

DEVELOPMENT OF A WASTE HEAT RECOVERY ORC PROTOTYPE USING AN OIL-FREE SCROLL EXPANDER

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ABSTRACT

The world is facing a historical increase in energy demand and energy consumption. As consequence the conventional fossil fuels are depleting faster with an inherent pollution causing severe damages to our environment. Renewable energy sources are considered as a solution to both environmental issue and energy demand. At the same time a lot of waste heat is witnessed in processes in industries. Our objective is to contribute to the development of ORC systems, that appear to us as a good solution to recover this wasted heat.

In such waste heat applications, depending on the heat source flow rate and temperature, electrical power output can be as low as a few kilowatts. In this power range, there is no cost effective expansion machine available on the market. On existing prototypes, expansion devices are usually retrofitted volumetric compressors originally designed for refrigeration or air compression applications. Air compressors have the advantage to handle higher inlet temperature but tightness is often an issue in ORC application since the fluids used have a non negligible environmental impact.

This paper presents the development of a small-scale WHR ORC unit at the Thermodynamic Laboratory of the University of Liège: the prototype uses a scroll expander, plate heat exchangers, a diaphragm piston pump and a liquid receiver. This system was tested with different working fluids (R123, R245fa and HFE7000) and a thermal efficiency close to 8% was obtained for a net output power of about 2 kW_e.

The specificity of the proposed prototype is the absence of lubrication: in order to avoid oil circulation in the ORC loop, an oil-free scroll expander is developed. This expander is originally an air scroll compressor that was modified using a magnetic coupling to ensure tightness. The experimental results highlight the good efficiency of the device, despite a relatively high internal leakage due to absence of lubrication. The necessity of using magnetic coupling is also justified by comparing the experimental results with previous ones obtained using mechanical sealing.

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