

In this project, surface modifications in HX materials for heat transfer (i.e. the plates in the plate-type HXs) are being developed. Properties such as corrosion resistant and anti scaling properties are wanted for the brine side, but also, high heat transfer is necessary. In the condensation HX, the wetting plays a critical role in the heating/cooling transfer efficiency, for this reason, surfaces that promote dropwise condensation, instead of film-wise condensation are been seek, see *Figure 1.*

CHARACTERISTICS OF HX MOCK UP RIG AND EXPERIMENTAL APPROACH

The device comprises of two systems, a refrigerated water circuit and a working fluid (R134a) circuit, see *Figure 2.* Temperature, pressure and flow sensors are incorporated for heat transfer evaluation. The condenser chamber have two sided optical windows for allowance of imaging of the condensation, see *Figure 3.* The test rig can be putted in 2 positions, vertical and horizontal, to examine the influence of the condensing film in the heat transfer.

Preliminary tests have been conducted using an inlet water temperature of 7oC and a pressure of 9bar and 7.5bar, the test duration was ≈ 200h in the carbon steel (CS) and stainless steel (SS) and ≈ 100h in the aluminium alloy (Al).

RESULTS AND DISCUSSION

The tests display a gradual drop off in the heat transfer, see figure 4, which cannot be explained given that this is a bare metal, and no appreciable changes are observed in the surface of the plates, or in the wetting.

Heat transfer coefficients for Al and CS, at the very start of the tests, seem to be higher than for SS. However, the shape of the drop in the profiles is not at all consistent, therefore at some points in the test, it might appear that SS has higher heat transfer coefficient. It is unclear if the tests can differentiate between different materials at this stage.

