



UNIVERSITY OF ZILINA
FACULTY OF MECHANICAL ENGINEERING
DEPARTMENT OF POWER ENGINEERING



Utilization of solar energy for heating of the working fluid of hot-air engine

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„Rozvoj spolupráce medzi VEC a KET so zameraním na odborný rast doktorandov a výskumných pracovníkov“ ITMS 22410320106

Demänovská dolina, 13.03. – 14.03.2014



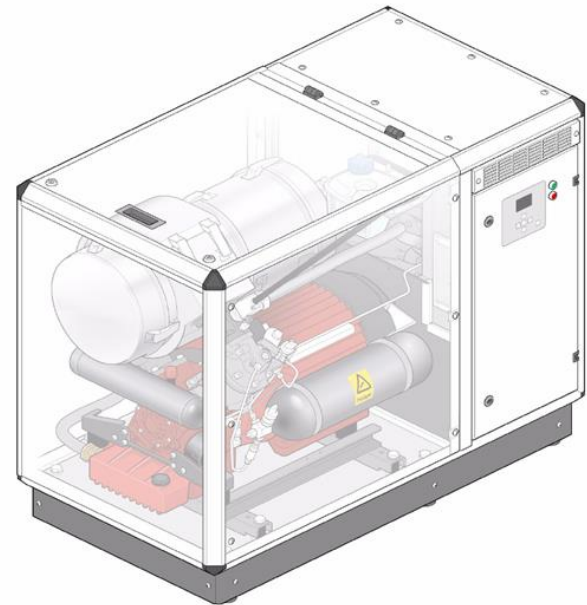
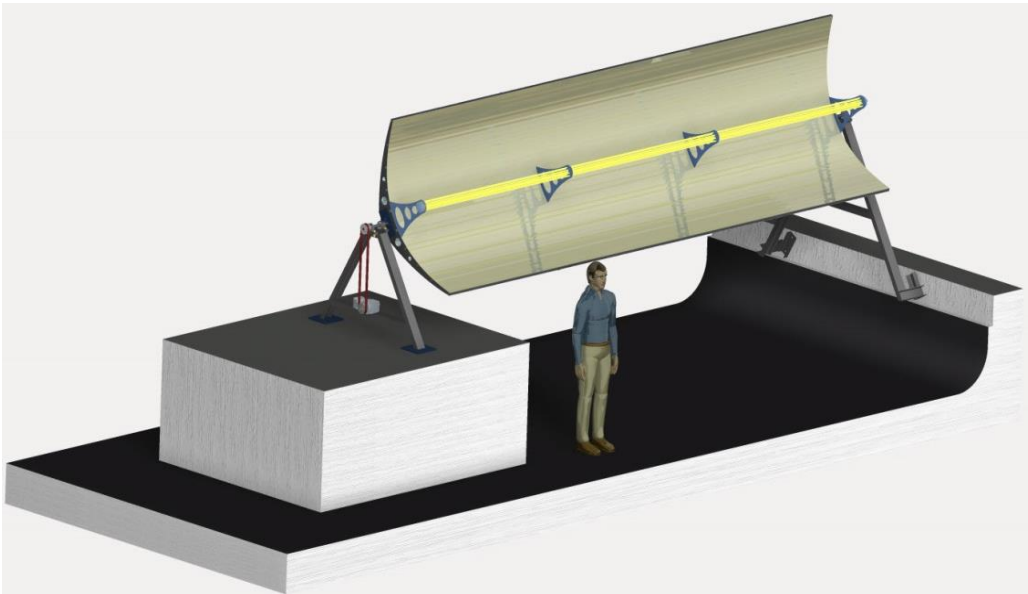
PROGRAM
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Introduction

