

AC Kinetics Variable Frequency Drive Transient Testing (60Hp)

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Introduction

In 2014, AC Kinetics contacted Advanced Energy in regards to testing their newly developed Variable Frequency Drive (VFD) control technology. Multiple sets of comparative tests were completed throughout that year. AC Kinetics has now expanded the scope of their test plan to include energy consumption under transient inertial loading conditions. This testing was conducted to replicate a paper winding application in a Georgia Pacific plant in Savannah, GA. Data was taken from the winder by AC Kinetics, and a load profile developed to mimic the operation of that winder. The winder currently uses a 60Hp Marathon motor that is controlled by a 60Hp VFD-6*. Comparative inertial tests were conducted on a 60Hp VFD-6* and the AC Kinetics VFD.

A 60Hp motor and 60Hp VFD-6* were purchased by AC Kinetics and sent to Advanced Energy for the testing. The motor and VFD are the same models as the ones used on the paper winder in the Georgia Pacific plant. Nameplate data for the motor and VFD-6* drive is shown in Appendix A. Nameplate data for the AC Kinetics drive was not available during testing.

VFD settings were downloaded from the VFD-6* in the Georgia Pacific plant and uploaded to the VFD-6* tested by Advanced Energy. Both the VFD-6* and AC Kinetics VFD were operated in Vector Mode using an encoder (supplied by AC Kinetics).

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Test Procedure

Test Set Up

Inertial load testing using the 60Hp motor was performed on one of Advanced Energy's AC dynamometers. The inertial load came from a larger electric motor having approximately 14 times the inertia of the rotor in the 60Hp Marathon test motor. This best approximated the inertia of the paper winder based on the data recorded by AC Kinetics. A rotary torque transducer connected the test motor to the inertial load and provided torque and speed feedback. A diagram of the test setup is shown in Figure 1.

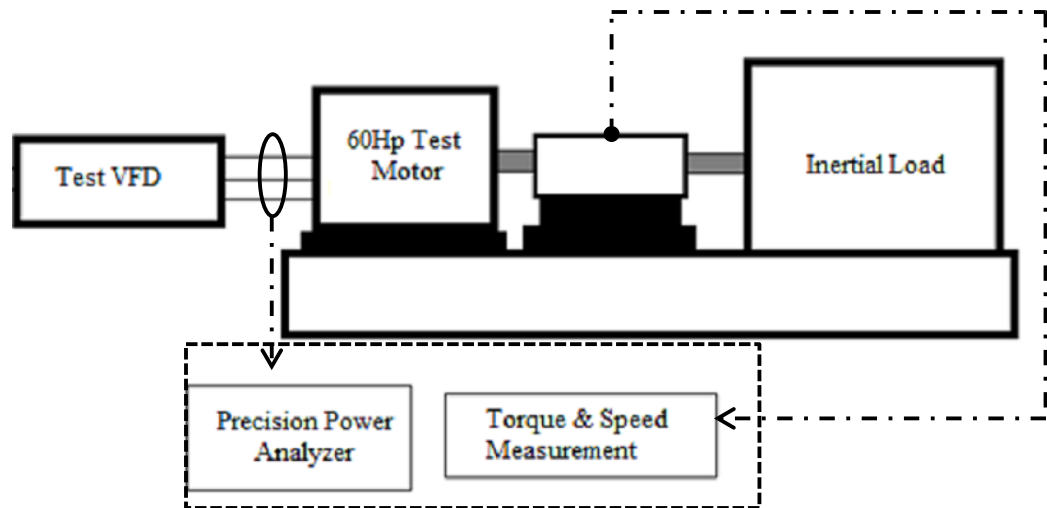


Figure 1: Test setup diagram

Any regenerative energy created during testing was diverted through a braking transistor and into a resistive load bank of adequate size. Both the VFD-6* and AC Kinetics VDF used the same braking transistor and load bank, each supplied by Advanced Energy.

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The AC Kinetics VFD lacked the AC rectification components necessary to create a DC bus. The DC bus from an independent VFD was used to power the AC Kinetics VFD. All electrical measurements were recorded at the motor terminals using Advanced Energy's Yokogawa WT-3000 Precision Power Analyzer.

