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SOLAR THERMAL ENERGY
RESEARCH GROUP

Modelling, simulation and development of a testable 200 We _dual generator free piston Stirling engine

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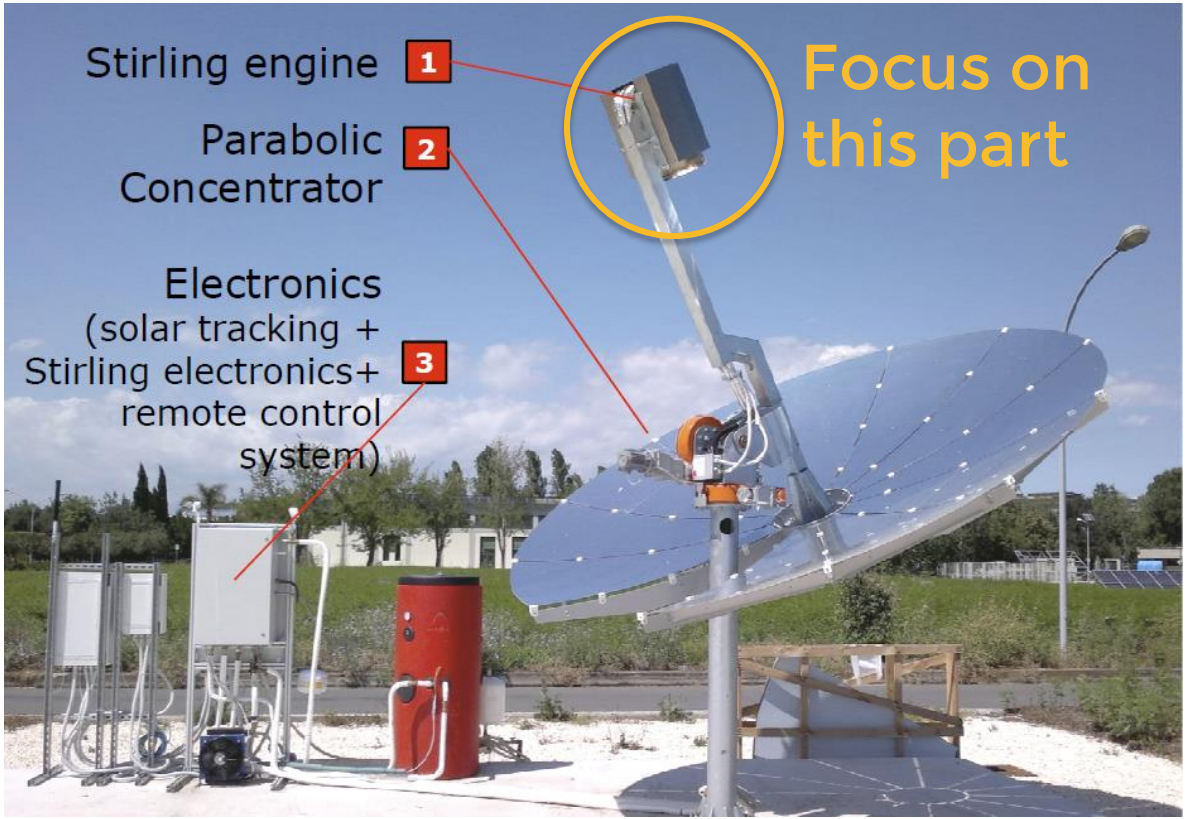
Contents

1. Introduction and motivation

What is a free piston Stirling engine and where is it used

- External combustion heat engine
- Convert thermal energy into electricity
- Micro combined heat and power (mCHP) application
- Parabolic dish integration
- Rural Africa

