Mobile HV Test System with IGBT Inverter Technology for Electrostatic Precipitators

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1 Summary / Abstract:

The system performance of ESPs is considerably influenced by the type and capability of the high-voltage power supply. Switched mode type power supplies - like IGBT inverters - have proven very beneficial for this purpose during the last decade in many applications.
Unfortunately, it is very difficult to define exactly the improvement in ESP efficiency prior to the installation of the IGBT based power supply. There are many different process variables and uncertainty factors which cause the theoretical results to be unreliable. Therefore, a practical and reliable determination of possible improvements requires a trial installation of the entire high-voltage power supply equipment on site and accurate analysis of the measured data. The proposed solution features a mobile self-contained trial unit, which can be connected easily to any electrostatic precipitator to run the tests in a real environment.
A significant increase in electrical power could be shown in many applications – e.g. a factor 2 could be achieved - which lead to significant improvements in the dust collection performance. Additionally, the energy efficiency of the precipitation process has become more important. With the switched mode power supply technology both collection and energy efficiency can be improved.
With the mobile HV test system and the IGBT inverter technology, test results show exactly the possible extent of improvements in ESP efficiency under real-life ESP and plant operating conditions.

2 The Challenge

Many power plants are faced with having to modernize their aging ESP control systems as a result of

- More stringent regulatory emission limits
- Changing operating conditions
- Unreliable system performance
- Unavailable spare parts and services

Continuous reporting of emissions does not allow for a lengthy ESP downtime during system upgrades or modernization.

There are many factors that influence the behavior and performance of an ESP. Evaluating ESP performance requires a functional test.

In many configurations there are special arrangements that need to be considered, e.g.

- Components are mounted in different locations (on top of the ESP, electrical rooms).
- Control units need to be placed in the vicinity of existing cabinets to utilize their connections; if this is not possible, temporary cabling has to be installed.
- T/R sets are installed in transformer cells or on top of the ESP; installation of a test unit often requires removal and re-installation of existing units.

Depending on the configuration, this can lead to high setup costs for the functional tests and often repair or cleaning prior to returning to service.

3 The Solution

The mobile HV test system represents the development of a unique, self-contained test unit (Figure 1) that connects to the customer's electrostatic precipitator without the need for additional test setup equipment. This test

system provides the complete electrical equipment to allow for a quick review of the improvement potential of the customer's ESP. In addition to the test equipment a particulate monitoring system can be installed, if no measurement is available on the plant.

The mobile HV test system was specifically designed for the unique requirements of electrostatic precipitators and flexibly performs all the required test operations.
This mobile test system utilizes innovative technologies to sustainable increase the efficiency of an ESP: from a high-powered IGBT inverter system to the transformer rectifier unit and the PC-based software for optimization of the customer's ESP operation. This allows the customer to increase his system's performance and effectively minimize its energy consumption.
The integrated operator station uses in-house engineered software that automatically optimizes the customer's ESP as a function of the process parameters. This software provides all the required diagnostic tools that can also be used for remote monitoring and optimizing the control system via modem or internet connection.

All power and control components have been integrated in a self-contained robust standard container. The high-voltage part has been separated from the low-voltage and operating part.

Fig. 1: Mobile test system installation

Main components

The installation includes the following components as shown in Figure 2:

- Inverter control cabinet with IGBT technology
- Power distribution cabinet
- HV rectifier unit with single-phase HV transformer
- Autotransformer for adaptation to standard voltage classes (480 – 690 V) as needed
- Custom-built cable drum arrangement with the necessary power and control cables, including an HV cable (to 110 kV) of 100 m length
- Specially designed cable penetrations to route cables through either the rear or side walls
- Cable routing gantry to traverse obstacles and provide routing in case cables have to be laid to the ESP roof
- Particulate monitoring system for the confirmation of improved collecting efficiency
- PC-based operating system with control, monitoring and optimization software
- HVAC systems in the control section and transformer compartment

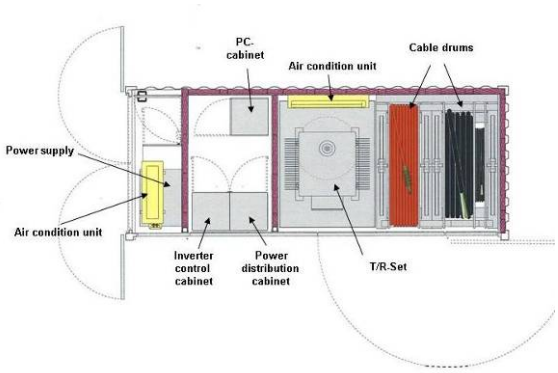

Fig. 2: Layout of mobile test system

50Hz/60Hz vs. 500Hz HV transformer rectifier

Based on the state and rating of the existing T/R set, the customer can choose between using the T/R of the plant or the T/R set provided with the test system. The different effects of the stray inductances of the transformers and further parameters can be identified during the test. In some installations the existing transformers have a sufficient rating, so they can be retained and operated with IGBT inverters. But there are other transformers which should preferably be replaced by medium-frequency type equipment to achieve the required precipitator performance.

Fig. 3: Integrated 500Hz HV transformer

The power and control cables needed for both installation concepts are provided, including the HV cable.
An installation example using the 500 Hz transformer is shown below. The few electrical connections are easy to implement.