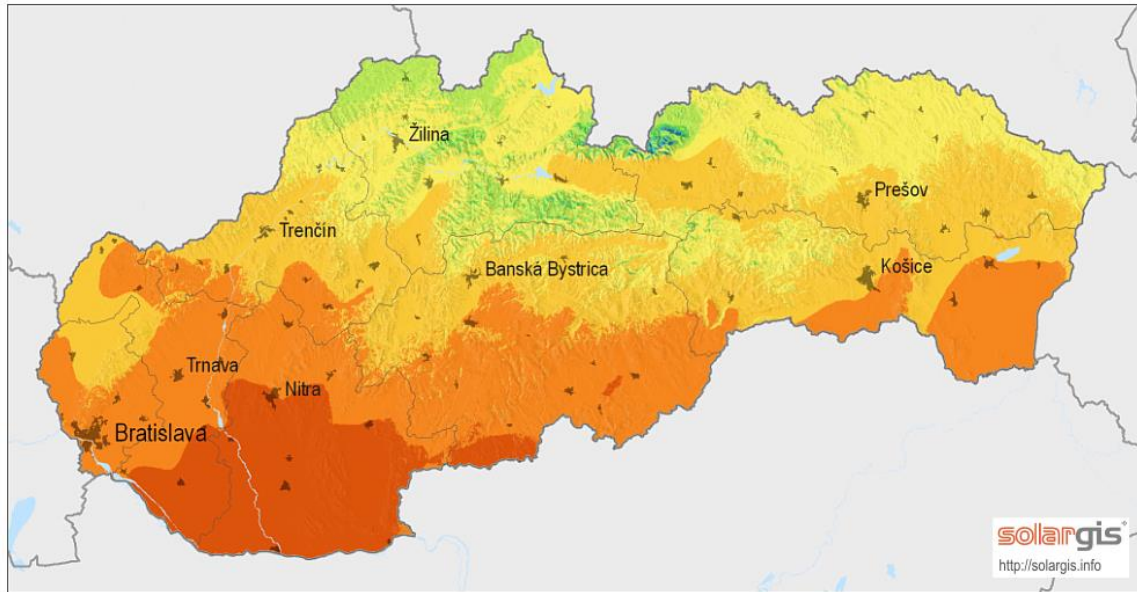
- The project is focused on the utilization of renewable energy (Solar energy), Solar conditions in Slovakia (city Zilina).
- The analyzy of operating conditions (parameters based of Stirling engine).
- The calculation of the basic dimensions of the collector.
- The structural design of The trough parabolic solar collector.



Conditions for utilisation of solar energy in Slovakia

Global horizontal irradiation

Slovakia



Average annual sum (4/2004 - 3/2010)



