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Editorial: Advances in research on ORC turbomachinery

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Power plants operating according to the Rankine thermodynamic cycle, but using an organic substance as a working fluid in place of water, are termed organic Rankine cycle (ORC) power plants. The selection of the working fluid is a degree of freedom of design that allows the optimization of the system depending on the temperature of the thermal energy source, which can vary approximately between 100 °C and 600 °C, and the capacity, which can range from tens of kW to tens of MW (for more details, see e.g., Colonna et al. (2015)).

ORC power plants are suitable for the conversion of renewable energy sources into electricity. The technology is mature if the power output is large and the maximum cycle temperature is below ~350 °C. Its application for the exploitation of geothermal reservoirs is growing at a fast pace around the world. Many biomass-fired ORC power plants have been deployed in Europe since the early 2000s. Relevant opportunities exist if the conversion of otherwise wasted thermal energy from industrial installations is considered, and the potential is even larger if the recovery from propulsion engines is included, see, e.g., the recent report of the Knowledge Center for Organic Rankine Cycle technology (KCORC) (Astolfi et al., 2025).

KCORC is the not-for-profit association that organizes every two years the *International Seminar on Organic Rankine Cycle Power Systems* since 2011. The 7th edition of the seminar was held in Seville, Spain, from September 4th to 6th, 2023. The event gathered 191 participants from more than 30 countries, with representatives from industry, research institutes, and universities, and with a significant presence of young professionals. This special issue of the Journal of the Global Power and Propulsion Society is a collection of four articles whose content was first presented at the seminar in Seville, and it is focused on ORC turbomachinery research.

The efficiency of the supersonic expansion of organic fluid vapor into the stator of ORC turbines is critical for the performance of the turbine, therefore the article (Oliveti et al., 2025) is of particular interest as it documents for the first time the accurate characterization of such flow field, whereby the thermodynamic state of the working fluid at the inlet of the stator is highly nonideal. A blow-down facility, the TROVA at Politecnico di Milano, was used to generate a flow of hexamethyldisiloxane (MM) vapor through a planar cascade. The variation of the static pressure in the streamwise flow direction along the blade channels is measured together with the total pressure loss across the cascade. Schlieren imaging was also performed during each experiment. The experimental data are compared to the results of CFD simulations and are in good agreement.

The article (Zakeralhoseini and Schiffmann, 2025) documents a method for obtaining novel design maps, namely efficiency contour plots as a function of specific speed and specific diameter, for centrifugal

ORC pumps. The maps were computed by fitting data obtained with a meanline model and corroborated with results from high-fidelity CFD calculations. Two small-scale unshrouded turbopumps operating with R245fa as working fluid and characterized by different specific speed values were then designed, built, and tested in the ORC facility of EPFL. Measurements resulted in an estimation of the maximum efficiency that deviates by about 11% from that calculated based on CFD simulations, while the head coefficient was found to be in better agreement with the model predictions.

The article (Romei et al., 2025) presents a CFD-based shape optimization method based on Kriging surrogate modeling and a genetic algorithm. The method encompasses an experimentally validated two-phase CFD model that assumes that the fluid is in thermodynamic equilibrium and barotropic. The shape of the impeller blade and the meridional surface of the vaneless diffuser of a centrifugal compressor for MW-scale supercritical CO_2 power systems were concurrently optimized, leading to a calculated increase of compressor efficiency of about 1% at the nominal operating conditions. At these conditions the thermodynamic states of the fluid are close to the critical point.

High-speed radial ORC turbines are unconventional and novel. These turbines are at the core of waste heat recovery systems for propulsive engines, such as those equipping innovative combined-cycle power trains for trucks that have been investigated and recently tested on road. Other applications are envisaged in the maritime and aerospace sector. The ORCHID turbine that is being developed at Delft University of Technology is a unique laboratory turbine for high-temperature ORC systems. A detailed description of the turbine assembly, including that of bearings and sealing, is documented in Majer et al. (2025). In particular, a study on the rotor-dynamics of these unconventional turbines is reported for the first time. The ORCHID turbine is being realized and it will be commissioned during 2025.

These four articles are examples of research activities aimed at boosting turbomachinery technology for the further adoption of high-temperature ORC technology and for the two relevant cases of small-capacity and large-capacity systems. Many research questions on this type of machines are still unanswered and need to be investigated in order for the envisaged ORC systems to be industrialized. For example, the possibility of using bearings lubricated with the working fluid is arguably critical for bringing waste heat recovery ORC units for propulsion systems to commercialization. Moreover, theory shows that organic Rankine cycles whose expansion is partly occurring with the fluid in vapor-liquid thermodynamic states might be more efficient for the recovery of sensible heat. Research on machines capable of expanding vapor-liquid flows is therefore essential. As it is the case for other more traditional turbomachinery, like, e.g., gas or steam turbines, fluid dynamic performance of ORC turbomachinery can be considerably enhanced by means of automated shape optimization methods.

Such methods have been recently extended to treat axial and radial ORC turbomachines, though more research is needed in order to make them capable of dealing with complex industrial problems, so as to be deployable into the design chain of commercial companies. Compared to turbomachinery, less research has been devoted to the improvement of ORC heat exchangers, namely condensers, evaporators and regenerators. Anecdotal knowledge suggests that this equipment could be much improved, thus increasing the economic viability of ORC power plants. Additive manufacturing technologies could be adopted to realize heat exchanger cores designed with automated shape optimization methods and more specialized materials, particularly if weight must be reduced. A large potential for improvement might arise from the integration of the turbogenerator and the regenerator into a single assembly.

In conclusion, the editors of this special issue warmly suggest to the many colleagues that are engaged in ORC research to study these articles, and look forward to the new developments in these research directions.

Competing interests

Matteo Pini declares that he has no conflict of interest. Piero Colonna declares that he has no conflict of interest.

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