SVC in steel manufacturing: an Indian case

ABB has installed a Static Var Compensator (SVC) rated at 33 kV, 0-200 Mvar capacitive at Jindal Steel & Power Ltd (JSPL), Raigarh, India. The SVC was commissioned in 2009.

In steel plants, Electric Arc Furnaces (EAF) are troublesome loads on the feeding three-phase power supply, usually the public grid. The EAF has strong and stochastically fluctuating reactive power consumption, which, unless remedied, will lead to voltage fluctuations and flicker. Furthermore, the EAF acts as an unbalanced load, creating negative-phase sequence components in currents and voltages, which will have a detrimental impact on other installations connected to the same grid as the EAF. Also, due to a low power factor of the EAF, the system losses are high, which is unfavourable from the point of view of electric energy consumption per unit steel. And finally, the EAF is a strong source of harmonics. SVC is an efficient means of mitigating these mentioned impediments to power quality in the plant as well as in the feeding grid. As additional benefits, productivity and process economy can be improved.

Main circuit design

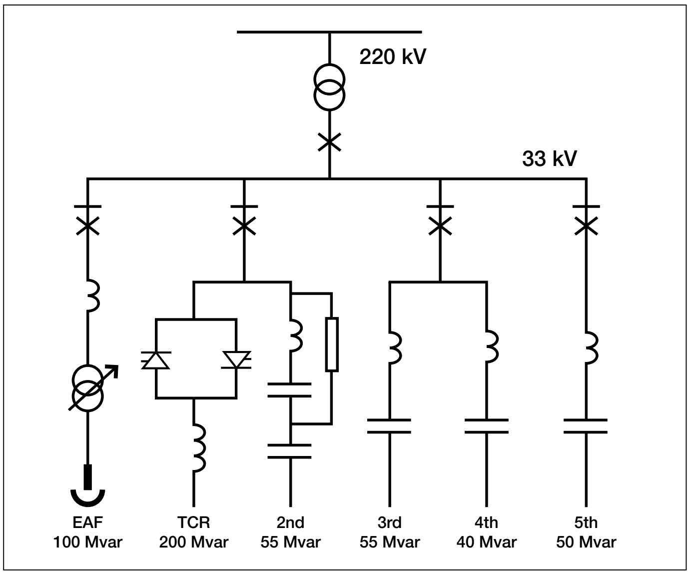
The SVC comprises a Thyristor-Controlled Reactor (TCR) rated at 200 Mvar, as well as 2nd, 3rd, 4th and 5th Harmonic Filters, altogether also rated at 200 Mvar. All in all, the reactive power control range of the SVC amounts to 0-200 Mvar (capacitive), continuously controllable. The SVC is rated to accommodate two alternative options of EAF compensation:

- A present EAF located on the same 33 kV bus as the SVC, rated at 100 MVA;
- A possible future, alternative scheme comprising two other EAFs located at a neighbouring 33 kV bus, each rated at 100 MVA.

By phase angle control of the TCR, the RMS value of the current through the reactor can be continuously controlled from zero up to the value given by the rated inductance of the reactor. Together with the capacitive reactance provided by the harmonic filters at 50 Hz, the total dynamic range of the SVC is made capacitive. Harmonics generated by thyristor control of the reactor current are absorbed within the harmonic filters.

Thyristor valve

The thyristor valve employs series connected thyristors, water-cooled, together with associated snubber circuits, thyristor electronics, heat sinks and clamping arrangement. The valve is designed with free standing single-phase assemblies, each with a stack of BCT (Bi-directionally Controlled Thyristors). The high power thyristors are electrically fired and the energy for firing is taken from the snubber capacitors. Thyristor firing orders are communicated via optical light guides from the valve control unit. This type of system is normally called "indirect light firing".



Single-line diagram of the SVC and EAF.

Harmonic filter design features

By introducing damping in the 2nd harmonic filter, possible problems with inter-harmonics and parallel resonances with the grid can be mastered. A resistor is connected across the tuning reactor and the nearest capacitor part. The latter is chosen such that it forms a series resonance circuit with the reactor at the fundamental frequency. The fundamental current is thus by-passed the resistor, and substantial resistive losses are thereby avoided. The 3rd, 4th and 5th harmonic filters are designed as band-pass filters and consist of a reactor and a capacitor in series to attain the required tuning.

Control system

The control system is based on the ABB MACH 2 concept, which is a system of both hardware and software, specifically developed for power applications. The MACH 2 concept is built around an industrial PC with add-in boards and I/O racks connected through standard type field busses like CAN and TDM. The aim of the SVC is to control the power factor on the incoming line, stabilise the voltage at the furnace bus, and reduce the flicker at the Point of Common Connection (PCC). The automatic control system consists of an open loop phase-wise susceptance regulator and a closed loop susceptance regulator. All regulators are located in the MACH 2 computer.

The main objective of the open loop regulator is to generate fast susceptance references for the SVC in order to suppress flicker and phase unbalances. The SVC compensates for the EAF currents consisting of the reactive part of the positive phase sequence current, and both the active and reactive part of the negative phase sequence current. Hence, the voltage drop over the AC network is minimized. In addition to the open loop control there is a closed loop control. Two different control strategies can be used:

- Reactive power control
- Power factor control

Performance

The following contractual versus measured performance values are valid at the 220 kV PCC. As can be seen, the SVC more than fulfils the contractual requirements in all respects.

Performance parameters	Contractual values	Measured values
Power factor	≥ 0.95	0.99
Flicker, Pst (95%)	≤ 1.2	0.51
Total Voltage Distortion, THD (95%)	≤ 1.5%	1.21%
Voltage fluctuations (95%)	≤ 2%	1.3%

Voltage unbalance was measured, as well. The result showed that with the SVC in operation, the unbalance was lower than the background unbalance level, i.e. not only has the EAF unbalance been eliminated altogether, but also a portion of the background unbalance.

Main technical data

Bus voltage	33 kV
SVC rating	0-200 Mvar capacitive
Harmonic filters	2nd harmonic / 55 Mvar 3rd harmonic / 55 Mvar 4th harmonic / 40 Mvar 5th harmonic / 50 Mvar
Control scheme	Phasewise, open loop susceptance regulator, plus a three phase closed loop susceptance regulator.
Thyristor valve	BCT equipped, water cooled, with indirect light firing.

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Application Note A02-0219 E, 2010-06