NFPA Sponsored Project

Hydrostatic Wind Turbine

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The goal of this project was to develop a hydrostatic transmission for a one kW wind turbine to provide renewable energy for third-world communities. The Innovative Engineers group at the University of Minnesota has fabricated multiple one kW wind turbines for third-world communities, including an installation in La Hermita, Nicaragua. Two major challenges previously encountered with these small wind turbines is managing the large variations in power with a directly driven generator and managing over-speed protection. To address these challenges, a hydrostatic transmission was proposed.

The team, consisting of nine mechanical engineering and electrical engineering students, modeled, designed, fabricated, and tested a hydrostatic transmission in a custom one kW wind turbine. The transmission consists of a variable displacement axial piston pump directly coupled to the wind turbine rotor and a variable displacement axial piston motor, located at ground level, coupled to an electric generator through a synchronous belt drive. The system uses the hydraulic power generated from the wind to actively control the angle of the vane of the wind turbine to turn it out of the wind during region 3 operation to avoid overloading the hydraulic and electrical systems. Further protection is provided through an actively controlled disc brake that can stop the turbine rotor during extreme wind speeds to avoid structural damage.

To date, all of the subsystems of the wind turbine have been constructed and the system will be raised this coming weekend at a site on the St. Paul campus of the University of Minnesota. Last year, the team deployed a wind speed anemometer on this same site and has been collecting wind speed data. These data were implemented in a multi-energy domain computational model to size the individual components for maximum total energy capture. The team constructed a CAD model of the wind turbine and transmission and fabricated the custom components in the student machine shop. All of the subsystems and control methodology were tested in the Mechanical Energy and Power Systems Laboratory using a hydraulic power supply.

The project was a great success in exposed socially concerned undergraduate engineering students to fluid power while also creating a research tool for studying hydraulic transmissions in the emerging market of wind power. The team will be presenting their work at the National Conference on Undergraduate Research (NCUR), which will take place in April 11-13, 2013 at the University of Wisconsin-La Crosse. The team greatly appreciates the support from NFPA, the Center for Compact and Efficient Fluid Power, and Innovative Engineers.

Figure 1. Assembled wind turbine in the laboratory.

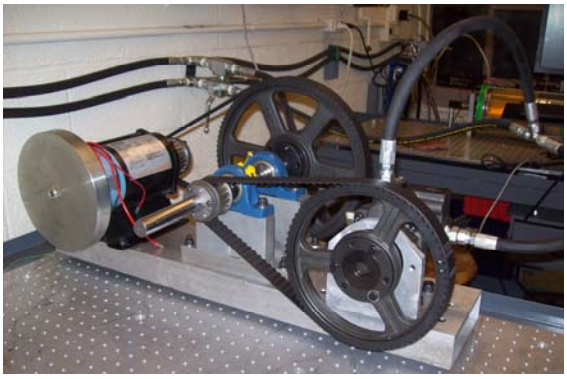

Figure 2 (top). CAD model of wind turbine nacelle.
Figure 3 (bottom). Electric generator driven by the hydraulic motor through a synchronous belt drive.

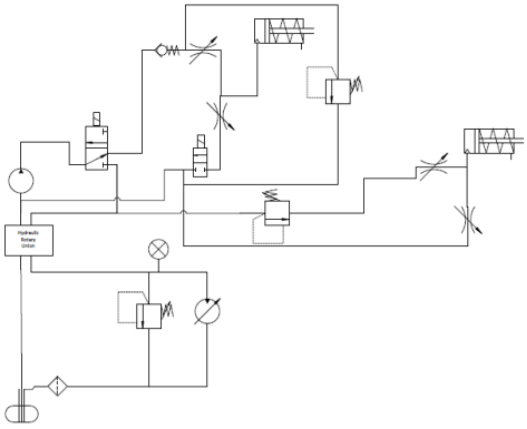

Figure 4. Hydraulic circuit drawing.

Figure 5. Student team picture.

Figure 6. Machining in the student shop.