

# Feasibility study for the realization by AM of an heat exchanger for absorption machines

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**Abstract:** Absorption machines can be used in air conditioning for both cooling and heating applications. In the past, during almost 35 years of activity, ENEA realized several reversible absorption machine prototypes, driven by natural gas or solar energy, for heating only or for both cooling and heating operation. The thermodynamic cycles adopted have been always based on the ammonia-water pair. In term of materials and costs, one of the most critical issues in realizing these machines is constructing the many tailored heat exchangers involved, in order to resist to the heavy corrosive environment due to ammonia and operating conditions (pressure and temperature). About 20 years ago, In order to give an industrial solution, ENEA together with the Merloni Termosanitari SpA and Italgas, realized an innovative heat exchanger composed by carbon steel perforated plates and brazed with a special Ni-Cr filler alloy. This former exchanger design is now inspiring the actual realization of 3D printed exchangers. First of all the current feasibility study considers the realization of a ferrous alloy, reinforced by the use of suitable dispersoids, thinking to the additive manufacturing of heat exchangers. The alloy, a ferritic one, has been designed for application in liquid and vapour ammonia-water solutions. Moreover this work considers the optimization of the design of the heat exchanger in order to be realized by 3D metal printers using the new alloy. The activity is funded by the Program Agreement with the Italian Ministry of Economic Development "Advanced materials for energy".

