Advanced Locomotive Propulsion System

project overview

Project Objective

The objective of the Advanced Locomotive Propulsion System (ALPS) project is to operate a hybrid propulsion system consisting of a gas turbine prime mover, energy storage flywheel and high speed alternator in a railroad environment. The ultimate goal of the project is to develop a fossil fueled locomotive capable of sustained speeds of 150 mph with acceleration comparable to an electric locomotive, improved reliability and efficiency, and reduced exhaust emissions.

Team Members

- The University of Texas at Austin Center for Electromechanics
- AlliedSignal Aerospace
- AlliedSignal Engines
- Argonne National Laboratory
- Association of American Railroads
- AVCON Advanced Controls Technology
- Center for Transportation and the Environment (CTE)

The first step in developing a higher speed, non-electric passenger locomotive is to replace the heavy diesel engine with an advanced gas turbine engine. The higher rotational speed of the turbine makes it much smaller and lighter than the diesel for the same power level.

While there are significant size and weight advantages to turbines for high-speed locomotives, there are issues with the use of turbine powered locomotives. First, a turbine is generally less efficient than a diesel and will therefore not provide the same fuel economy. Fuel economy is further compromised when the turbine is operated at low power during deceleration or constant train speed operation. Second, maintenance requirements for turbine engines are strongly dependent on the number of thermal cycles.

Initial simulations of turbine powered locomotives on high speed rail corridors indicate that thermal cycling due to variable power demands will require an engine overhaul at least once per year of operation. Use of the energy storage flywheel compensates for these limitations. During acceleration and grade negotiation, turbine power can be supplemented with additional power from the flywheel. During regenerative braking, a portion of the kinetic energy of the trainset can be captured by the flywheel and returned to the traction system, improving overall system efficiency. The flywheel also enables short term load leveling of the gas turbine, reducing the number of thermal cycles. During steady state turbine operation, the flywheel can be accelerated when excess turbine power is available or decelerated to provide power for increased traction system power demands.

Figure 1 shows the basic configuration of the ALPS locomotive propulsion system.

Project Description

The ALPS team is developing several technologies for application to propulsion systems for high speed rail. The 3 MW high speed alternator is an eight pole, three phase synchronous alternator designed to operate at 15,000 rpm. Operation at this speed will allow the alternator to be directly driven by a compact 4,000 hp TF40 gas turbine, significantly reducing the size and weight of the prime mover for the locomotive. Figure 2 is a picture of the high speed generator during laboratory testing at The University of Texas Center for Electromechanics facility in Austin, Texas.

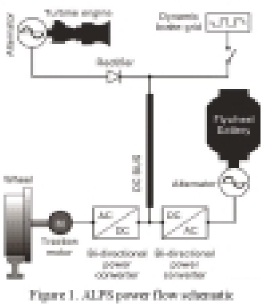

Figure1. ALPS power flow schematic

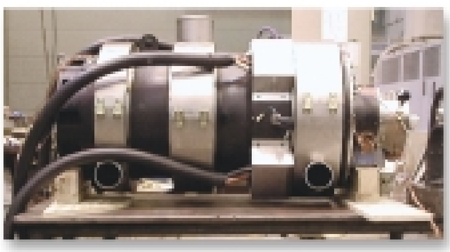

Figure 2. Generator during lab testing.

The flywheel is designed to store 480 MJ at 15,000 rpm and provides up to 2 MW of supplemental power for acceleration and grade negotiation, and enables recovery of braking energy, improving overall system efficiency. The flywheel will also provide load leveling for the turbine, greatly extending maintenance intervals by minimizing thermal cycling. The flywheel rotor is built of high performance graphite epoxy composites and is levitated on non-contacting magnetic bearings. The flywheel incorporates a composite containment liner that contributes to safe operation. A compact high performance bi-directional power converter is also being developed to interface the flywheel and its motor/generator with the locomotive dc bus. Figure 3 shows a cutaway view of the flywheel and a picture of the assembled flywheel in the laboratory.

Project Results

The ALPS project has completed fabrication and assembly of the high speed generator and has begun laboratory testing. The energy storage flywheel has been partially assembled in preparation for low energy testing of the magnetic bearing system. Fabrication and assembly of the remaining components of the propulsion system is in progress.

Next Steps

In addition to applications for high speed passenger locomotives, the ALPS concept can also be used for commuter and light rail transit applications. The components of the propulsion system can also be used to provide distributed generation for remote site power as well as improved power quality and UPS application for the utility and process industries.

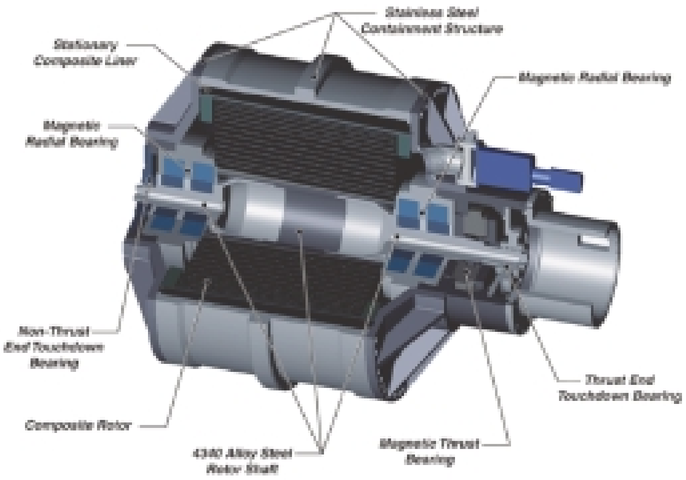

Figure 3. ALPS energy storage flywheel.

Center for Transportation and the Environment
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