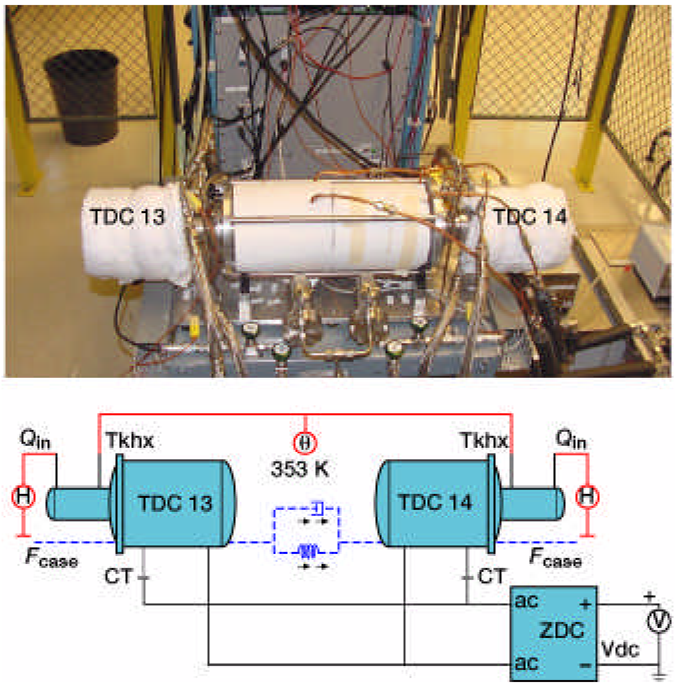
Development of Electronic Load Controllers for Free-Piston Stirling Convertors Aided by Stirling Simulation Model



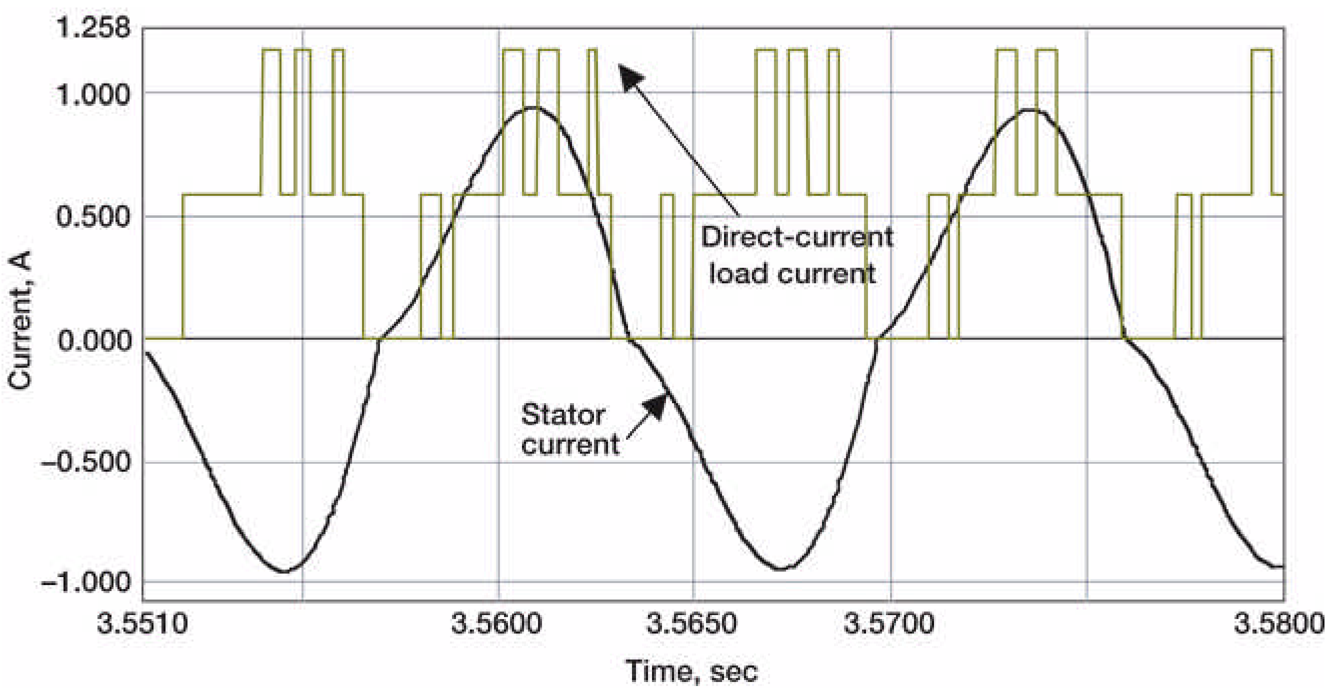
Technology Demonstration Convertors (TDC) 13 and 14 on the test stand (top) and in the simulation model (bottom). Heat flux applied to these Stirling convertors is connected to the Q_{in} nodes. The rejection temperature is connected to the nodes labeled Tkhx. The alternating current (ac) electrical power output of the TDCs is connected to the Zener diode controller (ZDC) through tuning capacitors labeled CT. The stainless steel rods connecting the two convertors in the photograph are modeled by the dashed line in the simulation diagram, and F_{case} is a node through which the net force on the convertor case can be accessed.

The free-piston Stirling convertor end-to-end modeling effort at the NASA Glenn Research Center has produced a software-based test bed in which free-piston Stirling convertors can be simulated and evaluated. The simulation model includes all the components of the convertor: the Stirling cycle engine, heat source, linear alternator, controller, and load. So far, it has been used in evaluating the performance of electronic controller designs. Three different controller design concepts were simulated using the model:

1. Controllers with parasitic direct current loading.

2. Controllers with parasitic alternating current loading.
3. Controllers that maintain a reference current.

The free-piston Stirling convertor is an electromechanical device that operates at resonance. It is the function of the electronic load controller to ensure that the electrical load seen by the machine is always great enough to keep the amplitude of the piston and alternator oscillation at the rated value. This is done by regulating the load on the output bus. The controller monitors the instantaneous voltage, regulating it by switching loads called parasitic loads onto the bus whenever the bus voltage is too high and removing them whenever the voltage is too low. In the first type of controller, the monitor-ing and switching are done on the direct-current (dc) bus. In the second type, the alternating-current bus is used. The model allows designers to test a controller concept before investing time in hardware. The simulation code used to develop the model also offers detailed models of digital and analog electronic components so that the resulting designs are realistic enough to translate directly into hardware circuits.



Typical output waveform of the simulation model. This shows the ac flowing through the stator windings of TDC 14 and the direct current (dc) dissipated in the ZDC.

Find out more about this research: http://www.grc.nasa.gov/WWW/tmsb/stirling.html

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