Owl Energy Technologies

FAIRFORD ELECTRONICS

White Paper investigating a technology for improving the energy efficiency of Fixed Speed Alternating Current Motors, Commercial and Industrial Applications:

This example: Oil Field Pump Jacks

Other possible applications: Plastic Injection Molding Machines, Compressors, Conveyors and more

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iERS intelligent energy recovery system

Abstract

Pump Jacks are the work horses of onshore oil wells that require mechanical lift due to the insufficient pressure at the bottom of the well. The AC induction motor that controls the Pump Jack has a number of inefficiencies and losses that cause energy wastage.

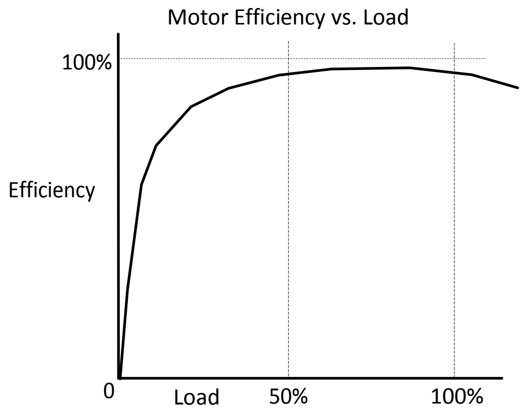
This paper will investigate the losses attributed with these motors. It will detail a technology which helps to reduce the losses within these motors to reduce the energy consumption and carbon footprint of the sucker rod pump jacks.

Finally it will detail a test on a 50HP Baldor motor controlling a pump jack installed at the Hawn Holt Project in Gonzales County, Texas, Eagle Ford Shale Formation.

Contents

The Problem

AC induction motors are designed to run at the highest efficiency when the motor is between 75 - 85% load. As the load is reduced the overall efficiency of the motor declines and the losses inherent within the motor play a bigger part in the overall inefficiency of the system.



When the load drops below 30 – 40% the efficiency declines. By reducing the losses in this portion of the loading cycle, the energy efficiency of the motor could be dramatically improved. The losses present in an AC induction motor are:

- Load Losses (i^2R Losses) - these are losses in relation to the heat produced by electrical current flowing in the conductor.
- Stray Losses - caused by the higher flux density harmonics due to the slotting effects into the bar rotor currents and skewing.
- Mechanical Losses - caused by friction in the bearings, belts and cooling fans.
- Iron/Excitation Losses (Magnetizing Losses) - these are voltage related and therefore are constant for any motor irrespective of load. The magnitude of these losses is determined by the construction of the motor. At low load, the greatest proportion of losses is the iron loss and produces a lower power factor.

In a pump jack, the motor driving the crank experiences different loads throughout the cycle. In one part of the cycle the motor is fully loaded (or even nominally overloaded), then as the counter weight begins to drop the load declines, and during part of the cycle the motor is also in a generation phase.

When the motor is in the low load phase the iron losses are still fixed, however the amount of energy supplied to the motor is higher than is required to maintain the speed at this load.

The Solution

In the 1970's Frank Nola, of NASA, developed an algorithm for reducing the iron losses in single phase motors. This was used to reduce the energy consumption of single phase motors on the Apollo rockets.

In 1982 Fairford Electronics was the first company in the world to design and produce a three phase digital energy saving soft starter. This product has continually been modified and improved by Fairford and the most recent products launched are the most advanced motor controllers for fixed speed motors ever conceived.

The intelligent Energy Recovery System (iERS), standard on all Fairford motor controllers and included in the Boxer Pump Jack Controller, reduces the iron losses on fixed speed AC induction motors which in turn reduces the amount of energy consumed when the motor is lightly loaded. The iER system achieves this by monitoring the running power factor of the motor. When the power factor drops (which indicates the motor is lightly loaded), the iER system detects this and reduces the voltage and current to the motor to only supply the exact amount of energy required to maintain full speed, causing a reduction in power demanded by the motor (kW) and an improved fractional load power factor.

Another feature incorporated into the Boxer, which has been specifically designed for pump jacks, is Impact Load. Due to the cycle time being fairly short and the change of load rapid, the frequency at which the unit monitors the load and makes changes to the Voltage and the Current has been increased. This ensures the best energy savings possible and reliable running of the pump jack is maintained.