0 25 50 km

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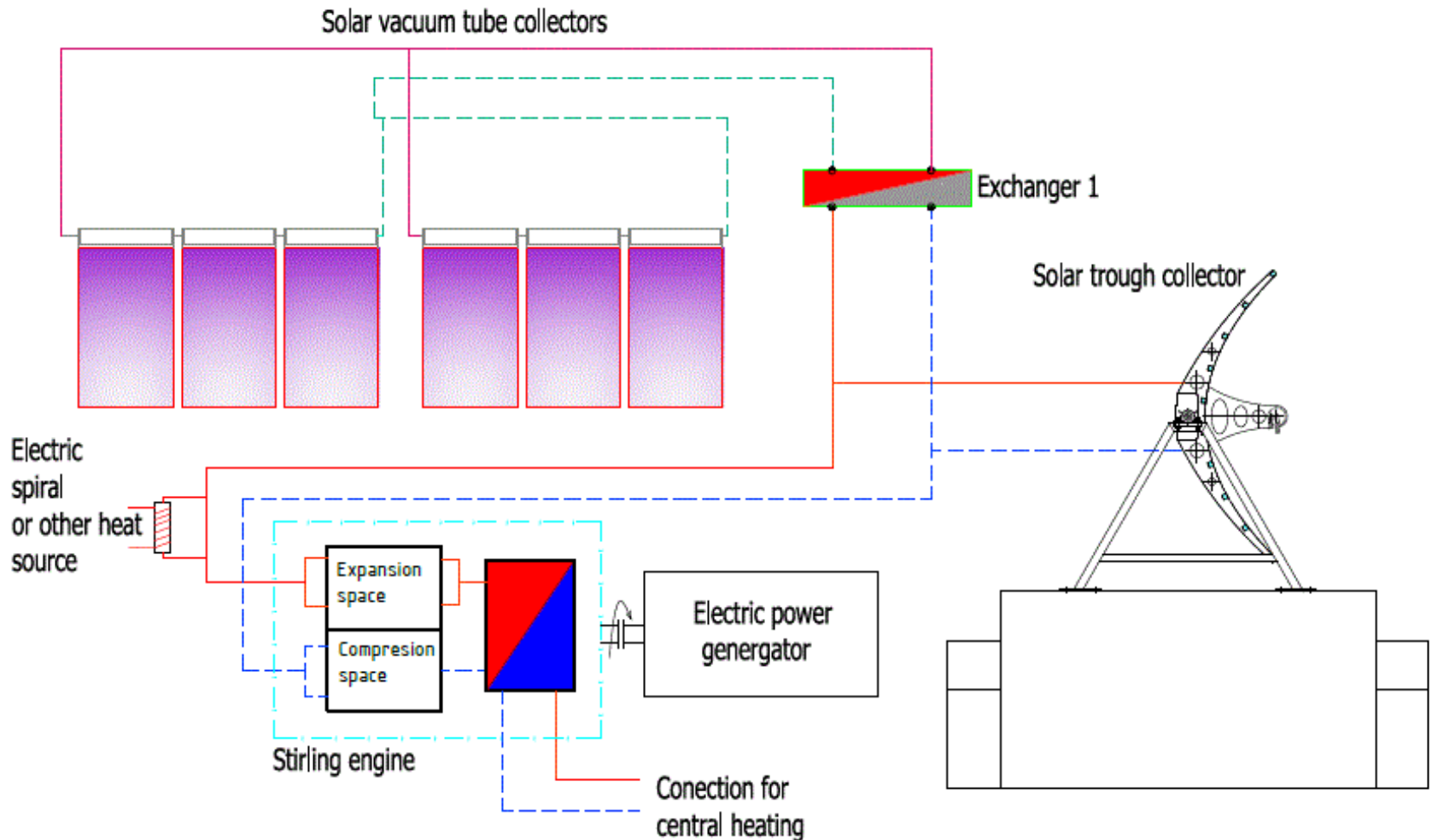
- Country: Slovakia.
- City: Zilina.
- Place: University of Zilina.
- Coordinates:
- Latitude: 49,202 °.
- Elevation above sea level: 370 m.
- Intensity of solar radiation (Žilina) 700 – 800 Wh/m².
- Operating temperatures from -20 till 500 °C.

Climate data for Žilina

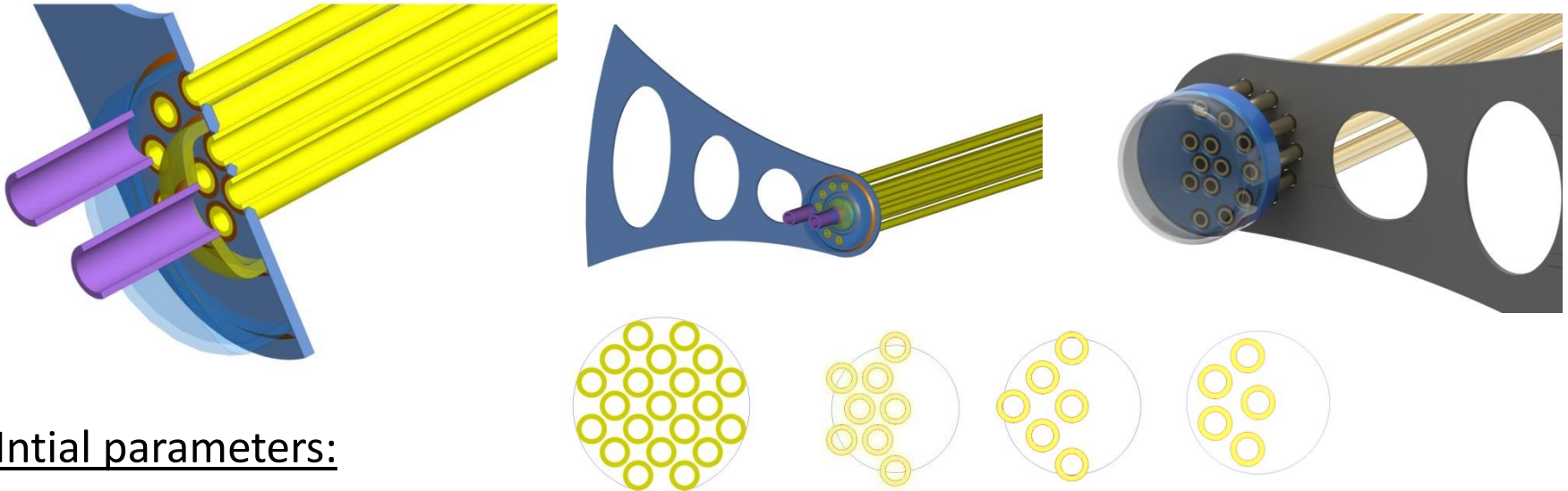
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	0 (33)	3 (38)	8 (47)	14 (58)	20 (68)	22 (72)	25 (76)	25 (77)	20 (67)	14 (58)	6 (44)	1 (35)	13.2 (56.1)
Average low °C (°F)	-5 (22)	-5 (23)	-1 (30)	3 (37)	8 (46)	10 (51)	12 (54)	12 (53)	9 (47)	5 (41)	0 (33)	-4 (26)	3.7 (38.6)

