Impedance Adjustment Method Study of Thermo-Acoustic Electric Generator Without Resonator

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Background

Thermo-acoustic electric generator is a novel thermal-to-electric power conversion mechanism. It has a potential application in deep-space detection because of the characteristic of longtime and high efficiency. In order to decrease the dimension and weight, the linear alternator are used to replace the resonator. It makes impedance match between engine and alternator more important when the resonator is replaced by alternator. There were rarely analysis of impedance adjustment method in the connecting part. In this present, a new impedance adjustment method is proposed and tested. the effects of structure and dimension of connecting part to impedance and performance are analyzed and tested.

Conclusion

In this present, impedance adjustment setup in the connecting part was analyzed and built. Setups with different dimension and position were tested in existing thermo-acoustic electric generator without resonator.

- Simulation results supplied method of improving thermo-acoustic electric generator without resonator.
- Appropriate filling could cause maximum 20.2% electric power increase with about 10.3% system efficiency increase.
- The shape, dimension and position of filling would intensively affect performance.
- It supplied a kind of impedance adjustment method to thermo-acoustic electric generator without resonator.

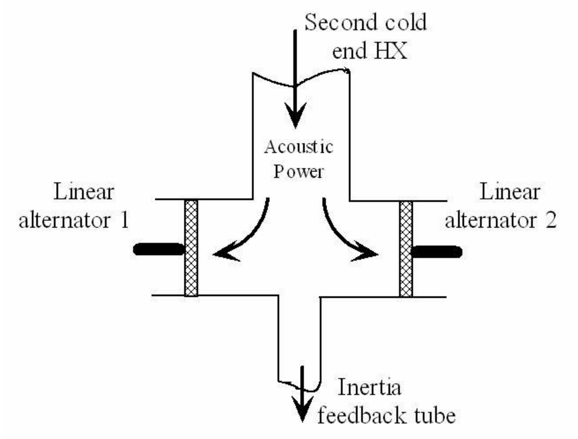
Theoretical analysis

According to topology of TAEG, a simulation model was built in the DeltaE.

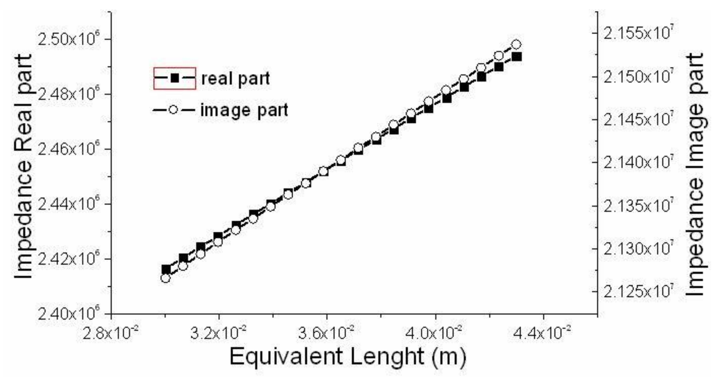
Acoustic power flow direction is shown in figure

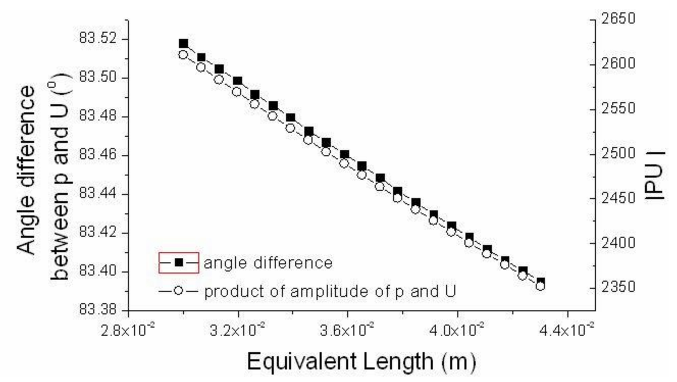
Increasing the acoustic power transmitting into the linear alternator branches can improve electric power

It can be realized by increasing PU and decreasing the angle difference between P and U.



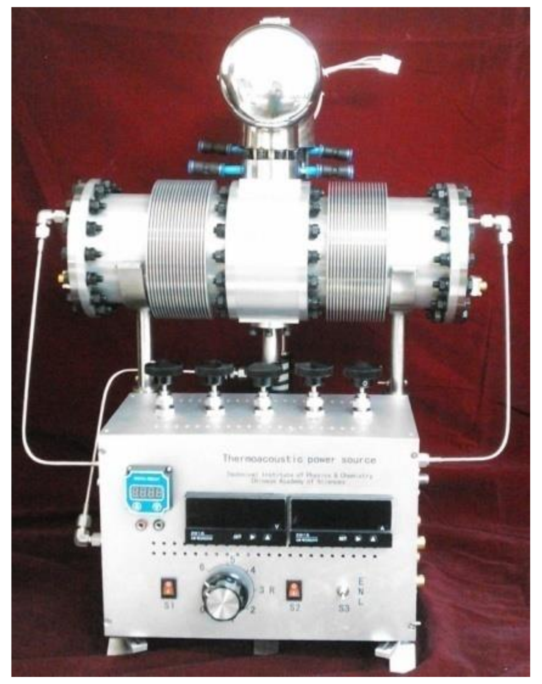
The space between pistons are seen as acoustic tube. Its equivalent length can affect the acoustic power transmitting into the alternator.
Decreasing the length will decrease the input impedance of branches, then improve the performance.
Placing filling in the connecting port can decrease the length.



