STERG

SOLAR THERMAL ENERGY RESEARCH GROUP

Design and manufacture of a testable 100We dual generator free piston Stirling engine

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M.Eng Thesis

Solar Thermal Energy Research Group (STERG),

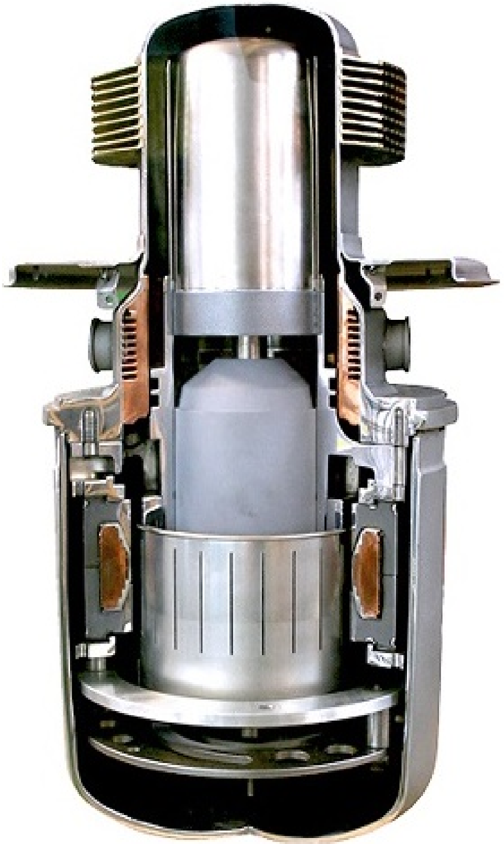
University of Stellenbosch

Contents

1. Introduction

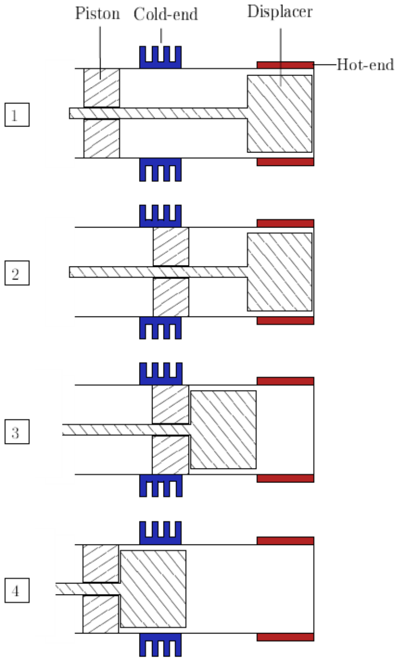
What is a free piston Stirling engine

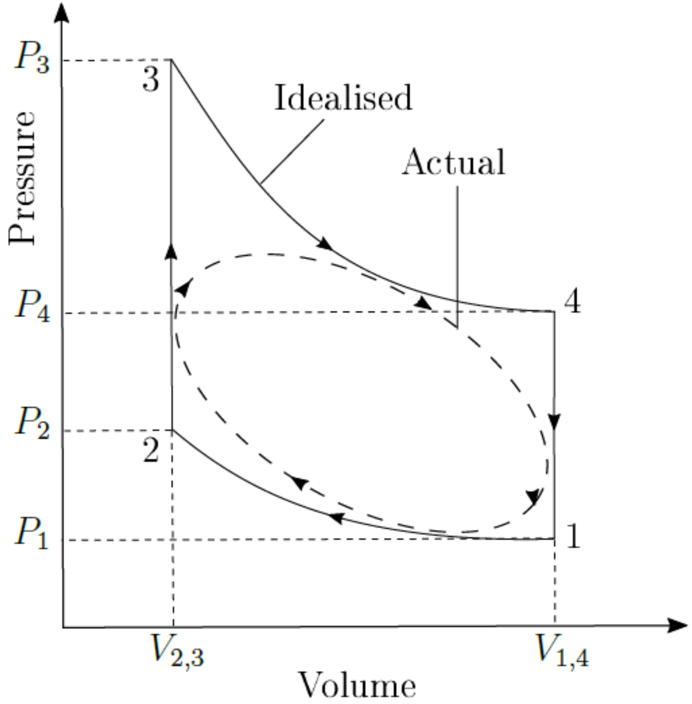
- External combustion heat engine
- Converts thermal energy into electricity
- Micro combined heat and power (mCHP) application
- Parabolic dish integration



1. Introduction

Idealised working cycle





- 1-2: Isothermal compression by power-piston
- 2-3: Constant volume heat addition
- 3-4: Isothermal expansion
- 4-1: Constant volume heat rejection.