Source: MSN Weather

Schematic visualisation connecting of components

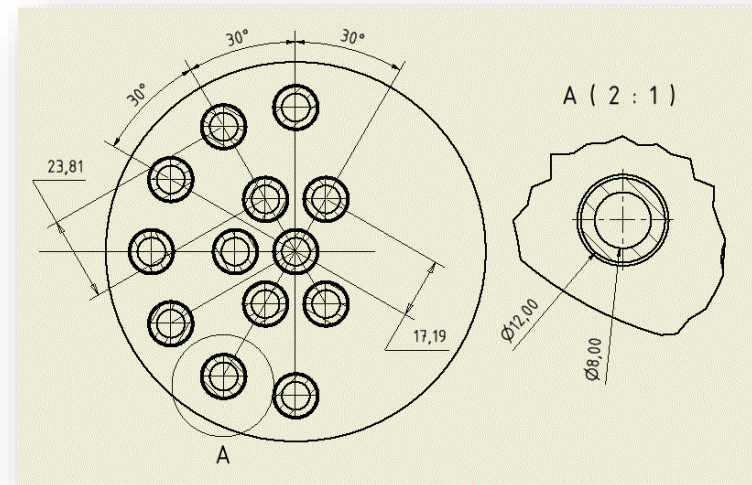


Proposal the focal absorber (exchanger)

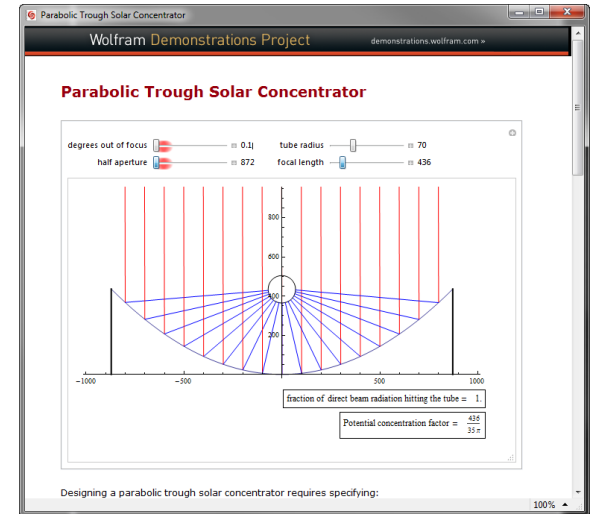
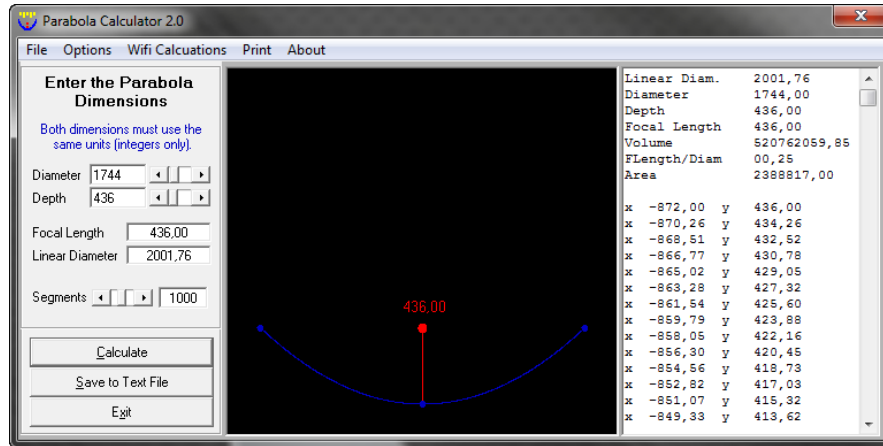


