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Inside this issue:

Flicker Reduction in Electric Arc Furnaces

Electric Arc Furnaces, EAF, have been one of the greatest contributors to voltage flicker on an electric system. Extreme non-linear characteristics, and highly fluctuating load makes EAF difficult to compensate. Most steel mills that have large EAFs have used synchronous condensers and/or SVCs, to help control voltage, but have fallen short in the reduction of flicker. More recently, STATCOMs have been used. STATCOMs have shown extremely good voltage control for instabilities and flicker, but overall performance is very dependent on the control strategy implemented. The following article presents performance comparisons of a non-compensated EAF, a SVC compensator and a STATCOM compensator. The simulation results were prepared using PSCAD.

The 80 MVA EAF system chosen for the study is fed from a 138 kV bus with a 2500 MVA short circuit capacity. The EAF transformer secondary voltage is 15 kV and the EAF operates at 900V. The EAF is simulated by a chaotic arc model. The power delivered to the EAF load is 80 MVA and kept constant to the EAF in part by adjusting

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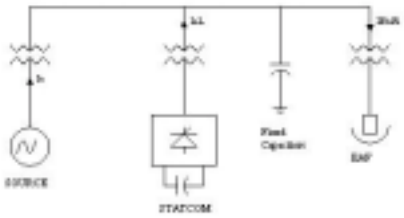

Fig 1: System Single Line Diagram

The Changing Centre

The staff of the Centre have been hard at work on a variety of fronts. Significant effort has gone into further development of PSCAD for the V3.0.5 release plus new work planned for a major upgrade. The on-line monitoring project work plus other R&D initiatives gives testimonial to the diverse expertise here at the Research Centre. We are changing and are on the move.

Dennis Woodford and Garth Irwin have decided to leave the Centre to pursue their interests. Their new company, called Electranix Corporation, will focus on power system consulting with PSCAD for model development, system simulation, training, and study work. The Centre wishes to see them succeed and we will work with them to our mutual benefit.

Replacing Garth in his duties as Simulation Development Manager is Craig Muller. Craig is an Electrical Engineer with 10 years experience and has been actively involved in PSCAD development work started 6 years ago. We welcome him back to the team.

Craig Muller

Another visual change is the new Centre logo featured in this Centre Journal. The old logo needed an update in order to make it more recognizable and relevant to our customers worldwide.

The last change coming this April will be a move to larger premises. The Centre will have its own building with laboratories, a classroom, more space, and a stronger infrastructure to serve you better. In closing, the staff of the Centre wishes you and your families all the best in the upcoming new year and indeed the new millennium.

By Paul Wilson

MANITOBA·HVDC RESEARCH CENTRE

Collaborative Research Project Report
On-line Monitoring of High Voltage Circuit Breakers

A three year field implementation of on-line monitoring technology was applied to a 240 kV SF6 circuit breaker. The main focus of the project was to evaluate the state of the art in on-line monitoring technology by first hand experience, thus providing an understanding of the benefits and the practical issues of implementing this technology.

The project implemented a comprehensive range of monitoring for electrical, energy, operating mechanism and SF6 gas systems. Transducers of various types were installed. The breaker was operated over 1000 times during the test period with ambient temperature conditions ranging from –35ºc to +30ºc. The on-line monitoring was supplemented with off-line testing performed 4 times during weeklong outages.

The application of on-line monitoring has produced many valuable results and enhanced the knowledge base for the apparatus under test. Clearly on-line monitoring of HV circuit breakers has potential, however the installation of on-line monitoring systems must be considered carefully. Monitoring systems can provide improvement in the understanding of the operation of a breaker and provide input into reliability centered maintenance programs. However, the monitoring systems themselves require maintenance and attention. The application area of data interpretation and/or conversion of this data into information requires continued research and development.

The intensive monitoring and investigation did achieve some interesting results. SF6 gas density is generally calculated by using a temperature compensated method. This method requires both a measurement of gas pressure and gas temperature to be collected. A total of five SF6/CF4 gas systems were installed and each system generated erroneous results when the ambient temperature was below –20°c. For this particular breaker, there is a SF6 gasket heater, which is activated at –20°c. The location of this heater is physically close to the temperature sensor for the SF6 gas temperature and is realistically the only practical location for this particular breaker. As shown in the following Figure 1, the SF6 gas temperature recorded for ambient temperature below –20°c is notably disturbed, while the pressure remains linear with temperature. The SF6 gas density or compensated pressure readings are corrupted below an ambient temperature of –20°c. This systemic error resulted in false alarms from all monitoring systems.

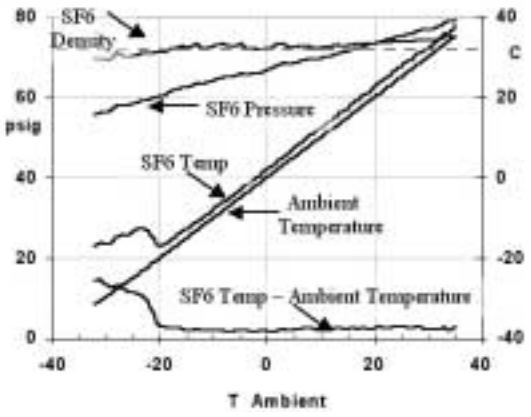

Fig 1: SF6 Density and Temperature

A complete project paper is available for download at http://www.hvdc.ca/main/projects/index.html. For further information, contact Randy Wachal at +204 989 1249 or rww@hvdc.ca.