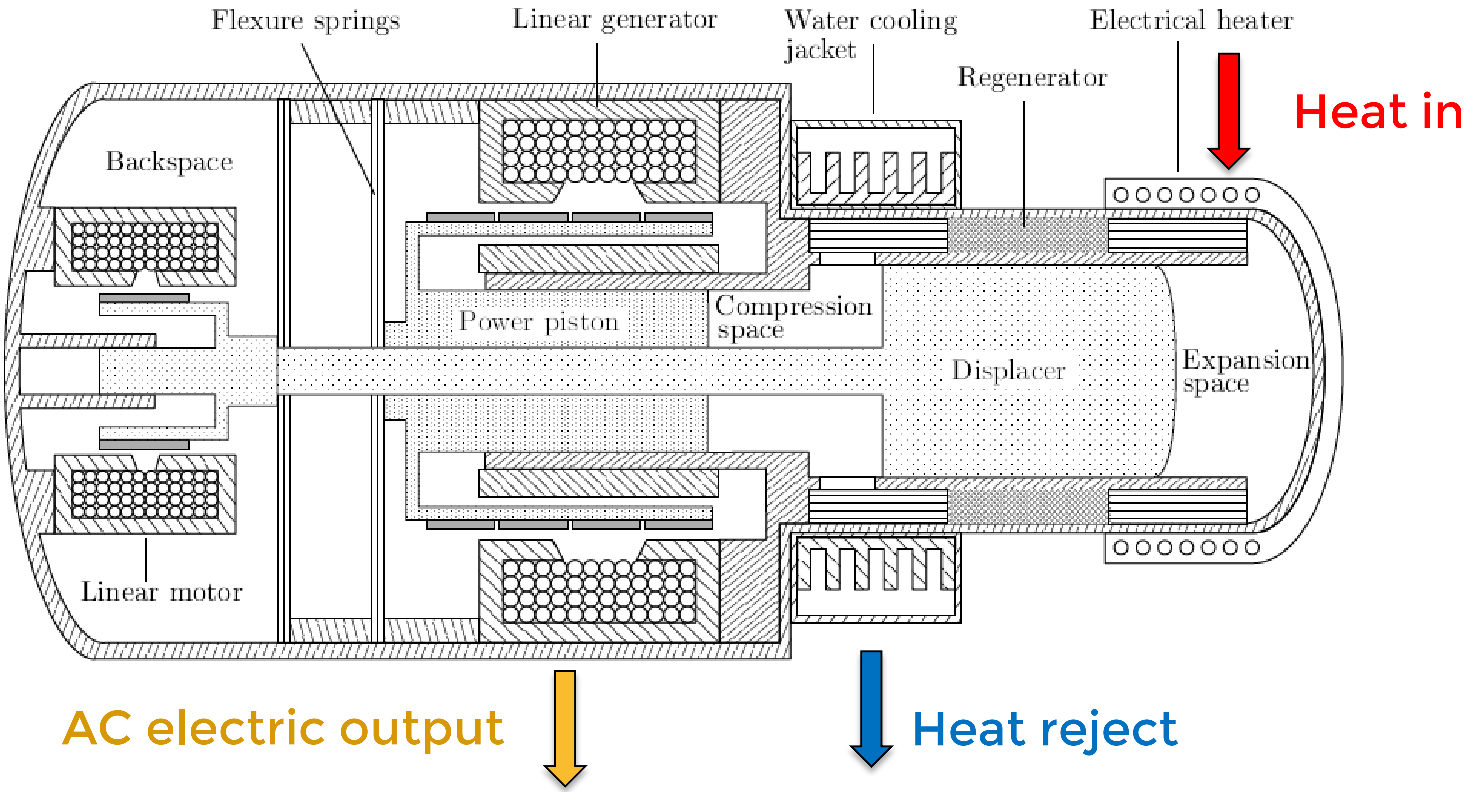
1. Introduction

Project methodology

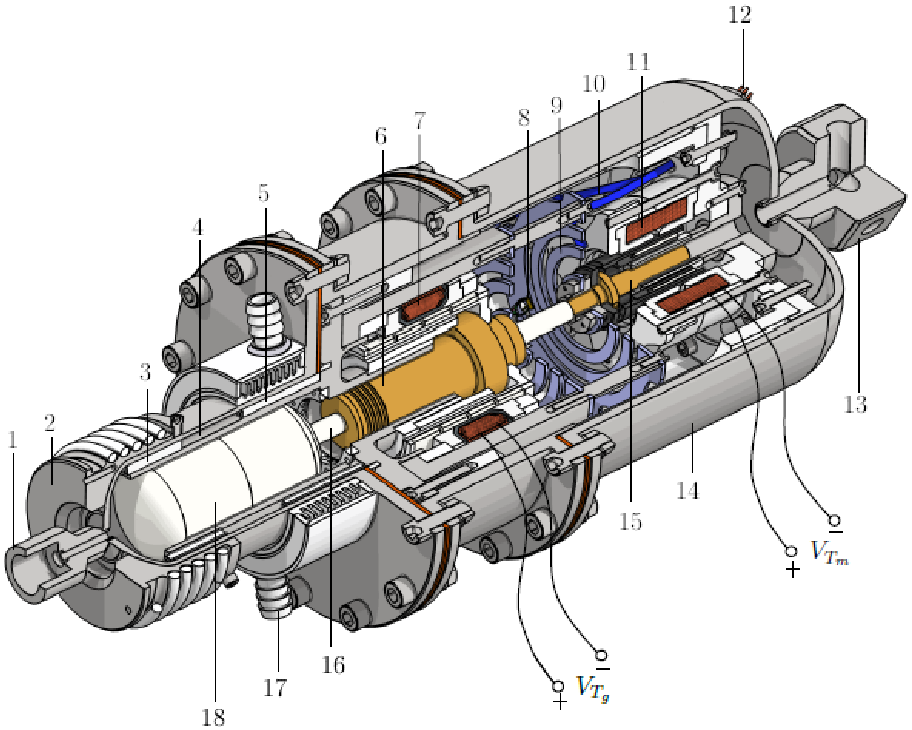
Theoretical modeling → Identification of design parameters → Prototype manufacture and testing → Model validation and refinement

