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Set GGA

Generator Gas Analyzer for monitoring of hydrogen cooled turbo generators

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Hydrogen cooled generators require safety measures that reliably prevent the formation of explosive gas mixtures during normal operation as well as maintenance periods. Thermal conductivity technology based gas analyzers are used for that task.

A standardized CALOMAT 6 analyzer system - Set GGA - has been designed especially for this measuring task. Regarding redundancy and explosion protection the system complies fully with the relevant directives.

Application

In order to increase operating efficiency of turbine generators in power plants, it is necessary to cool them. Hydrogen gas is used to cool the generators in spite of the strict safety requirements arising from that. Compared to air, hydrogen gas exhibits offers the following advantages:

- much more efficient cooling conditions, due to a far higher thermal conductivity and heat capacity
- lower friction losses at the rotating parts due to a lower gas density
- higher dielectric breakdown strength

With these features, hydrogen gas provides best conditions for optimal operating efficiency of turbine generators. Hydrogen gas, however, is potentially explosive in mixtures with air over a wide concentration range (4 to 77 %). Formation of such mixtures must be prevented for safety reasons during normal operation as well as during maintenance work.

International Standards (EN and IEC) specify the installation of a redundant safety control system. Gas analyzers are used to monitor the gas concentrations continuously and alert explosive mixtures in time.

Hydrogen gas contamination with air will influence negatively the gas properties mentioned above. Contamination will increase the danger of explosions and, at the same time, reduce the operating efficiency. An increase in hydrogen purity from 95 to 99 % for instance, will save energy of approx. 0.8 MW (in case of a 970 MW generator) by reducing friction losses at the rotors. Thus, also economic reasons exist for continuous monitoring of the cooling gas.

Measuring tasks and Instrumentation

Gas analysis measuring tasks differ depending on the actual operating state of the generator such as normal operation or maintenance (see table). Basically, any possible contact between hydrogen and air must be prohibited or, in case of malfunction, recognized as early as possible by monitoring the gas concentration:

- During normal operation the cooling gas is monitored in between the measuring range 80 to 100 % H_2 in air for possible impurities. A limit alarm is set in case of H_2 concentrations fall below a preset value (e.g. < 95 %).
- During charging the generator with cooling gas a 2-step process is employed that involves (1) displacing the air with Ar or CO_2 as inert gas and (2) displacing Ar or CO_2 with H_2. These purging procedures are also controlled by gas analysis. The measuring ranges are here 0 to 100 % for monitoring inert gas in air and H_2 in inert gas.
- During discharge of the generator the purging cycle is employed inversely; gas analysis measuring tasks remain unchanged.

Consequently, analysis tasks include concentration measurement of 2 or 3 (in case of changing between Ar and CO_2) respectively components within the relevant measuring ranges.

CALOMAT 6 Analyzer
The CALOMAT 6 is used for continuous determination of primarily H_2 and He in binary or quasi-binary gas mixtures. The measuring principle is based on the different thermal conductivity of gases. A micro-mechanically manufactured Si chip is used as sensor which is particularly characterized by a short T90 time. Additional safety is provided by a flame arrestor that is mounted at the measuring gas inlet and would reliably prevent a possible detonation from propagation.

Oper. state	Operational step	Meas. task	Meas. range
Maintenance Charge of hydrogen	1. Purging with inert gas	inert gas in air	0 ... 100 % Ar/CO_2
	2. Purging with H_2	H_2 in inert gas	0 ... 100 % H_2
Maintenance Discharge of hydrogen	1. Purging with inert gas	H_2 in inert gas	0 ... 100 % H_2
	2. Purging with air	Ainert gas in air	0 ... 100 % Ar/CO_2
Operation	Cooling gas purity monitoring	H_2 in air	80 ... 100 % H_2

Measuring tasks for turbine generator cooling gas control

Set GGA - System for monitoring of hydrogen cooled turbo generators

To monitor and control hydrogen gas cooled turbine generators Siemens offers a specifically and ready for use designed CALOMAT 6 based analyzer system, see fig. The device is approved for use in EEx Zone 2, 3G but gas mixtures according to zone 1 may be introduced. The safety class is IP54.

According to DIN EN 60034-3 and IEC 842 standards two independent measuring systems are required for turbine generator control. The Set GGA complies with this directives by using two entirely independent (from gas sampling at the generator to gas outlet at the analyzer) gas analyzer lines in one cabinet. A forced ventilation of the housing or purging is not required as the air exchange rate caused by convection is sufficient to prevent the formation of explosive gas mixtures.

Set GGA provides analogue and digital output signals which are transmitted to the safety control system for further processing. However, the CALOMAT 6 is also capable to deliver limit values after being parameterized. On delivery the analyzer system is already applied to the measurement with Ar and CO_2 as an inert gas.

The required operating mode is selected at the analyzer by parameterization (Software). Errors in selecting gases or measuring ranges and thus faulty operation are excluded by an internal plausibility check. The system has been tested successfully under harsh field conditions. The innovative system is based on a robust design and high level of measurement accuracy:

- reproducibility < 0.1 %
- drift / 3 weeks < 0.1 % and
- T90 time < 5 s

Additional options for the Set GGA are the test gas skid and the mounting rack. The test gas skid is consisting of system components on a mounting plate to prepare the sample and measuring gases for analysis. Using the gas entries for measuring, reference and inert gases as well as 5-way-ball-valves, that ensure a comprehensive separation between the gases, the gas to be analysed goes through a pressure reducer and a flow meter with limit contact to the analyzer. For security reasons the test gas skid does have an additional flame arrestor and overflow valves. Together with the mounting frame the system is freestanding.

User benefits

Simple and reliable handling

- Staged operation levels using access codes to prevent incorrect operation
- Simple, menu-guided calibration including plausibility check
- Selection between three measuring ranges and the type of inert gas at the analyzer
- Completely redundant measurement
- Integrated limit value monitoring in between the measuring ranges

Low total cost of ownership

- No expensive test gases required, use of hydrogen and the inert gas only for calibration
- No special purging or ventilation required
- Installation of the whole system in EEx Zone 2, inclusive electronics and analytics
- Highly accurate measuring system for optimized turbo generator efficiency

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