KAI-ORC

Konstruktion
Aufbau &
Inbetriebnahme
einer Mikro-ORC-Anlage

Conception, Installation and Operation of a **Micro-O**rganic-**R**ankine-**C**ycle-**Power plant**

Albrecht Eicke, Slawomir Smolen

HSB Hochschule Bremen
City University of Applied Sciences

Challenge

The general goal of this project was the concept development, design, evaluation and optimization of an ORC plant in power range of ca. 1 kW with a scroll expander Air Squared Inc., E15H22N4.25 .

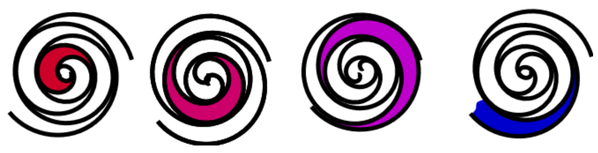
Requirement

Clarity for teaching and demonstration purposes

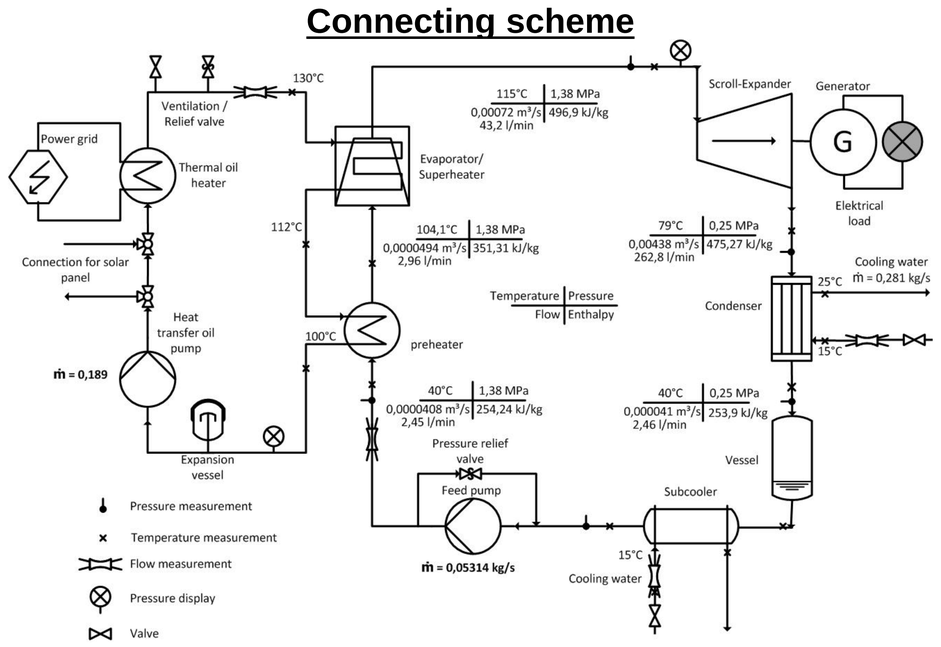
transportable for use at trade fairs

Integration of **solar thermal** systems

Scroll expansion



Connecting scheme



Description

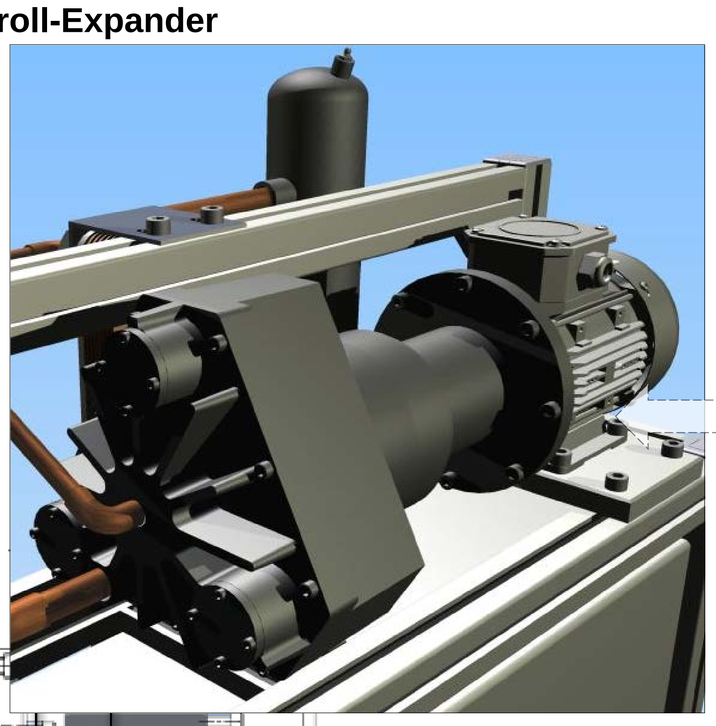
The installation will be coupled to solar collectors, which will provide the heat at 130°C to keep the ORC process running. Alternatively the heat can be generated by an electric driven thermal heater rated at a nominal power of 20 kW to demonstrate the functionality of the ORC itself without using solar energy. Disregarding the source of the heat, it is transmitted by two plate heat exchangers to the working fluid (**R245fa**). The operating pressure of 1,38 MPa is maintained by a sliding vane pump. The fluid can be completely evaporated and superheated to a temperature of 115 ° C. Subsequently, the refrigerant vapor enters the core of the plant - the scroll expander. The fluid is expanding to volume with a ratio of 3,5. After this expansion the refrigerant vapor is desuperheated and fully condensed in the condensator. Between the storage vessel and the feed pump is built in a subcooler to avoid cavitation in the positive displacement feed pump.