Intial parameters:

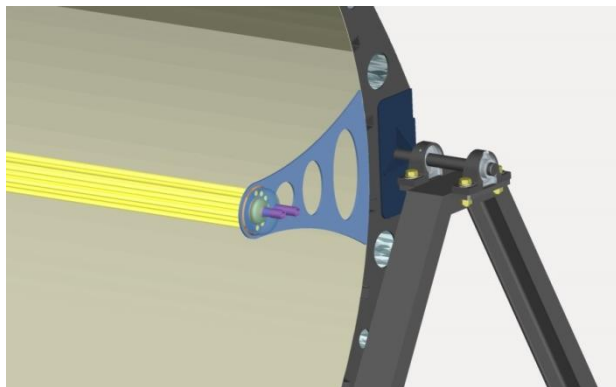
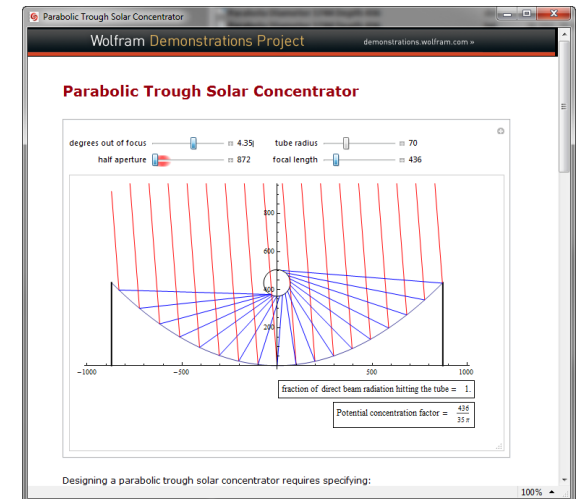
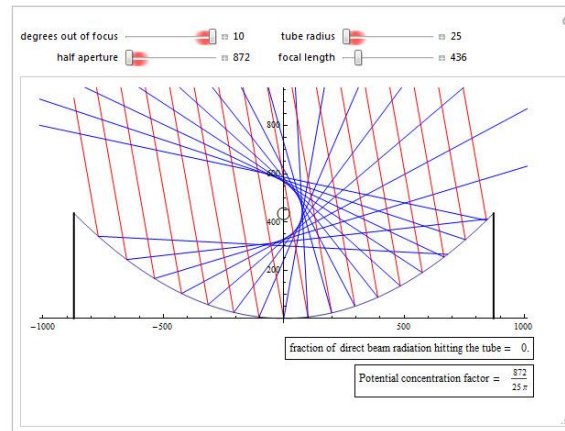
- tube dimension: diameter 12 mm with a wall thickness 2 mm with total length 6000 mm.
- Number of tubes 13.
- Working temperature from -20 °C to 500 °C.
- Pressure 2,5 MPa.
- Area of collector 12 m² .
- Material of absorber - Steel 15128.5



