Power system studies for the oil and gas industry

Ensuring stability and reliability of power supply solutions and overall production processes

At a glance

Worldwide the importance of new oil and gas occurrences is increasing: In the U.S. a new industrial boom is triggered by gas fracking, in Australia gas is gaining in importance. Gas also plays an increasingly important role in the energy market. New types of production plants like GTL (gas to liquid) or LNG (liquefied natural gas) will be built in the U.S., Asia and Australia. The new plants need larger compressors with a higher degree of flexibility. Electrical solutions like large VSD (variable speed drive)-driven compressors are necessary for the increasing production. The new sources for oil and gas are located far away from existing infrastructure. Larger plants, operated under electrically islanded conditions, longer pipelines with large compression units and subsea locations outside the shelf sea with water depth of some thousand meters, are some examples for today's challenges in this sector.

The challenge

These developments create new and stronger requirements, including:

- reduction of energy costs
- reduction of maintenance costs
- reduction of CO_2 emission
- improved guaranteed availability
- high operation flexibility
- no outage tolerance

In order to reach the new targets it is of essential importance to investigate the electrical systems in more detail. In former times steady-state investigations have produced suitable solutions. Nowadays it is necessary to investigate the dynamics of the oil and gas systems.

Aspects of these dynamic investigations are:

- generation stability
- control of voltage, speed and frequency
- power reserve strategies
- local shedding philosophies
- design of filters for large compression units
- VSD (variable speed drive) interaction
- subsynchronous interaction
- electrical-steam and compression interaction

A big challenge is the very high demand on availability and the related guarantees of, for example, 3XX days per year for an outage-free operation with minimum maintenance demand. To cover these risks intensive dynamic studies are necessary to find the weak points of the system and to take suitable improvement and counter measures in the design phase to reduce the operational risks. This includes, for instance, the definition of the size of the gas turbines in a combined cycle plant (CCPP) to cover the temperature depending power reserve of gas turbines or to decide the necessity of supplementary firing.

In large islanded plants the spinning reserve of the generators is of very high importance for the reliability of the plant. In modern LNG plants the loads are very large compressors (up to 80 MW each) and the variable speed drive load is up to 90 % in total. Outages of individual VSDs or combination of groups of VSDs result in process interruptions. To overcome these problems the flexible and fast control of the VSDs can be used to support the system's reserve. The operational range of the compressors is typically 90-105 %. In case of an outage of a generator the process can be reduced to 90 % speed which reduces the power demand and stabilizes the system frequency (together with the classical countermeasures).

The use of electrically-driven compression in modern so-called eLNG-plants has many advantages as compared to classical direct gas turbine-driven compressor plants:

- compressor design process-optimized (not drive-optimized)
- high energy efficiency (> 50 % in CCPPs)
- reduction of CO2 emission
- low maintenance restrictions
- high availability and flexibility

A combined cycle power concept is necessary to reach these targets together with an elaborated power management system which is responsible for the requirements of control action and limitation, the electrical system balance and stability and the control of the influence of the steam system (power generation and process demand).

Our solution

In the frame of technical feasibility all aspects of the steady-state and dynamic behavior will be investigated:

- load flow and short circuit investigations
- harmonics / interharmonics
- dynamics of the electrical system
  - fault and outage analysis, frequency stability, voltage recovery, generator stability, impact of VSDs, impact of generation control
  - improvement of availability and reliability
  - design of power management system
  - design of generation control
  - design of load shedding and support of loads for frequency stability
  - optimization of control
- detailed design studies
  - interaction on control, influence of harmonics and interharmonics
  - reduction of risks from subsynchronos resonances
  - recommendations for control and countermeasures
  - protection studies

The investigation of the overall system design allows the fast development and optimization of the overall control concept. One implicit simulation system guarantees stability and accuracy. It allows high flexibility for the customer challenges. The impact on interaction between different processes can be investigated (electrical steam compression process) critical situations and outages can be detected and countermeasures can be realistically coordinated. The example below shows the Siemens approach to solve complex questions in the oil and gas sector.

Application example

Figure 1 shows the combined system to simulate electrical systems and steam systems based on the SIMOPLAN steam design tool for the CCPP of a large LNG plant. The steam process is parameterized and connected as a SIMULINK data base (this can also be done for other processes like compression). A subroutine generates a PSS®-NETOMAC readable macro. The combined electrical and steam system can be simulated using the design model of the steam process.

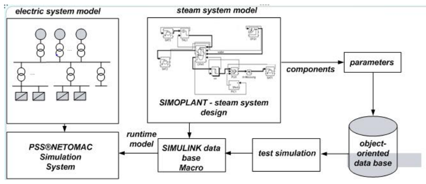

Figure 1: Combined system to simulate electrical systems and steam systems based on SIMOPLANT steam design tool

Figure 2 shows the electrical behavior (generation torque and frequency) and the steam behavior (header pressure and temperature) in case of process outage (trip of one LNG train with 35 % gas reduction and trip of two turbines).

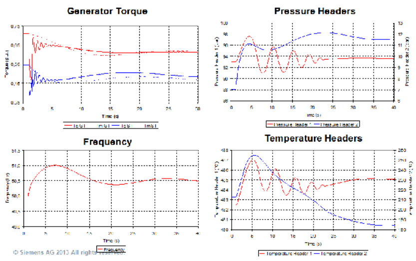

Figure 2: Process outage (trip one train), N-operation (phase II) 35 % gas reduction, two turbines tripped

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