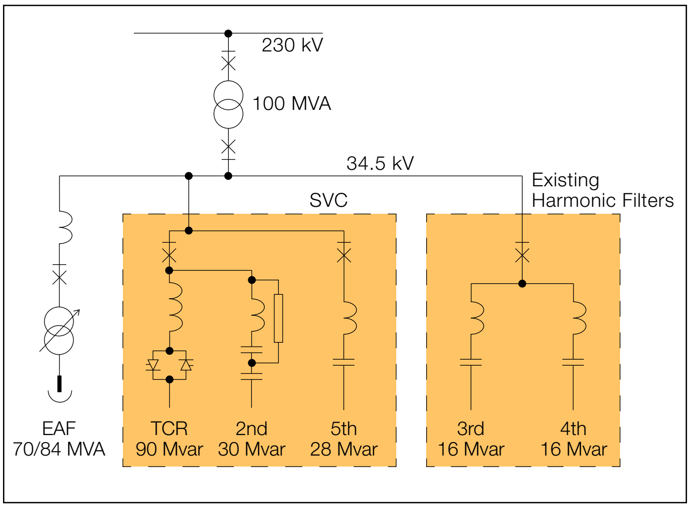
SVC to improve productivity and power quality in a steel plant fed by a 230 kV grid

Since 2002, Cascade Steel in McMinnville, Oregon, USA has been operating an ABB Static Var Compensator (SVC) in its Electric Arc Furnace (EAF) based melt shop. The SVC was installed for a dual purpose:

Firstly, the plant wished to run its EAF at a higher power output without risking to infringe on the flicker requirements of the 230 kV power supplier, Bonneville Power Administration (BPA). This would enable an increase of EAF power from 65 MW up to 84 MW, the maximum yield of the furnace in question.

Secondly, the plant wished to lower the overall impact of flicker and harmonics on the transmission supply system, while obtaining an improved power factor at the 230 kV Point of Common Coupling (PCC).



The SVC is rated at 34.5 kV, 0-90 Mvar (capacitive), continuously variable. It has the following tasks:

- Keep a high and stable power factor at the PCC, independently of the reactive power fluctuations from the furnace load.
- Reduce the flicker at the 230 kV PCC to acceptable levels.
- Mitigate the harmonic distortion generated by the furnace.
- Stabilize the system voltage at the 34.5 kV furnace bus.

The SVC comprises the following main parts:

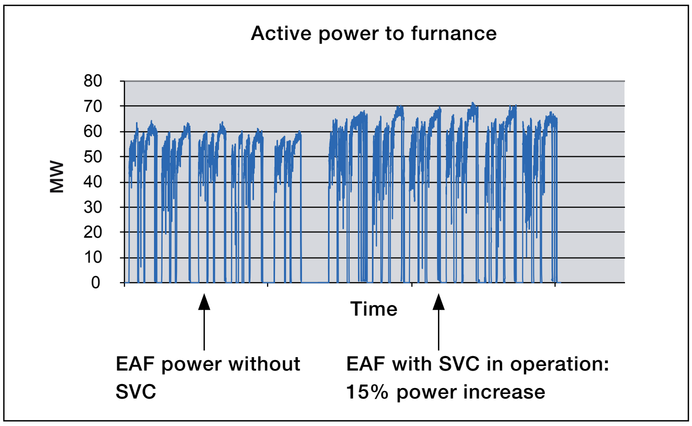
- A Thyristor-Controlled Reactor (TCR), rated at 34.5 kV, 90 Mvar.
- A 2nd Harmonic Filter rated at 34.5 kV, 30 Mvar.
- A 5th Harmonic Filter rated at 34.5 kV, 28 Mvar.
- An existing 3rd Harmonic Filter rated at 34.5 kV, 16 Mvar.
- An existing 4th Harmonic Filter rated at 34.5 kV, 16 Mvar.

By phase angle control of the TCR, the current through the reactor can be continuously controlled from zero up to the value given by the bus voltage and rated inductance of the reactor. The harmonics generated in the process are absorbed in the harmonic filters which are also part of the SVC.

