**THERMODYNAMIC ORC CYCLE DESIGN OPTIMIZATION FOR MEDIUM-LOW TEMPERATURE ENERGY SOURCES**

**M. Astolfi, M.C. Romano, P. Bombarda**
Politecnico di Milano – Energy Department
Via Lambruschini 4, 20156 Milano, Italy
E-mail: marco.astolfi@mail.polimi.it
matteo.romano@polimi.it
paola.bombarda@polimi.it

## ABSTRACT

In the last ten years, the increasing attention to pollutants and greenhouse gases emission from the power generation sector and the concerns about fossil fuel supply and price have led to a massive growth of those technologies that can produce electric energy from renewable sources or from waste heat recovery.

In this context, the exploitation of heat from a wide variety of sources, like hot geothermal brines, sun and exhaust gases from engines and industrial processes using an Organic Rankine Cycle (ORC) is certainly one of the most promising solution.

The basic idea is to exploit low and medium enthalpy energy sources by a Rankine cycle using an organic fluids instead of water as working fluid. This choice is confirmed by several feasibility studies and industrial applications which clearly show that, in a range from 500kW to 5MW, ORC power plants can reach higher efficiencies than common Rankine steam cycles. Moreover, ORC power plants guarantee a compact design of turbines, primarily thanks to the properties of organic fluids, and permit to overcome the drawbacks related to the challenging design and the high specific cost of steam turbines in the considered power range.

Fluids normally used in ORC plants cover a large variety of different compounds like siloxanes and perflourated organic molecules, whose thermodynamic properties notably differ from each other in term of critical parameters, maximum allowable temperatures and chemical stability.

The wide option in the available working fluids and the various types of cycles that can be adopted entail a non univocal choice for the exploitation of a given heat source.

An Excel®-VBA code was created in order to define the most efficient combination of fluid and cycle thermodynamic parameters. Thermodynamic properties of fluids are taken from Refprop® database, which allows to carry out the study with huge number of fluids including most of the commercial refrigerants, hydrocarbons and siloxanes.

To achieve the purpose of this study, different heat sources at variable temperature are considered, in order to model the exploitation of different primary energy sources like medium-low enthalpy geothermal brine, solar energy and biomass or waste heat from industrial processes and endothermic engine exhaust gasses.

For all the above-mentioned cases, an extensive thermodynamic analysis is carried out by investigating the potential of a number of fluids with different cycle configurations, starting from the basic non-recuperative saturated cycle up to supercritical and two pressure level cycles that allows the achievement of the highest efficiencies. The effects of fluid choice and cycle parameters on the main component design, e.g. heat exchangers surface and turbine size, are also discussed to provide a further term of comparison between the different options.

All the plant assumptions for the calculation of the plant components, in particular related to heat exchangers and turbo-machinery, are set on the basis of data from literature, real power plants data sheets and preliminary design.