Realization of heat exchangers in composite materials and metal alloy by AM

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In the past ENEA realized absorption machine, based on ammonia-water cycle, which could be used in air conditioning and for heating applications. A 18 kW machine was realized to demonstrate the potentialities of these systems, in particular when heat could be supplied by renewable energy sources, as for example using solar collectors. For this type of machines critical components are represented by the heat exchangers and by the pump for the rich solution. Ammonia-water solutions cause corrosion in a severe alkaline environment. Heat exchangers realized stacking plates and brazing cannot be used as many pastes for brazing contain Cu and Ni, which are known to suffer the formation of complexes in presence of ammonia. For this reason the activity focused on the realization of heat exchangers, firstly in composite material using SLA method and successively in stainless steel by DMLS. The first part of the activity allowed to demonstrate the potentialities of additive manufacturing in realizing highly convoluted geometries and to rapid prototype internal geometry. After realizing heat exchangers with different internal channels and in a single block, they have been qualified on a test facility. The internal channel have been optimized to reduce head losses and increase heat transfer coefficient. The last part of the activity considered the realization of the heat exchangers, previously optimized, in stainless steel by DMLS and their qualification. The work reports also microstructural characterization and NDT of the materials used to realize the heat exchangers.

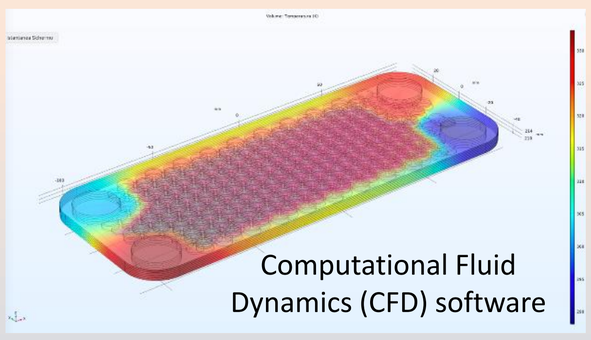
- 18 kW solar driven absorption prototype realized in ENEA [*];
- Intended for Solar Heating and Cooling applications;
- It can be coupled with solar collectors at medium temperatures (100°C);
- Ammonia (refrigerant) is present in the system at different concentrations in water (absorbent) solution $NH_3+H_2O \Leftrightarrow NH_4^+ + OH^-$
- Corrosive environment

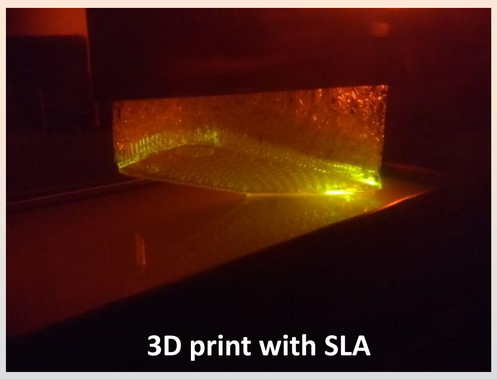
Heat exchanger for absorption machines realized in ENEA. The brazed heat exchanger has been realized with stacked carbon steel perforated plates.

The use of brazing compounds based on Cu and Ni in presence of ammonia must be avoided because of the formation of complexes.

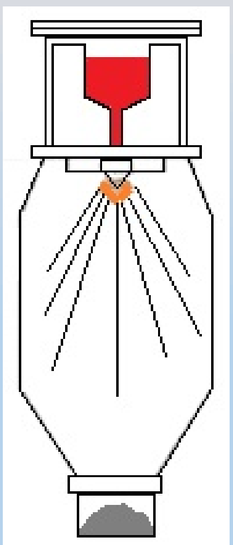
Design of the new 3D printed heat exchanger

- Preliminary realization in polymeric and composite materials (use of fine fillers) and heat exchange testing;
- Computer Aided Design optimization also by means of software simulating liquid flow and thermal behaviour;

