

**DIGITEK
AND
ENERGY SAVING ON OIL PUMP JACKS
IN CHINA**

DIGITEK TECHNOLOGY

1. INTRODUCTION

Since the oil crisis in the 70's, energy conservation has become a mainstream issue worldwide and energy conservation research has become exceptionally active thereafter. In the late 70's, US NASA scientists had noticed that an AC induction motor consumes more energy than needed at low load and further suggested a method to save the wasted energy. Though it has been more than twenty years after the idea was first suggested, there has been limited progress in practical application due to limitation on the electronic technology. On the other hand, oil has become one of the power sources and the production of oil requires electricity. In the United States, in different areas the electricity rates are different and in some areas the oil production cost on electricity is as high as 40% of the total production cost. Therefore an efficient energy saver for oil pump jack is important for cutting down the oil production cost. Furthermore, saving on electricity from oil production not only can help further development of other industries, it also lowers the environmental contamination and reduces ecological damage.

2. Features of oil pump jack

Oil pump jack has the following features:

- a. An oil pump jack motor has a special characteristic. In each cycle there are two high loads and two low loads. There are different types of pump jacks with different cycle periods. In general each cycle is about 10 to 16 seconds. Some of the pump jacks can be as fast as 5 seconds per cycle.
For a type 12 pump jack, it is about 15 seconds per cycle with heavy load less than 5 seconds. In other words, a pump jack motor has only about 30% at heavy load each cycle. 70% of each cycle the load is below 50% of the rated power. At low load, the real power is small and the reactive power is large, and the power factor is small. In general, at low load the power factor is less than 0.3.
- b. It saves more energy when the difference of the currents at the two heavy load picks is smaller. In general, it is better to be smaller than 20 ~25 amps.
- c. In each cycle there is a short period while the motor generates electricity.
- d. The motor runs continuously for a long time.
- e. Depending on the power supply condition, there might be some

instability on the power supply. Though the rated voltage is 380 V in China, there might be a big instability on the voltage. It can be as high as 420 V and as low as 310 V. The large instability on the voltage makes the design of an energy saver more difficult.

- f. The motors are installed in the field and it is not so easy to monitor the motor operation.

3. The features an energy saver for oil pump jack motor should have

Based on the characteristics of an oil pump jack described above, an energy saver for oil pump jack should have the following features:

- a. Energy saving should vary as the load is changed. At high load the energy saving in percentage is smaller in order to maintain the needed torque and at low load the energy saving in percentage is better.
- b. The period of each cycle is different depending on the type of the pump jack, therefore the reaction speed on the energy saving should be adjustable depending on the load variation speed.
- c. The motor can continuously run for long time.
- d. During the power generation period, the energy saver should not be interfered by the possible eddy current.
- e. In general, there is less voltage variation on the industrial power and the design for its application is easier, but for oil pump jack an energy saver should be able to accommodate the special situation of large instability on the voltage. Its design is more involved. When the supplied voltage is already very low, one should not lower the voltage further for energy saving purpose so that the torque will not be too low for normal operation. Therefore it should be able to switch to no saving mode when the supplied voltage is too low.
- f. It should have automatic protection features such as phase loss protection, over current protection etc.

4. Energy Saver and Energy Saving on Oil Pump Jack

A good energy saver for an oil pump jack should have the following features:

- a. Saving real power.
- b. Saving reactive power.
- c. Providing phase loss protection.
- d. Prolonging the life span of the motor.

Saving on real power:

Saving on wasted energy usually means saving on real power KW charged by the utility company. Saving on real power not only save electricity cost but also prolongs the life span of motors. The wasted energy not only raises the temperature of a motor, but also increases its vibration and friction, and as a result shortens the life span of the motor. In the market, there is often some misconception on the energy saving. An energy saver should mean saving on real energy. Very often capacitors for power factor enhancement is also called energy saver. There are a few ways to save the real power.

- a. Lower the voltage by brut force such as using variable voltage transformer (e.g. variac):

In area where the voltage is higher than the rated voltage, this is a useful way to save some energy. However, the energy saving is quite limited. Furthermore, for motor with variable load this mechanism might effect the proper operation of the motor and might create problems. For oil pump jack use of variable voltage transformer is not adequate.

- b. Intermittent operation of oil pump jack:

This is the most primitive way to save energy. For some of the old well, when the oil level is low one can stop pumping oil by stopping the motor. In practice, there is some difficulty in design a device that can effectively detect the level of the oil. Especially for a well with high content on sand there is high risk of having the well dead.