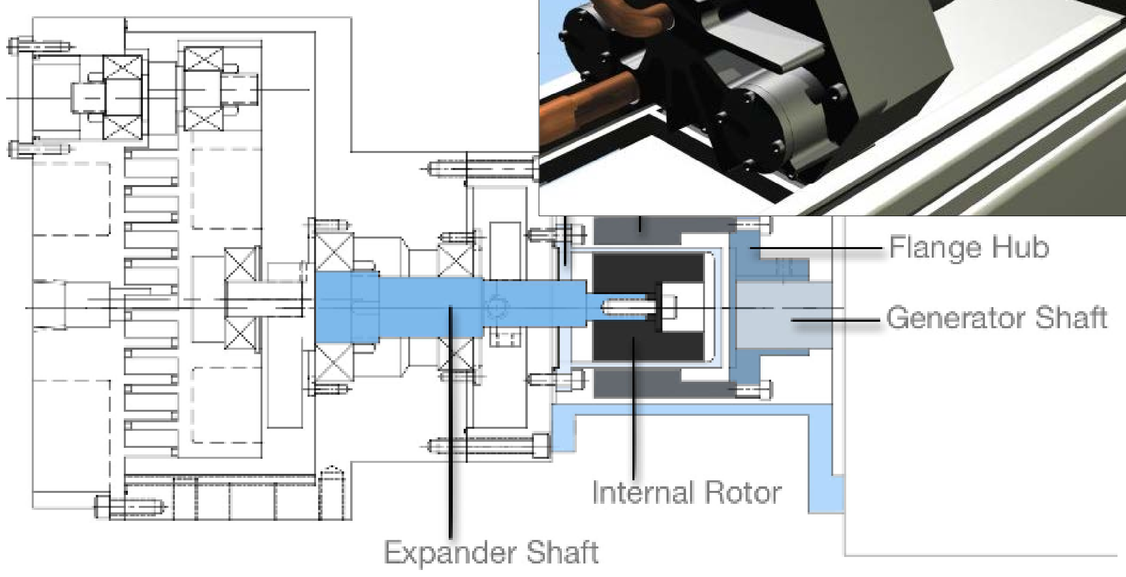
The generator is loaded with a series of controlled shiftable halogen lamps each of about 100 W electric power. Voltage and current are measured to calculate the electrical power.

Scroll-Expander

Air Squared Inc.