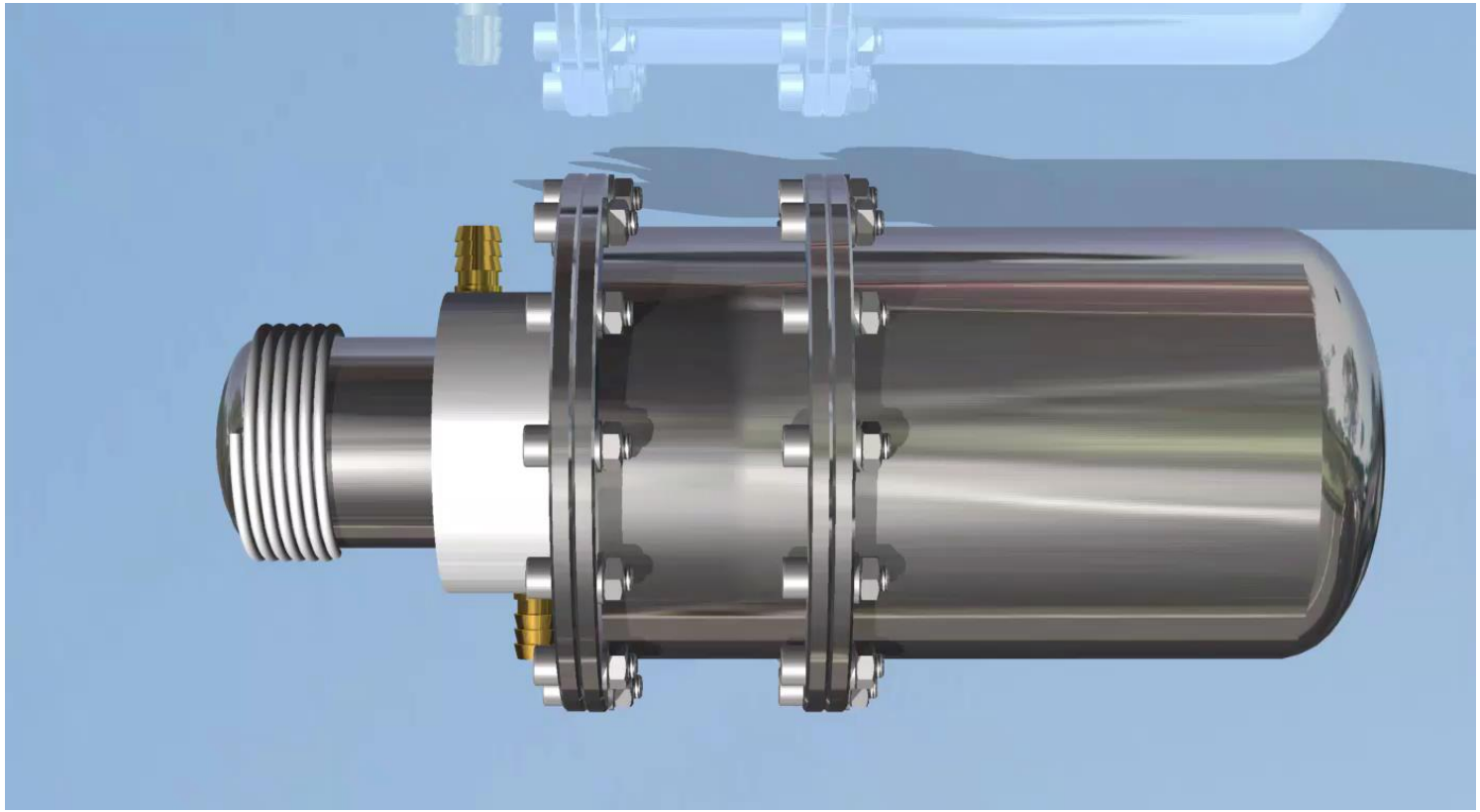
1. Introduction and motivation



- Recently attained Trinum 1 kWe mCHP engine
- Poor understanding of working principles of FPSE
- Develop local FPSE for rural Africa