- c. Y- switch:

This can be used on low load well. It has been recommended and tried on many oil pump jacks in China. The idea is to use Y connection on the motor when the over all load is low. When the oil level is high and the load becomes high, the motor switches to connection. This has practical difficulty and has only very limited application.

- d. Inverter:

One may use an inverter to change the speed of a motor. When the load is low the inverter may lower the speed of the motor to save energy. This possibility has been considered in China for oil pump jack energy saving purpose. First of all, inverter is rather expensive. Furthermore, it is not appropriate to change the speed of a motor of a pump jack.

- e. Control the power supply to the motor according to the load of the pump jack:

This is the most effective way to save energy on oil pump jack. It simply detects the load of the motor and provides the motor with energy needed to run the motor smoothly. When the current through the SCR of the energy saver is zero, the SCR

closes and no current is sent out to the motor. Depending the load, the SCR opens to let the electricity go out to the motor. This is just like a water dam. When the motor has higher load and needs more power the SCR closes shorter and the motor gets more power. On the other hand, when the load is lower and the motor needs less power, the SCR closes longer and the motor gets less power. The higher the load the energy saving percentage is smaller and the lower the load the energy saving percentage is bigger. This type of energy saver is not for power factor control as was often claimed in the past. Power factor is only used as a reference of the load of a motor. A SCR closes the gate to lower the electricity supply. It does not necessary lower the real power. For example, for a single-phase motor, the real power is related to voltage, current, and power factor as follows:

$$KW = V \times I \times \text{Power Factor (Cos } \phi \text{)}$$

As we can see, lowering of voltage and current can't guarantee lowering of real power. It all depends on over all changes of voltage, current and power factor. Sometime the power factor increases so much that it balances out the decrease of voltage and current so that the over all real power is increased.

Based on the motor characteristics, a motor can save more energy in terms of percentage when the load is lower. When the load the higher the energy saving percentage is lower. For oil pump jack, according to our field experience, the energy saving is in general 5% to 20% depending the type and condition of the pump jack.

Reactive energy saving:

Recently saving on reactive power has become more important issue. In the United States, fine on high reactive power has become a big concern to a consumer. Use of an energy saver to lower the real power also lowers the reactive power. On the other hand, a power factor enhancement capacitor can also enhance the power factor. Use of DIGITEK along with capacitors can lower the reactive power to the lowest. However, in China, we do not use capacitors. The over all load of a pump jack changes depending on many factors. In a short period the change might be small. However, in a long period, the change might be noticeable. If we compute the capacitor based on certain short period and get a good power factor enhancement, in a long period due to the change of the well condition the load might change drastically. As a result the capacitor might be too small and the power factor is under compensated. On the other hand, the power factor might be over compensated. Especially, when the power factor is raised to 1, a magnetic

resonance might happen and damage the motor.

Phase loss protection:

For a three-phase motor the motor can continue to run when there is a phase loss. However, a motor running under phase loss situation can easily be damaged. When phase loss occurs at the line side or the load side of the energy saver, there should be a phase loss protection to protect the motor from further damage.

Over low voltage protection:

An energy saver lowers the current and voltage to save the energy. When the supplied voltage is already too low and is barely enough to keep the motor running, it should not make any further energy saving. The energy saver should automatically switch to full voltage mode so that there is no voltage drop.

5. Choice on oil wells

On the installation and test of energy saver in China, we find a few factors that would effect the energy saving. Here are a few guidelines for choosing a well good for energy saving:

a. Stability of the voltage:

The area for energy saver installation should have rather stable voltage. It should not be lower than 10% of the rated voltage. The voltage unbalance should not be too big, not more than 5%.

b. The current of the motor:

The highest current should not exceed 60% of the rated current of the motor. The current unbalance should not be too big. The difference on the current for any two phases should not exceed 10% of the rated current of the motor. Otherwise there will be some damage on the motor.

c. Before installation of an energy saver, the temperature of the motor should not be close to that of the rated temperature of the motor.

d. The working condition of the jack:

When the driving belt is slipping, the energy saver should not be installed before the problem is fixed. When the driving belt is slipping, the heavy load time in each cycle will be increased which in turn increases the overall load of the motor. As a result the efficiency on energy saving is effected. If there is

some abnormal situation on the jack, energy saver should not be installed, because the problem on the jack can increase the difference on highest current and lowest current and effect the energy saving.

e. The noise and vibration of the motor:

When the motor has unusual noise and vibration energy saver should not be installed.

f. When a pump the jack is not well balanced the energy saving on it will not be good. In China the balance requirement on a pump jack is no less than 85%. In terms of current, this is roughly equivalent to have the current at lowest load no less than 85% of the current at highest load. With this balance condition one can get rather good saving.