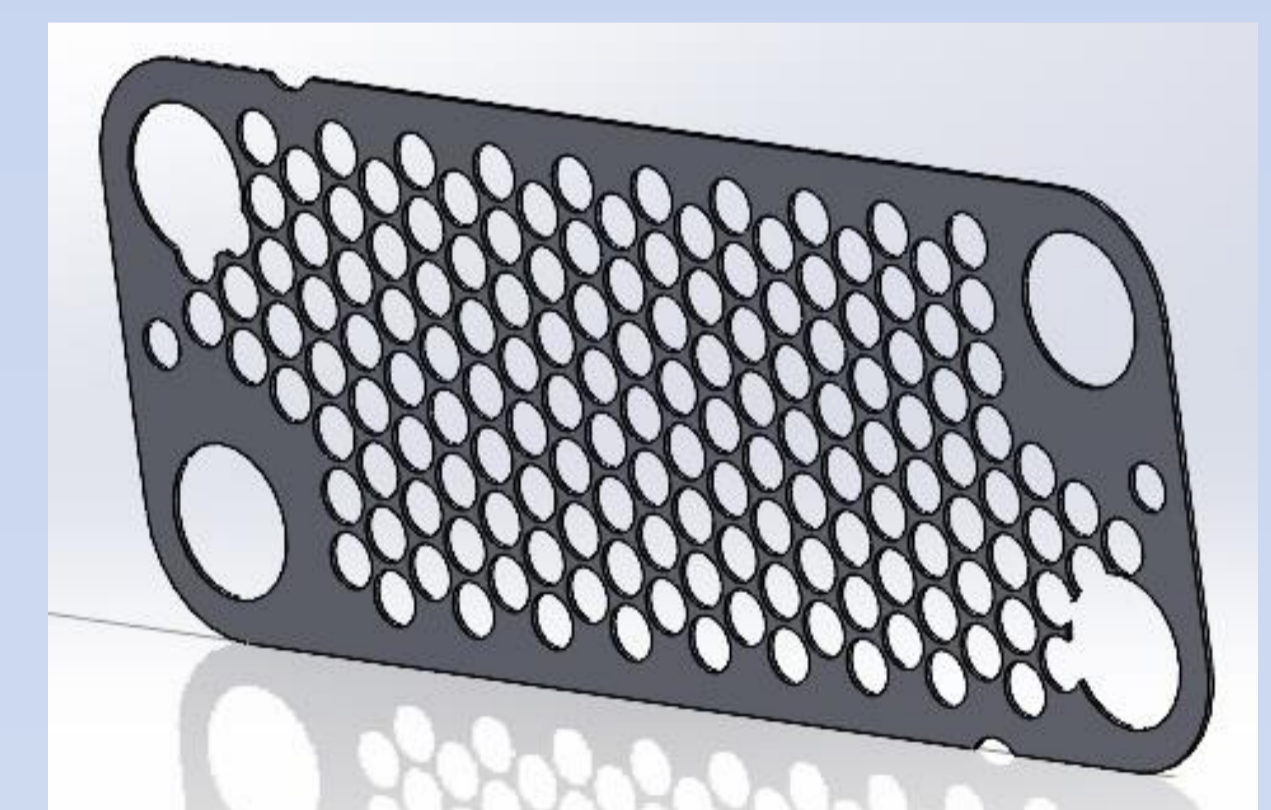
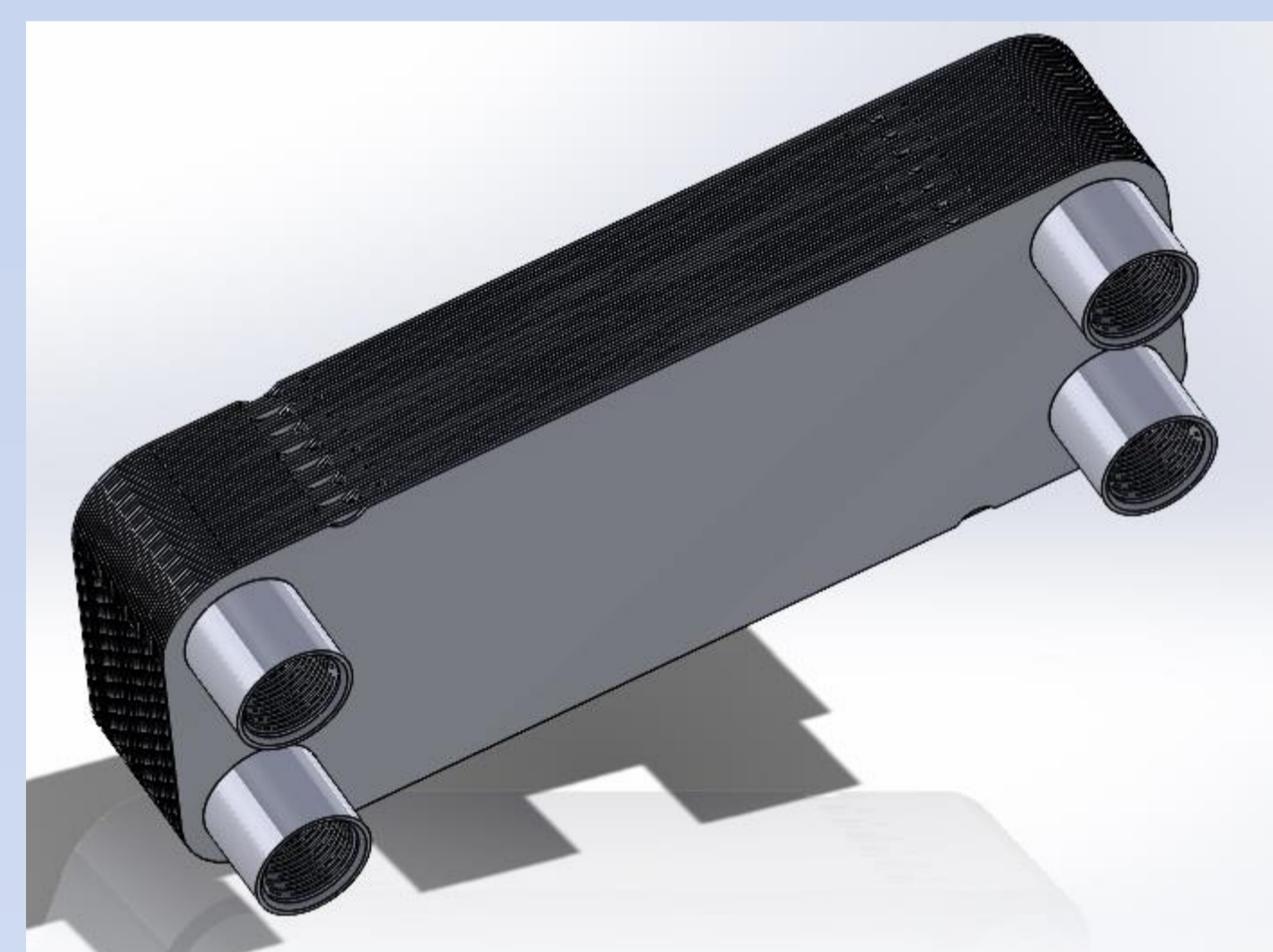


Heat exchanger for absorption machines realized in ENEA .

The brazed heat exchanger has been realized with stacked carbon steel perforated plates.

