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Optimization of Renewable Energy Penetration in Hybrid Systems through Pneumatic Hybridization of Diesel Generators

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Abstract

One of the most difficult challenges facing our society is reducing Greenhouse Gas (GHG) emissions to mitigate climate changes and their effect on the planet. Most of the GHG emissions in Canada are from fossil fuels for transportation, heating, and electricity production in remote areas with diesel generators.

A typical diesel engine and its turbocharging system are optimized to operate most efficiently at 75-85% of the maximum charge. At this regime, the turbo-compressor is designed to provide the airflow that allows the optimal Air/Fuel ratio corresponding to maximum indicated efficiency. Outside this optimal regime range and especially at a low charge, the efficiency decreases considerably as the airflow provided by the turbocharger is insufficient to ensure an optimal A/F ratio. The Pneumatic Hybridization of Diesel Engines (PHDE) uses stored compressed air and heat to ensure optimal temperature and pressure at admission, such as Air/Fuel ratio is optimal. Consequently, the indicated efficiency is maximum at all operating regimes.

As such, PHDE significantly improves the renewable energy penetration in hybrid Wind-Diesel systems with Compressed Air Storage (WDCAS). In a typical WDCAS application, we have higher wind power penetration, and the surplus of wind power during strong winds is used to compress and store energy used afterward for PHDE. The heat is recovered and stored during compression using a Heat Energy Storage (HES) system. When the wind energy is insufficient to supply the charge, the stored energy is used to compress air and overcharge the diesel to operate at optimal Air/Fuel ratio at each regime. Before entering the engine, the compressed air is heated using the HES reserve. Compared with a wind-diesel system without storage, the overall renewable energy percentage increases by 30% to 60%.