TURBOALGOR AND VIRECO
Two tools for the efficiency of refrigeration systems

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Abstract

Angelantoni Industries group has been working for many years in refrigeration energy efficiency; Turboalgor and Vireco are two important results of this activity.
The Turboalgor kit, which applies to both new and existing refrigeration systems, is confirming the energy saving levels shown by bench testing in the first pilot applications and soon will be available on the market.
Turboalgor leaves the research witness to another project whose name is Vireco.
Vireco aims at a major innovation in the operation of reciprocating compressors by introducing technologies used in the world of internal combustion engines.
If the experimental test will confirm the theory, it will be possible to increase compressor energy efficiency to 17% and increase cooling capacity, for the same displacement, up to 55%; this will be obtainable with fairly simple modifications to cylinders geometry.

1. Project Turboalgor

Turboalgor project is based on the introduction of a turbocharger and two energy recovery heat exchangers within a vapour compression refrigeration cycle. The improvement in terms of performances and energy saving are evident, in particular in low temperatures range.

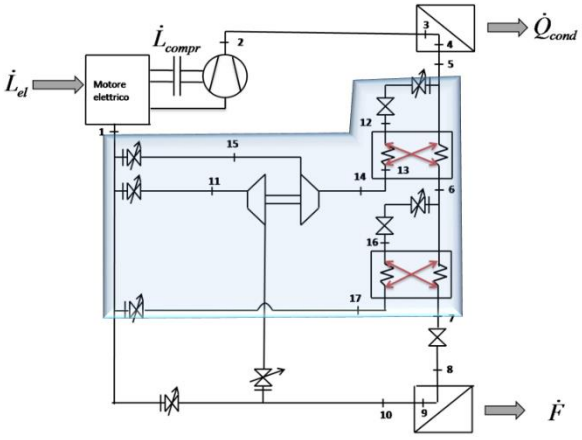

Figure 1: Turboalgor cycle scheme

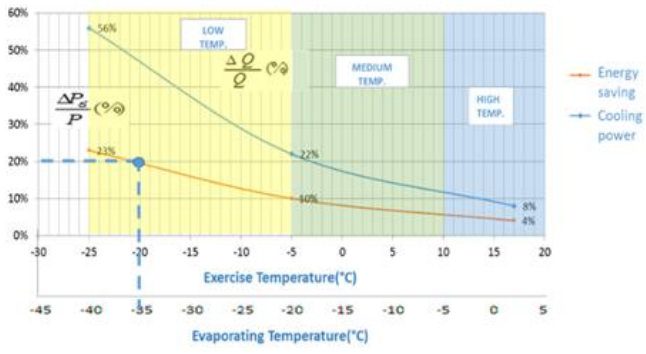

Figure 2: Turboalgor performance graph

The results reached in the research and experimental phase, have allowed to develop a very smart kit, applicable to both new and existing refrigerating units, easy to be implemented mainly due to its small dimensions and only 4 battery limit connections.

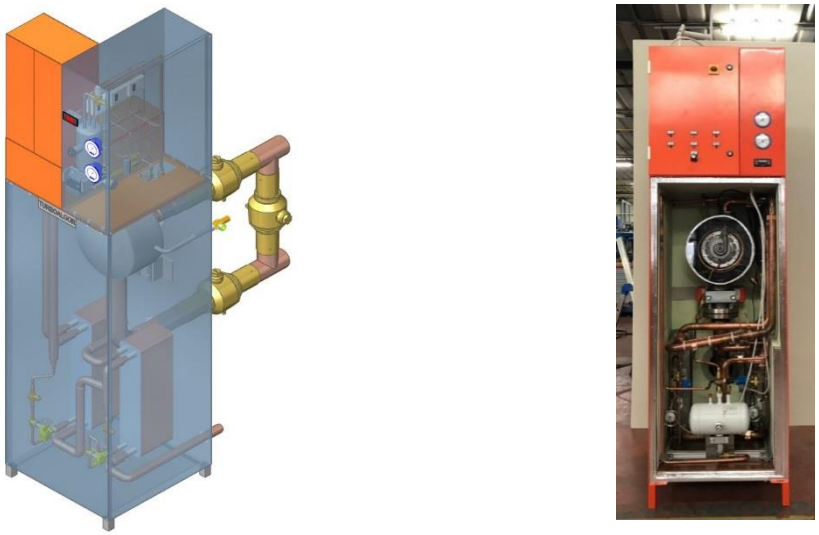

Figure 3: Turbolagor Kit

The first pilot installations done confirm the performance gains obtained in the experimental phase.
As example case, it can be considered the implementation of the kit in a storage plant for frozen food (cooling power 30 kW), done in December 2018.