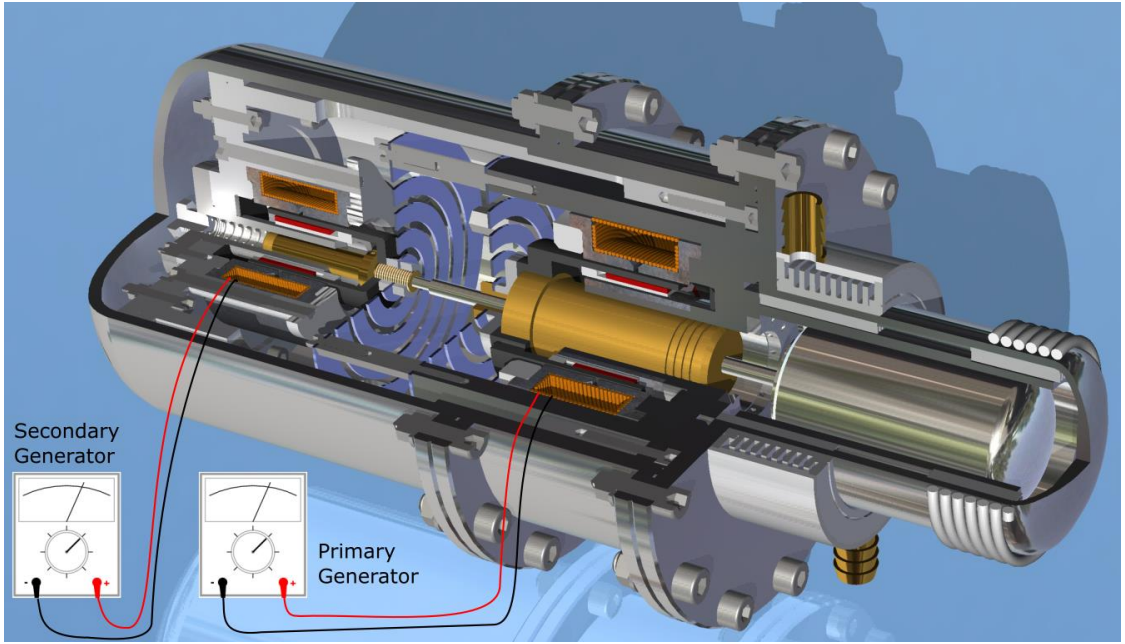
(Image adapted from Innova, 2011)

2. Prototype



2. Prototype

Working principle



- Hermetically sealed, filled with helium under pressure
- Cyclic heating and cooling of working fluid
- Oscillates in shared natural frequency
- Direct control of displacer