6. Present status and future development tendency of energy saver for oil pump jack

Based on the characteristic features of pump jack, we analyze the applicability of different kinds of energy saving devices on pump jacks. We find that there are two categories of energy savers good for oil pump jack, namely, the intermittent operation control system and the SCR controlled energy saver. Currently both types of energy saver have been used in the oil production in China to some extent and there are many products of these kinds available.

The intermittent operation control system has advantage for low production well. However, technically it is not quite mature yet and it has to be used with care. Especially one has to avoid the danger of resulting in a dead well. If one can improve the technology it is a good way to save energy for low production well.

There are a few energy savers using SCR to control the energy supply to the motor. In general, the technology is not mature enough to very effective for energy saving on oil pump jack. This is because of the fact that the designers do not understand the pump jack enough to design good energy saver for it. After many years of study and experiment we find that DIGITEK-IIIGS is indeed good for energy saving on oil pump jack. It not only save energy on the pump jack, it also provides many protection features. It detects the load change of the motor on the pump jack and controls the power supply to the motor accordingly. Its installation and operation are very simple. We have installed more than 1,000 units in the oil fields in China since 1998. With DIGITEK energy saver, there are the following advantages:

a. It effectively saves energy to solve the energy shortage problem.

- b. It cuts down the oil production cost.
- c. Since DIGITEK can lower the temperature of the motor, it can prolong the life span of the motor. Furthermore, the protection features lower the damage rate on the motors and therefore lower the equipment cost. Due to the reduction on electricity consumption, the cost on the power generation is also reduced. The ecological damage due to power generation is also largely reduced. DIGITEK energy saver is a state of art product and it has special features good for application on oil pump jack.

If the intermittent operation control system can be improved, it can be useful for some low production wells. Use of SCR to control the power supply to the motor, however, is for continuous operation wells. Most of the oil wells are of this type. This kind of device can be used along with the intermittent operation control system. The wells applicable for intermittent operation are rather limited, therefore the use of SCR to control the power to the motor should be the main device for energy saving on oil pump jack. DIGITEK is the one proved to be the most successful one in the oil field application.

7. Use of energy savers in the oil fields in China

In the oil fields in China, motors consume 80% of electricity. 90% of this electricity consumption is by oil pump jacks. Therefore saving electricity has become an important policy of the oil companies. Presently there are all different kinds of energy saving devices. They can be categorized in three types:

- a. Power factor enhancement capacitors can effectively enhance the power factor and lower the reactive power. Its save on the real power by lowering the line loss is minimal.
- b. Y- switch switches between Y connection and connection depending on the load of the motor. The motor runs under connection at higher load and under Y connection at lower load. It can save both real power and reactive power. However, it has stringent requirement on its applicability and therefore there is only quite limited application.
- c. Use of SCR to control the power to the motor is the most effective way to save energy on oil pump jacks. DIGITEK is this type of product and is the only genuine energy saver successfully used in the oil fields in China.

Because of its reliability in operation and many protection features, it has been considered as high technology product by Oil and Gas Company of China and has been actively promoted for its application in the oil fields by the Oil and Gas Company of China.

So far, DIGITEK has installed more than 1,000 units in the oil fields of Da Qing, Hua Bei, Da Gang, Tsang Qing, and Jiang Han in China.



Tsang Qing oil field

8. Special design of DIGITEK used in the oil fields in China

With the request by the Oil and Gas Company of China, we have designed DIGITEK energy saver including many additional features. First of all, the DIGITEK used in oil fields in China are in three sizes in KW, namely, 60 KW, 45 KW and 30 KW. It includes the following basic features:

- a. The best energy saving.
- b. It can be started manually and automatically. When it is in automatic starting mode, a motor starts 30 seconds after the power is turned on. After the power is turned on and before the motor is started, there is an alarm to warn personal nearby that the motor is about to start.
- c. Short circuit protection.
- d. Ground protection.

- e. Over load protection.
- f. Current indication.



Original DIGITEK energy saver



Modified DIGITEK energy saver



DIGITEK installed at Da Qing oil field



DIGITEK installed at Da Qing oil field