Figure 4: Pilot Plant – Cooling Power 30kW

The performance of the plant and the energy saving reached since December 2018, confirm this innovative technology is strategic in terms of costs saving and environmental impact reduction.

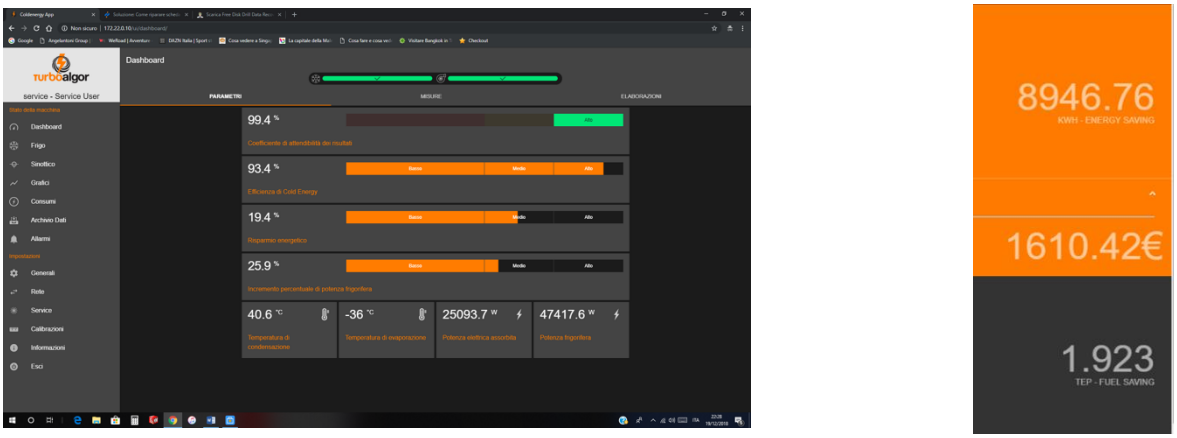

Figure 5: Performance levels and cost/energy saving indicators of a pilot plant installation

2. Vireco Project

VIRECO (Vapour Injected Reciprocating Compressor) project started in 2017, based on two patents concerning a new reciprocating compressor for refrigeration units, with two injection ports in the cylinders, close to the BDC (Bottom Dead Center).

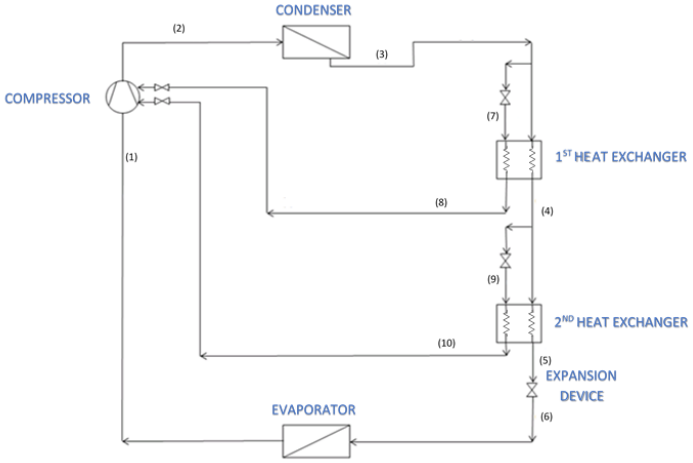

Figure 6: Vireco cycle scheme

The expected improvements of the refrigeration unit performance foreseen by the basic design study, consist mainly in:

- energy saving compared with the standard configuration at the same cooling power level
- cooling power increase compared with the standard configuration equipped with the same compressor size (displacement volume)

In Figure 7, a graph showing the performance gains as a function of the temperature level. The first results obtained in the test bench, actually still in progress, are confirming the theoretical previsions, in particular in low temperatures range (evaporation temperature -40°C ÷ -20°C).