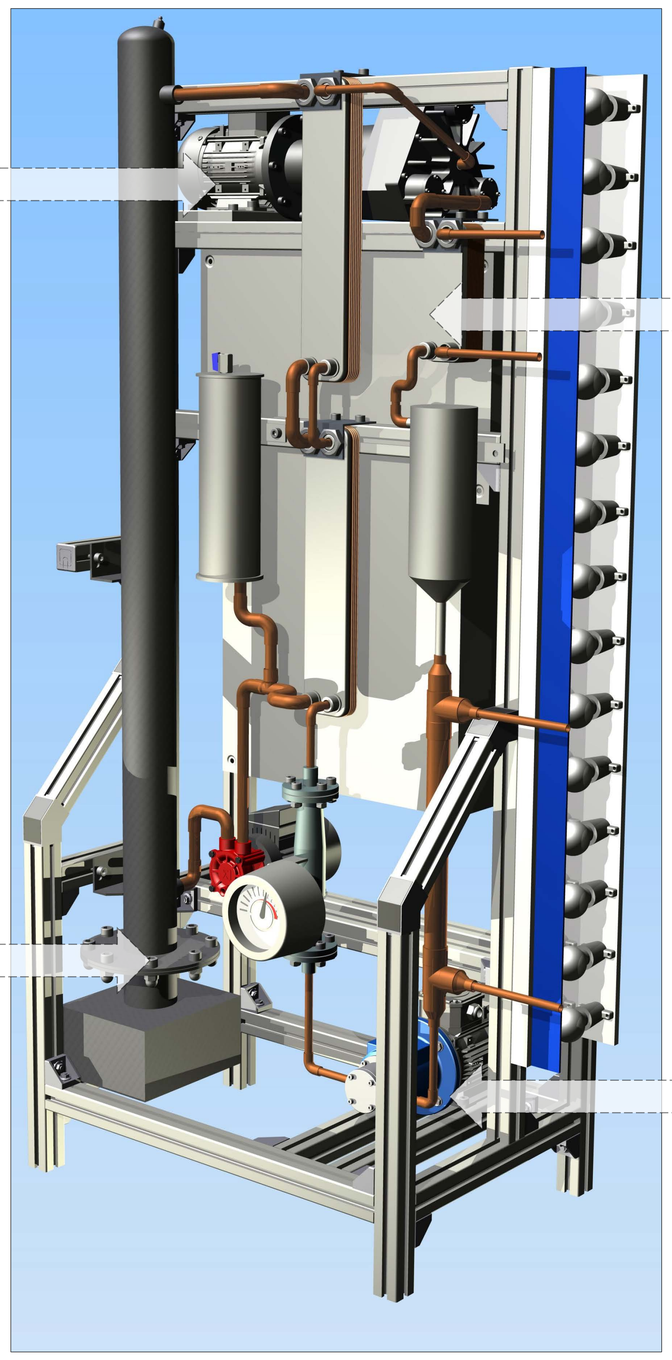
parameter	value	unit
power	1	kW
rpm	3000	min^{-1}
Volume	12	cm^3/U
V_2/V_1	3,5	-
fluid	R245fa / R134a	





CHARACTERISTICS

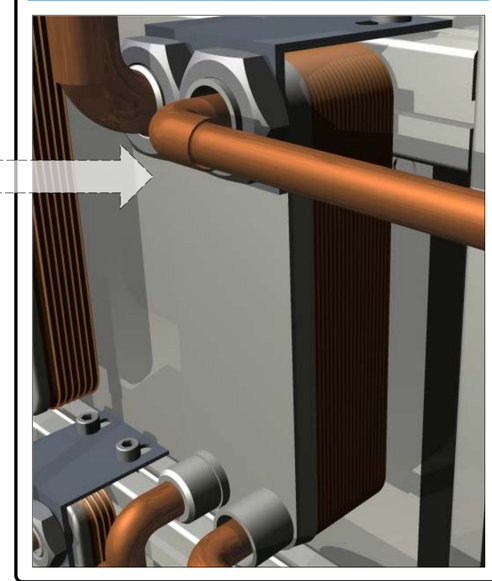
electrical power	1	kW
heat power	11,5	kW
efficiency	8,7	%



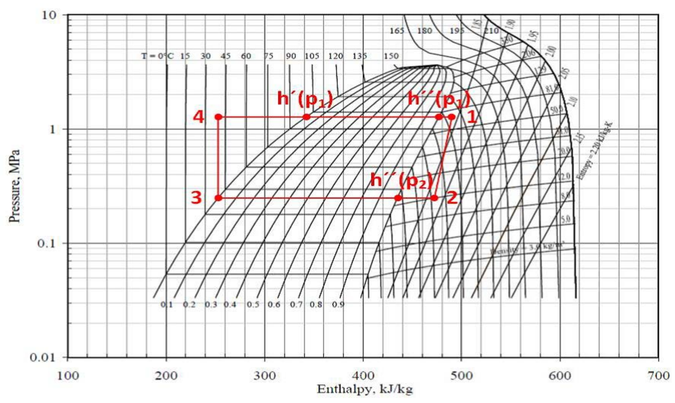
Condensator

Funke Wärmeaustauscher Apparatebau GmbH

parameter	value	unit
power	16	kW
surface	0,25	m^2
plates	20	-
$\Delta\vartheta_{ln}$	20,3	K