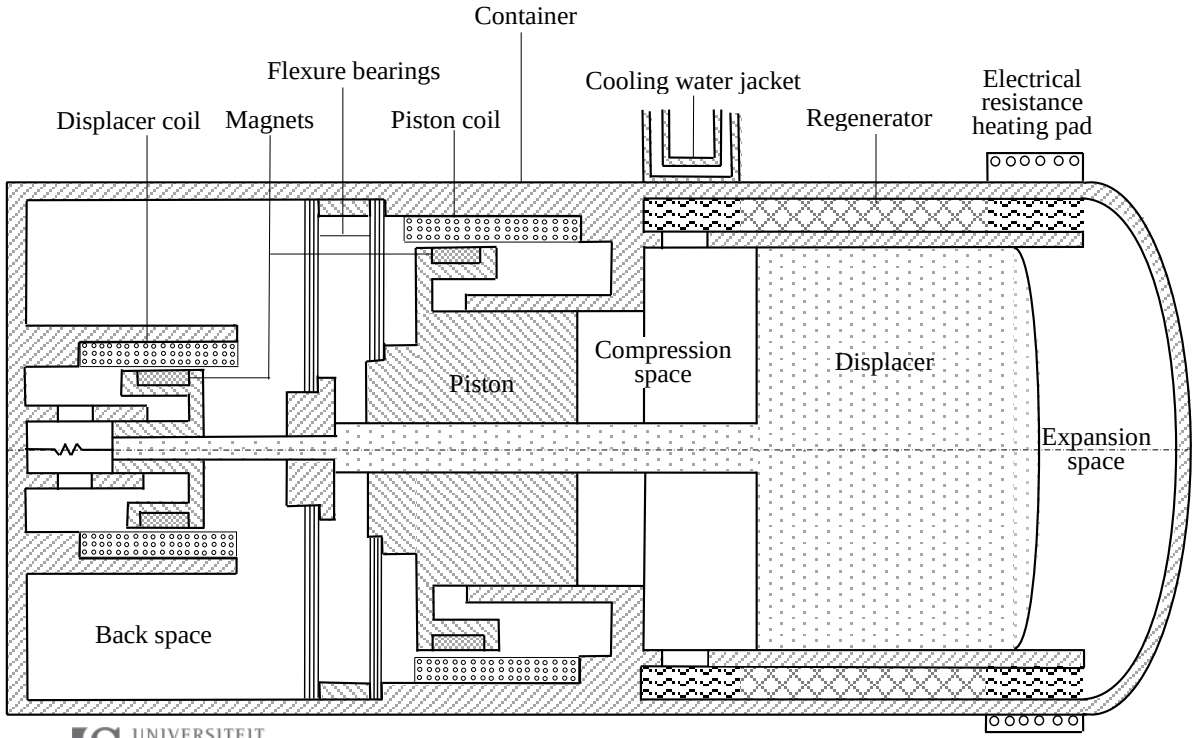
3. Theoretical model

- To understand “how it works”
- Design tool

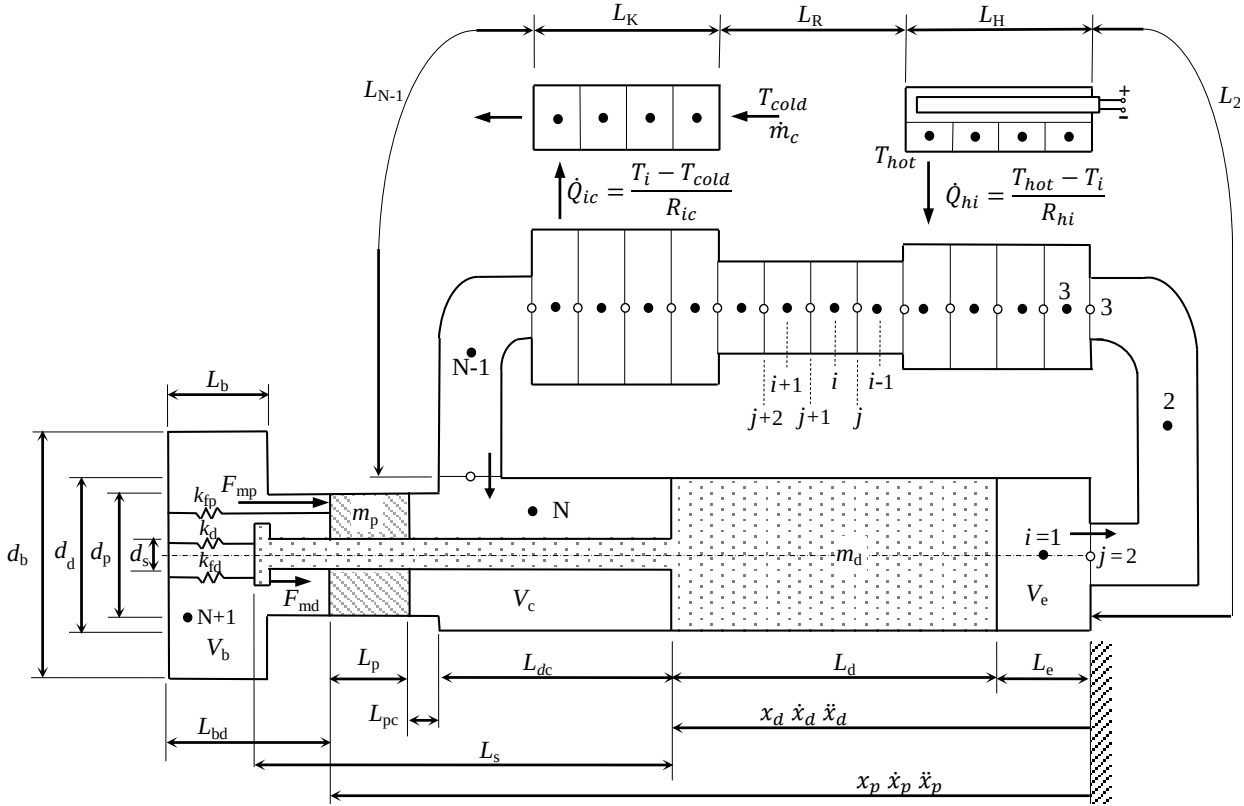
1. Divide working fluid into network of 1D finite volume elements
2. Solve for
    1. Conservation of mass
    2. Conservation of momentum
    3. Conservation of energy
3. Thermodynamics – kinematics – electromagnetics; “multi physics model”

