Molten Salt Lab Plant (MSTP) for Heat Transfer Fluid (HTF) tests

M.S.T.P

Molten Salt Test Plant

Electric power imput	35 kW, 400 V, 3 Ph, 50 Hz
Max working temperature	600 °C
Design temperature	650 °C
Max working pressure	1 bar
Design pressure	3 bar
Nominal mass flow	8000 kg/h
Nominal volume flow	4 m^3/h
Max external thermal power	10 kW
Molten salt content	500 kg

H2020 EU research program H2020-EE-2016-PPP
Project: SMARTREC Grant Agreement n. 723838

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Built whit the contribution of the EC for project

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March 2021

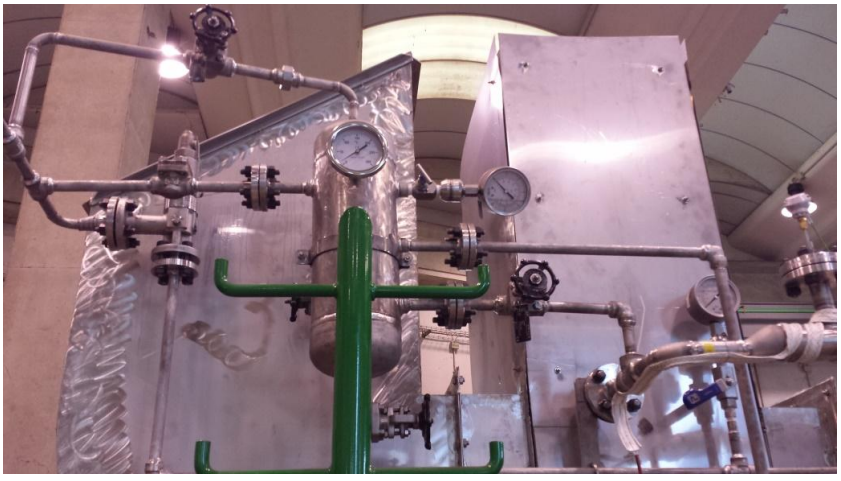
Design and Test of a Molten Salt Test Plant (MSTP) for waste heat recovery application

Energy efficiency in industries has improved significantly in the last decade, and one of the greatest opportunities for reducing energy use is waste heat recovery. Industrial waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces. Waste heat recovery entails capturing and reusing the waste heat in industrial processes for heating or for generating mechanical or electrical work. Many recovery technologies are already well developed and technically proven; however, there are numerous applications where heat is not recovered due to a combination of economic and technical barriers, especially at high temperature where mechanical components and material constraints may impede a profitable installation.

The EU H2020 Smartrec project aims to develop a technology capable to recover heat at high temperature from industrial processes, thanks to the utilization of a Heat Transfer Fluid (HTF) stable at high temperature (≥600°C) such as Molten Salts (MS). The main characteristics of this kind of fluids are stability at high temperatures, low vapour pressure, liquid state in a large range of temperatures, ability to dissolve many inorganic and organic compounds, viscosity generally low (as ions are mutually independent) and high heat capacity per unit volume.

A Molten Salt Test Lab Plant (MSTP) has been designed and assembled to test different molten salts under real operational conditions and therefore understand critical issues and technological problems before moving to full demonstration scale. MS are utilized as HTF at ambient pressure therefore the design of MSTP has proceeded with this assumption. The preliminary dimensioning of the components was made taking as a reference the characteristics of FLiBe and HITEC salts.

