inMotion
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VLT® low voltage drive replaces expensive high voltage drive

A standard low voltage VLT® drive has successfully replaced an expensive medium voltage drive in an Indonesian crude oil deep well pump-application and delivers great performance with respect to the required throughput and pump protection.
By adjusting the pump speed, it is now possible to extract crude from the well without rapid depletion, thereby optimizing the production and prolonging the application life time.

A standard low voltage (LV) drive offers a cost-effective alternative to its medium voltage (MV) counterpart when configured in a HI-LO-HI type power configuration. There are numerous advantages in using a VLT® drive in this configuration:

- The design represents a high degree of user friendliness by virtue of using standard components and proven low-voltage IGBT technology.
- It retains the existing ac motor, eliminates voltage reflections, common mode voltages and potentially harmful bearing currents, thereby prolonging the life of the motor. This is made possible by the use of a sine filter which delivers a sinusoidal voltage at the motor terminals. The solution is therefore motor friendly.
- Derating of the drive motor for inverter operation is not necessary, since the motor sees a sinusoidal voltage at its terminals and losses remain the same as for operation from a fixed frequency mains supply.
- The user has the advantage of stocking standard spares and thereby reduces inventory costs.

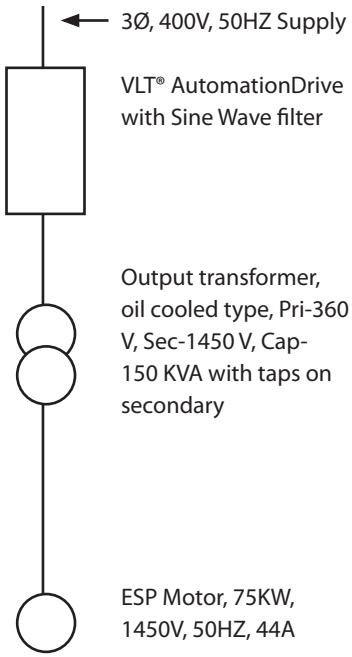
- Existing users of VLT® drives need not undergo retraining to assimilate new technology, which would be the case with a direct MV Drive. Hence the system saves on training costs.

The solution was put into practice at an application involving an electric submersible pump (ESP) for crude oil extraction from an underground oil well.
Sinar Surya Graha Persada, a sub-contractor for Pertamina Corporation, a state owned Petroleum Company located in Jambi province of Sumatra, Indonesia, decided to use the Danfoss solution.
This involved replacement of an existing MV Drive with a VLT ® Automation Drive which was engineered in a LO-HI configuration.

Some key reasons for choosing Danfoss, included:

- Its vast experience of supplying drives for critical applications.
- Positive feedback from other customers regarding the performance of VLT® Automation Drive
- Its ability to provide quality application know-how, and service at short notice.

Installed deep inside the ground
The ESP (page 1 lower left) is of the centrifugal type and has been used extensively to lift crude from oil wells. The technique is referred to as artificial lift. The pump and motor are assembled together and encased in a rugged enclosure which is resistant to high temperature. It is installed deep inside the ground and is capable of withstanding adverse working conditions. For correct operation, the pump capacity is closely matched to that of the well - that is, the ability of the well to produce crude at the required rate. Since it is difficult to match the two for optimum yield, oil well users have increasingly opted for a variable frequency drive to achieve the desired matching. By adjusting the motor frequency, it will be possible to vary the pump discharge and match it with that of the well. The use of a drive protects the pump from under- or overload conditions and thereby prolongs its useful working life. Additionally, the well's rate of return (ROR) figure remains high, since crude production is optimized with the use of VFD.



The following are the data for the drive motor and pump:

MOTOR
- Capacity - 100HP (75 kW)
- Design Terminal Voltage - 1450 V
- Nominal Design Frequency - 50 Hz
- Rated Full load current - 44 A

PUMP
- Capacity - 3500 Barrels/hour (557m3/hour)
- Design Pressure - 265psi.
- Type - Centrifugal Multistage

A 400 V, 50 Hz, 3 Ø supply being available at the end user's premises, an input step down transformer was not required. The only need was to size the drive, sine filter and output transformer. (page 2 lower left)

Design of components
With reference to the SLD (Fig#2 above), assuming a maximum drop of 10% (of rated inverter output voltage) due to the sine filter,
The voltage at the primary of Tx. will be given by the following equation:

$$V1 = Vinv * 0.9$$

Where Vinv = Inverter rated output voltage.

This gives a value of 360V.

The current rating of the Inverter will be given by the following equation:

$$Iinv = (Im*Vm)/V1$$

where Im = Rated motor current.

Vm = Rated motor terminal voltage.

This gives a value of 177.22A.

A drive with a variable torque rating of 177 A will suffice for these conditions. However, considering outdoor operation at elevated ambient (50°C) and availability, it was decided to offer a drive with constant torque rating of 212 A. The choice thus fell on VLT® AutomationDrive FC302.

The photo on page one top right shows the actual installation and the underground pump assembly.
The matching sine filter assembly for this model is 130B2286 with a current rating of 212 A and a design frequency of 3 KHz.

The capacity of the output transformer is given by the following equation:

$$C= (1.7321*Iinv*V1)/1000$$

This gives a value of 132.19KVA.

The nearest available capacity (150 KVA) with taps on the secondary was selected by the customer for the trials.
This completes the design of the main power components.

Trouble-free operation
Trials commenced in the third week of February on the ESP with the pump discharge rate matched with the well capacity. For this, the motor was run at a speed corresponding to 45Hz inverter frequency. Due to the long cable length between the drive panel and motor (≈550m) and the regulation characteristics of the output transformer, the tap was required to be set at higher than 1450 V to compensate for the voltage drop. The end user has reported trouble-free operation of the drive since commissioning. Recently, to increase the well throughput, the inverter frequency has been increased to 52 Hz.

High quality service
Danfoss provided high quality service to the customer at the time of commissioning. Looking at the performance of the drive and the customer-friendly approach of Danfoss, Mr. Pepen Supendi, Senior Manager (Projects) at Sinar Surya Graha Persada, the company in charge of operating the well, is now planning to place an order for additional units.