3. Theoretical model

Schematic drawing of the FPSE



3. Theoretical model



- Discretisation scheme
- 30 Control volumes
- Staggered stacked velocity elements
- Solve in computer program (Fortran 95)

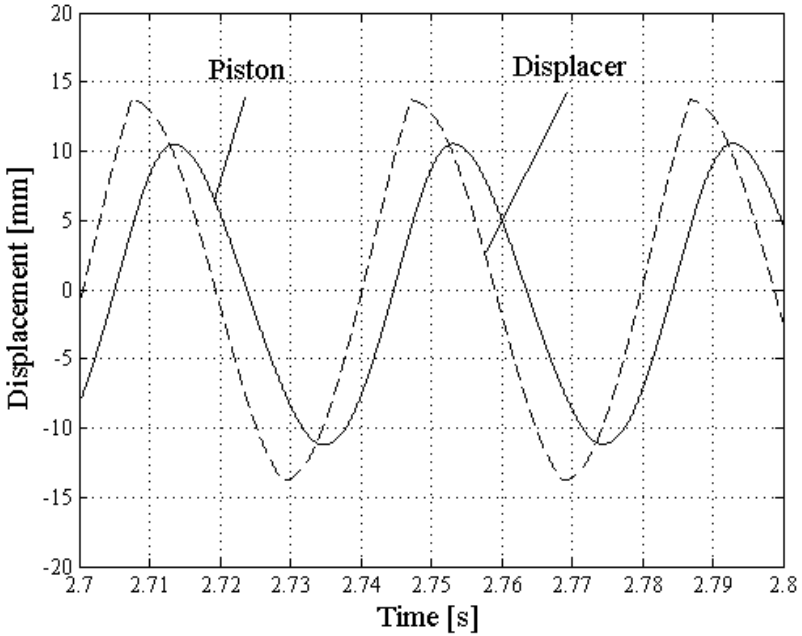
4. Simulation and results

Fully-transient computer simulation, Fortran 95

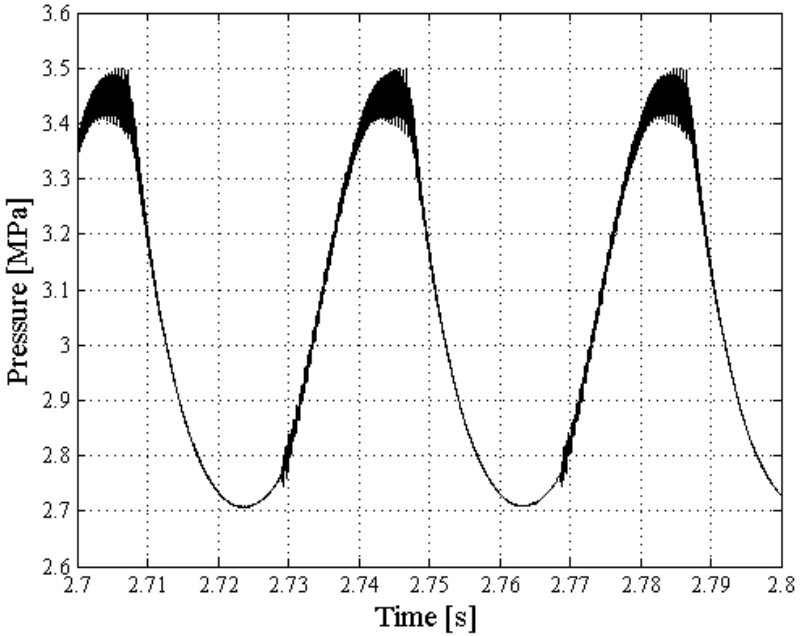
- Simulate operation from start-up
- Piston and displacer motion, pressures, power
- Insight into design of prototype

