INDUSTRIAL ENERGY RECOVERY ANALYSIS USING VARIABLE FREQUENCY DRIVE MOTOR DYNAMOMETER/HALBACH ARRAY

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ABSTRACT

The need for an energy recovery test bench that could be used to analyze and simulate potential usage scenarios for a variety of industrial applications will be addressed. This addresses energy recovery concerns in the industrial space and can provide decision information on possible returns on investment for upgrade or equipment additions. The experimental portion uses a high speed industrial Halbach Array motor paired to a high-speed spindle motor for power input while still allowing the ability to incorporate multiple study configurations. A dynamometer was designed to limit outside variables pertaining to the unique circumstances of the Halbach Array in the study, paired with LabVIEW and an electrical control panel housing the various sensors for data acquisition and analysis. The system uses phase voltage and current to analyze apparent power losses and energy recovery ability of the equipment without the need for torque and speed measurement or equipment specific estimates and calculations. Motor load of the Halbach Array was simulated using sinusoidal, ramp, and manual step input functions. These functions represent normal circumstances, such as gravitational potential loading and deloading as well as solar, tidal, and wind power generation, that a motor may experience in the field. The results of the simulation show an average the electromechanical conversion efficiency of 51.38 percent over all simulation functions for the power conversion from spindle motor to Halbach Array. The results also show under certain circumstances such as lower speeds of the motor paired with a gradual rate of change in the frequency input by the variable frequency drive, the efficiency could achieve upwards of 73.3 percent. The results also show that likewise, given undesirable conditions such as quick erratic changes, or higher speeds, efficiency will fall with the lowest being 43.3 percent. The implications of the results show that the test bench dynamometer and data acquisition system achieved the goal in providing information that can help advise on energy regeneration systems and efficiency of motors. The experiment was also able to show that there may be additional benefits to the design of the Halbach Array motor and testing apparatus by the addition of a purpose-built power controller, as well as electrical and mechanical sensors to corroborate load conditions.

INTRODUCTION

Emphasis on smarter energy usage has arisen due to the increasing demand on current infrastructure, leading to higher costs and penalties for high draw applications in the industrial space. In order to determine the potential recoverable energy of mechanical output systems, a method needed to be developed to properly analyze, control and recover generalized mechanical energy, in order to feed recovered energy back into the grid or storage systems.

EXPERIMENTAL

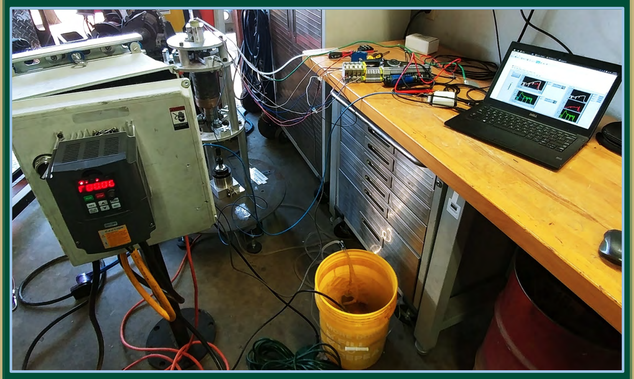
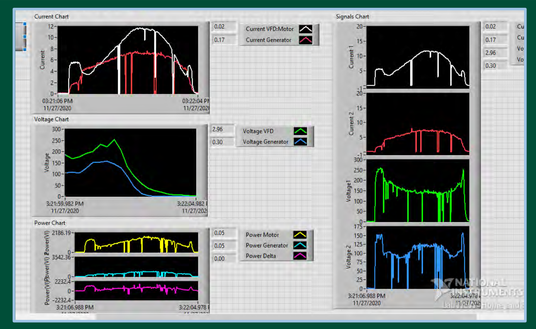
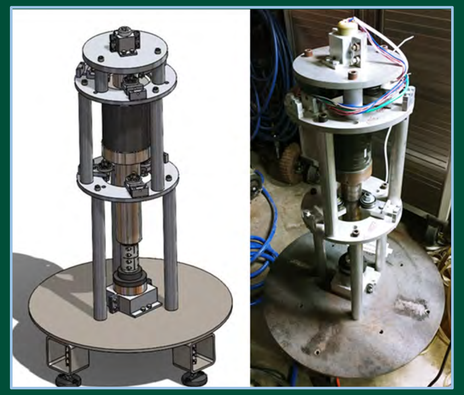


Figure 1: The Test Bench consists of the electrical control panel, VFD, high-speed dynamometer and computer running the LabVIEW DAQ system.

RESULTS & DISCUSSION

Figure 2: (Right) LabView Front Panel Showing Current, Voltage and Power for a Ramping Function Test Simulation.
Figure 3: (below) 3D model of the dynamometer featuring Halbach Array motor





Test Bench Performance and Evaluation

- Positive Simulation Data Output Result.
- 50% Average motor efficiency rate.
- Highest efficiency rate achieve at 73%.
- Better performance during low acceleration of Halbach motor.
- Design-Specific Power Controller would likely aid in Motor efficiency gains.

	Sum Power Motor (VA)	Sum Power Generator (VA)	Sum of Power Delta (VA)		
Total Period Sum	74172.59992	38945.87407	36407.44717		
1st Step Interval Sum	14271.77305	3880.837966	10472.31786		
2nd Step Interval Sum	60616.09193	35477.96316	26237.46731		
Total Period Average	3708.629996	1947.293703	1820.372359	%Efficiency	49.08%
1st Step Interval Ave	2378.628842	646.8063277	1745.386311	%Efficiency	73.38%
2nd Step Interval Ave	4329.720852	2534.140226	1874.104808	%Efficiency	43.28%

Figure 4: Halbach Array Efficiency evaluated for entire test simulation and period specific Performance

ANALYSIS & SUMMARY

Intended Application and Use

- Achieves Design Intent to Test Industrial Motor applications for energy evaluation.
- Inclusion of Torque and Speed sensors recommended for more advanced testing.
- Will be used for Electro-Mechanical Conversion Course.

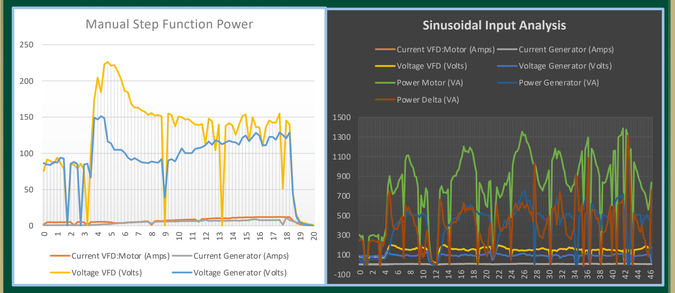


Figure 5: Step and Sin Input Analysis: current voltage and power

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