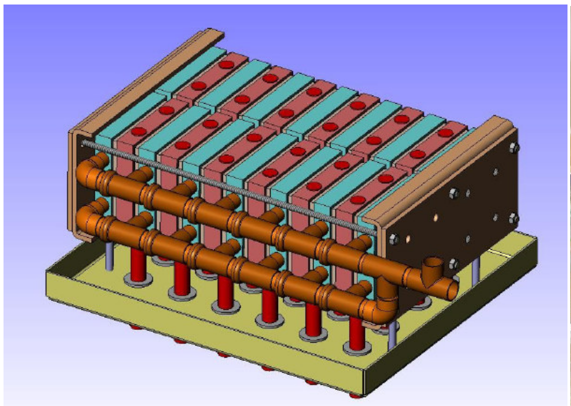
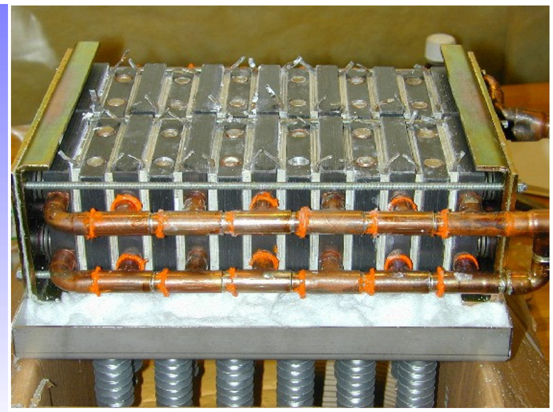
Biofuel Thermoelectric Generator
Technical information Version 1

Prototype design

General information

The thermoelectric generator (TEG) is a solid-state unit that converts heat energy to electric energy by means of the Seebeck effect.

Critical parameters for at Thermoelectric Generator:

- Temperature difference (delta T) between the hot side and the cool side of the TEG.
- Total available heat energy
- Heat transfer efficiency of the heat exchanger system
- Maximum module temperature.

The output power will decrease if the delta T is decreased. If the delta T is reduced to 1/2 the power output will decrease to approximately ¼.

Description

TEG Components

- Modules: 24 unsoldered bismuth telluride modules. Nominal power 19W/module at design temperature: T_h 230C- T_c 30C
- Hot side heat exchanger: 24 Heat pipes evaporator with fins in flue channel, aluminium block on condenser side.
  Heat transport capacity exceeding 500W/pipe with propane burner as heat source

Fig: Heat pipe

- Cool side heat exchanger: Water-cooled aluminium blocks. Parallel flow water circuit
- The cool side heat exchanger efficiency is enhanced by means of a turbulator
- The surfaces of the heat exchanger aluminium blocks on hot and cool side are hard anodized
- Heat shield (flue channel – TEG chamber separator) is made from 253MA heat resistant alloy.
- High stiffness end plates/spring holders are made from yellow chromatized dual layer steel.
- Heavy duty Belleville spring packages are used to ensure correct compression force on the modules at all times
- Thermal insulation: Alumina felt and alumina wool

Heat pipes

A heat pipe is a very efficient heat conductor compared to metals. It is made from an evacuated sealed tube partly filled with a working fluid.

Pure copper has a heat conductivity of 390 [W/m*K]; a heat pipe can have a heat conductivity of 50000 [W/m*K]

This high heat conductivity is caused by the operational principle. In the evaporator section the working fluid will boil and take up the heat of evaporation from the surroundings. This energy will be recovered when the fluid condenses in a slightly cooler section of the tube. At high thermal load there is also a mass transfer due to the boiling in the tube.

The pressure in the tube will rapidly increase as long as there is fluid in the tube. If the heat pipe is dry boiled the pressure will increase according to the gas law.

When the heat pipe is dry boiled the heat transfer will practically be cut off.

The heat pipes for the pellet burner is charged with enough fluid to avoid dry boiling. This will increase the heat transfer capability. The risk of a destroyed heat pipe in case an overheating situation occurs at insufficient cooling is also increased.

It is therefore critical to ensure a proper cooling water circulation at all times. The burner should be automatically be shut off in case of a low water flow.

The TEG is functional even in case a heat pipe breaks. The electric power will be reduced.

Performance

Test 3

Finned heat pipe heat exchanger.

It is assumed that the heat density of the flue is lower compared to the test situation with the propane burner.

The test was intended to simulate the behaviour of the TEG with the Kachelöfen burner:

A 12kW burner power is assumed.

Expected delta T is 125C.

	Maximum at 230/30C	**Expected working point**
Heat exchanger efficiency	50 %	50
Module efficiency	4,5 %	3
System efficiency calc	2,25	1,5 %
Heat power to get 250W el.	11111	16667
Calc output with pellet burner	270	180

At a heat power of 12kW in a pellet or biogas burner the tests indicate a power of 180W from the complete TEG.

The unit is tested in a boiler with a pellet burner. Measured electric output up to 200W.

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