Improved design

2. Design description



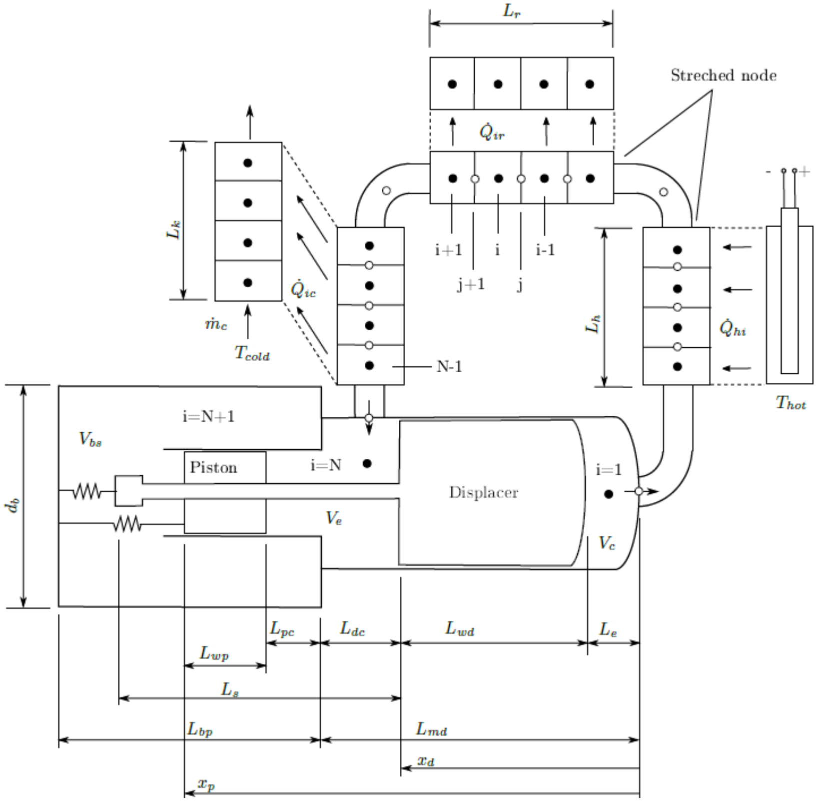
2. Design description



- Hermetically sealed, filled with helium under pressure 2 MPa
- Cyclic heating and cooling of working fluid
- Oscillates in shared natural frequency of 30 Hz
- Direct control of displacer