Test Data Points

The paper winder was found to operate at two different speed profiles. The profiles are similar in shape, but the winding speeds are different. With input from AC Kinetics, Advanced Energy created two speed profiles to mimic the operation of the paper winder. The first profile began with an acceleration from 0RPM to 1076RPM followed by a series of controlled transitions between 1076RPM and 1550RPM over a 10 minute period. Likewise, the second profile began with an acceleration from 0RPM to 1162RPM followed by a series of controlled transitions between 1162RPM and 1550RPM also over a 10 minute period. The speed profiles were converted into a series of approximately 3,000 discrete points that best approximated the supplied speed profile. The profiles were then appropriately scaled into a 0-10V analog signal. Advanced Energy's data acquisition system supplied the scaled analog signal to the VFD-6* and AC Kinetics VFD's which were configured to accept an external speed control reference. Plots of the applied speed profiles are shown in Figures 2 and 3.

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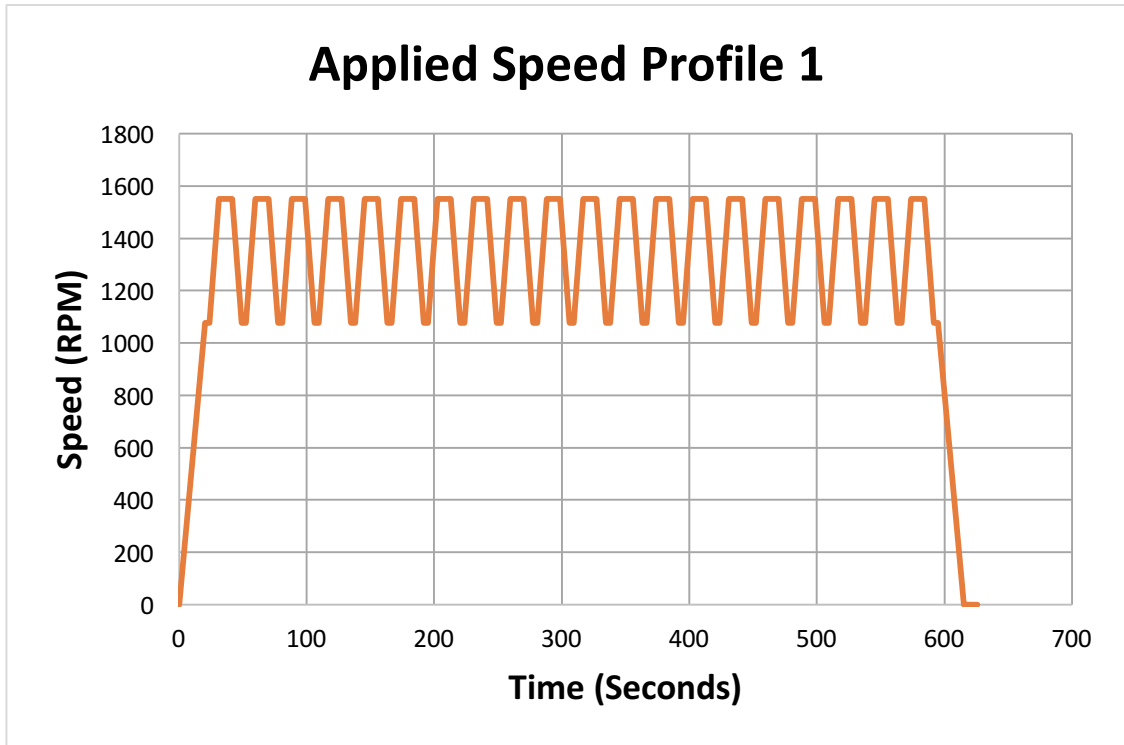


