
STERG
SOLAR THERMAL ENERGY
RESEARCH GROUP

Simulating the effect of solarisation on the performance of a gas turbine

C. Homann[1],

J. van der Spuy [2] and T. von Backström [2]

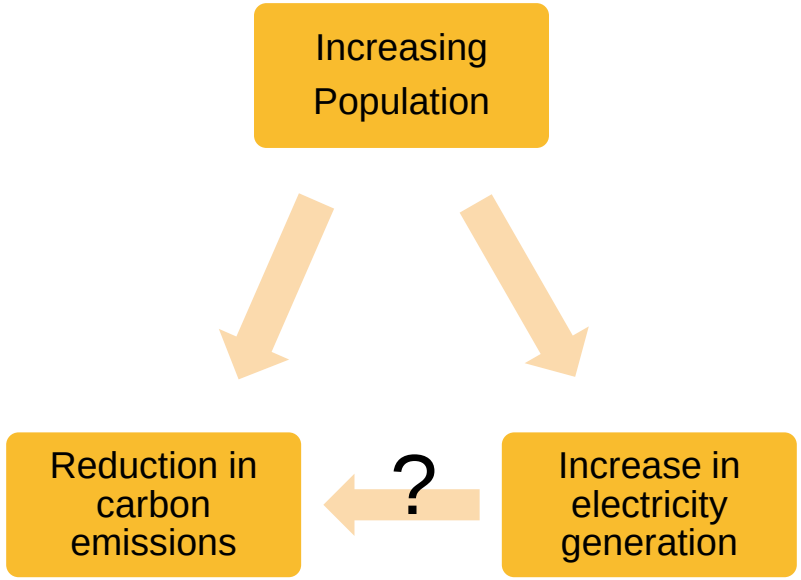
[1]BEng (2013), 2nd year Masters Student (MEng); Solar Thermal Energy Research Group (STERG), Department of Mechanical and Mechatronic Engineering, Stellenbosch University

[2] Solar Thermal Energy Research Group (STERG), Department of Mechanical and Mechatronic Engineering, Stellenbosch University

Contents

- Background
- Problem statement
- Methodology
  - Thermodynamic analysis
  - Flownex Simulation
- Results
- Conclusion
- Future work