### Design phases of the new 3D printed heat exchanger

- Preliminary realization in polymeric and composite materials (es.: with Carbon nanofibers) and heat exchange testing;
- Computer Aided Design optimization also by means of software simulating liquid flow and thermal behaviour ;
- Final realization in metal alloy by **3D printing** and heat exchange testing

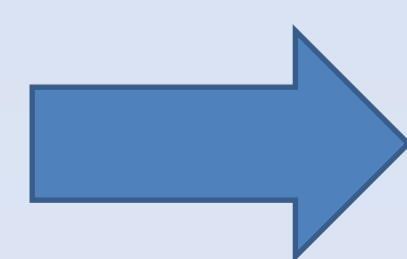


- 18 kW solar driven absorption prototype realized in ENEA [2];
- Intended for Solar Heating and Cooling applications;
- It can be coupled with solar collectors at medium temperatures ( 100°C);
- Ammonia (refrigerant) is present in the system at different concentrations in water (absorbent) solution
- Corrosive environment  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$

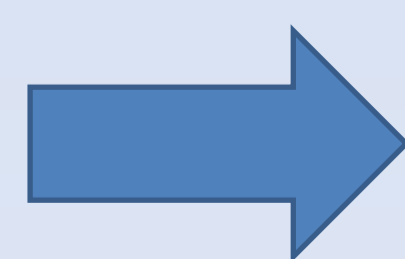
- Presence of ammonia aqueous solutions causes corrosion;
- Copper and Nickel are heavily affected by the presence of ammonia;
- A new ferritic alloy has been designed with the aim to realize heat exchangers by 3D printing

- Ferritic steels have generally higher thermal conductivity respect to stainless steels;
- lower linear expansion coefficient respect to austenitic steels;
- ODS alloy presents high mechanical strength allowing the reduction of the walls thickness of the channel, increasing the heat exchange [2].

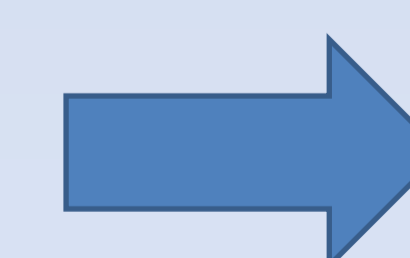
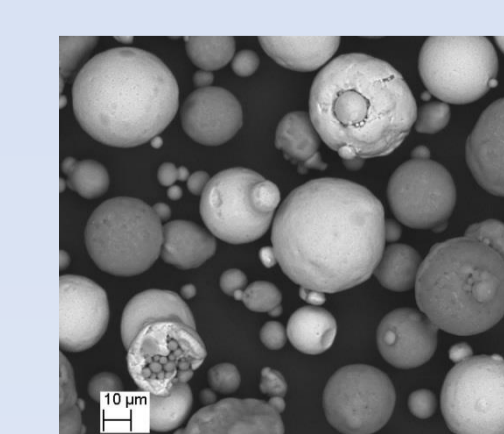
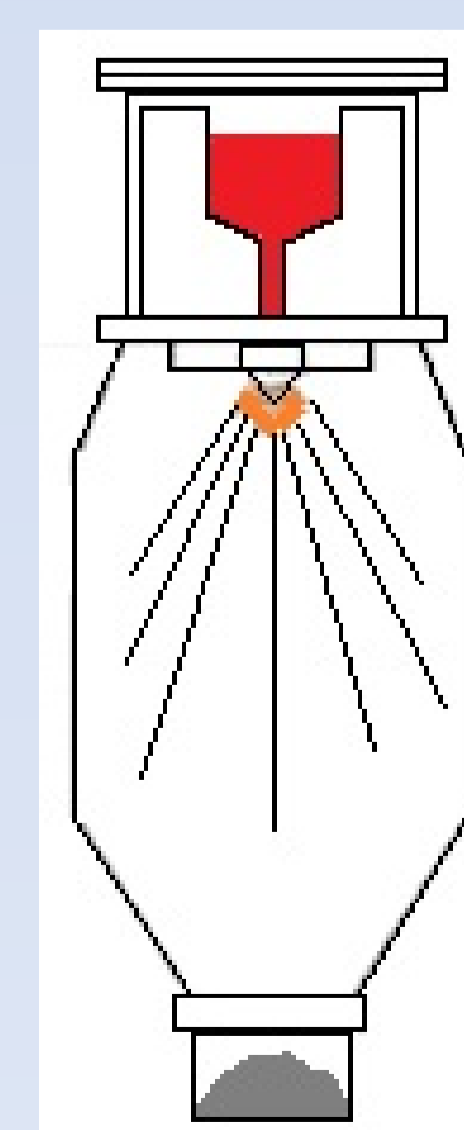
Alloy design



Alloy specification



Production by gas atomization



ODS preparation