Figure 2: First applied speed profile

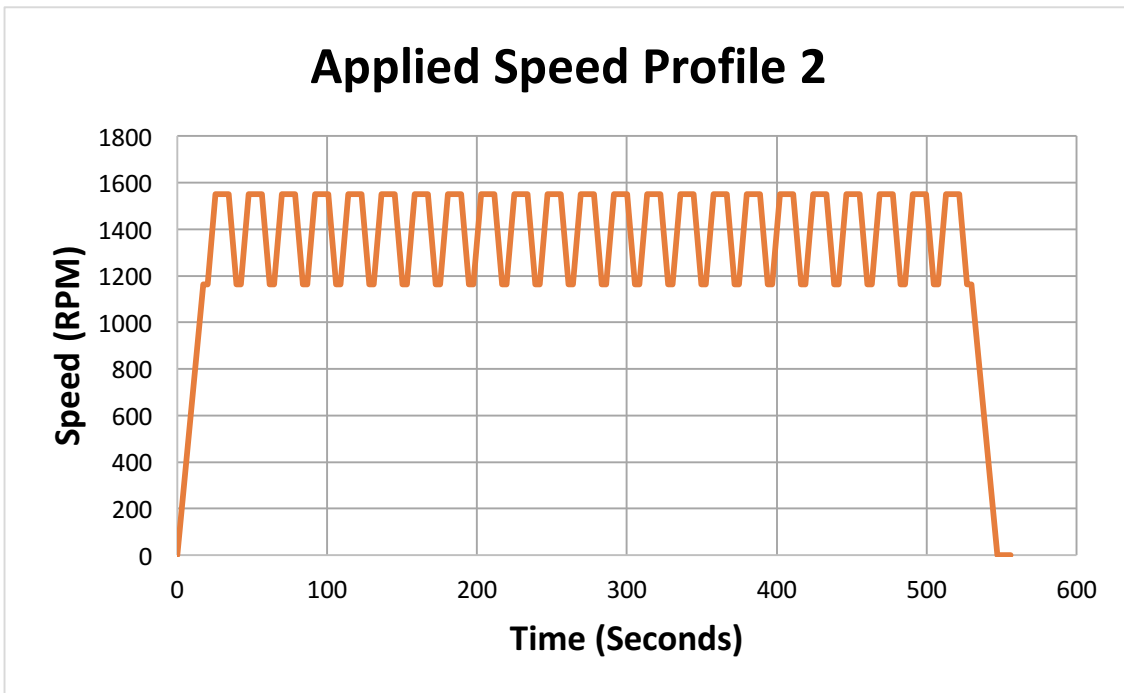


Figure 3: Second applied speed profile

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During each speed profile run, energy input to the motor was recorded using the built in watt-hour register functionality of the WT-3000. The speed profile was applied to each motor/VFD combination multiple times clearing the watt-hour register on the WT-3000 before each run.

Test Results

A performance comparison was carried out on the basis of total energy (watt-hours) into a 60Hp motor as measured at its input terminals. The best three runs through the speed profile from each motor/VFD combination were compiled and used in the comparative analysis between the competitor VFD and AC Kinetics' proprietary VFD control technology. Results from the inertia testing conducted on each 60Hp motor/VFD combination is provided in Table 1 for the 1076RPM base speed testing. Results from the inertia testing conducted on each 60Hp motor/VFD combination is provided in Table 2 for the 1172RPM base speed testing.

In Tables 1 and 2 the Wh+ register represents the watt-hours consumed by the motor during each ten minute load profile. The Wh- register represents the watt-hours returned to the power supply. The Wh_{total} register represents the summation of the Wh+ and Wh- registers.

Table 1: VFD-6* & AC Kinetics VFD Comparison (Profile 1)

Trial	VFD-6*			AC Kinetics VFD		
	Wh+	Wh-	Wh _{total}	Wh+	Wh-	Wh _{total}
1	1,530.6	1,013.2	517.4	767.9	346.0	421.9
2	1,524.7	1,014.3	510.4	760.5	346.8	413.8
3	1,521.7	1,014.2	507.5	764.8	346.6	418.2
Average	1,525.7	1,013.9	511.8	764.4	346.5	418.0
% Energy Reduction				49.9%		18.3%

Table 2: VFD No. 6* & AC Kinetics VFD Comparison (Profile 2)

Trial	VFD- 6*			AC Kinetics VFD		
	Wh+	Wh-	Wh _{total}	Wh+	Wh-	Wh _{total}
1	1437.4	939.5	497.9	717.2	321.0	396.2
2	1433.8	940.5	493.8	712.1	321.8	390.3
3	1425.0	940.8	484.3	710.7	324.1	386.6
Average	1432.1	940.8	492.0	713.3	322.3	391.1
% Energy Reduction				50.2%		20.5%

To evaluate possible cooler motor operation during extended transient inertial loading conditions, cycles were added to Speed Profile 2 to create a 30 minute total test period. This extended profile was applied to the VFD-6* first and the motor allowed to cool before beginning the profile run on the AC Kinetics VFD. Initial motor and ambient temperatures were the same before the speed profile was applied to each VFD. No attempt was made to cycle the motor until it reached thermal equilibrium on either VFD. A plot of motor Temperature vs. Time is provided in Figure 4.