Programs used for calculating the main parameters of parabola



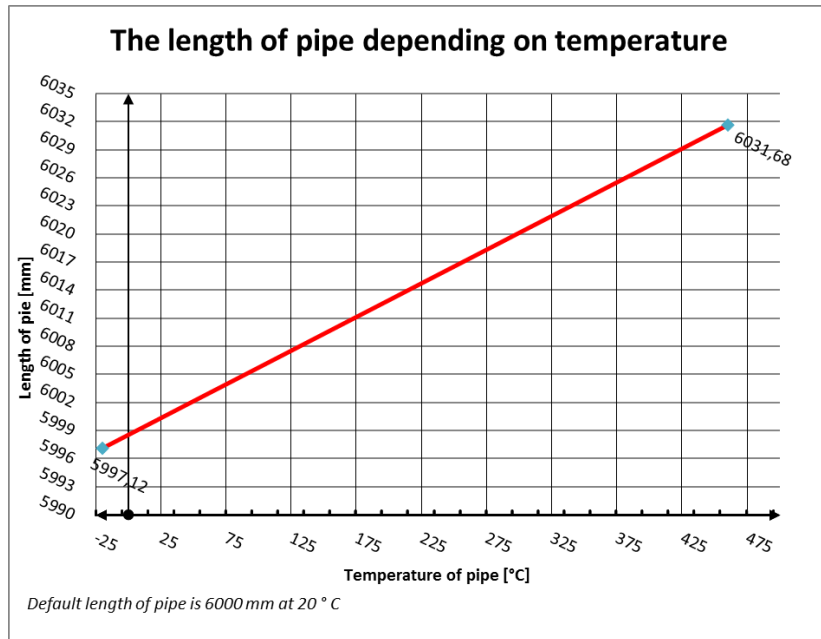
Parabolic Trough Solar Concentrator



Calculation of thermal expansion

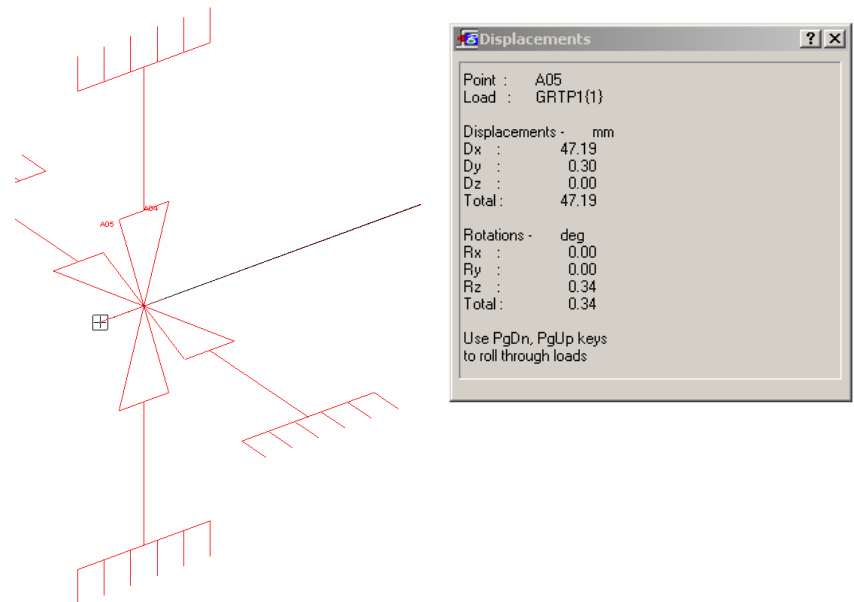
- By two method (Excel, AutoPipe).
- Value of thermal expansion for steel 15 128.5 is $12 \cdot 10^{-6}$ m/m.K