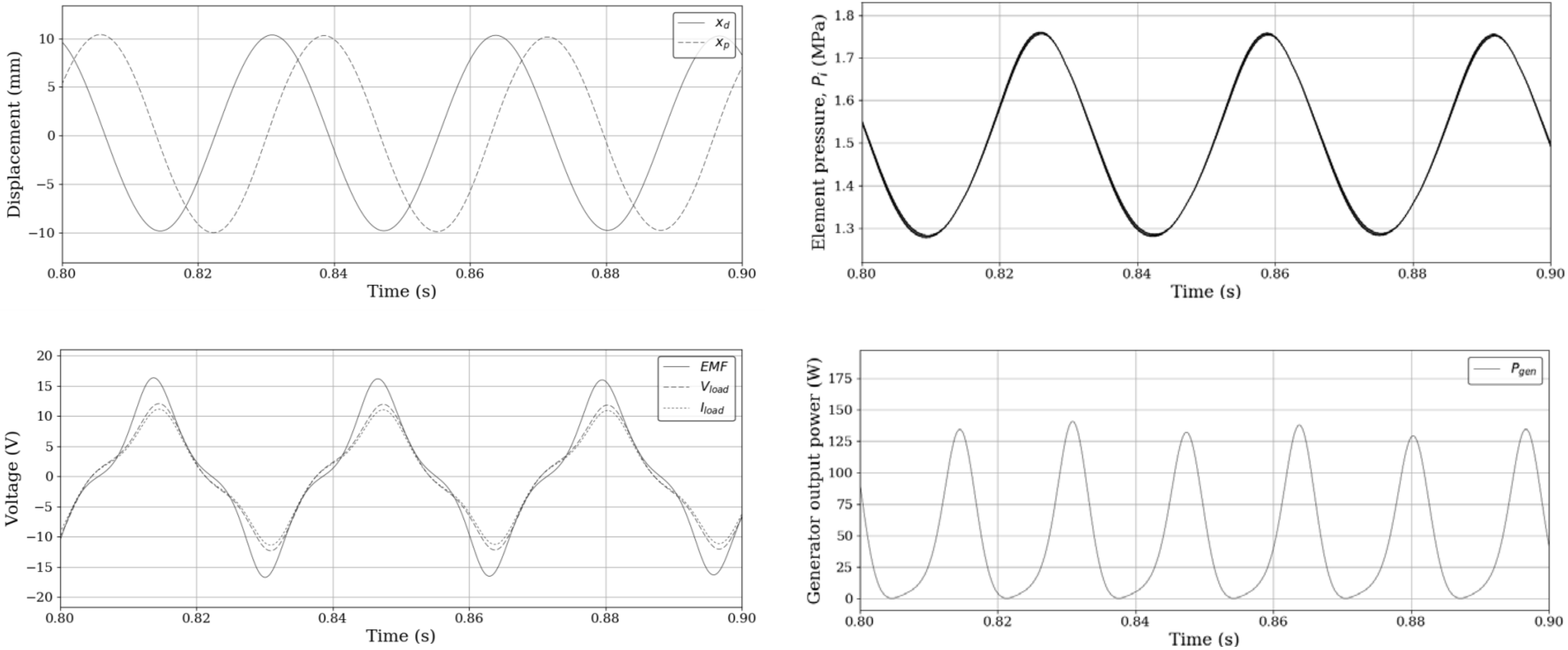
1	Expansion space pressure hub	10	Electrical wiring
2	Heater head	11	Linear electric motor
3	Heating fins	12	Electrical feed through
4	Regenerator	13	Backspace pressure hub
5	Cooling fins	14	Engine casing
6	Power piston assembly	15	Motor piston assembly
7	Linear electric generator	16	Displacer rod
8	Strain gauge	17	Cooling water jacket
9	Flexure springs	18	Displacer