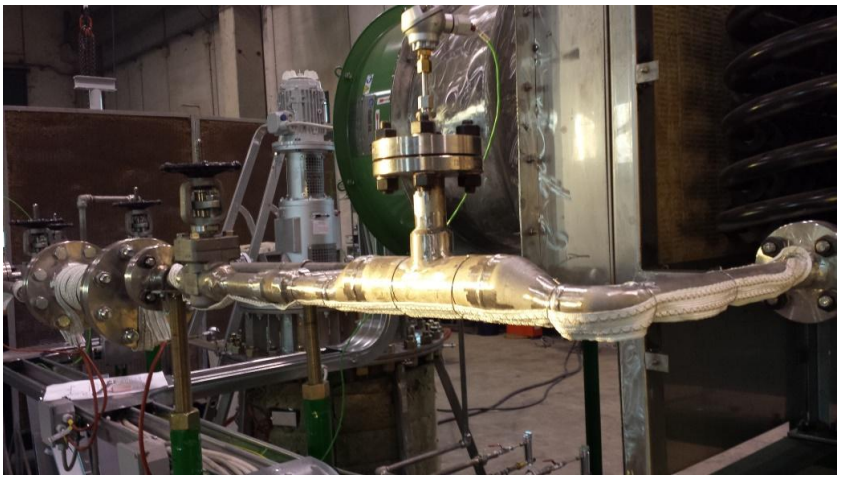
The choice of the material for the MSTP system was made considering corrosion issues related to the salt use; SS316 was chosen as it is widely utilized and gives a lot of possibility in function of its composition. The design of MSTP has been developed to make use of commercial components as much as possible; nevertheless, some customized components were necessary.



Plant details

The layout is composed by a MS draining tank with an electric resistor to melt the salt, an heat pipe heat exchanger to recover waste heat [optional], a MS test section and a cooling section. Pipes have been traced to preheat the tubes before plant start-up to avoid thermal shocks of the salts; the cooling section is heated by a radiative electric system. The MSTP has been designed to drain all salts in the tank when turned off.

The design MS velocity has been set to a range 0,5-2,5m/s. The pressure drop has been evaluated considering the properties of 4 four Molten Salts (the most representative) in the range between extreme points of use (Tmin, Tmax). The maximum evaluated pressure drop never reaches 1 bar.

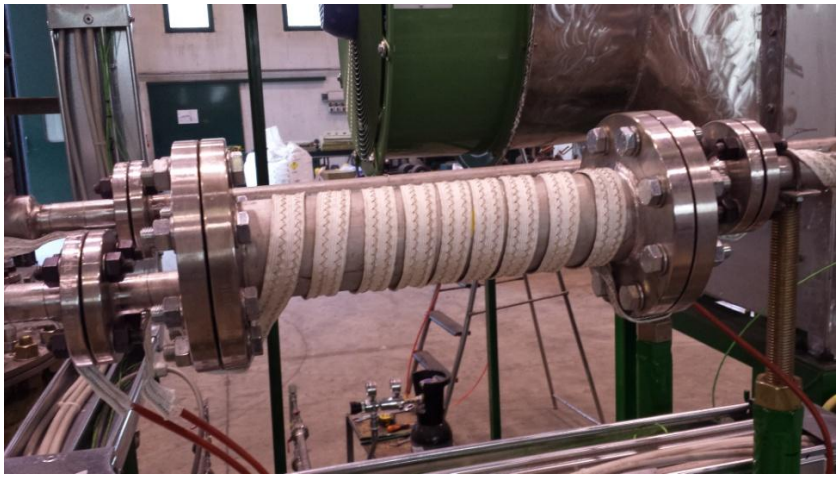


Plant details

Cooler detail

Molten Salt draining tank

General view



Test section

Test section deteail

The MSTP functionality has been positively tested (PLC logic, start/stop procedures) and the system has been tested with Nitrate salts $NaNO_3$-KNO_3 (65%-35%). The thermal and fluid properties of Molten salts (mix 60%-40%) as a function of temperature are the following:

MSTP applications: The solar salts are currently utilized in industrial plants specially in the CSP Plants and their characteristics and performances are well known. In industrial HR applications it may be necessary different or improved thermochemical HTF characteristics because of higher temperature or higher heat storage capacity; at the same time an industrial application require a fast break even point and a positive Business Plan. The utilization of fluorides and chlorites HTF for instance would allow higher performances in term of heat recovery (higher thermal conductivity and heat capacity) but would generate concerns on plant materials in contact with them. They would require expensive alloy for plant components like SS347, Hastelloy B and N, Incoloy 800H, Hayness 556, HR-160 determining most probably a non-profitable investment in the HR initiative because of the high cost of material (material and manufacturing costs). The availability of the MSTP would allow now to test in real operational conditions other HTF than solar salts and check the effects on the most common materials used in industrial plants like SS304 and SS316. It will be also possible to test fluorides, chlorides or other high corrosive HTFs taking into account that the performances of main components – in particular the HTF pump- will decrease proportionally of the test duration time.