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VALVELESS EXPANDER/COMPRESSOR WITH VARIABLE VOLUME RATIO BASED ON A FREE PISTON, E.G. FOR ORGANIC RANKINE CYCLES FOR WASTE HEAT RECOVERY

EnerGhentIC, the interdisciplinary community of Ghent University of researchers working on the energy challenge, is seeking partners interested in the further development and commercialization of a novel type of expander/compressor, patented under "WO2016198554 (A1) - FREE PISTON DEVICE."

Introduction

Researchers at Ghent University have developed a new type of expander/ compressor with variable volume ratio based on a free reciprocating piston.

For our research, the main topic for experimenting with this device are Organic Rankine Cycles (ORC's) for waste heat recovery. In waste heat recovery systems using ORC's, it is key to be able to adapt the volume ratio in the expander according to the load conditions. This volume ratio impact the amount of work extracted from the expander and is a key parameter in controlling the overall ORC cycle.

For instance, automotive applications are characterized by strongly varying waste heat flow rate and temperature, so an ORC with a variable expansion ratio expander would be a good choice for maximum power output.

To control the volume ratio and maximize the power output, a Single Axial Piston Variable Volume Ratio Expander (PEXP) has been developed. Contrary to what its name suggests, this device can also be used as a compressor.

Technology

In the case of an expander, the device comprises of a cylindrical housing with multiple inlets connected to a high pressure fluid or gas, and multiple outlets connected to a low pressure fluid or gas. (See figure 1). In the housing there is piston, which has two skirts, together with the housing these skirts create two opposite chambers, each of which having at least one opening in the skirt of the piston. The piston itself can move freely both in parallel to and along its axis.

In normal operation, the piston will exhibit a reciprocating linear movement in parallel to the axis. In the case of an expander, this movement is induced by allowing -during one half of the reciprocating period- a high pressure fluid to enter -via the inlet of the housing through one of the free openings in the skirt of the piston- into one of the chambers and allowing the expanded fluid to exit through the other opening during the other half of the reciprocating period.

Because the piston consists of a rotor assembly of a linear generator, and the housing comprises a stator assembly of the generator, the reciprocating movement will generate electrical power.

As indicated above, the piston itself can also rotate freely around its, as such the piston skirt and cylindrical housing can be operated as to act as a rotary valve. The rotation is controlled as to alternatively connect one of the free openings of one chamber to the inlet during a first half of the reciprocating period and connect the other free opening of that one chamber to the outlet during the second half of the reciprocating period, i.e. to ensure the linear movement is sustained through the expansion process.

The volumetric ratio is therefore controlled by the relative timing of the rotational movement of the piston in relation to the linear reciprocating movement of the piston.

Applications

All applications in need for a variable volumetric ratio expanders/compressor.

A specific application is waste heat recovery and the use of solar heat. In these applications volume ratio control is a key element to maximize the output over a wide range of operating conditions. Such will be required to allow the ORC technology to be adopted widely in these applications.

Advantages

First of all, the device has a variable and controllable volume ratio, leading towards a maximization of the system power output.

Due to the fact that no dedicated valves are needed (the skirt and the housing jointly act as a valve), the device can be made compact.

The lack of mechanical transmissions, such as crank systems, increases the efficiency of the device.

This device allows for an optimized displacement profile (instead of velocity profiles derived from a rotational movement when using a crank system). This can lead towards a thermodynamic optimization, e.g. a possible improvement of the operation in start/stop behavior.

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Status of development

We estimate the current technology status to be at TRL 3.

Next to the theoretical analysis and dedicated simulations, an air based, single stroke device has been successfully tested. In this experimental setup, a separate electrical motor and generator were used, both placed outside the piston.

Partnership

We are looking for a partner/partners for the further development and commercialization of the device, potentially as part of a subsidized R&D project.

The potential profile of the partner:

1. Manufacturers/designers of expanders/compressors
2. Manufacturers/designers of special types of electrical machines
3. OEM in need for expanders/compressors with variable volume ratio.

Intellectual property

Patent “Free Piston Device”; Inventor: Sergei Gusev; Application number: WO2016EP63223 20160609

Figure

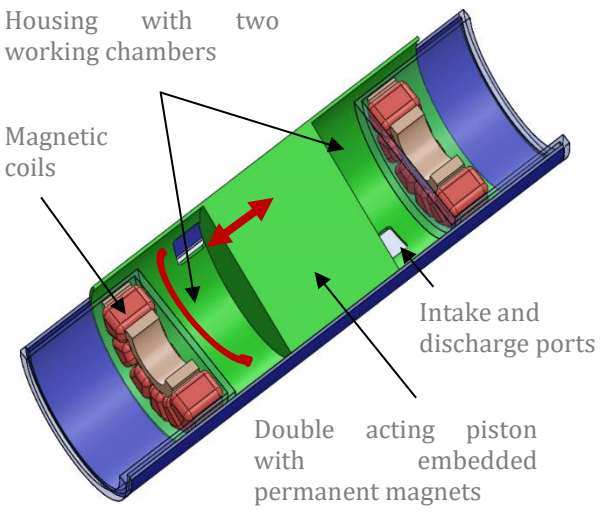

Figure 1: New expander cutaway

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References

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Keywords

Expander, Variable Volume Ratio, Compressor, Single piston, Linear Generator, Rotary Valve, Waste heat recovery, Organic Rankine Cycle (ORC)

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