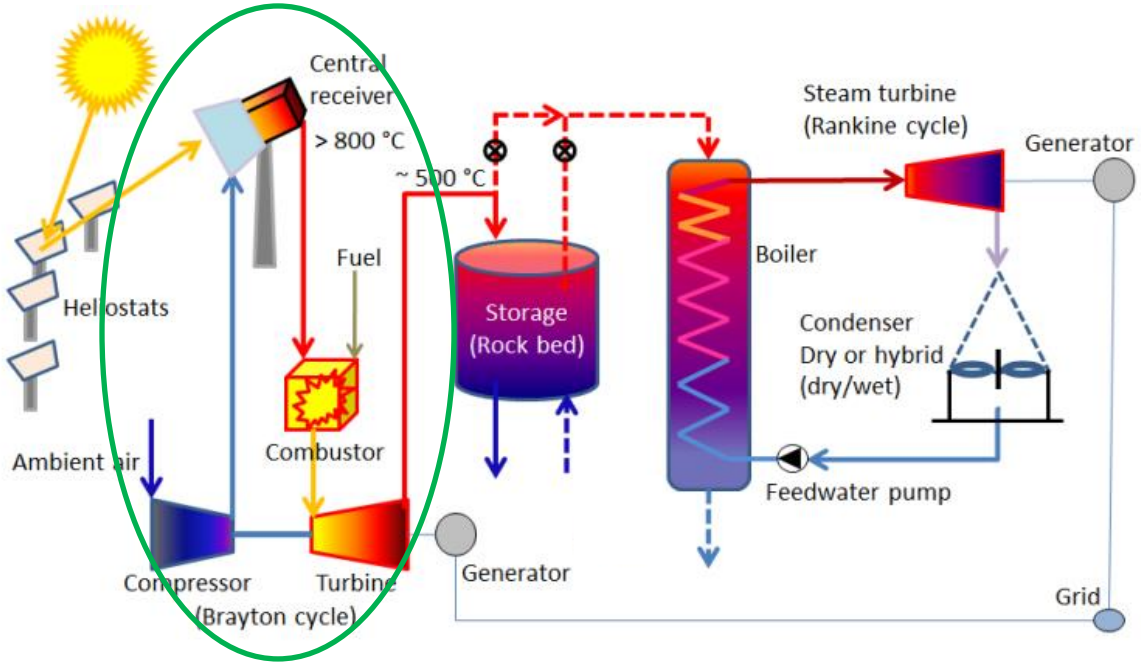
Background



- Biofuels
- Wind
- Hydro schemes
- Tide energy
- Solar energy

Background

SUNSPOT cycle (Kröger, 2011)



Solar-hybrid gas turbine

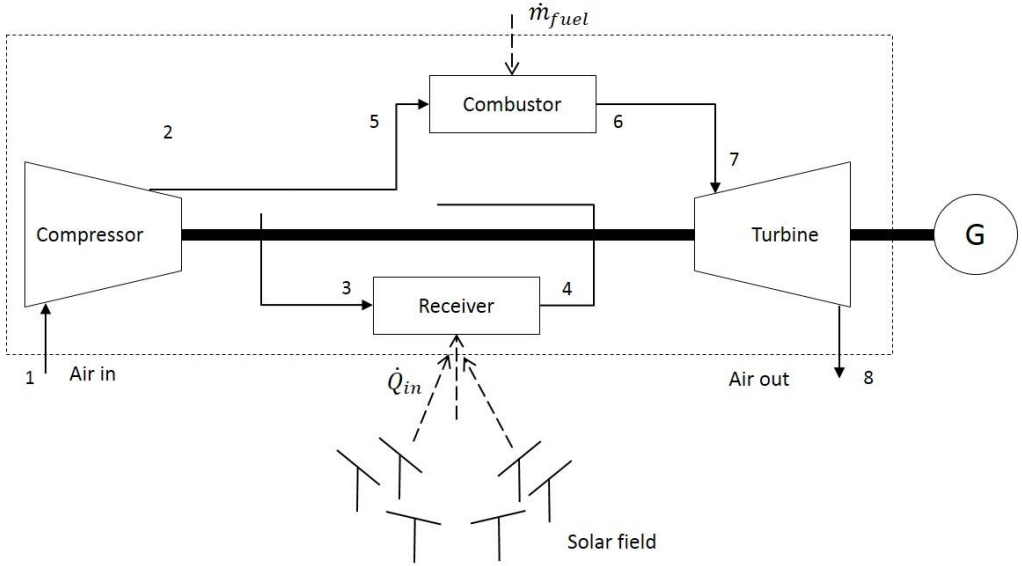
- Low water consumption
- High conversion efficiency
- Quick start-up/ shut-down times
- System reliability

Objectives

- Model the Rover gas turbine
- Design and model a solar hybrid Rover gas turbine
- Adapt and re-evaluate both the existing Rover gas turbine and solar hybrid Rover gas turbine, including a newly designed compressor
- Field testing of the Rover gas turbine
- Design and evaluate an interconnection device
- Feasibility of scaling

Thermodynamic analysis

Evaluating the Brayton cycle



Assumptions

- 5% pressure drop over combustor
- Turbine inlet temperature limit: 1032 K (manual)

