FIRST OPERATION OF A 12 kWe STIRLING POWER CONVERSION UNIT FOR FISSION POWER TECHNOLOGY DEMONSTRATION. J. G. Wood[1], E.S. Holliday[1],and J.C. Stanley[1], [1] Sunpower Inc. 1055 East State Street, Suite D, Athens, OH.

Introduction: Sunpower is developing a 12 kWe dual-opposed Stirling Power Conversion Unit (PCU) including an electronic controller to interface with user loads. This effort is funded by NASA-Glenn Research Center (GRC) and is to be implemented in a fission power technology system demonstration at NASA-GRC. The first operation of half of the unit (a single 6 kWe convertor) occurred in late October of 2011. Full power operation was achieved on December 13th. 2011. Current developmental testing is concentrating on birnging temperature levels up to the full design values of 575°C hot end and 110 °C reject.

Opposed 12 kW Convertor Design: Dual-opposed convertors are used in this application to cancel vibration, arranged with the alternators outboard and with a common inboard engine expansion space Heating for the final convertor will be by a pumped liquid metal (NaK) loop with heat rejection to pressurized pumped water fed to space radiators. The dual opposed convertor arrangement is shown in Fig. 1. The unit has a diameter of 0.3 meter and a length of 1.1 meter. A full scale system would eventually use 4 of these convertors to deliver a total of 48 kW. The unit operates at 60 Hz. and has a design pressure of 6.0 MPa. Internal details of the convertor has been described previously [1].

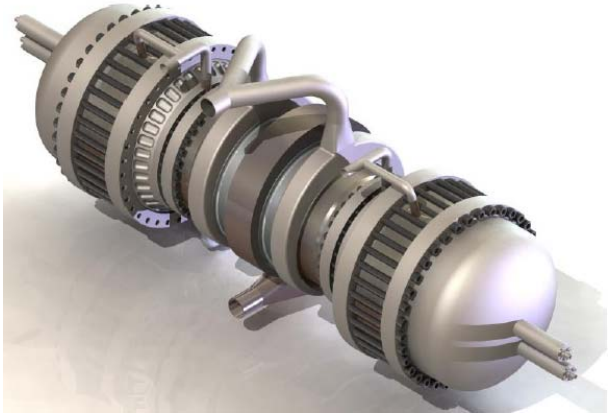

Figure 1. Dual Opposed 12 kWe Convertor Arrangement

Convertor Testing and Development: Individual 6 kWe convertors are being built and tested first using a temporary single-unit electrically heated test head. The individual convertors will then be combined with a common heater head with the expansion spaces directly connected .

Testing of single convertors is performed bolted to a large (2 ton) mass to minimize housing motion which would otherwise influence the internal displacer dynamics. Figure 2. shows the first assembled convertor mounted to this mass comprised of bolted steel plates.

Before operation as an engine we motored the convertor as a cooler during October 2011 and took the heater head to -60 °C at less than full engine piston amplitude. Piston amplitude when run in this manner is limited because of the phasing of internal displacer and piston dynamics.

Figure 2. Single Convertor Attached to Large Mass

Figure 3. Motoring Single Convertor as a Cooler

First Power Producing Operation: The first power producing run of the convertor occurred on Oc-

tober 26, 2011. We limited the piston amplitude during the first run to 25% of full amplitude and produced 1 kW electrical output at this point. Early testing has also been limited to reduced overall temperature levels, but at the design temperature ratio of 2.25. Early testing has thus been performed at a hot end temperature of 420° C with an average water temperature of 36° C.

Full Power Operation: Progress toward full piston amplitude and full power operation after the first run was quite successful. On December 13, 2011 we achieved slightly over the design power of 6 kWe at the design piston amplitude of 16 mm.

This progress involved only minor internal modifications/corrections to the hardware. The major effort concerned the clamp-on electrical heater blocks which are used to supply heat to the temporary single unit head. The difficulty here has been in maintaining good thermal contact for to the heater head. If the engine is stroked out too quickly local thermal contact is often lost. Thus with this arrangement we are required to slowly increase piston amplitude. The clamp-on heater assembly can be seen in Figure 4 below.

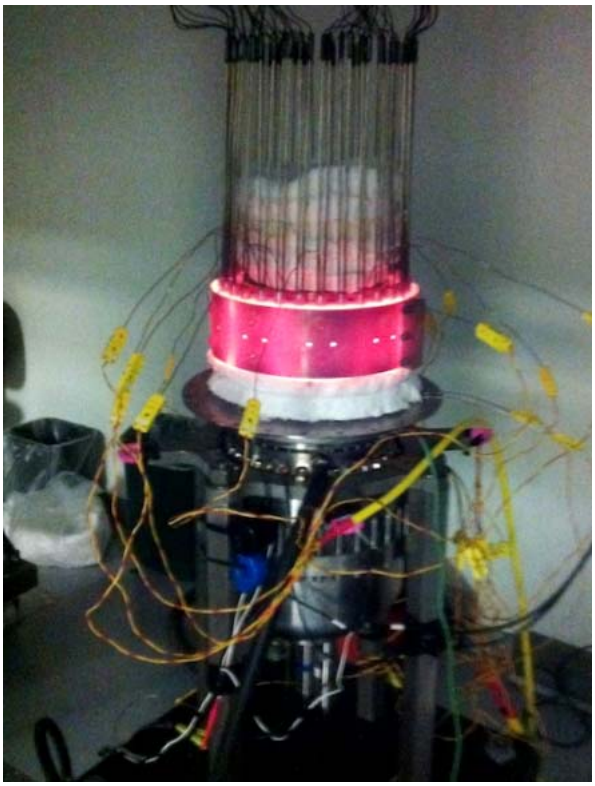

Figure 4. Operating Single Convertor with Clamp-On Heaters Exposed

Thus progress in achieving full power has been very good with essentially no internal convertor modifications. Currently we are proceeding to increase overall test temperature levels while maintaining the correct operating temperature ratio.

Controller: A controller has also been designed, and built to control the amplitude, frequency, and relative phase of the final dual-opposed of Stirling convertor.

To test the controller's ability to perform the desired level of control two Stirling convertors, a pair of Sunpower P2A 1kW Stirling convertors, were setup in a dual opposed configuration. The controller successfully maintained the engines operating frequency at their design value of 50 Hz while varying the piston amplitude to produce from one quarter power to full power of over 2 kW for the pair.

Summary: Progress in the development of the 12 kWe Power Conversion Unit has been very successful. Full power of a single unit was achieved less than 2 months after first operation. Initial testing has been at reduced overall temperature levels and the current effort involves increasing the temperatures to full design levels. The power capability of the convertors has thus been demonstrated. Basic controller operation for the opposed unit has also been demonstrated on a pair of 1 kWe convertors.

References: [1] Wood J. G. et al. (2011) *NETS-2011*.