log p – h - diagram



Thermal oil heater

ELMESS-Thermosystemtechnik GmbH & Co. KG

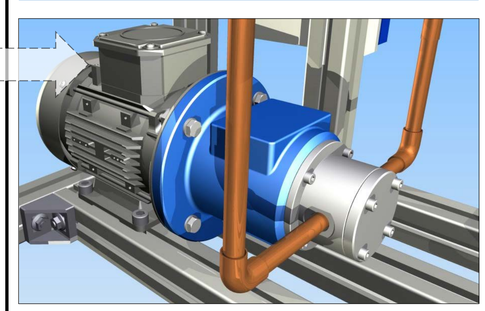
parameter	value	unit
power	20	kW
voltage	400	V
temperature	< 130	°C
fluid	Therminol ADX10	

autonomous use or serial connected to a solar thermal installation

Feed pump – vane pump

MARCH PUMPEN GmbH & Co. KG

parameter	value	unit
NPSH	1,8	m
pressure	< 1,3	MPa
Fluid flow	< 5,3	l/min



Measurement

A compact Data Acquisition System cDAQ 9178 from National Instrument was used for measuring the temperature and the pressure in each condition, the electric power, the volume flow and the revolution of the scroll expander. This system is built up in a modular way and cause of the integrated signal condition the sensors are clearly arranged and direct connected. The voltage and current flow of the generator are converted by a hall effect transducer into a signal of up to 5 Volt so that the effective electric power could be calculated. The measurement equipment is located in a separate switchboard to reduce electric noise from inverter and motor.

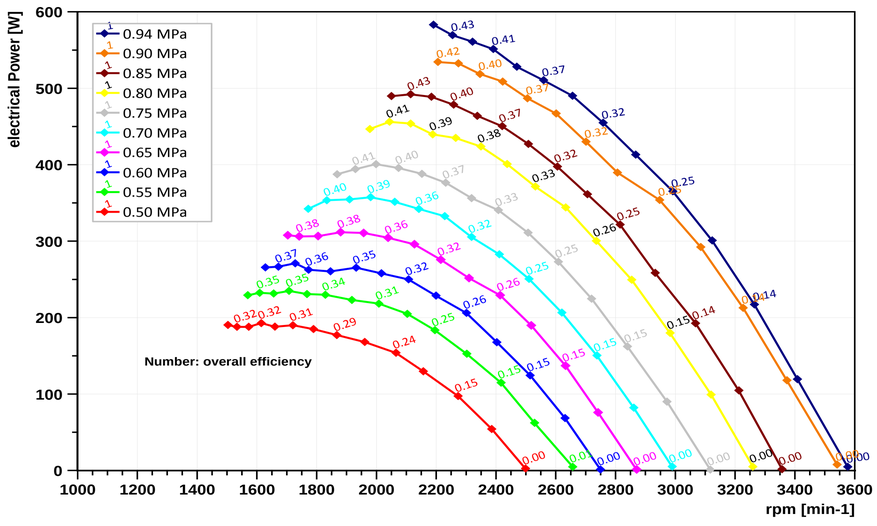
To hold the required voltage and the frequency, for example 230 Volt at 50 Hz, a LabVIEW program measures the revolutions per minute, calculates the electric load and turns on additional light bulbs or switches them off (each light bulb has nominal 100 Watt at 230 Volt). A maximum number of 15 light bulbs can show directly the produced power of the specific operating point.

The software searches for the measured temperature and pressure the values for enthalpy and entropy to the main condition points from a table. Additional to the heat power, the electrical power, the revolution and the efficiency these points are also visualized in a h-s-diagram and a T-s-diagram.

The speed of the feed pump is controlled over an inverter to steer the mass flow of the refrigerant in the cycle to hold the evaporating temperature on one hand and to control the revolution of the scroll expander on the other hand.

Results with compressed air

This figure shows the electric power versus revolution per minute for an air pressure from 0.50 MPa to the maximum of 0.94 MPa. The overall efficiency is noted in numbers at every second point. The volume flow through the scroll engine increases with the increase of speed but the torque goes down to zero at maximum speed. The efficiency is higher with higher suction pressure and rise up to a maximum value a little bit higher than the half of the revolution per minute with no load.



Contact: Prof. Dr.-Ing. Slawomir Smolen, Neustadtswall 30, 28199 Bremen, Germany, mail: Slawomir.Smolen@hs-bremen.de, Fon: +49-421-5905-3579