Low Cycle Fatigue Spin Testing Services

Rev. A

WHITEPAPER

Prepared by
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May 2009

Flywheel Energy Systems Inc.
A blueprint for a clean future in transportation

Abstract

This whitepaper describes the low cycle fatigue spin testing services offered by Flywheel Energy Systems Inc.

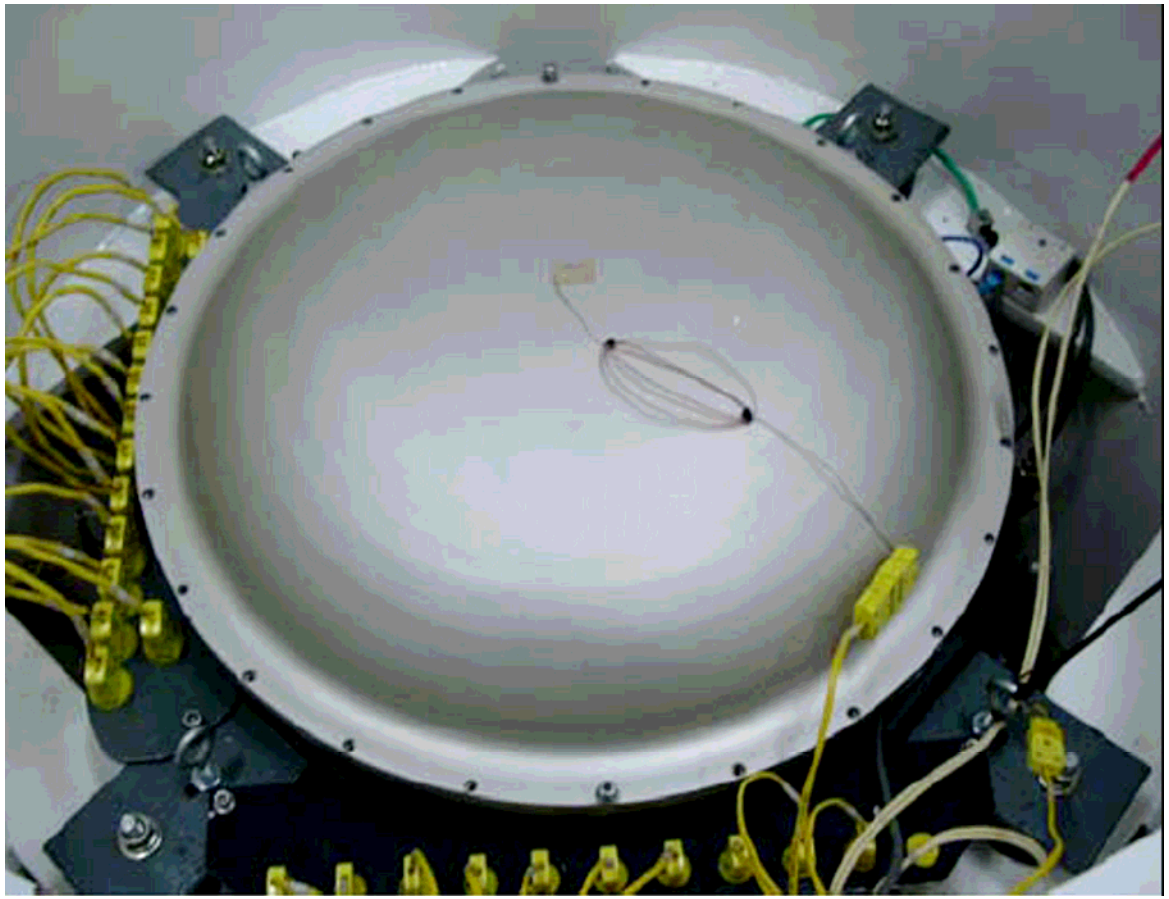
A partial client list for past spin testing services includes Natural Resources Canada, the Canadian Space Agency, Honeywell and the Charles Stark Draper Laboratory.

The paper is structured in three parts as detailed below.