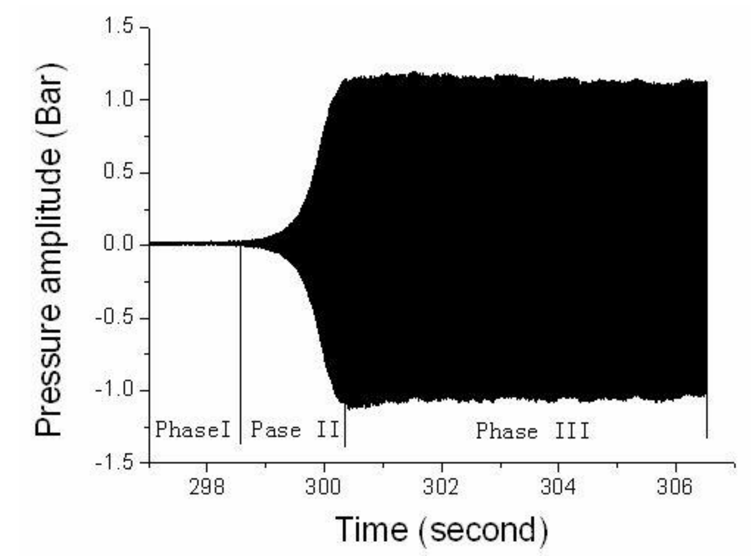


Experimental setup

Test bed



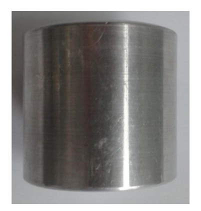
A test bed was used to test the performance caused by the structure and dimension of filling. With the same hot end temperature, the electric power and system efficiency were measured when adjustment setups were installed.



Results

Effect of filling dimension

Different shape filling had been tested.
Larger volume with less resistance loss
Ellipsoid were chosen.



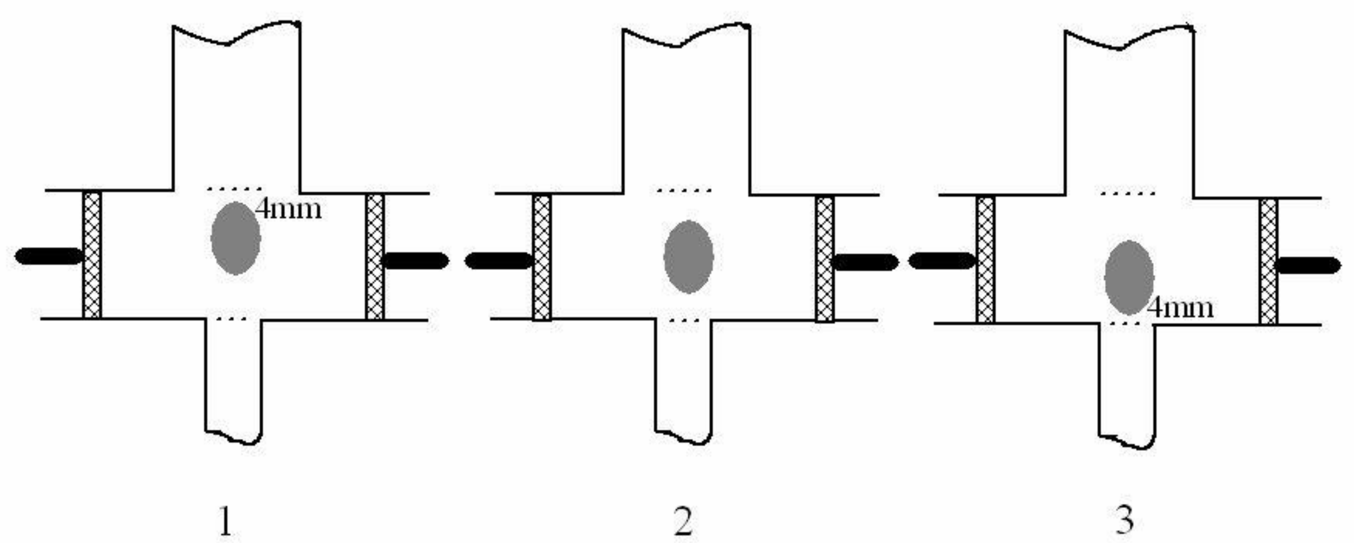
There were obvious difference between installing or no installing adjustment setup. It showed maximum 20.2% electric power increasing when appropriate ellipsoid was installed with about 10.3% system efficiency improvement.
Increase of length of major axial could improve the performance.

When the major axial dimension was over 40mm, the performance would decrease because of the block of flow field.

Dimension of adjustment setup	Electric power(Watt)	System efficiency
No filling	50.1	10.7%
Sphere filling with diameter 24mm	51.6	11.2%
Ellipsoid filling with major axial 30mm	53.4	11.4%
Ellipsoid filling with major axial 32mm	58.2	11.7%
Ellipsoid filling with major axial 36mm	60.2	11.8%
Ellipsoid filling with major axial 40mm	52.5	10.5%

Effect of filling position

The position of filling could affect the flow and whole machine performance.



Position	Electric power(Watt)	System efficiency
1	60.2	11.8%
2	57.1	11.2%
3	41	9.5%

When ellipsoid was placed near second cold end, more acoustic power would transmit into the linear alternator branches with less loss.

When ellipsoid was placed near inertia feedback tube, the flow would be blocked.

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