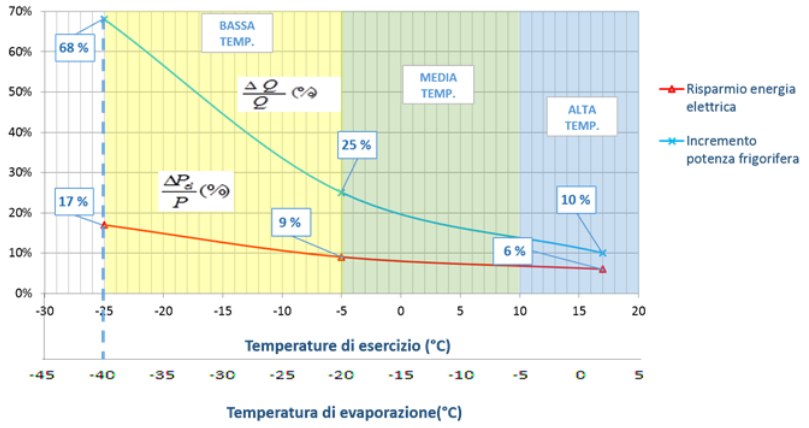

Figura 7: Vireco performance graph

The introduction of ecoports in refrigerating scroll or rotary screw compressors is a consolidated technology to improve the efficiency of the unit, but not applicable so far with reciprocating compressors.
The aim of Vireco project is finding a solution to recover part of the energy before the main expansion device, with reciprocating compressors also, through a technology coming from automotive field (competition engines).
This solution is based on the technology of “manifolds tuning”, an application for high performance engines, coming from the concept developed for musical wind instruments.
The target to achieve is optimizing the injected flowrate in the cylinders, according to the maximum capacity of the 1st and 2nd stage recovery heat exchangers, to increase the pressure inside the cylinder before the compression phase and consequently reducing the power consumption.

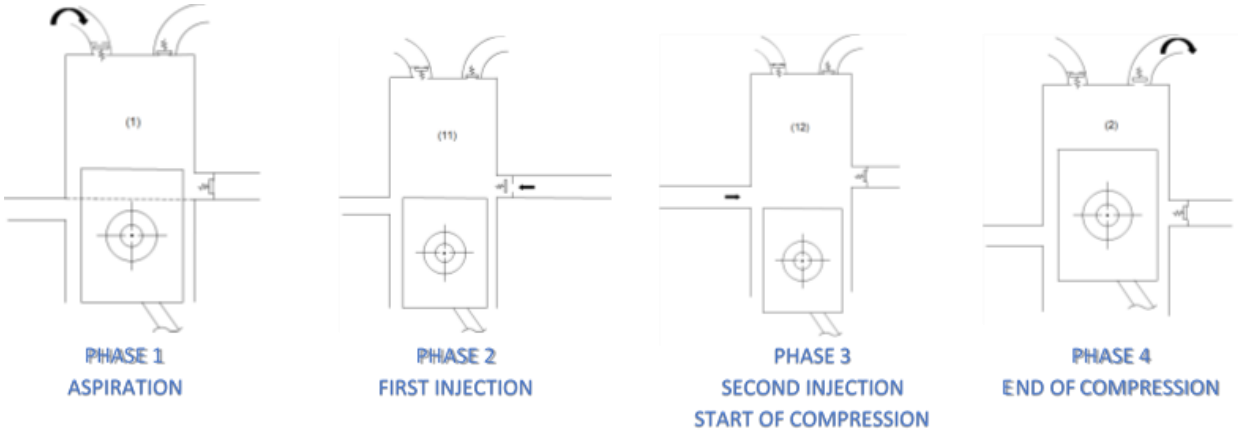

Figure 8: Sequence of Phases for a Vireco compressor

The project is developing mainly in three steps:

- Thermodynamic and fluid dynamic study to define the optimizing geometry and operating conditions
- Design and construction of the compressor prototypes, starting from conventional models
- Bench test experimental phase and check of performance improvements

After preliminary CFD simulations of simplified models, it has been developed the real model matching with the compressor prototype realized.
The aim of this study is showing the critical aspects of the system, in particular the key parameters affecting the flowrates through the injection lines, in the short time period of ports opening.
Crucial is the pressure waves influence in this scenario, generated after ports opening and closure.