Contents

Flywheel system durability testing

Client	Natural Resources Canada
Cycles	71 000
ω_{min}	15.5 krpm
ω_{max}	31 krpm
P_{avg}	42 kW
Duration	1500 h
Energy	63 MWh
J_p	0.683 kg-m^2

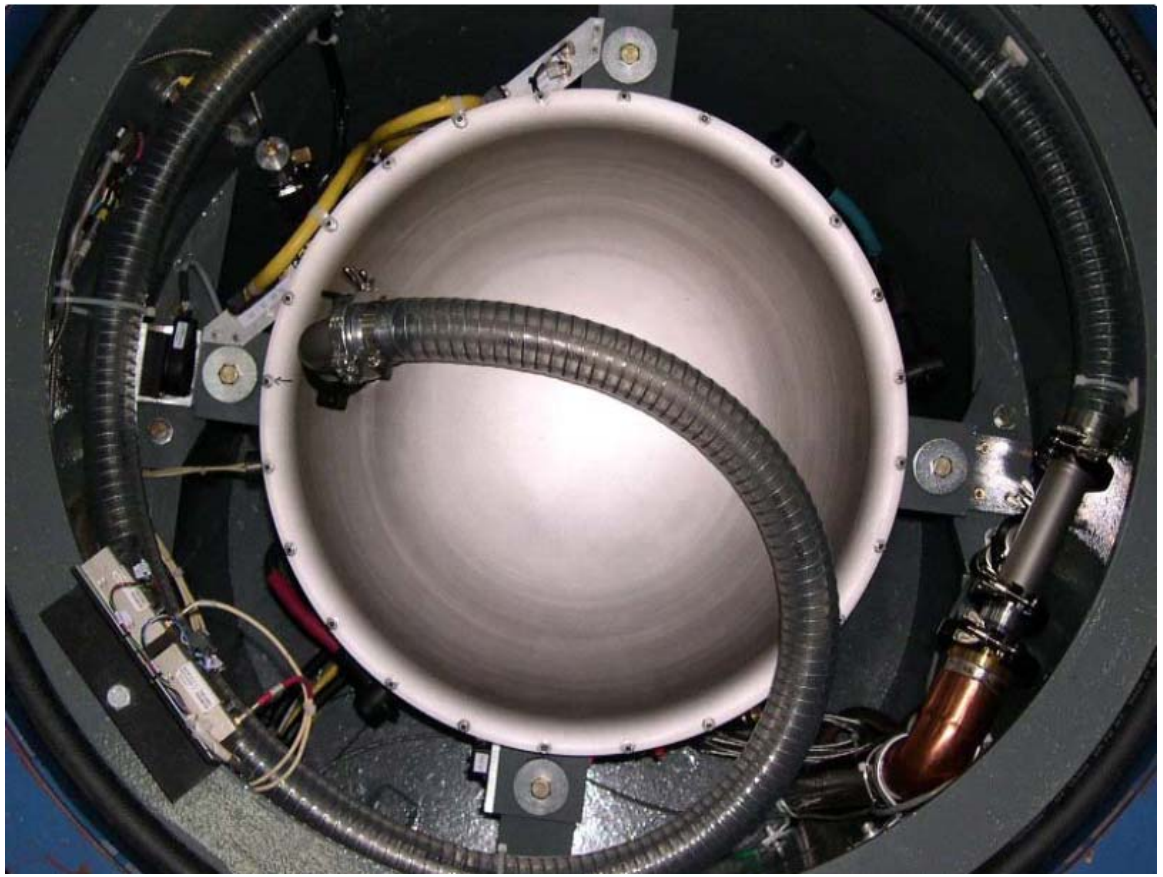


Test summary

- Variable power up to +50 kW, -90 kW
- Variable speed ranges

Flywheel hybrid bus simulation

Client	Natural Resources Canada
Cycles	40 000
ω_{min}	14 krpm
ω_{max}	28 krpm
P_{avg} P_{max}	16 kW 120 kW
Duration	1700 h
Energy	28 MWh
J_p	0.863 kg-m^2



Test summary

- Variable power up to +/-120 kW
- Variable speed ranges
- Off-axis roll excitation (10°, 10°/s, 1 Hz - 20 Hz)

