Drive Converters to Meet High Demands from Submersible Motors

In the Mongstad refinery located on the western coast of Norway, liquid propane gas is stored in large caverns excavated in the rocks. From here, the liquid propane is pumped into gas carriers for transport by sea. The variable-speed pumps operate completely submersed in the propane gas. This places especially high demands on the drive converters used. These not only have to operate with extreme reliability, but they must perfectly harmonize with the special motors integrated in the pumps. The Simovert MV medium-voltage drive converter supplies an almost perfect sinusoidal output voltage that is required for this application. Two of these drive converters are being used to feed the submersible pumps in the Mongstad refinery.

In the Mongstad refinery, the pipelines of the Vestprosess System, belonging to the Troll and Oseberg fields, merge. Next to the crude oil terminal and the appropriate processing equipment, there is a fractionation plant for natural gas liquids and a processing unit that converts the intermediate products into liquefied petroleum gases – propane and butane.

The final propane and butane products are stored in so-called caverns that have been artificially excavated in the rocks. These products are then transported from here using gas carriers. Up until now, there were two such caverns each with a capacity of 60.000 m^3. As part of an expansion project, Statoil has excavated an additional cavern in the rocks. From here, the gas is pumped to the gas carrier ships via a pipeline. In order to guarantee interruption-free loading, two redundant pumps are installed in the caverns. Each pump has separate drives and connections to the line supply.

Figure 1. The Mongstad refinery on the west coast of Norway: Here, natural gas is converted into, among other components, liquid propane

Variable-speed drive concept for optimized operation

There has been some negative experience as a result of pressure surges in the piping system of the existing propane caverns when the pumps are directly connected to the line supply. This was the main reason that Statoil decided to operate the pumps in the new cavern with variable speed (i.e. with drive converters). This will optimize the flow control, ensure that the pumps run-up softly in a controlled fashion, and will avoid any damage to the pumps and piping system. With variable-speed operation, potentially hazardous pressure surges, that under worst-case conditions can completely destroy the piping system, are completely eliminated. The drive converters generally reduce the overall stress levels therefore extending the lifetime of the pumps and piping systems. At the same time, maintenance costs are reduced. An operational advantage of the variable-speed system is that the gas carriers, that can only accept limited flow rates of the liquid propane gas, do not require any throttling devices. Furthermore, variable-speed systems are far superior to mechanical control concepts such as throttles when it comes to energy efficiency. While fixed-speed motors always output the full power, variable-speed systems precisely adapt themselves to the operational requirements. This means that the motor only draws as much power as is precisely required. As a result, in partial load operation, the energy requirement is significantly lower than for fixed-speed drives having the same power rating.

Siemens supplied the drive converter for the variable-speed operation. Two Simovert MV medium-voltage converters are included in the scope of supply (6 KV, 1500 kVA) as well as two Geafol 3-winding 1500 kVA drive converter transformers and a Sinett F128 transformer station.

HV-IGBTs for high reliability

Simovert MV is the first drive converter of its power class that uses HV-IGBTs (High-Voltage Insulated Gate Bipolar Transistor) power semi-

Figure 2. One of the caverns excavated in the rocks. From here, the liquid propane is pumped to the carrier vessels using submersible pumps with special motors

conductors. These devices significantly simplify the design of the medium voltage drive converter. As a result the Simovert MV is especially reliable, space-saving, modular and service-friendly. Furthermore, the use of HV-IGBTs in conjunction with the three-level technology and the high-performance Transvector control ensures sinusoidal motor currents. These sinusoidal motor currents reduce the motor losses and minimize the torque fluctuations and in turn reduce the mechanical stress on the complete mechanical transmission line.

High requirements using special motors

The Statoil-Mongstad project places special demands on the output voltage of the drive converter that feeds the motor:

The motors that are used are a special development from the pump manufacturer Ebara itself. These motors are fully submersed in the liquid propane gas that is at -43°C. These motors have many special characteristics that the drive converter must be able to handle. For instance, the motors and cabling have a significantly lower proportion of copper than is normally used because of the extremely low external temperature of -43°C, resulting in exceptional impedance levels. However, it is absolutely essential that the sinusoidal voltage does not have any voltage spikes, as these motors have not been designed for converter operation.

Sinusoidal voltage

Without applying any special measures, harmonics could therefore cause bearing currents and in turn bearing failures, the winding temperature rise would be exceptionally high and voltage spikes would damage the windings. This would result in arcing which is an absolutely unacceptable risk when considering that they are being operated in liquid propane gas.

This is the reason that Simovert MV is equipped with an IHV (Integrated High Voltage) filter to feed the special 6kV submersible motors in the propane cavern of Mongstad. This filter, integrated in the drive converter cabinet, generates an almost sinusoidal 6kV output voltage from the pulsed 2.3 kV output voltage of the voltage-source DC link converter. This output voltage has neither current nor voltage spikes which means that the submersible motors can be operated without any problems. The 6 kV output voltage, which corresponds precisely to the motor voltage, also means that an additional external step-up transformer is not required.

Rugged cast resin transformers

Geafol cast resin transformers are used for the converter transformers. The insulation of the Geafol cast resin transformers comprises a mixture of epoxy resin and quartz powder. This is an environmentally friendly material. Not only this, the windings are maintenance-free, resistant to humidity, tropics-capable, flame resistant and self-extinguishing. Furthermore, even when subject to arcing, the Geafol cast resin transformers do not emit hazardous gases. They generally have a smaller footprint than comparable transformers, which saves additional space.

The windings are clamped between distance elements. This means that they are de-coupled, from a vibration standpoint, from the iron core and between themselves. As a result, they are insensitive to shock and vibration and are just as quiet as oil-filled transformers.

Practically and cost effectively accommodated

The two transformers are accommodated in a small steel enclosure mounted on a concrete base. The complete enclosure was installed in just a few hours. When the transformers were supplied, the roof was raised and the transformers lowered in from the top. The steel enclosure has three doors so that the transformers can be visually inspected from all sides without having to enter the enclosure. This solution costs approximately one third of the alternative complete concrete design.

In addition to supplying the Simovert MV units including the drive converter transformers and the transformer enclosure for the Mongstad project, Siemens also handled all of the technical services associated with the drive system. This included, in addition to the installation and cabling, all of the supplied components, engineering and also the documentation of the drive converters, the power cables from the switchgear through the transformer and drive converter up to the motor terminal boxes for the interfaces to the automation system and the power supply shutdown system. Siemens has also drawn-up a spare parts management concept which means that the customer does not have to establish his own stock of spare parts.

Two drive converters for six motors

In the near future, Statoil-Mongstad will also consider retrofitting the existing submersible pump motors of the underground propane gas storage system to become variable-speed systems. This is the reason as to why Statoil-Mongstad, together with Siemens, is developing a concept where the two Simovert MV drive converters will not only feed the two new pumps, but also the four existing motors. Statoil therefore benefits as a result of the minimum capital investment together with all of the advantages associated with closed-loop speed control:

- Optimized closed-loop flow control
- Energy efficiency
- Soft pump starting and stopping therefore reducing stress on the system
- Potentially hazardous pressure surges in the piping system are eliminated.

This publication thanks Mr. Wil van Mol for providing this article. Currently Mr. Wil van Mol is responsible for the ASEAN & Korea Centre of Competence of Siemens, Business Unit Large Drives. He has been working for Siemens for over 20 years in different fields from commissioning, engineering, project management to sales. Most of his experience is related to drive technologies with the associated automation systems. He has also given lectures and training to young engineers in the field of drive technologies.

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