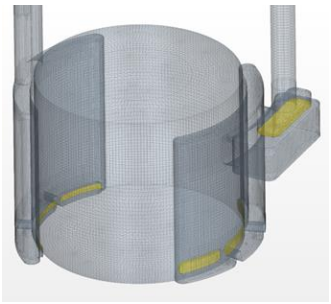

Figure 9: Fluid Dynamic model

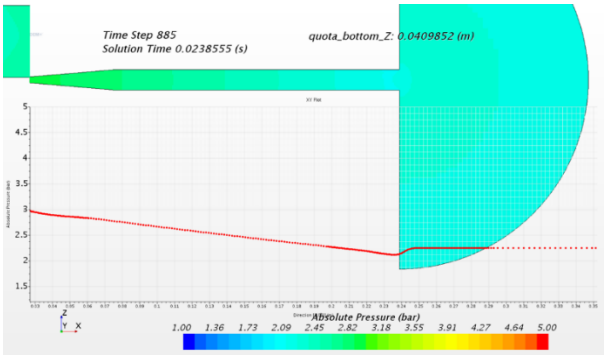

Figure 10: Pressure trend in the high-pressure line

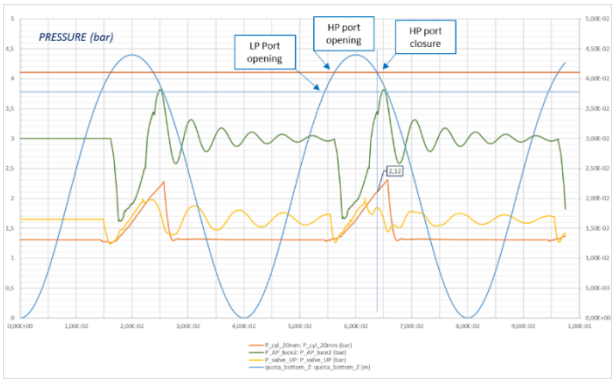

Figure 11: Pressure graph vs time

The mechanical constraints due to the realization of the compressor prototype from a conventional one, affected the achieved performances compared with the optimized ideal configuration, but anyway the efficiency gain obtained confirmed the innovation potentiality.

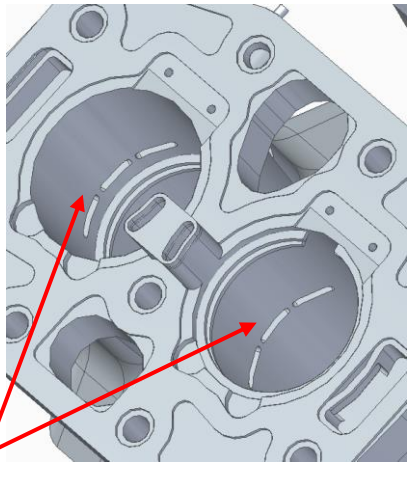

Figure 12: Head of prototype compressor with 2 cylinders

The first experimental phase on the compressor with 2 cylinders are actually in progress. In the next experimental phase, a 4 cylinders compressor prototype will be tested.

Figure 13: Test Bench

The development of the project and the transfer of technology on an industrial scale, have extremely interesting premises, considering the widespread use of reciprocating compressors in civil and industrial refrigeration systems (domestic refrigerators, air conditioning systems, chain systems of the cold in the agri-food sector, pharmaceutical processes, etc.).

It is a class of machines which, due to the wide field of application and the extended range of powers covered starting from small sizes (from powers of 1 kW to 100 kW), represents a significant portion of the energy needs of industrialized countries.

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