Spacecraft rotor accelerated life testing

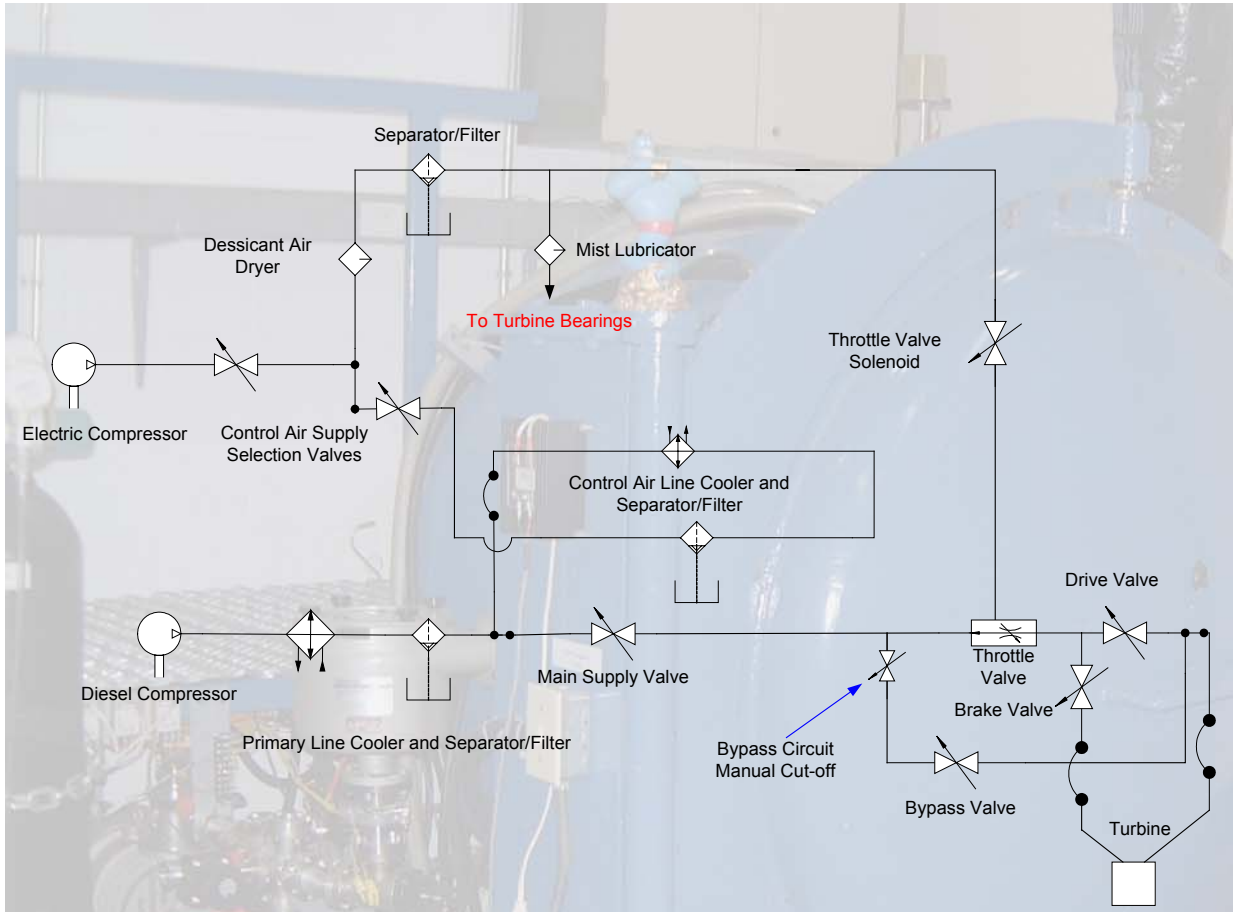
To spacecraft power industries, our primary offering is high specific energy composite flywheel rotors.

Our core technology consists of lightweight composite rotors that provide energy storage and angular momentum vectors for attitude control in low earth orbit spacecraft.

We have completed an accelerated life testing program that has verified the rated service life by testing to four times service life in accordance with standardized spacecraft systems verification guidelines.

Spacecraft power technology is a controlled strategic good per Canada's Export Control List Item 5504. Consequently, we cannot openly disclose technical specifications. Please contact us for more information about how to exchange technical data relating to spacecraft power technologies.