1

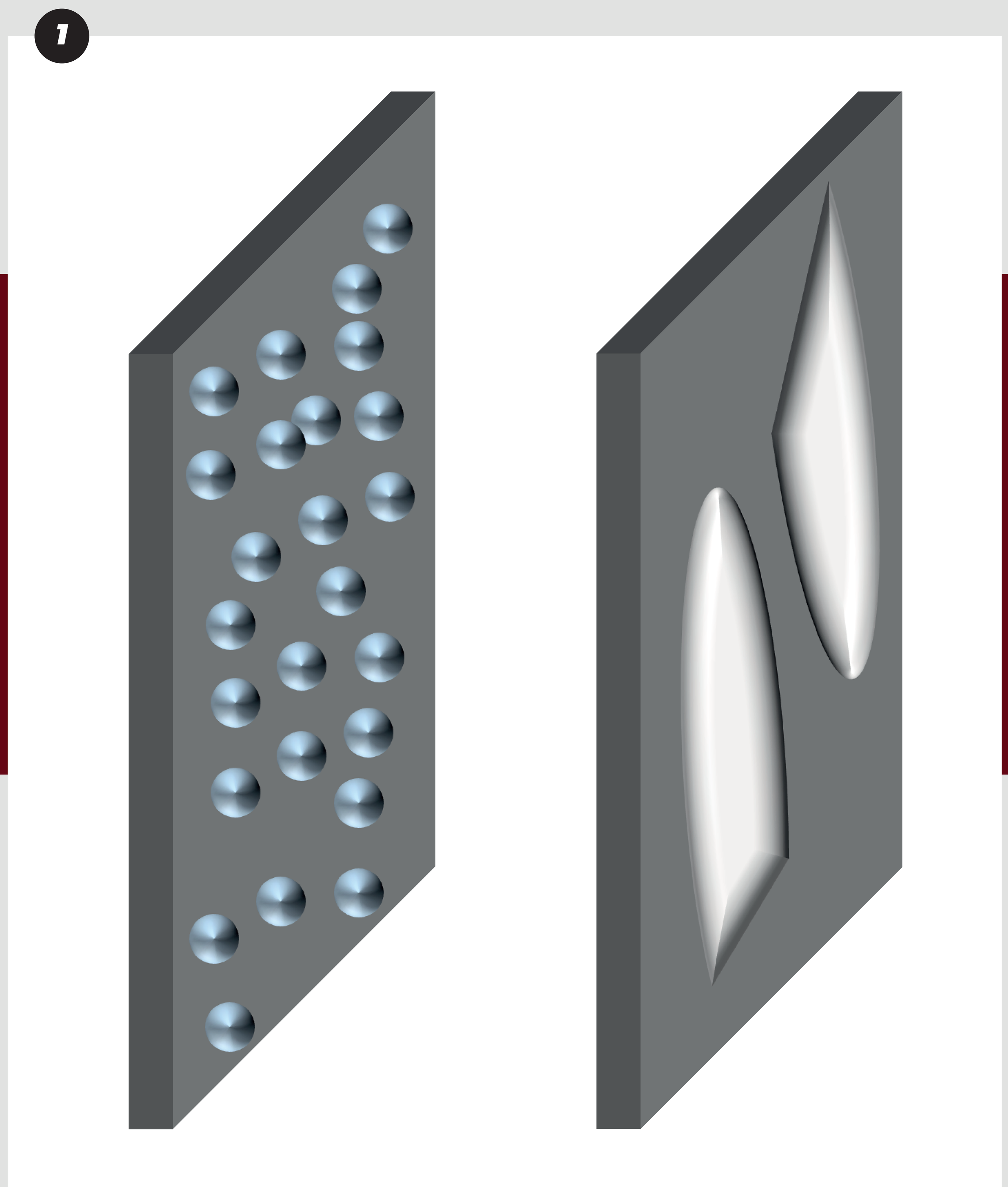

Figure 1: *Schematic illustrating (a) filmwise vs (b)dropwise condensation.*

2

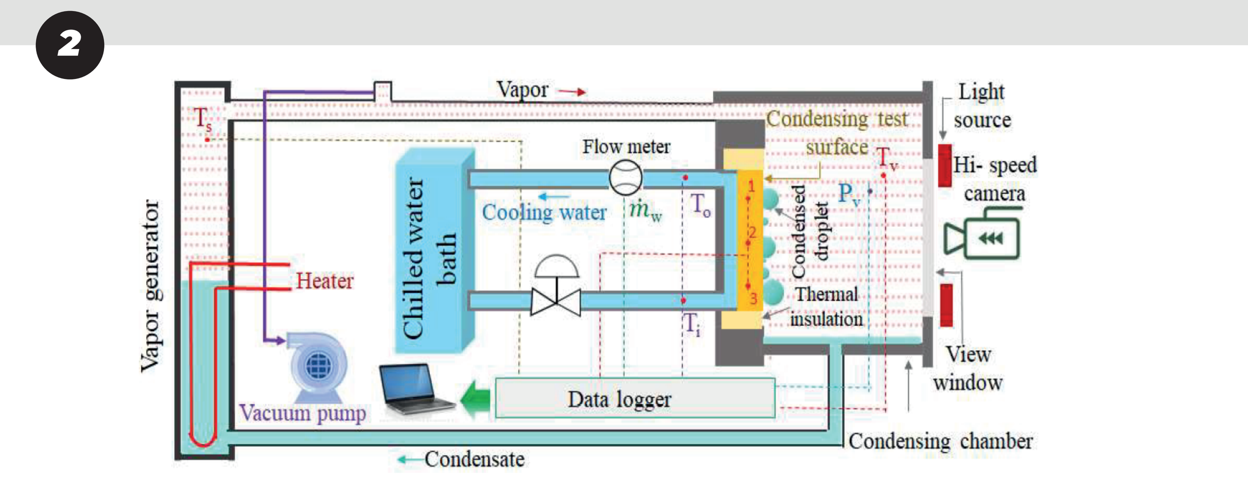

Figure 2: *Schematic of experimental set up for condensation heat transfer tests*