3. Simulating engine operation

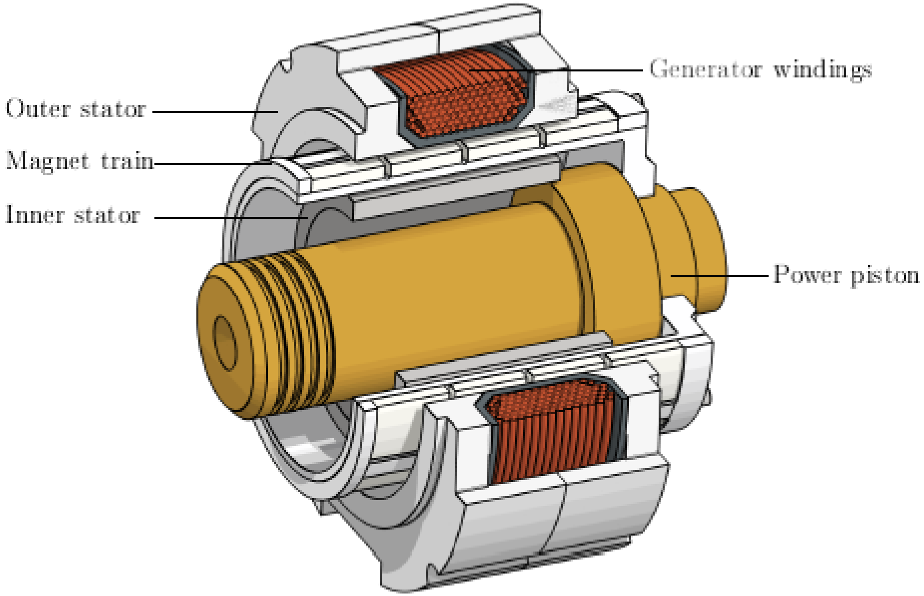


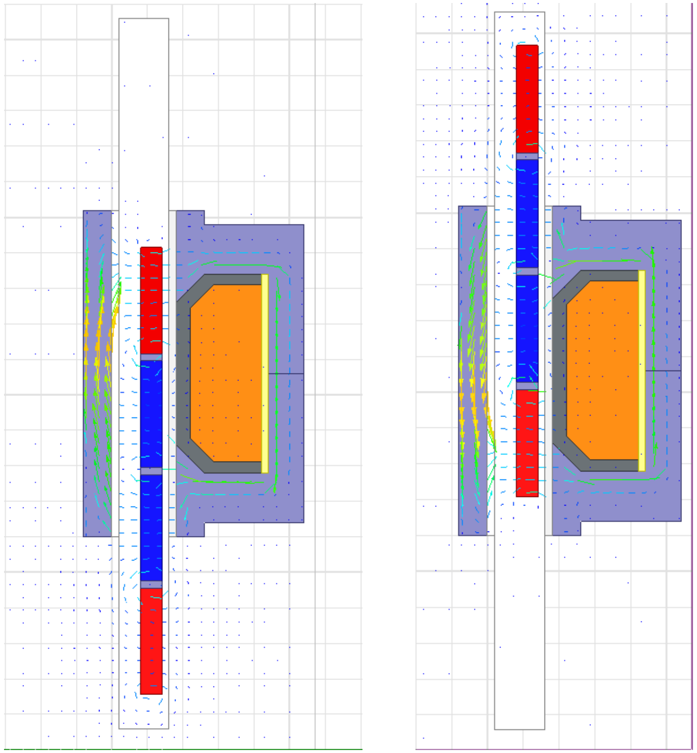
- Discretise work space into 1D control volume elements
- Solve conservation of mass, momentum and energy
- Thermodynamic-kinematic-electromagnetic ‘multi-physics’ problem
- Fully explicit computer simulation, Fortran
- Tool for design insight
- Results discussed at last year’s presentation