Air turbine test facility



ω_{max} (krpm)	60
Diameter (mm)	700
Mass (kg)	90
Pressure	10-100 mTorr
Temperature	20°C - 100°C
Environment	Nitrogen or argon bleed

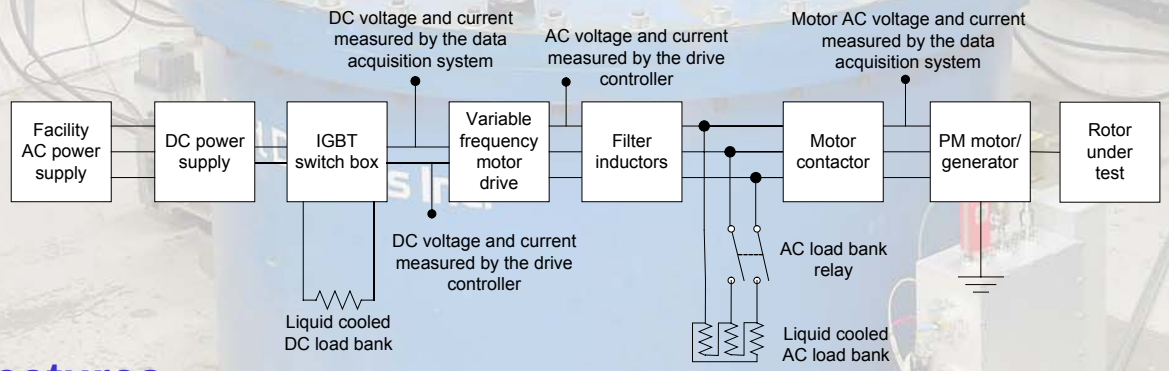
Features

Compliant, oil damped quill shaft attachment

Non-contacting displacement and temperature measurement

Axial and radial bumpers above and below the rotor capture loose rotor events

Electric drive LCF test facility



ω_{max} (krpm)	40	28
Diameter (mm)	430	500
Mass (kg)	20	35
Pressure	5-10 mTorr	
Temperature	20°C - 50°C	
Environment	Nitrogen or argon bleed	

Features

Rotor is constrained in compliant bearings

Order analysis of rotor vibration to 50 kHz

Multi-channel displacement, acceleration and temperature measurement

Rotor mass and diameter limits can be increased with job specific tooling

Data acquisition

Features

- High speed simultaneous data acquisition
  - 8 channel, 12 bit, 1 MHz
  - 2 channel, 12 bit, 10 MHz
- 32 channel temperature monitoring
- Multi-plane synchronous dynamic response
- Order analysis of sub-synchronous and higher order harmonics
- LabVIEW programming and data acquisition software

Data acquisition equipment list
National Instruments (PCI-6115) 4-channel simultaneous multifunction i/o (x2)
National Instruments (SCXI-1102) 32-channel thermocouple module
National Instruments (SCXI-1000) 4-slot chassis
National Instruments (TC-2095) thermocouple module terminal block
National Instruments (4351) 14-channel precision thermocouple meter
National Instruments (GPIB) general purpose interface bus
National Instruments (6035E) multifunction i/o
National Instruments (BNC-2110) high speed i/o (x2)
National Instruments (BNC-2120) high speed i/o and function generator
National Instruments (ER-8 POD) 8-channel electromechanical relay
National Instruments (TBX-68T) isothermal terminal block
Bentley Nevada series 9000 monitor system
Bentley Nevada 2-channel digital vector filter
Bentley Nevada series 7200 proximiter (x5)
Brüel and Kjær charge amplifier model 2626
Brüel and Kjær charge amplifier model 2635 (x2)
Ono-Sokki model CF 920 2-Channel FFT analyzer

Why choose Flywheel for LCF

- ✓ Registered with Canada's Controlled Goods Directorate
- ✓ Certified to receive unclassisfied military critical technical data by the Canada/U.S. Joint Certification Office of the Defense Logistics Information Service
- ✓ End-to-end job traceability
- ✓ Comprehensive test documentation
- ✓ In-situ multi-plane precision balancing
- ✓ High efficiency PMSM drive technology
- ✓ Reduced drive energy costs
- ✓ Lower cyclic cost base
- ✓ Reduced CO_2 emissions from LCF testing

How to request a quote

- Contact us for a non-disclosure agreement
- Preliminary technical data disclosure
  - Rotor material(s), diameter, length, mass, J_p, J_t
- Test plan description
  - Load profile
    - ω_{max}, ω_{min}, applicable dwell time(s), no. of cycles
    - an alternative description of more complex load spectra
  - Environmental constraints
    - permitted gas type, pressure, temperature
  - Data capture requirements
    - number of displacement, acceleration, and temperature traces
  - End of life description
    - expected failure mode(s), success criteria, failure criteria

Contact us

For more information, please contact us.

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