3

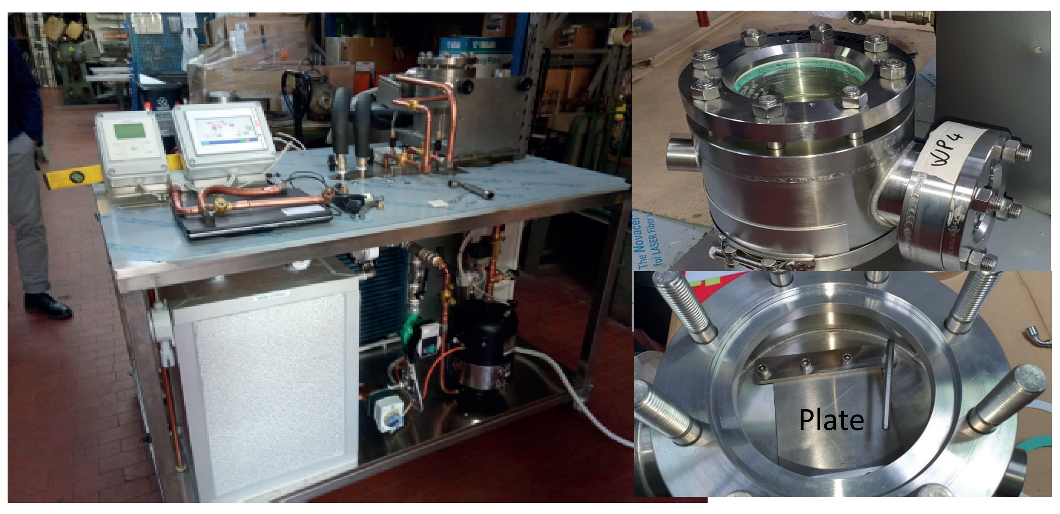

Figure 3: *Photography of the fabricated test rig, with details of HX unit.*

4

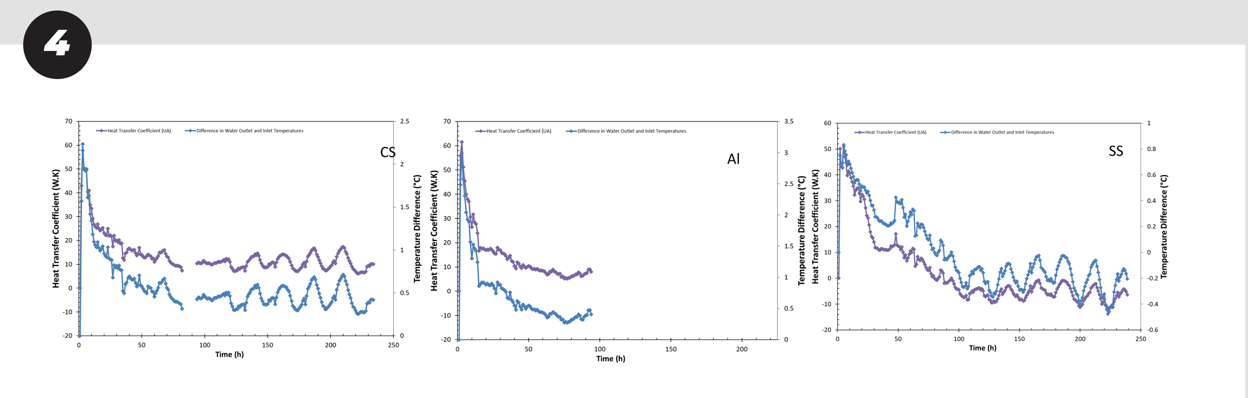

Figure 4: *Results of heat transfer coefficient measurements in bare carbon steel, aluminium and stainless steel as a function of time.*

CONCLUSIONS

A test rig has been designed and fabricated to study the influence of the surface (bare metal and coating) in the heat transfer coefficient, simulating the conditions of a HX condenser.

It is thought that no consistent results have been obtained, due to the measurements taken by the sensors of the system are being corrupted by the chiller unit, therefore, modifications in the rig are taking place; consistent results should be obtained after these modifications be completed.

This project has received funding from European Union's Horizon 2020 Research and Innovation Programme. Grant Agreement 851917.