3. Simulating engine operation



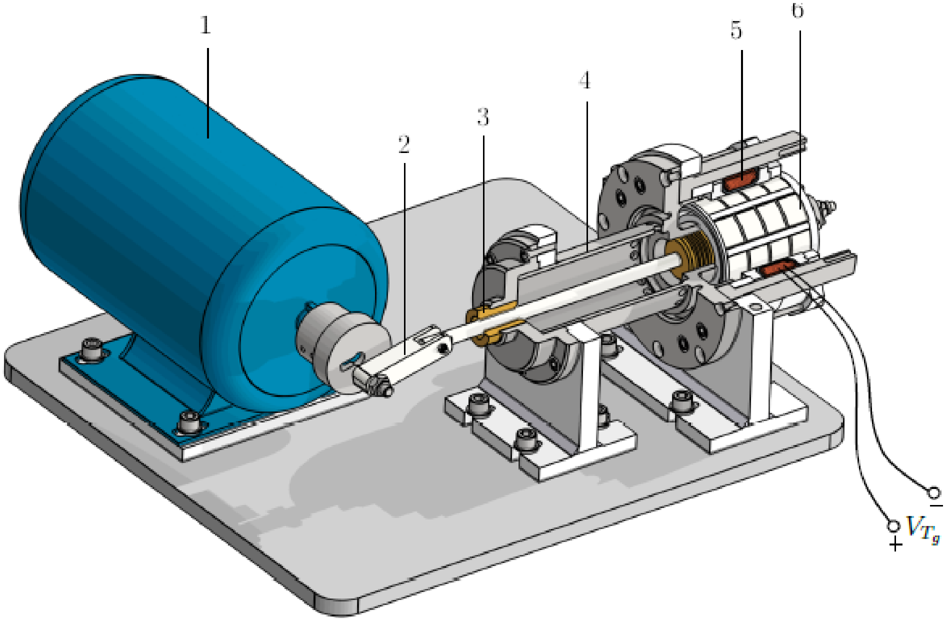
4. Linear generator development





32 NeFeB 42H arc magnets make up magnet train

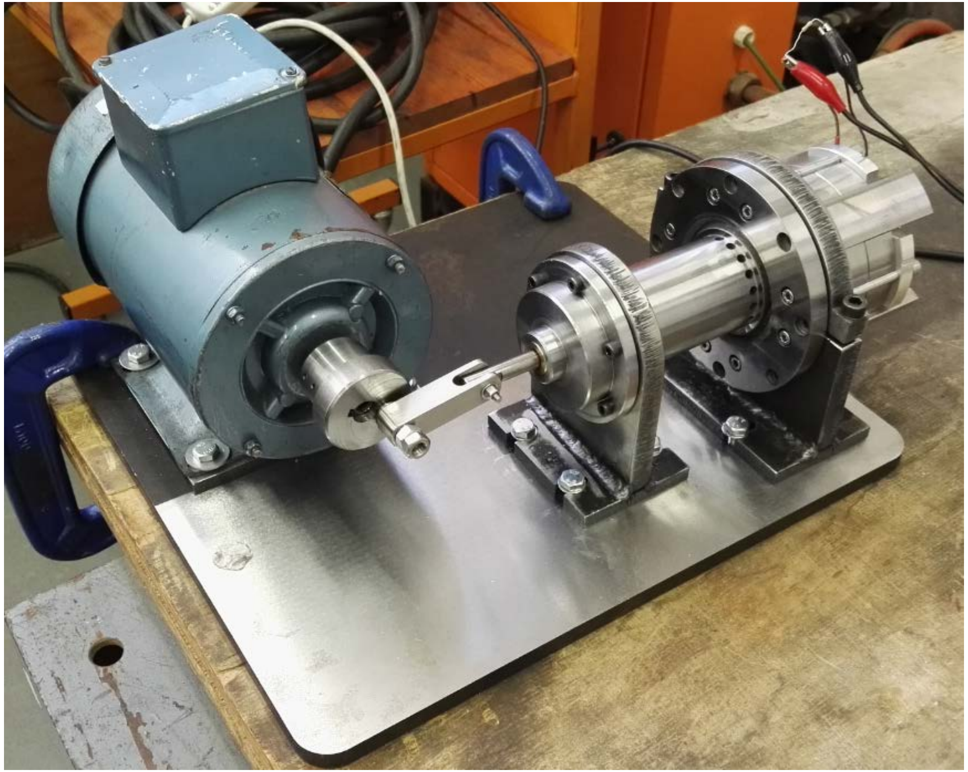
4. Linear generator development

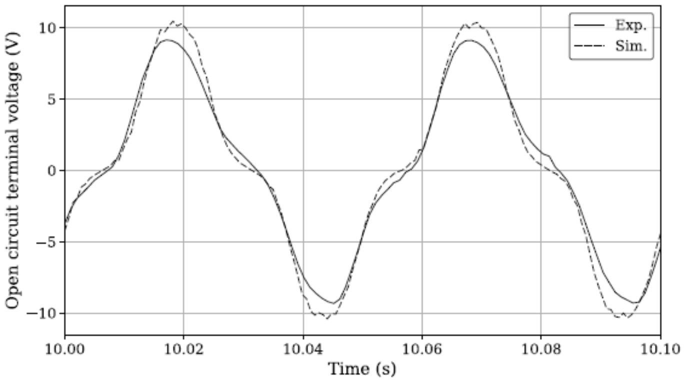


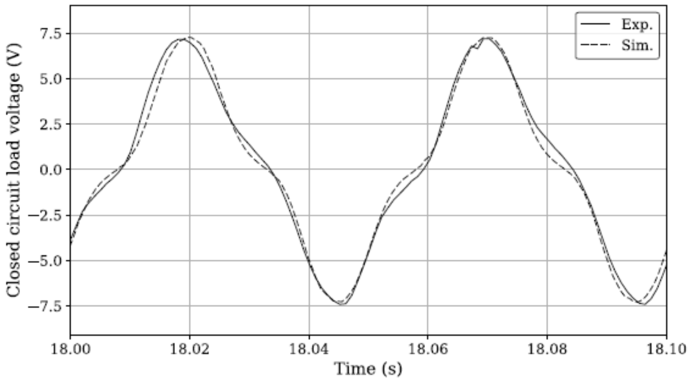
1	3-Phase induction motor	4	Internal engine body
2	Crank-shaft assembly	5	Generator stator and coil
3	Linear guide bush	6	Magnet train assembly

- Fixed 20 mm stroke
- Driven between 5-25 Hz
- Open voltage and closed voltage measurements
- 1 Ohm, 100 W load resistor

