ProEcoPolyNet

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Fact Sheet
"SOLO Stirling 161"

RTD Project Identification

RTD Project Name: grant programme

Programme: German Federal Environmental foundation (grant for field test 1996/98)

Description of technology

Stirling engine with a 2 V-cylinder motor and helium as operating gas

Operating principle

The 90° V-2-Cylinder engine is built of a compression- and an expansion-cylinder in which the working gas is moved in a closed thermodynamic cycle. Inside the compression-cylinder the gas is isothermally compressed at a low temperature level by cooling with water, then it is moved through the regenerator, where it is heated up to 650 °C, to the expansion-cylinder. During the isothermal expansion the gas is heated by the heater, afterwards the gas is moved back through the regenerator, where it is cooled down, to the compression cylinder. The heater consists of small tubes which are heated up to approx. 700 °C from the outside by a burner. The working gas cooler is a small heat exchanger cooled by water. The regenerator is a compressed metal fabric screen being a thermal storage during the cycle. Usually Helium is used as working gas due to the good thermal and aerodynamic properties. Due to the closed cycle with the heat transfer from the outside through the heater, the Stirling engine is independent from the heat source. If a burner is used, the flue gases are leaving the combustion chamber with a temperature of approx. 800 °C. To reach a good efficiency, the thermal energy has to be transferred to the combustion air by an air preheater, where the air is heated up to 600 °C. For this reason, burners for efficient Stirling engines differ by the pre-heating of air from normal heating combustors and are working on a much higher temperature level of 1200-2000 °C.

The piston rods are connected to the crankshaft by connecting rods, the dry-running pistons in the high pressure chambers are sealed against the oil-lubricated crankcase by (especially developped material) piston seals. The output performance can be adjusted by the working gas pressure between 40 and 130 bar in the range of 3 to 9 kW (mecanical). This is realized by a small piston-pump which pumps the working gas from the engine to a storage bottle with a higher pressure level. By opening a second magnetic valve, the engine pressure can be raised again.

The engine is electronically controlled, the temperature of the working gas is hold constant through controlling the combustion or through controlling the pressure (for solar applications).

Technical characteristics of installation

External dimensions

- *Length: 1280 mm*
- *Depth: 700 mm*
- *Height: 980 mm*
- *Weight: 460 kg*

General performance data

- *Maximum exit temp. outer circuit:65 °C*
- *Performance temperature at heating inlet: 50 °C*
- *Electrical output capacity: 2-9,5 kW*
- *Thermal output capacity: 8-26 kW*
- *Electrical efficiency: 22-24,5 %*
- *Thermal efficiency: 65-75 %*
- *Total efficiency: 92- 96 %*

Engine data

- *Type: V 2- stirling engine*
- *Cylinder capacity: 160 ccm*
- *Operating gas: helium*
- *Max. medium operating pressure: 150 bar*
- *Nominal engine speed: 1500 rpm*

Burner and combustion chamber

- *Burner performance, min-max: 16-40 kW*
- *Fuel: natural gas, liquid gas* (pellets in near future)

► *Gas line pressure: 50+15/ -5 mbar*

► *Exhaust back pressure, partial-full load: max. 2 mbar*

► *Exhaust gas temperature: 85 ^{o}C*

► *Volume of exhaust gas flow : 40-100 kg/h*

► *System: flameless oxidation*

► *Flame control system start/operation: ionization/temperature*

► *Emission of nitrogen monoxide: 80-120 mg/m3*

► *Emission of carbon monoxide: 40.60 mg/m3*

Cooling system

► *Volume of cooling fluid, internal: 4,12 l*

► *Plate heat exchanger: stainless steel, copper soldered*

► *Cooling water flow via external pump: 0,5-2 m3/h*

► *Cooling water pressure: 3 bar*

Mains network connection

► *Voltage: 400 V*

► *Frequency: 50 Hz*

► *Phases: 3*

► *Stating current: 25 A*

► *Operating current: 15,5 A*

Fuel consumption and emissions

Fuel consumption: 1.2-3.8 Nm3/h (net calorific value)

NOx emissions: 80-120 mg/m3 (at 5% O2)

CO emissions: 50 mg/m3 (at 5% O2)

Capital investment and maintenance costs

► *Capital investment Cost of unit:* approx. 25.000 €

► *Specific cost of unit (€/kWe):* 12.500 - 2.632

► *Maintenance*

Service intervals: 4-6.000 operating hours

Location and use

► *Private Buildings: yes*

► *Residential Buildings: yes*

► *Commercial Buildings*

► *Public Buildings: yes*

► *Others:* suitable application for medium to large living areas, factories or semi-government facilities

