



ProEcoPolyNet

Best practice Sheet

'''Experimental Examination of different micro-CHP's'''

RTD Project Identification

RTD Project Name "Experimental Examination of micro-CHP's"

RTD Contract No.: 17 083 03

Programme: aFuE funded by German Federal Ministry of Education and Research

Duration: 1.11.2003 – 31.5.2005

Summary

In order to examine the performance of different micro-CHP units, which are currently available, a project funded by the German Federal Ministry of Education and Research (BMBF) has been started at Reutlingen University. Within this project 4 micro-CHP units were investigated experimentally, two of them based on a Stirling engine, namely the SOLO STIRLING 161 and the 9 kW_{el} biogas engine SM5A from Stirling Denmark. The remaining two units were conventional gas engines based on the Otto-cycle: Firstly, the SenerTec "Dachs" CHP, which is by far market leader in Germany with more than 15.000 units sold, and, secondly, the ecopower micro CHP, which is also quite well known, even though selling numbers are much smaller.

On the University test-stand, which was erected especially for testing of micro CHP's, various experiments have been completed. As a special feature, the test-stand is equipped with frequency converters. By this means, frequency, and consequently engine speed, can be varied in order to obtain part load operation. In stationary operation the effect of return and supply temperature variation on electric and heating power as well as corresponding efficiencies were analysed. If possible, the units were tested in part load as well, in order to examine part load efficiencies. Moreover, in-stationary tests were performed for analyses of start-stop behaviour and operation in combination with hot water storage tanks. Finally, the units were tested with regard to the regulations of the German environmental label "Blauer Engel". Here, electric and overall

efficiency as well as exhaust gas emissions, CO and NO_x, have to meet certain limits in order to be approved. The test-stand at Reutlingen University qualifies for these approved measurements.

As a result, a tremendous amount of test data and experience is available, which is meanwhile published in a book /1/. Herein, performance data with regard to nominal data provided by the manufactures will be shown as well as results of the testing for the environmental label "Der Blaue Engel". In detail, the comparison between Stirling powered and conventional IC-engines reveals some interesting conclusions about the special benefits as well as drawbacks of each kind of engine concept for micro CHP units, which are discussed in the book. Moreover, a general overview about different technologies is given as well as guidelines for installation and cost calculation.

/1/ Thomas, B.: "Mini-Blockheizkraftwerke", Vogel Verlag, Würzburg, 2007 (so far available in German language, only.)

Operating principle

Stirling and Gas-Otto engines

Technical characteristics of installation as measured on test-stand

SenerTec "Dachs"

- ▶ *Technology: Gas-Otto engine*
- ▶ *State of development: Full market implementation*
- ▶ *Type: Dachs HKA G 5.5*
- ▶ *Electrical output capacity: 5,4 kW*
- ▶ *Thermal output capacity: 11,8 kW*
- ▶ *Noise emissions (1 meter): 53 dB(A)*

"Blauer Engel"-testing results:

- ▶ *Electrical efficiency: 27,7 %*
- ▶ *Total efficiency (no condensor): 88,4 %*
- ▶ *Total efficiency (incl. condensor): 91,3 %*
- ▶ *CO emissions: ≈ 0*
- ▶ *NO_x emissions: 500-600 mg/Nm³ (5% O₂)*

SOLO Stirling 161

- ▶ *Technology: Stirling engine*
 - ▶ *State of development: Full market implementation*
 - ▶ *Type: SOLO Stirling 161*
 - ▶ *Electrical output capacity: 1,1-8,9 kW*
 - ▶ *Thermal output capacity: 6,0-24,8 kW*
 - ▶ *Noise emissions (1 meter): 65 dB(A)*
- “Blauer Engel”-testing results:*
- ▶ *Electrical efficiency: 26,8 %*
 - ▶ *Total efficiency: 98,5 %*
 - ▶ *CO emissions: 191 mg/Nm³ (5% O₂)*
 - ▶ *NO_x emissions: 105 mg/Nm³ (5% O₂)*

PowerPlus Technologies “ecopower”

- ▶ *Technology: Gas-Otto engine*
 - ▶ *State of development: Full market implementation*
 - ▶ *Type: ecopower*
 - ▶ *Electrical output capacity: 1,2-4,4 kW*
 - ▶ *Thermal output capacity: 4,3-12,2 kW*
 - ▶ *Noise emissions(1 meter): 59 dB(A)*
- “Blauer Engel”-testing results:*
- ▶ *Electrical efficiency: 24,7 %*
 - ▶ *Total efficiency: 88,9 %*
 - ▶ *CO emissions: ≈ 0*
 - ▶ *NO_x emissions: 8,4 mg/Nm³ (5% O₂)*

Stirling Denmark SM5A

- ▶ *Technology: Stirling engine*
 - ▶ *State of development: Field tested*
 - ▶ *Type: SM5A*
 - ▶ *Electrical output capacity: 8,1 kW*
 - ▶ *Thermal output capacity: 24,9 kW*
 - ▶ *Noise emissions (1 meter, without capsule): 82 dB(A)*
- “Blauer Engel”-testing results:*
- ▶ *Electrical efficiency: 21,1 %*
 - ▶ *Total efficiency: 86,3 %*
 - ▶ *CO emissions: 154 mg/Nm³ (5% O₂)*
 - ▶ *NO_x emissions: 365 mg/Nm³ (5% O₂)*

Conclusion

Due to the need for internal cooling temperatures of 80 – 85 °C, gas Otto engines can not take advantage of low temperatures in the heating system in order to increase electric efficiency. Despite this fact, the gas Otto unit SenerTec “Dachs” was superior in terms of

electric efficiency compared to the Stirling units. In contrast, high internal cooling and consequently engine temperatures result in higher heat losses. Thus, Stirling engine powered micro-CHP’s show better overall efficiencies than gas Otto units, as proved by the SOLO Stirling CHP.

Regarding emissions gas Otto units need a catalyst for reduction of emissions while Stirling units can work without catalyst. However, if a catalyst is installed, gas Otto units bear the potential for very low emissions, especially, if a 3-way catalyst is used and steady state is reached, as proved by the ecopower unit.

Taking the environmental label “Der Blaue Engel” as an overall measure for an adequate combination of sufficient electric and overall efficiency and acceptable emissions, the SOLO Stirling micro-CHP is the only unit meeting all requirements.

Further information

“Mini-Blockheizkraftwerke – Grundlagen, Gerätetechnik, Betriebsdaten” by Bernd Thomas



1st ed. 2007, Vogel-Buchverlag, Würzburg
ISBN: 978-3-8343-3069-7

Contact

Hochschule Reutlingen
Prof. Dr.-Ing. Bernd Thomas
Technik / Maschinenbau
Alteburgstr. 150
D-72762 Reutlingen
Tel: +49 7121 271-7041
Email: bernd.thomas@reutlingen-university.de
<http://userserv.hs-reutlingen.de/~thomas>

Date of release of this Best Practice Sheet
20.8.2007

Photos of test-stand and micro-CHP's tested

▶ Test-stand at Reutlingen University



▶ PowerPlus Technologies "ecopower"



▶ SenerTec "Dachs"



▶ Stirling Denmark SM5A



▶ SOLO Stirling 161