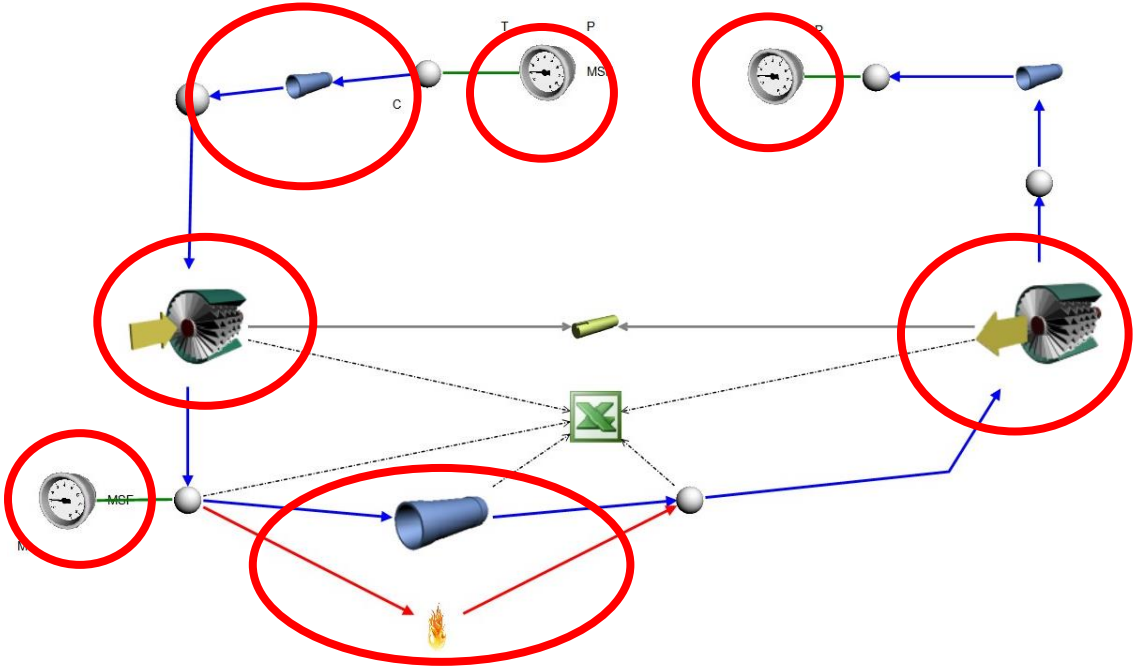
Equation summary

$$\dot{W}_{net} = \dot{W}_t - \dot{W}_c$$

$$\eta_{th} = \frac{\dot{W}_{net}}{q_{combustor}\dot{m}}$$

Flownex Simulation Environment

Rover gas turbine



- Intake system
- Compressor
- Turbine
- Combustion chamber
- Boundary conditions

Results

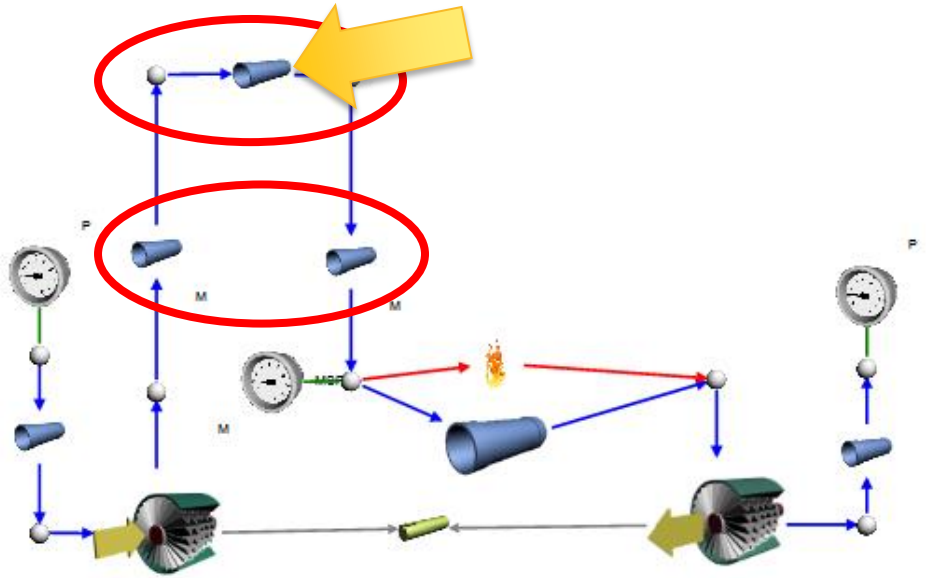
Model Validation

	Thermodynamic analysis	Flownex gas turbine model
Work output [kW]	43.32	42.41
Thermal efficiency	10.39%	10.59%
Combustion chamber ΔP [kPa]	14.18	13.95
Compressor efficiency	69.91%	70.00%
Turbine efficiency	85.14%	84.97%