4. Linear generator development



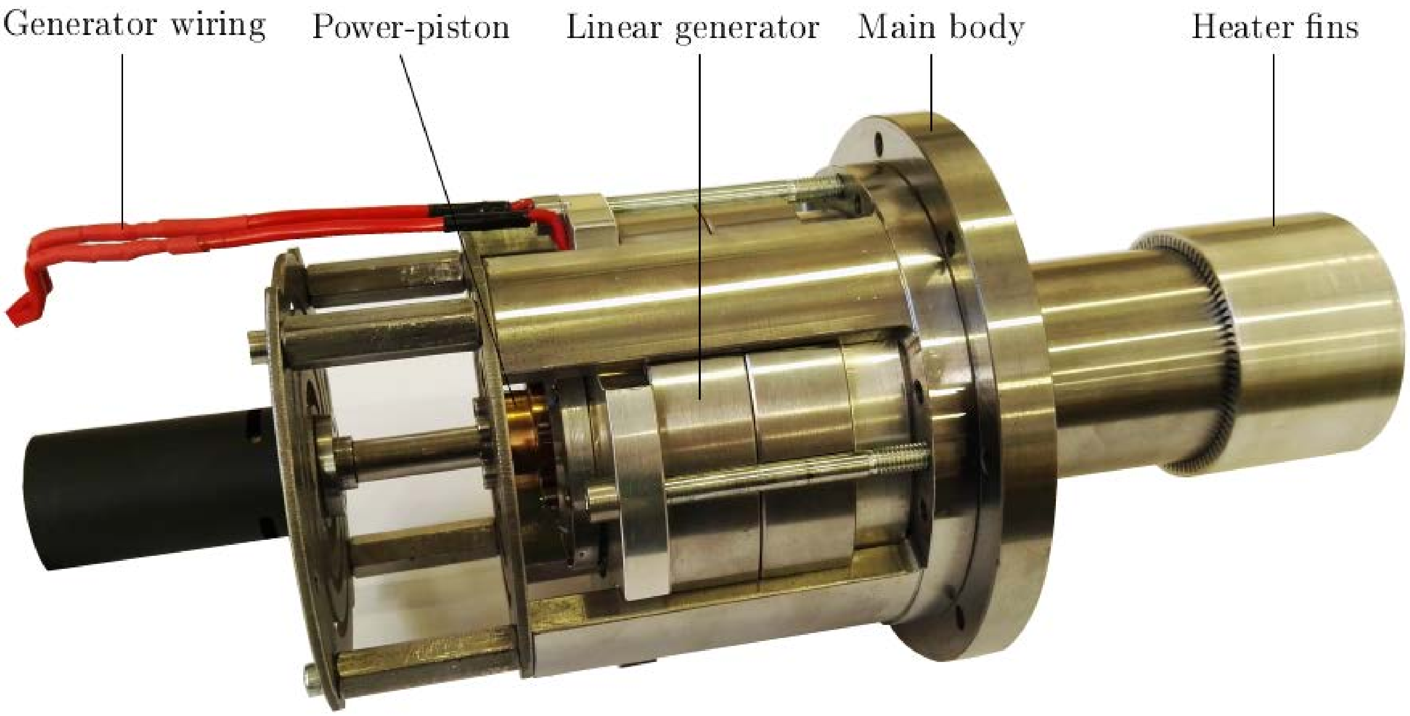




5. Prototype manufacture

Inside view with pressure housing removed

5. Prototype manufacture



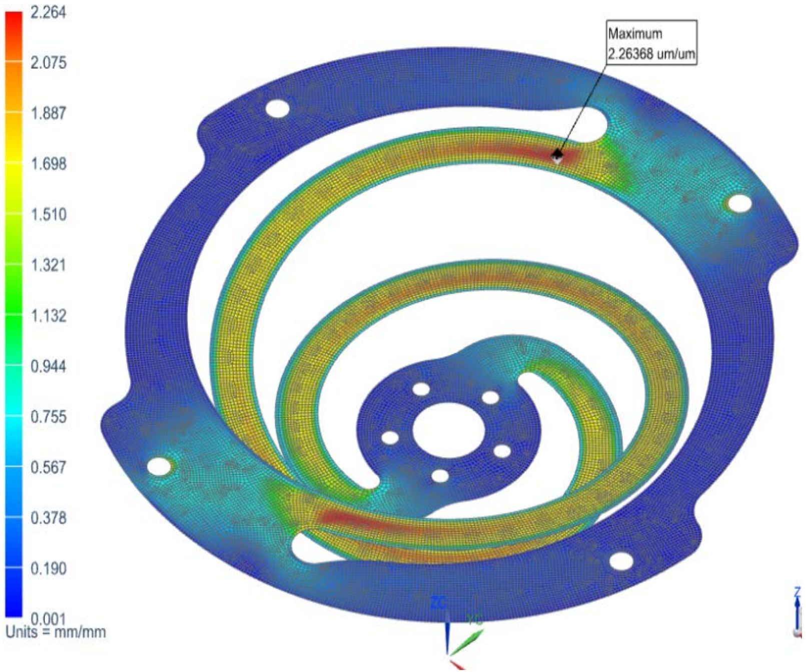
5. Prototype manufacture

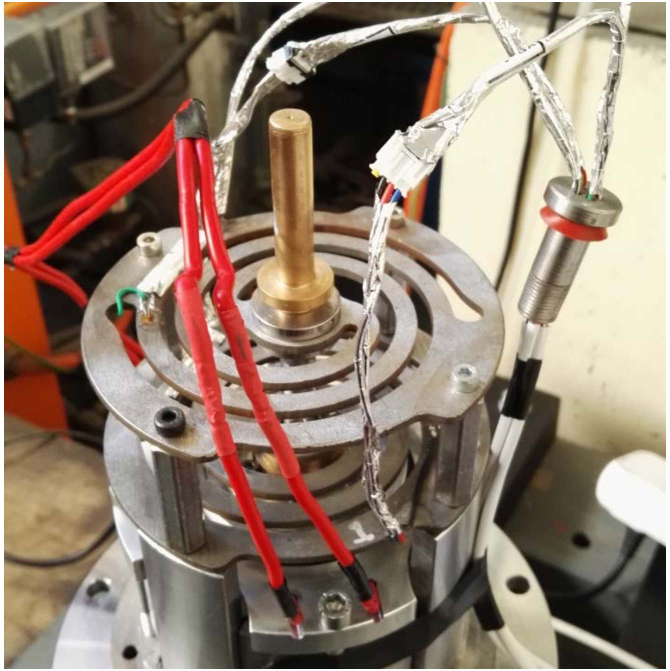
Disassembled engine 'main body' and generator stator

5. Prototype manufacture

- Piston designed for 27 Hz resonance
- Displacer designed for 31 Hz resonance
- Safety feature against growing resonance
- Good alignment critical