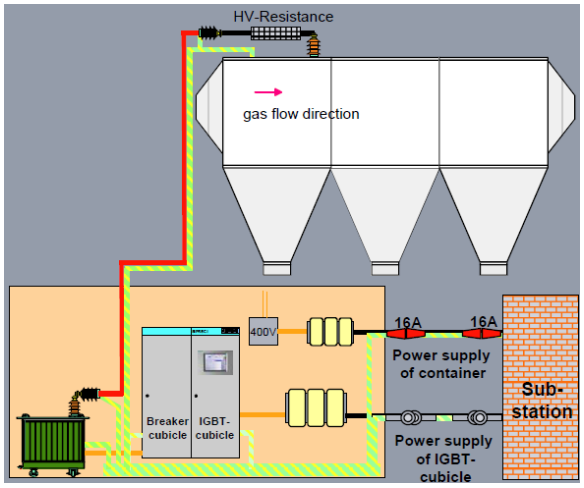

Fig. 3: Operation of the integrated 500Hz T/R-set

The advantages of the mobile HV test systems are:

- Fast verification of the optimization potential for improving ESP performance and energy savings
- Safe and quick setup and dismantling times reduce costs
- Installation of test unit without interruption of ESP operations
- Independent location due to on-board cables
- Simple adaptation to existing ESP, only minimal parameter adjustments to match operating conditions
- Mobile test unit can also serve as emergency equipment
- Flexible signal interface to plant control system

4 Test Procedure

The best effects in increasing the performance can be achieved if the mobile HV test system is installed for the ESP gas inlet fields, where the particulate concentration is high. One mobile HV test system is designed to supply just one or some parallel connected electrical fields. For large ESPs with several parallel fields more than one HV test system will be installed to obtain significant results. A particulate monitoring system (opacity) is recommended for the automatic optimization of the IGBT control and the interaction with PC-based optimization software.

The required local arrangements for the trial facility have to be determined. All cables with the test equipment are sized for maximum 100m cable routing.

The most important part is the HV connection on the roof of the ESP (Fig. 4). Normally the connection is made at the support insulators of the discharge electrode system.

Fig. 4: Example of an HV connection

A test period of 30 days is usually sufficient to achieve optimum parameters for different process conditions of the existing ESP.

The parameters can be defined through a remote service access via modem or internet. In close collaboration with the customer the test parameters are changed to find the optimum adjustment.

At the end of the test period a final report containing all the results and recommendations is handed over to the customer.

5 Experimental Results

Switched mode type power supplies (SMPS) have been successfully tested on many ESP applications as:

- Coal fired power plants (lignite and hard coal)
- Waste incineration plants
- Residue incineration plants
- Refinery power plants
- Cement plants - kiln, mill, bypass
- Paper - recovery boiler
- Steel – converter, sinter plants
- Glass plants - furnace
- Chemical plants - sulfur acid collection

The most success was found, when SMPS were installed at the gas inlet fields, where the corona suppression based on the space charge was high, while the ESP voltage was limited due to the presence of flash-overs.

As an example the following results where achieved with the mobile test unit installed on an ESP after a refinery boiler. The ESP consists of 2 parallel fields and 2 fields in series. The IGBT HV power supply was used to supply one of the gas inlet fields (1 of in total 4 electrical fields). After 1 month of operation and optimization the result was compared with measured values recorded before the trial installation. The average emission value was decreased from 9,3mg/Nm³ (original HV power supply) to 7,4mg/Nm³ (with 1 SMPS) and typical emission peaks were evidently suppressed during the test period.

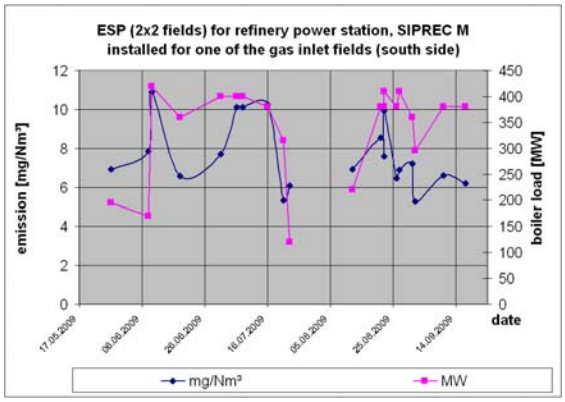

Fig. 5: Comparison of the test results

With this already conducted SMPS test installation it has been proven that the particulate emission can be decreased by more than 20% when SMPS are installed for the gas inlet fields. As not requested at this time there is still potential for further improvement when also the gas outlet fields are equipped with SMPS.

It was found during the optimization period that this ESP reacts very sensitive to an increased number of flash-over. The IGBT control was therefore adapted accordingly.

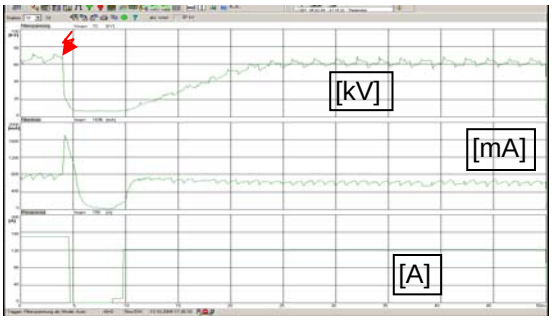

Fig. 6: Oscilloscope measurement of ESP voltage/Current and IGBT target current value

6 Literature

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