By Randy Wachal
Manitoba HVDC Research Centre

Written-Pole® Machine Modeling

A revolutionary concept that appears to break many of the established traditions governing the design of rotating electric machines, Written-Pole® technology offers an interesting alternative to conventional electric motors and generators. Using a hybrid layout that incorporates the best features from several different classes of electric machines, Written-Pole® machines are characterized by a unique rotor design that utilizes a laminated steel core with a standard induction cage covered by a continuous hard-ferrite magnetic surface.

Written-Pole® machines are designed in a manner that allows the ferrite magnets to be re-magnetized into any desired magnetic pole configuration using a stationary excitation winding located in the stator, thereby enabling the machine to attain synchronous type operation at non-synchronous speeds. In sharp contrast to the conventional idealized synchronous motor, Written-Pole® motors are capable of achieving synchronization over a period of cycles or even seconds while under load due to their ability to develop significant starting torque throughout the speed range. Similarly, Written-Pole® generators are capable of maintaining constant frequency under variable speed conditions due to their ability to continuously modify the magnetic pole structure on the rotor to match the rotating fields produced by the stator winding.

Using the PSCAD software package, Manitoba HVDC Research Centre has been able for the first time to accurately model the behavior of a Written-Pole® machine. Centre engineers cooperated with the University of Manitoba

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PSCAD EMTDC™

Announcing PSCAD Release 3.0.5

The PSCAD Development Team have unveiled an updated and improved version of PSCAD and EMTDC.

The key new features include:

- Enhanced PSCAD Setup and User Profile
- PSCAD drawing Delete and Undo
- Improved Plotting Features. (Plot Timestep changed during run)
- Improved Graphical Display
- Updated Error Handling and Identification
- Improved linking with other applications
- Improved Multiple Run components

Much More …

Last Free Version 3 Upgrade

Download a free PSCAD 3.0.5 Personal Edition version http://www.hvdc.ca

4TH INTERNATIONAL HVDC TRANSMISSION OPERATING CONFERENCE

In Yichang, China September 6 - 8, 2001

Hosted by
State Power Corporation of China
and
Manitoba HVDC Research Centre (Canada)

The 4th International HVDC Transmission Operating Conference will immediately follow the CIGRE Symposium scheduled in nearby Wuhan September 3 to 5, 2001. At the completion of the joint field trip to Three Gorges on September 6, there will be opportunity to stay in Yichang and participate in the Operating Conference sessions September 7 to 8. In order to register, submit a paper or find more information visit: http://www.hvdc.ca/OpConf

Benefits of PSCAD Software Maintenance

Telephone, fax and e-mail support for the installation and operation of the software, price discount for major releases of the software and documentation, notification of any defects found in the software, and software patches free of charge from our website.

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and Precise Power Corporation, in order to develop the model which successfully simulates the various modes of operation present in a Written-Pole® machine.

The PSCAD model utilizes a methodology that divides the Written-Pole® machine into radial segments, each consisting of a stator slot, air gap, permanent magnet and rotor bar, allowing it to predict relevant phenomena during start-up and steady state operation using Ampere's Law. The ability to accurately simulate magnetic field and magnetomotive force distribution, induced rotor bar currents, power losses, load currents and rotor velocity under both steady state and transient conditions represents an invaluable tool for designers utilizing Written-Pole® technology.

While still being refined, the Research Centre has been able to achieve excellent matches between measure laboratory and simulation results using the PSCAD/EMTDC model. Figure 1 shows a comparison of induced rotor bar currents under locked rotor conditions for both measured and simulated results. Further work being undertaken in this area will allow the Centre to optimize the model and develop additional features that will be incorporated into future versions.

For more information on Written-Pole® technology and its use in several innovative products, please contact Dale Friesen, P.Eng., General Manager, Meridium Power Inc. at +204 474 4541 or sales@meridiumpower.com.

Meridium Power is a wholly owned subsidiary of Manitoba Hydro.

By Dale Friesen, Meridium Power Inc.