Testing of the Boxer

On the 4th of February 2013, Fairford Electronics and Houston Motor & Control undertook testing and measurement of the Boxer on a Pump Jack at the Hawn Holt Project in Gonzales County, Texas, Eagle Ford Shale Formation.

Pump Jack Model: C640D-365-144
Motor: Baldor 50 HP Nema D 1125 RPM ODP
Controller: The Boxer, which included a QFE85K Motor Controller
Power Meter: Metrel M2092 Power Analyzer

Methodology

The Boxer was connected directly to the motor to allow for full control and the power meter's voltage probes were connected to the input of the QFE Motor Controller. The Current Transformers were connected to the output of the QFE Motor Controller.

The Pump Jack was run for 30 minutes with the energy saving feature turned off and the data were recorded. Once the 30 minutes had elapsed the energy saving feature was turned on and the Pump Jack was run for an additional 30 minutes and the data were recorded.

The figure above shows the Boxer, QFE Motor Controller and Metrel Power Meter

Results

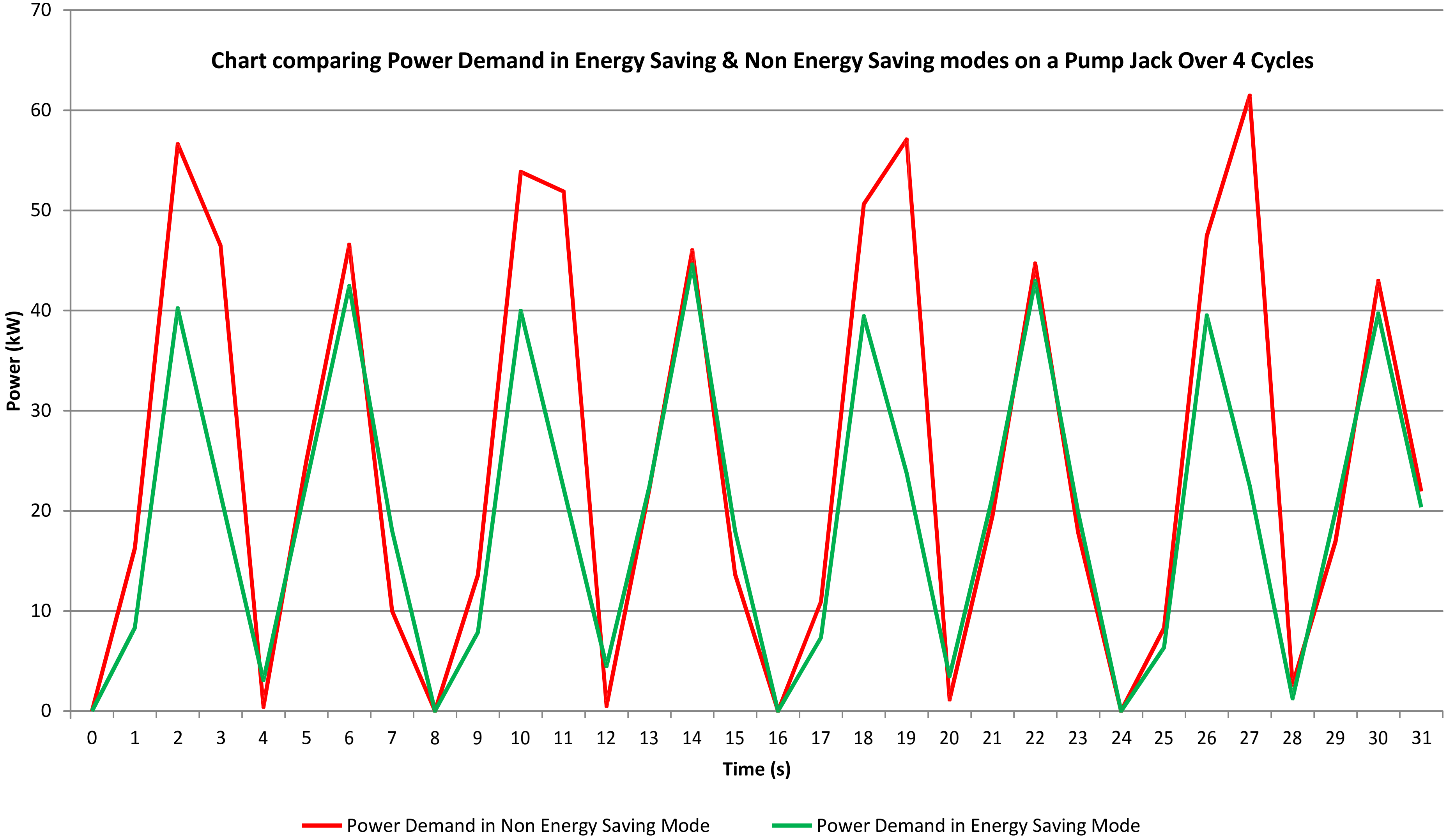
A reading was taken every second and the following information was collected: Average Demand in kW, Average Power Factor, Average Potential in Volts (all three phases) and Average Current in Amps (all three phases).