Results obtained from the Excel



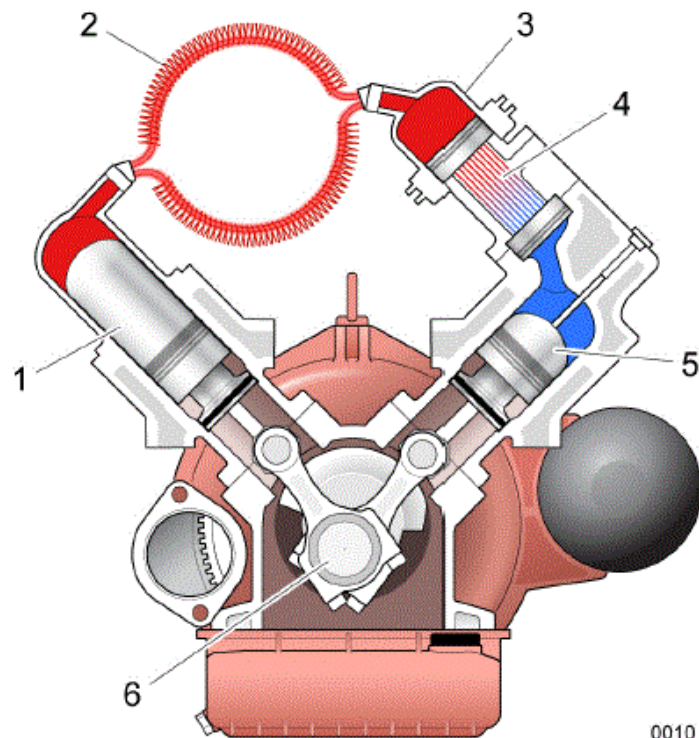
Total value of the thermal expansion is 34,56 mm.

Results obtained from the AutoPipe

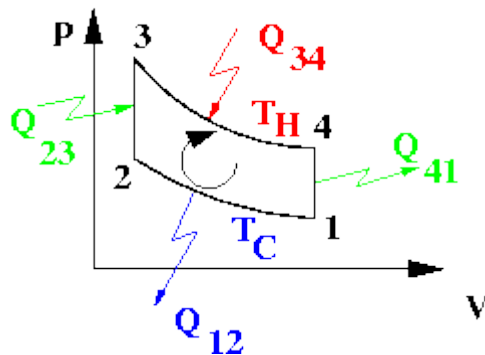


Calculated with the following parameters :
temperature, internal pressure, gravitaton
constant.

Stirling engine – alfa model



1. Expansion piston
2. Gas heater
3. Regenerator
4. Gas cooler
5. Compression piston
6. Crankshaft



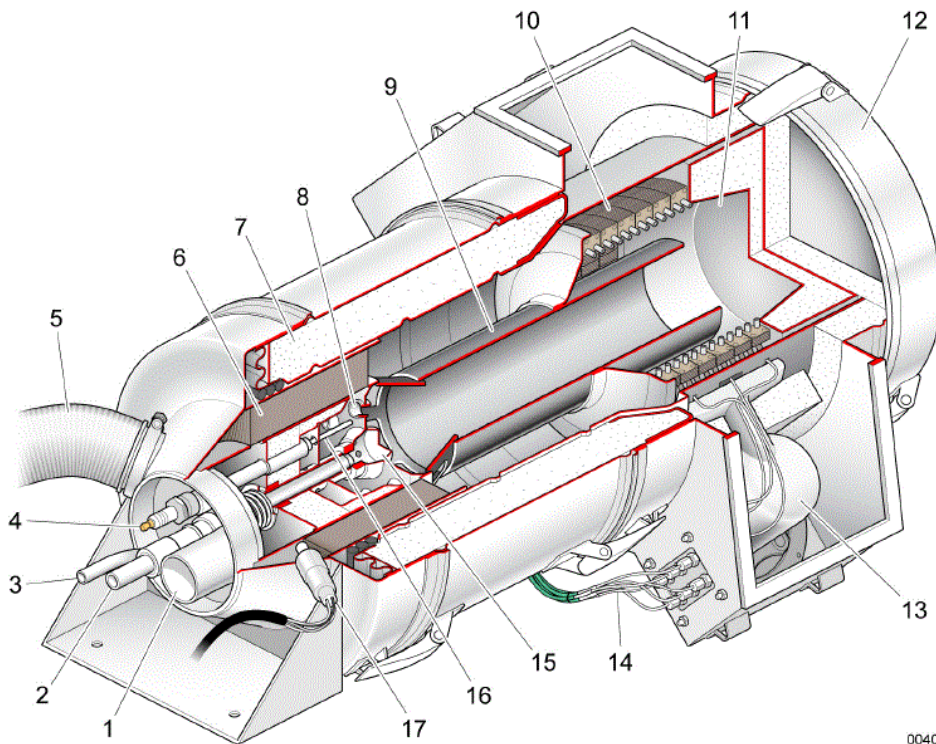
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Engine data