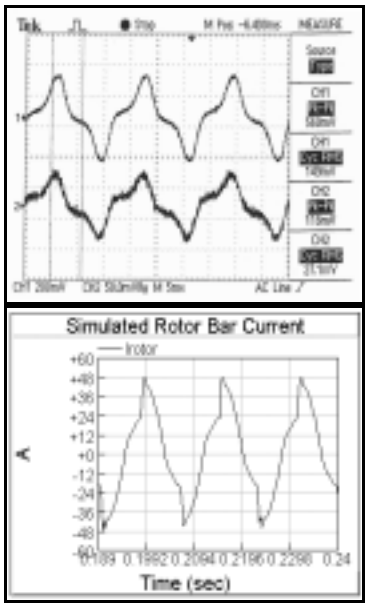

Fig 1: Comparison of Measured and Simulation Results

(Continued from page 1)

the tap changers on the EAF transformers. Figure 1 illustrates the system that was investigated. Results shown in Figure 2 are for the initial case, without any compensation. Notice the distortion in the currents demanded from the ac system. A 64 MVar SVC, with a TCR and fixed capacitors on the 15 kV bus is added as compensation. The controls for the SVC work to maintain the voltage magnitude at the EAF 15 kV bus at a steady state level. The SVC performance in compensating for the EAF currents is observed in Figure 3.

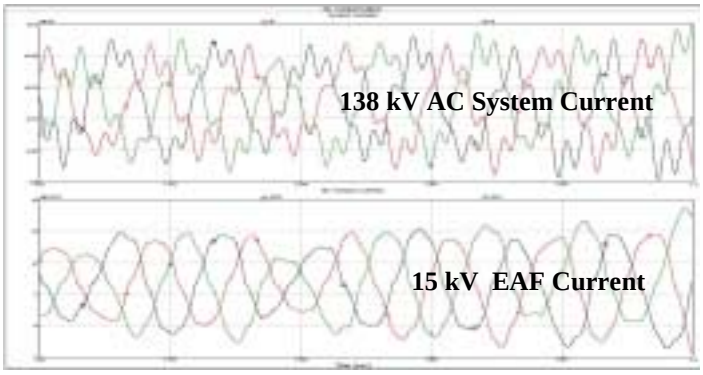

Fig 2: EAF with no Compensation

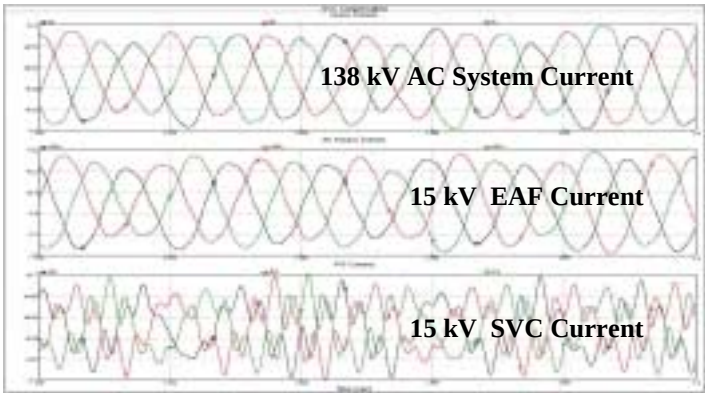

Fig 3: EAF with SVC Compensation

Finally a ±32 MVar STATCOM is evaluated with an additional 32 MVar of fixed capacitors on the 15 kV bus, making the STATCOM rating similar to the SVC. The STATCOM is a two level Voltage Sourced Converter (VSC), with a novel vector control strategy. The STATCOM is able to dynamically eliminate the harmonics by injecting the precise currents needed and is able to produce currents in order to almost completely eliminate the current fluctuations on the source side of the bus. It is these current

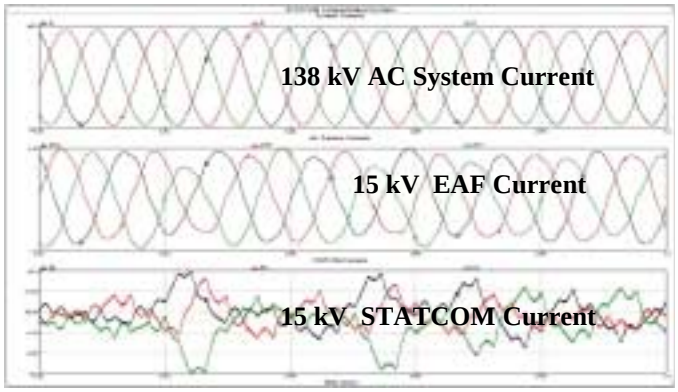

Fig 4: EAF with STATCOM Compensation

fluctuations which result in voltage flicker. The STATCOM performance in observed in Figure 4.

The results demonstrate STATCOM compensation can effectively compensate flicker for EAF applications. PSCAD has the ability to model electric power systems, power electronics and complex controls. This combination allows the user to test many different electrical configurations and control strategies in order to determine the most appropriate solution. If you have difficulty studying system effectiveness, the Centre can provide assistance.

by Dan Kell, Manitoba HVDC Research Centre

IEEE Winter Power Meeting in Columbus, Ohio

IEEE Exhibition Hall
Tuesday and Wednesday,
January 30 - 31, 2001 from 8:00 am to 5:00 pm

PSCAD software provides professional 'State of the Art' visual solutions without requiring the user to become a simulation specialist. Simulate the electric power system and power electronics, together with complex control systems and get results quickly and accurately.

You are invited to visit us at our booth. Bring your questions, discussions and feedback. Your comments are an important link in the continued development of PSCAD and RTP.

See you there !

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