Performance

The SVC was designed to fulfill the following performance requirements at the 230 kV PCC, with the furnace in full operation:

- Power factor, P.F. ≥ 0.95
- Total harmonic voltage distortion, THD ≤ 1.5 %



The values measured during test runs of the installation not only fulfilled the demands, but actually surpassed them:

	Measured values	Required values
Power factor	0.998	≥ 0.95
THD	1.25%	≤ 1.5%

Productivity improvements

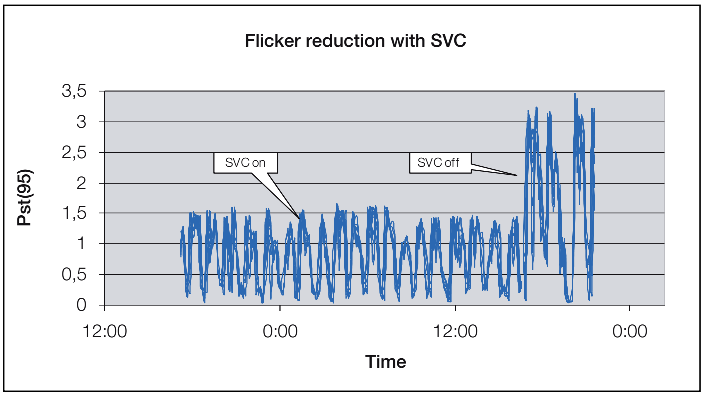
The SVC not only mitigates random voltage fluctuations at the point of common coupling, but also brings about a genuine increase of the RMS value of the EAF bus voltage (please see the recordings above). This provides higher active power in the furnace, which can be utilized to the benefit of the steel plant as follows:

- Shorter melting times
- Reduced specific electrode consumption
- Reduced specific energy losses
- Reduced wear of furnace lining.

The improvement of the power factor at the PCC furthermore enables a reduction of plant losses emanating from the flow of reactive power, and opens up the potential for more favorable power rates from the local utility. These factors all offer potential for improving plant productivity and economy.

Increased productivity

By means of the SVC, the busbar voltage is stabilized to have an increased available power of some 15 % at the furnace in the given case. Due to this increased active power yield in the EAF, each tonne of scrap needs less time for melting. This can be used to increase the total production output of the plant. Alternatively, it can be utilized for additional flexibility in the production pattern, for instance, to simplify meeting peak production demands.



Electrode savings

The graphite electrode consumption can be split into two constituents:

- Side oxidation, mainly dependent on tap to tap time.
- Tip consumption, mainly dependent on electrode current.

In the given case, electrode current remains the same, with the tap to tap time reduced. Reduction in side oxidation results, leading to reduced electrode consumption.

Loss reduction

With decreased tap to tap times, specific furnace losses, equal to losses per melt, decrease as well. Furthermore, as mentioned above, electric losses from the substation to the furnace are decreased, due to smaller flows of reactive power.

Flicker improvement

The below plot shows a flicker measurement at the 230 kV bus. To verify the flicker improvement effect of the SVC, flicker was measured both with and without the SVC in operation. With the SVC, The P_{st} (95) value was shown to decrease by more than a factor 2.

Main technical data:

Controlled voltage	34.5 kV
SVC rating	0-90 Mvar capacitive
Harmonic filters	2^{nd} harmonic / 30 Mvar
	3^{rd} harmonic / 16 Mvar
	4^{th} harmonic / 16 Mvar
	5^{th} harmonic / 28 Mvar
Control system	Phasewise, open loop susceptance regulator, plus a three phase closed loop power factor control.
Thyristor valve	BCT[1] equipped, water cooled, with indirect light firing.

[1] Bi-Directional Controlled Thyristor

Performance with SVC:

Power factor	0.998
Flicker improvement factor	> 2
THD	1.25%
Increased available melting power	15 %

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Application Note 1JNS013212, 2012-12