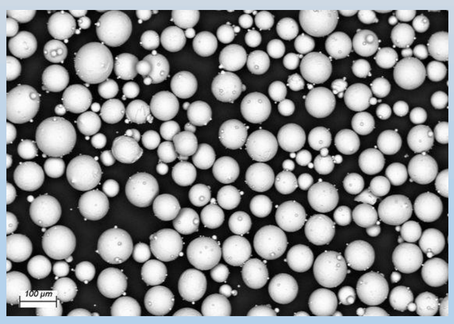




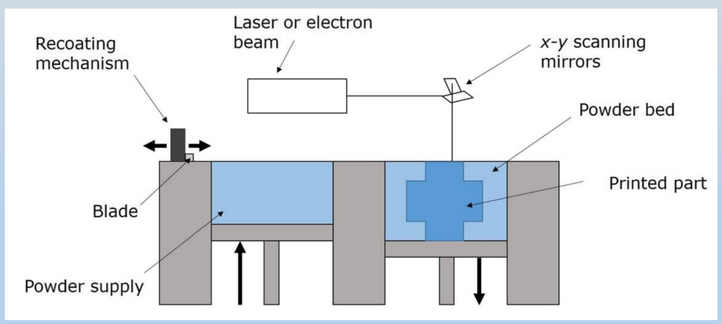
Resins with fine fillers



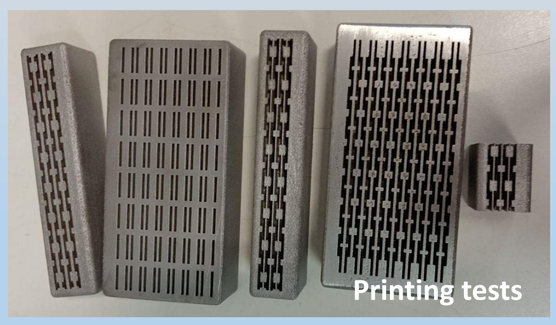
- Final realization in metal alloy by **3D printing** and heat exchange testing **

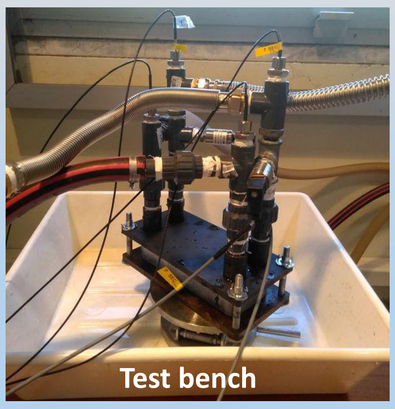


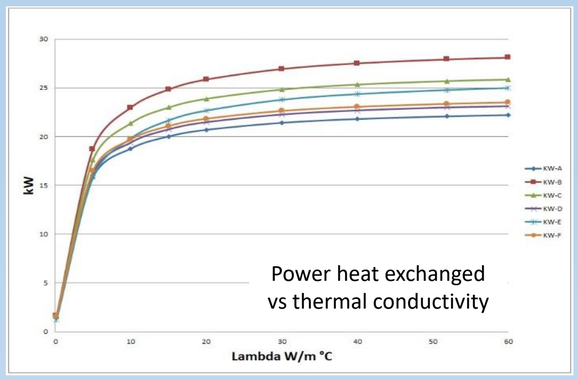
Gas atomized powders

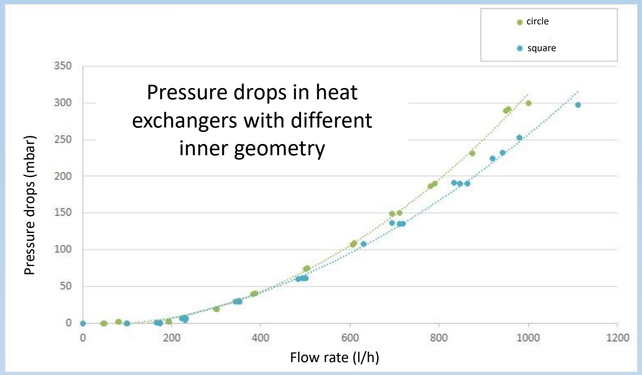


Generic powder bed 3D printing process









Conclusions: heat exchangers with improved inner geometry have been firstly designed and successively realized by 3D printing with different materials: composite materials with fine fillers and stainless steel. The heat exchangers have been qualified on a test bench.

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Ref.: *G. Corallo, A. Franchi, Report RdS/2011/246; **D. Mirabile Gattia, G. Corallo, L. Pilloni, Report RdS/PTR2021/233