- Less than 3% difference between analysis and Flownex model

Flownex® Simulation Environment

Solar-hybrid gas turbine model

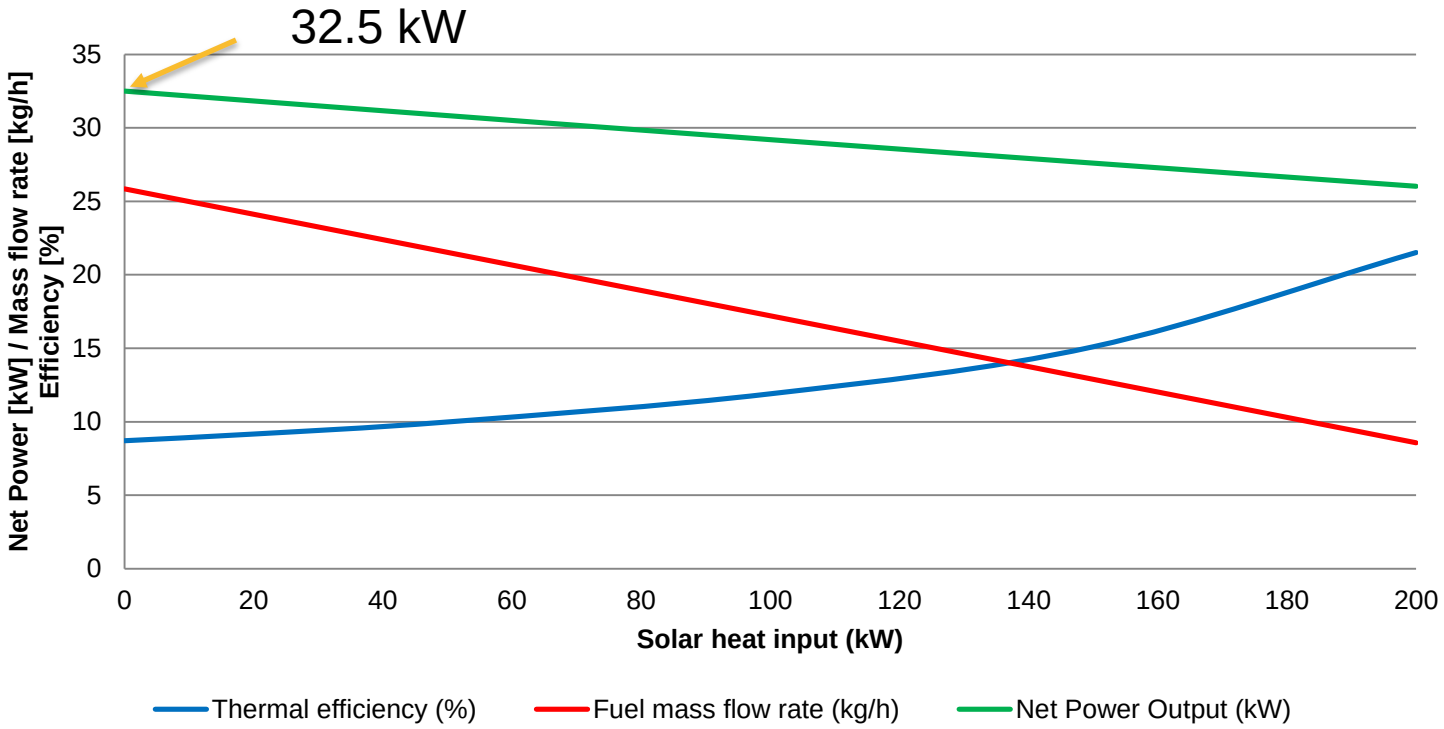


Solar receiver

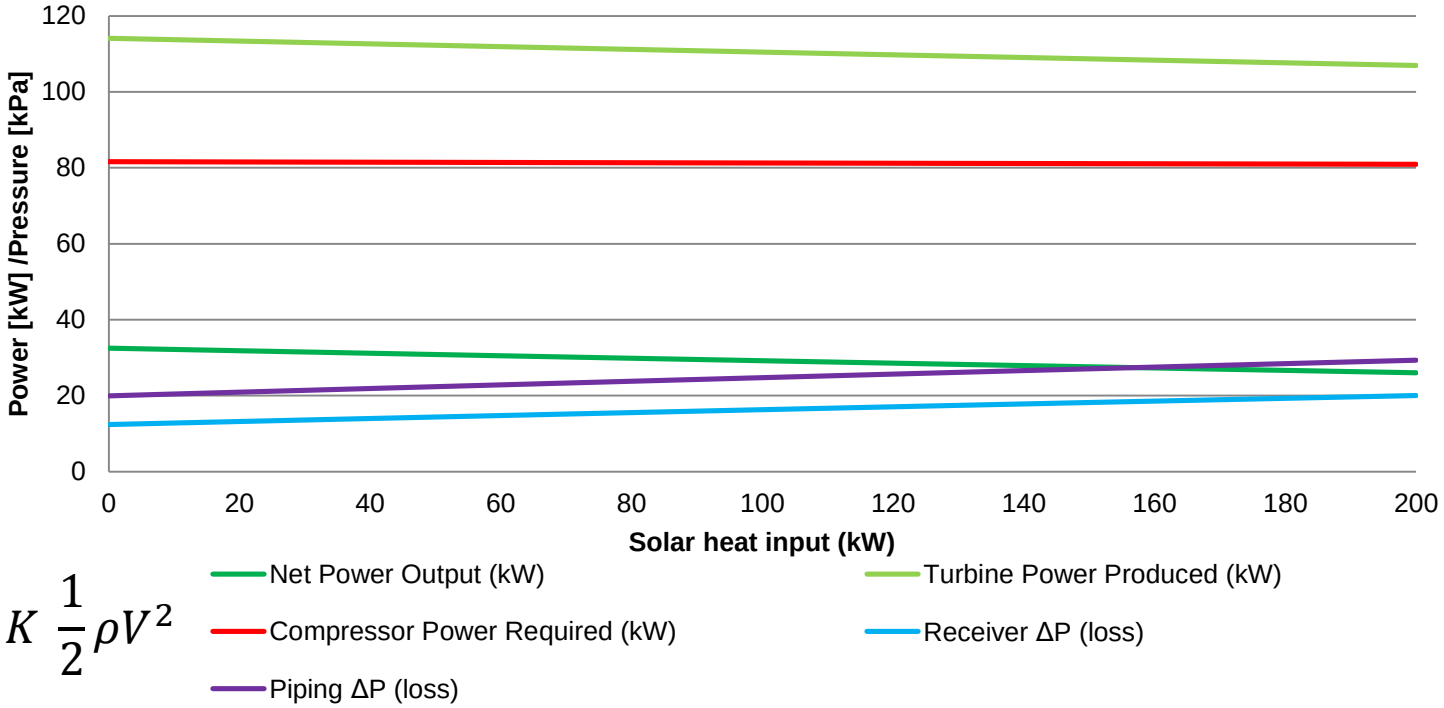
- Pressure drop 12 kPa (SOLGATE receiver)

Piping up and down the tower

Results


32.5 kW
Net Power [kW] / Mass flow rate [kg/h]
Efficiency [%]
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
Solar heat input (kW)
Thermal efficiency (%)
Fuel mass flow rate (kg/h)
Net Power Output (kW)

Results



$$\Delta P = K \frac{1}{2} \rho V^2$$

Conclusion

- Simulations predicted Rover gas turbine performance within 3%
- Solar-hybrid gas turbine
  - Increase in efficiency
  - Decreased net power output

Future work

- Implement newly designed compressor
- Further refinement of the model
- Gas turbine field testing
- Design and analyse interconnection device
- Feasibility of scaling

References

- Flownex (2014) *Flownex Library Manual*, [online] Available from: www.flownex.com/info@flownex.com.

- Quarta, N. J. (2012) *Simulation of a Hybridised Solar Gas Turbine System*, University of the Witwatersrand, Johannesburg.

- SOLGATE Report (2005) Solar hybrid gas turbine electric power system, Energy.

Thank you

ACKNOWLEDGEMENTS:

NRF
CRSES

CONTACT DETAILS:

Christiaan Homann
Solar Thermal Energy Research Group (STERG)
Stellenbosch University
South Africa

chomann@sun.ac.za
+27 (0)21 808 4016

visit us: concentrating.sun.ac.za