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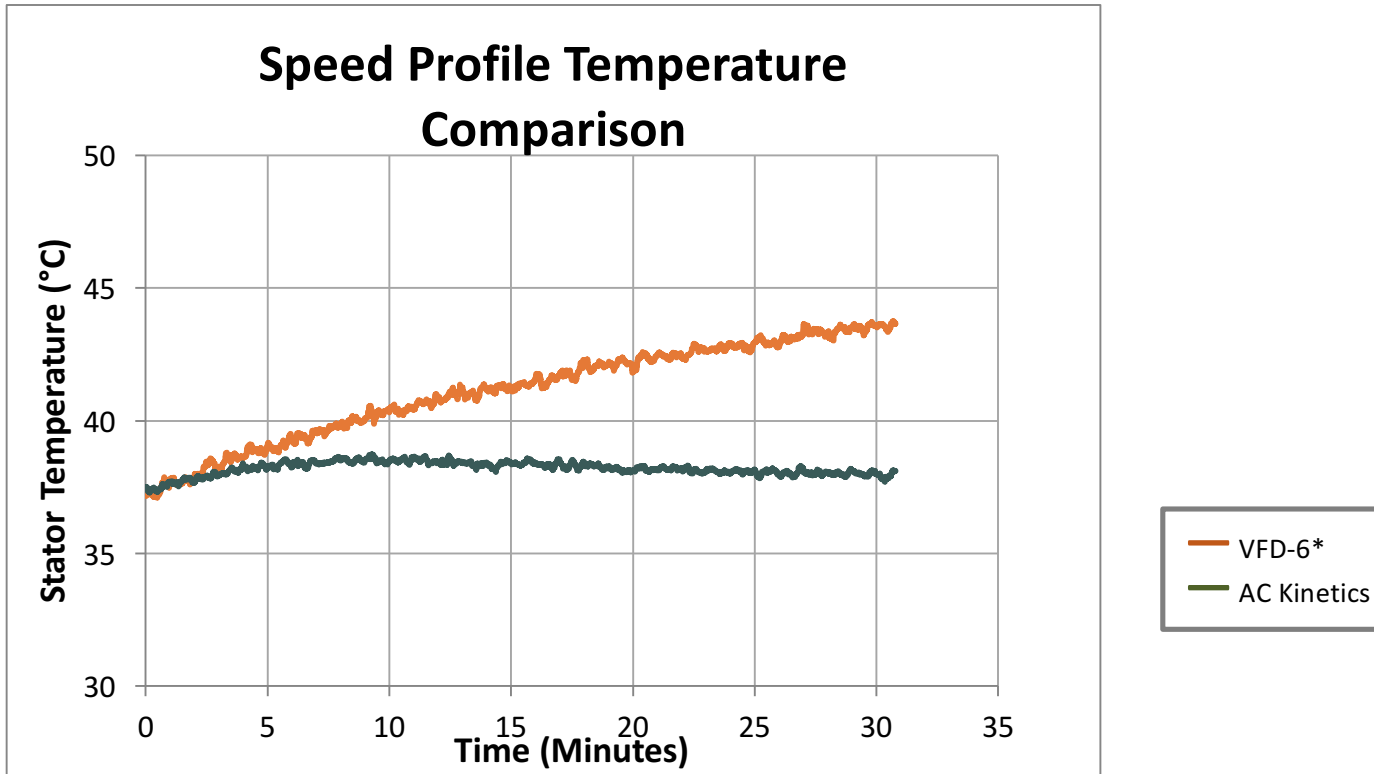


Figure 4: Temperature comparison

Conclusion

Comparative inertial testing was carried out between a commercially available VFD-6* and AC Kinetics' proprietary VFD control technology. This report covers the findings of the comparative inertial testing performed using a 60Hp motor and VFD.

Inertial test results show that the AC Kinetics VFD has significant energy saving potential under transient loading conditions when compared to the motor and drive tested. During an extended period of continuous inertial cycling AC Kinetics control strategy also showed a reduction in overall motor temperature compared to the commercially available VFD.

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Appendix A:

Nameplate information of motor and commercially available VFD used.

Table A1: 60Hp Motor Nameplate

60Hp Motor Nameplate			
Sample Number:	2876	Phases:	3
Rated Voltage (V):	230/460	Frequency (Hz):	60
Rated Output (Hp):	60.0	Rated Speed (RPM):	1782
Rated Current (A):	147/73.5	Sync. RPM:	1800
Frame:	364T	Type:	TFS
NEMA Design:	A	Encl.:	TEFC
Nameplate Eff.(Nom):	92.4%	Ins. Class:	H1
Nameplate Eff.(Min):	-	SF:	1.00
Power Factor:	0.83	Code:	J

Table A2: VFD-6* 60Hp VFD Nameplate

VFD-6* 60Hp VFD Nameplate: ND (HD)			
Sample Number:	2899	Output Voltage (V):	0-460
Input Voltage (V):	432-528	Output Current (A):	96 (77)
Input Current (A):	90.1 (72.3)	Output Frequency (Hz):	0-400
Input Frequency (Hz):	47-63	Output Phases:	3
Input Phases:	3	Power (Hp):	75 (60)

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Appendix B:

Reported Data and Republication

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