Model	Cleanergy Stirling C9G	
Engine configuration	V 2 Stirling, alpha type	
Capacity	160	cm ³
Stroke	44	mm
Bore	68	mm
Engine working gas	Helium	
Max. average process working gas pressure	150	bar
Max. control temperature	740	°C
Nominal speed	1500	rpm

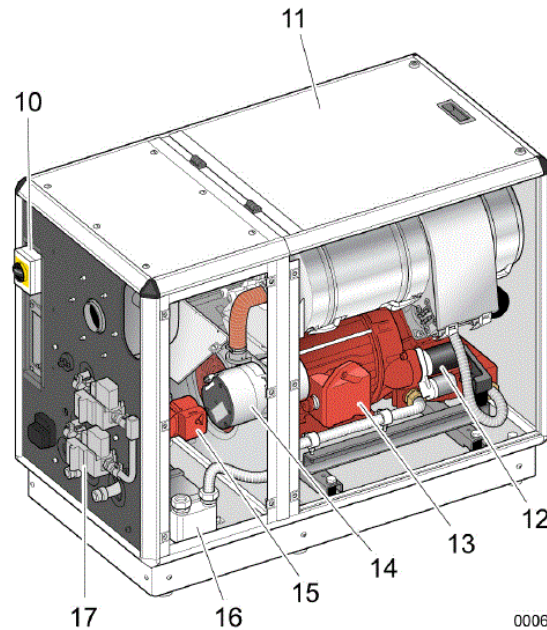
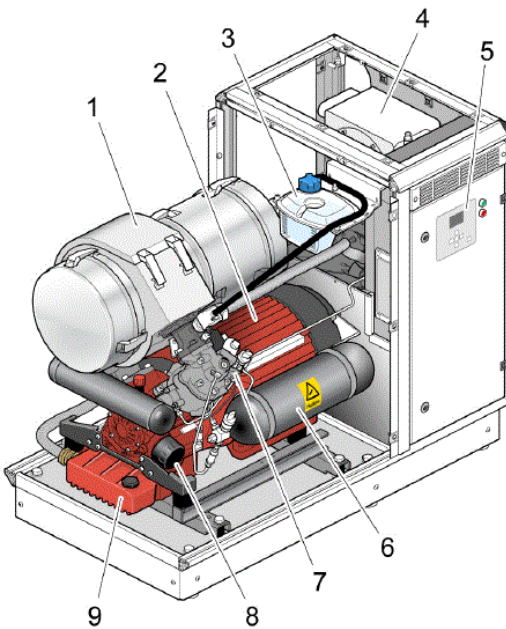
Output electrical power	2.9	kW
Output thermal power	8.25	kW
Burner output	18-40	kW

Customizing of the combustion chamber



1. Air inlet
2. Gas inlet (FLOX®) - during operation
3. Gas inlet - during start
4. Ignitor and ionization sensor electrode
5. Exhaust gas outlet
6. Pre heater
7. Insulation
8. Front combustor nozzle
9. Mixing tube
10. Heater head
11. Baffle plate
12. Front cover
13. Piston dome expansion gas
14. Thermocouple wires
15. Gas distributor
16. Ignitor and ionization sensor electrode
17. Lambda sensor (if applicable)

Cogeneration unit



1. Combustion unit
2. Generator
3. Expansion tank
4. Exhaust gas heat exchanger (if applicable)
5. Control panel/control cabinet
6. Pressurized working gas bottle
7. Working gas valves
8. Oil filter
9. Oil pan
10. Main circuit breaker
11. Top cover
12. Starter (if applicable)
13. Electrical connection box, generator
14. Burner fan
15. Circulation pump
16. Plate heat exchanger
17. Fuel gas valves

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Main tasks of Dissertation thesis

- Analysis of the thermodynamic parameters of device with the thermodynamic cycle, which is able transformed solar energy into mechanical work with the working medium – air.
- Proposal of schematic diagrams of circuits heating and cooling of working medium and specification parameter individual elements.
- Calculation of the heat exchanger for solar heating of working medium – hot air with the required parameters.
- Simulation of thermodynamic parameters in the circuit hot – air engine.

Preparation of search devices





Thank you for attention!

Acknowledgments

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