State of Development/Market implementation

► *Field tested: yes, CE certification*

► *Serial production: since 2004 (about 120 gas fired SOLO Stirling 161 were sold)*

► *Full market implementation: in next future (several demonstration projects are in operation, field tests are ongoing)*

► *Main problems: material problems/ precision of main components of the engine like con-rod*

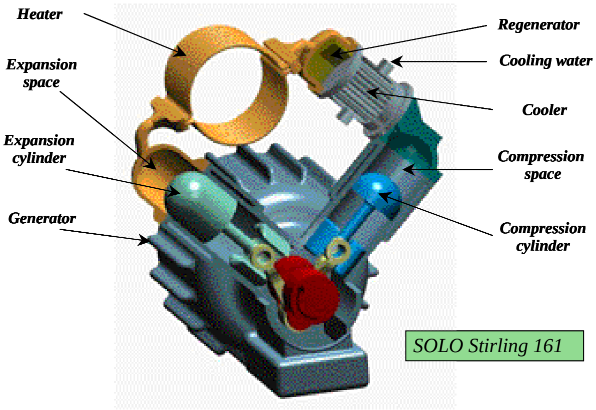
Operational data

► *Average hours of operation (h/a): example Berlin-Kreuzberg, fire station 5.800 h (full load)-7.800 h (partial load)*.

Benefits and obstacles

Fossil fuels such as oil or gas can be used as well as re-generative solar energy and bio-mass. Combustion residue cannot penetrate the interior of the engine with the clear advantages of low wear and long maintenance intervals. Operating costs are considerably lower than for gas driven Otto engines. The emission of harmful substances from Stirling burners compare with the latest data in modern gas burner technology and may be as low as 1/10th of the emission from gas driven Otto engines with catalysts.

Photo / function diagram



Solar stirling energy system

Solar Energy Systems

The solar version of the Stirling 161 engine is now applied in various concentrations by several users. At the Plataforma Solar de Almeria in Spain, six systems have been operational since 1997. Together with three earlier models (Distal 1 with SPS V160) approx. 40.000 operating hours have accumulated.

In conjunction with a project supported by the European Union and in co-operation with Schlaich Bergermann and Partner as well as MERO Raumsysteme GmbH, a new generation 10kW el Dish Stirling System has been constructed.

The project target is the reduction of investment costs to 5000,- EURO/kW. The Stirling 161, with modifications to receiver, cavity and housing, is again in use.

Specifications of the new Dish/Stirling System (EURODISH):

Nominal Total Performance	10,0 kW_{el}
Parabolic dish diameter	8,5 m

Project Eurodish:

SOLO Stirling 161 solar Stirling

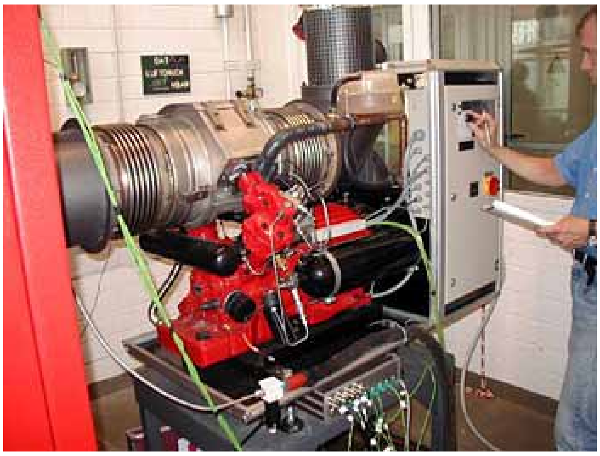
Stirling engine with biomass as fuel

Utilization of Biomass for the Decentralized Generation of Electricity

The direct utilization of solid fuels, preferably wood, with a de-centralized Stirling Cogeneration System is very attractive but also difficult. In co-operation with a university and a manufacturer of biomass furnaces we are continuing our research into various operational technologies, such as the early separation of ash and the avoidance of any build-up of residual ash particles.

Tests during summer 1998 with a prototype of a wood to gas conversion unit showed excellent combustion of the produced furnace gas and residual tar was burnt up completely in the hot combustion chamber. The combination wood – gas / Stirling could be very attractive mainly because the burner is not sensitive to gas quality and because of the excellent conversion efficiency (pre-heater can remain and wood gas may not have to be cooled).

SOLO Stirling 161 tests fired with biomass:



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ProEcoPolyNet is a **Net**work for the **Pro**motion of RTD results in the field of **Eco**-building technologies, small **Poly**generation and renewable heating and cooling technologies for buildings.
The Consortium consists of the following partners.

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SIXTH FRAMEWORK PROGRAMME