4. Simulation and results

Displacement

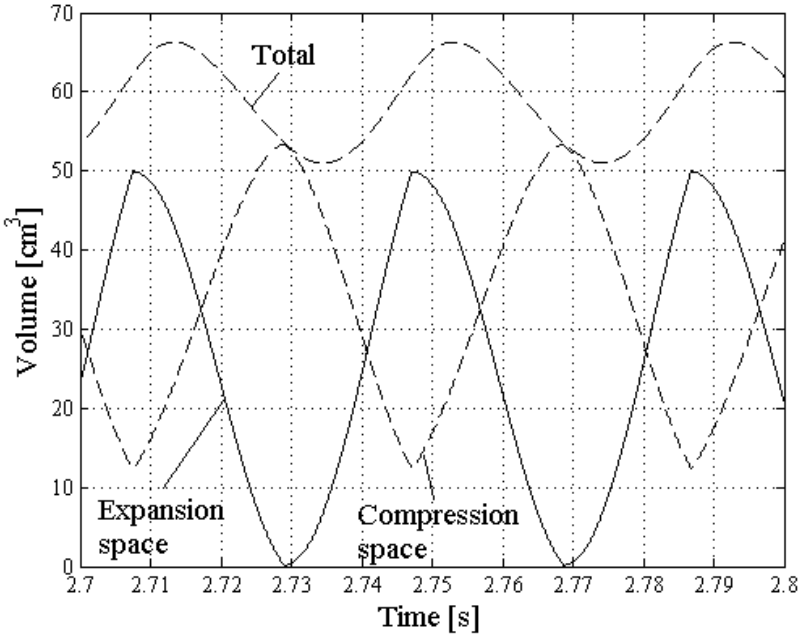


Working fluid pressure

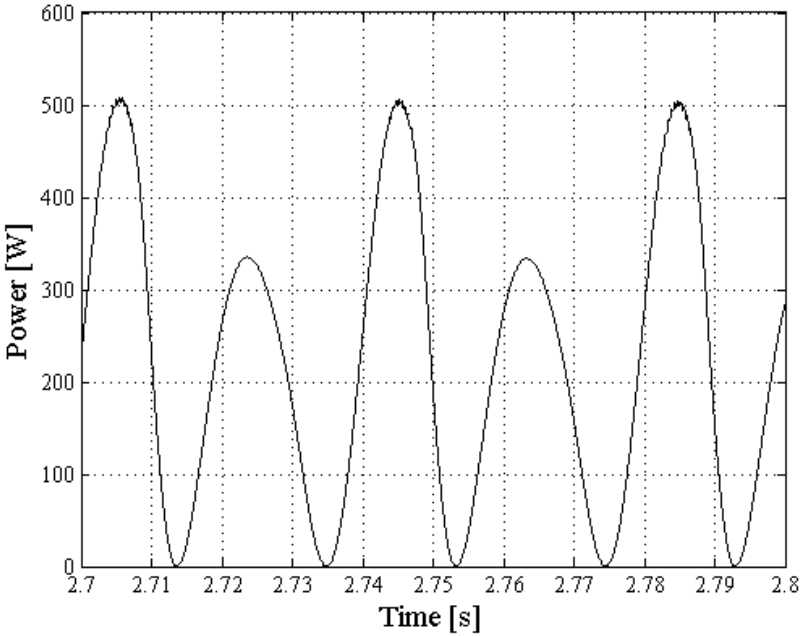


4. Simulation and results

Volume



Primary gen. power



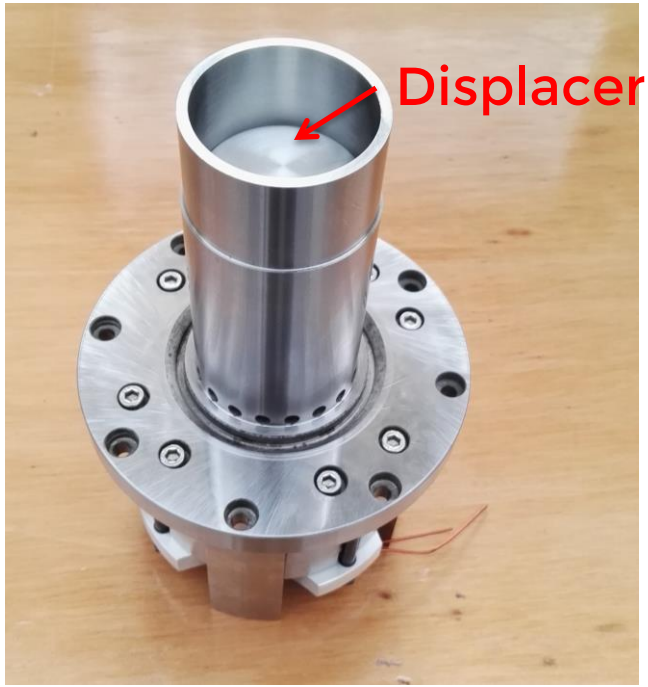
5. Current state of project

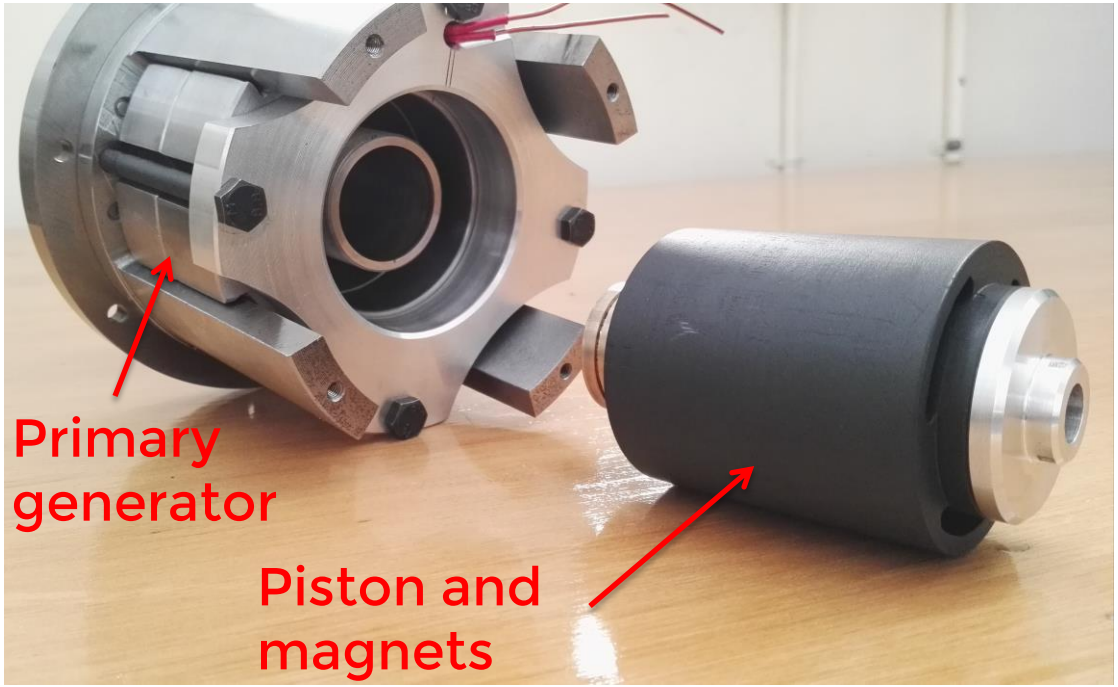
- Completed
  - Theoretical model and simulation
  - Design of prototype
  - 90% of components have been manufactured

- In progress
  - Assembly
  - Experimental setup

5. Current state of project

Pictures of FPSE so far





6. Conclusion

- Have simulated the operation of a FPSE
- In progress of developing a prototype
- Will soon validate model
- Groundwork for producing a local FPSE for concentrator dish integration

End

ACKNOWLEDGEMENTS:

Mr. Robert Dobson, for funding the project

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