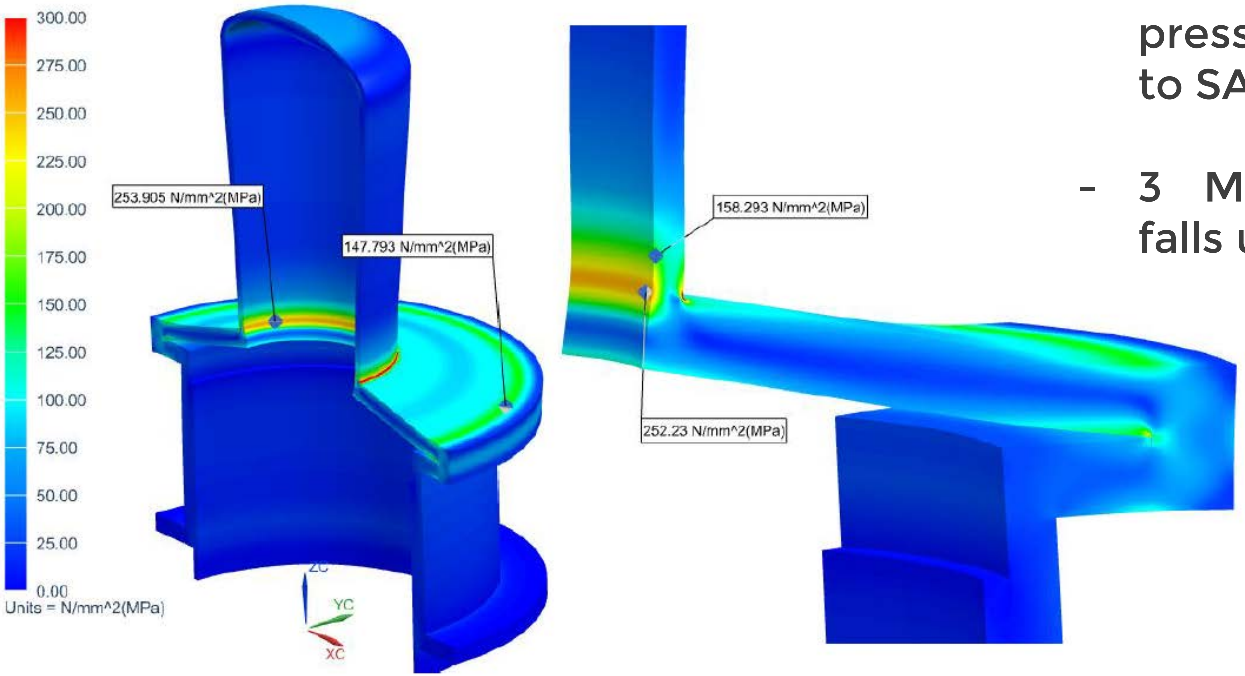
5. Prototype manufacture





Strain gauges attached to flexure springs measure displacement

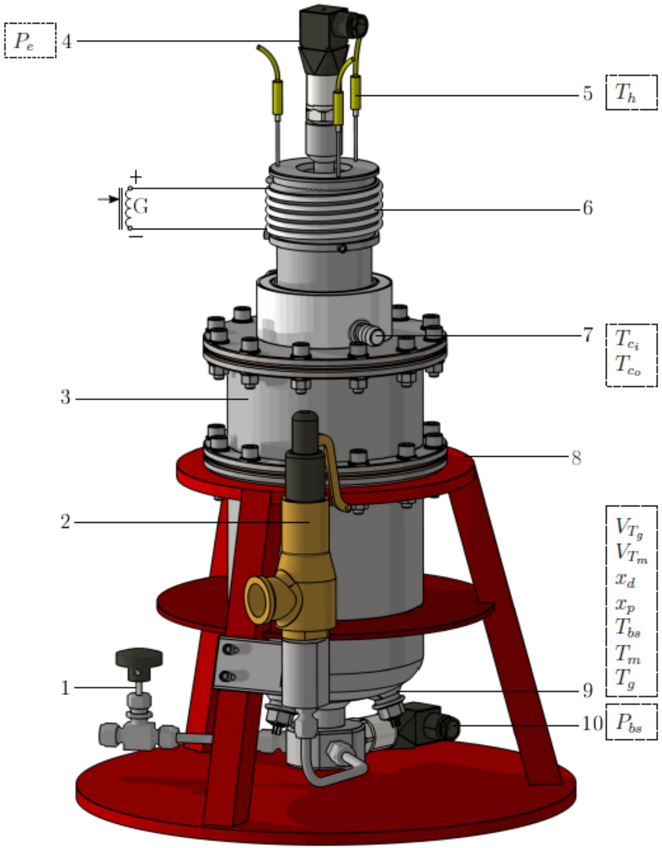
5. Prototype manufacture



- 'SEP' hazard category pressure vessel according to SABS 347

- 3 Mpa design pressure falls under category 1

6. Experimental setup



1 Gas shut-off valve
2 Pressure relief valve
3 Assembled FPSE prototype
4 Top pressure transducer
5 Heater thermocouples
6 Resistance wire heating coil
7 Cooling water inlet
8 Support stand
9 Electrical feed through plug
10 Bottom pressure transducer

6. Experimental setup

400 Watt electrical heater, feedback controlled by DAQ

6. Conclusions

- Experimental setup, calibration has been completed.

- Currently in progress of testing.

- Shall conclude with test results at STERG's 4th quarterly meeting

End

ACKNOWLEDGEMENTS:

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