The first results taken were comparing individual cycles; four cycles were taken from the start of the 30 minute non energy saving period and compared against subsequent cycles in the energy saving period.

Data Point	Demand when not Energy Saving (kW)	Demand when Energy Saving (kW)	Data Point	Demand when not Energy Saving (kW)	Demand when Energy Saving (kW)
0	0	0	16	0	0
1	16.26	8.32	17	10.93	7.34
2	56.61	40.22	18	50.64	39.42
3	46.48	21.52	19	57.07	23.75
4	0.44	3.08	20	1.16	3.49
5	24.98	23	21	19.52	21.38
6	46.57	42.43	22	44.68	42.94
7	9.98	18.03	23	17.82	19.82
8	0	0	24	0	0
9	13.57	7.86	25	8.28	6.34
10	53.85	39.95	26	47.44	39.49
11	51.88	22.44	27	61.45	22.5
12	0.51	4.49	28	2.63	1.27
13	22.23	22.42	29	16.96	19.93
14	46.02	44.58	30	42.95	39.68
15	13.64	17.97	31	21.93	20.35

Figure 1 – Table comparing the demand (kW) with the Energy Saving feature enabled and disabled over 4 cycles of the pump jack.

Please note the regen proportion of the cycle was not recorded on this test.



The Chart above shows the power consumed by the motor with the energy saving feature turned off (Red) and then with the energy saving feature turned on (Green).

Results (con'td)

- The average power demand of the motor over the four cycles when the energy saving feature was turned off was 25.20 kW.
- The average power demand when the energy saving feature was turned on was 19.50 kW.
- This yielded a kW saving of 5.7 kW. This equates to an energy saving of 22.63%.

Taking the above information as a basis, the next set of results to be compared was the average energy consumption over the entire 30 minutes. The full data table can be provided on request.

- The average power demand of the motor over the non-energy saving 30 minute interval was 23.99 kW.
- The average power demand of the motor over the energy saving 30 minute interval was 19.85 kW.
- This yielded and energy saving of 4.14 kWh or 17.27%.

What does this mean in real terms?

This particular Pump Jack runs for 12 hours per day, 7 days per week, which is typical for this type of pumping system.

Over the course of the year the Pump Jack runs for 4380 hours.

From the information above the energy saved per hour is 4.14kWh, so the energy savings over the year will be 18,133kWh.

Based on a unit electricity cost of $0.1/kWh, the annual saving will be $1813.

Conclusion

In conclusion, by utilizing the Boxer Pump Jack Controller with the Fairford iER System, the energy consumption of pump jacks can be reduced by, on average, 17%. These are significant energy savings and in addition to this, utilizing the soft start feature will also help to: reduce the peak in-rush current, reduce the strain on the mechanical components, reduce unscheduled down time, reduce motor temperature which will increase the motor life which all plays a part in reducing your carbon foot print along with reducing pump jack related expenditures.

The Boxer and iER System is a tried and tested technology which has been extensively used in over 80 countries worldwide with great success. It is an incredibly simple product to install and maintain as no regular input from the user is required to manage this technology in its normal operation.

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