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SVC Light: a powerful means for improvement of power quality in industry and distribution.

With ABBs SVC Light, VSC (Voltage Source Converters) and IGBT (Insulated Gate Bipolar Transistors) have been brought together to offer possibilities hitherto unseen for power quality improvement in industry and power distribution.

This opens up new options for power quality control such as mitigation of voltage dips and fluctuations, dynamic load balancing, active filtering of harmonics, and last but not least, mitigation of voltage flicker from large electric arc furnaces for steel making.

Power quality: a matter in focus

Modern society relies heavily upon electricity. With deregulation, electricity has become a commodity as well as a means for competition. Power quality, as a consequence, is coming into focus to an extent hitherto unseen. Industry as well as commercial and domestic groups of users simply demand power quality. Flickering lamps and TV sets are no longer accepted, nor are deratings or interruptions of industrial processes due to unsufficient power quality.

In fact, the interruption of an industrial process for instance due to a voltage sag can result in very substantial costs to the operation. These costs include lost productivity, labour costs for cleaning and restart, damaged product, reduced product quality, delays in delivery, and reduced customer satisfaction. Thus, costs previously hidden in poor power quality are brought forward to their face value and may become an issue of dispute involving consumers as well as suppliers.

Disturbances emanating from any particular load will travel far, and, unless properly remedied, spread over the grid to neighbouring facilities.

Thus, for instance, voltage flicker and harmonics may turn up far away from their source and disturb other consumers, urban as well as industrial, and become a nuisance to many. At the end of the day, the disturbing equipment will therefore become an issue to many and not just to the owner of the particular equipment. We are then talking about lack of power quality.

Fortunately, there are means to deal with the problem of poor or unsufficient power quality in grids. One obvious way is to reinforce the power grid by building of new lines, installing new and bigger transformers, or moving the point of common coupling to a higher voltage level.

Such measures, however, are expensive and time-consuming, if they are at all permitted. As a matter of fact, there is a tendency in the opposite direction at present in some places, with Points of Common Connection in some cases being moved to lower voltage levels in the grid.

A simple, straightforward and cost-effective way of power quality improvement in such cases as well as similar is to install equipment especially developed for the purpose in immediate vicinity of the source(s) of disturbance.

As an additional, very useful benefit, improved process economy will often be attained as well, and as a matter of fact enable the said investment to turn out a profitable measure.

Voltage flicker

An electric arc furnace is a heavy consumer of reactive power. Also, the physical process inside the furnace is erratic in its nature, with electrodes striking and burning arcs between furnace and scrap. As a consequence, the consumption especially of reactive power becomes strongly fluctuating in a stochastic manner (Fig.1).

The voltage drop caused by reactive power flowing through circuit reactances in the electrodes, electrode arms and furnace transformer therefore becomes fluctuating, as well. This gives rise to voltage flicker, most clearly visualized in the flickering light of incandescent lamps fed from the polluted grid.

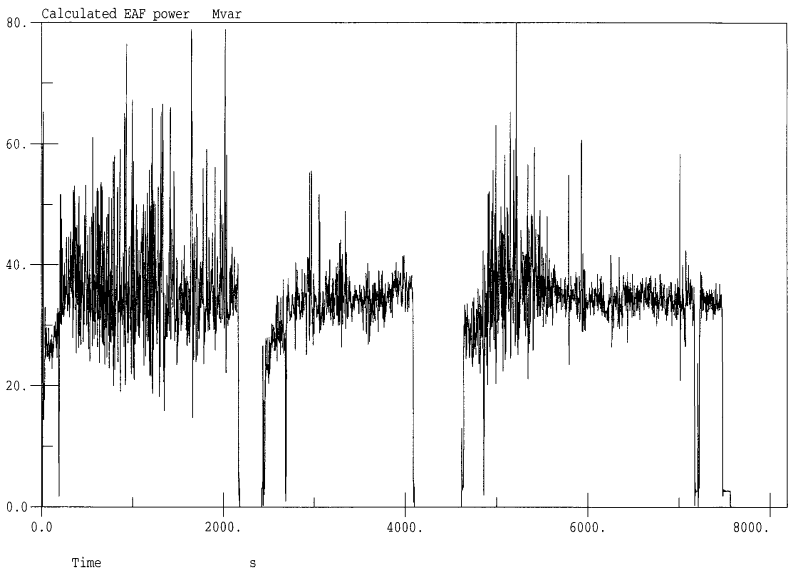

Figure 1: Reactive power consumption of an EAF

The International Union of Electroheat (UIE) in cooperation with IEC has defined a quantity for expressing flicker severity, P_{st}. According to this terminology, $P_{st} = 1$ means that in a group of people, half can observe light flicker that the group is being exposed to.

SVC Light

SVC Light is a flicker mitigating device. It achieves this by attacking the root of the problem, the erratic flow of reactive power through the supply grid down into the furnaces. By minimizing this flow, voltage flicker is decreased to a minimum, as well.

Important added benefits are a high and constant power factor, regardless of load fluctuations over furnace cycles, as well as a high and stable bus RMS voltage. These benefits can be capitalized as improved furnace productivity as well as decreased operational costs of the process in terms of lower specific electrode and energy consumption and reduced wear on furnace refractories.

The function of the VSC in this context is a fully controllable voltage source matching the furnace bus voltage in phase and frequency, and with an amplitude which can be continuously and rapidly controlled, so as to be used as the tool for reactive power control (Fig.2).

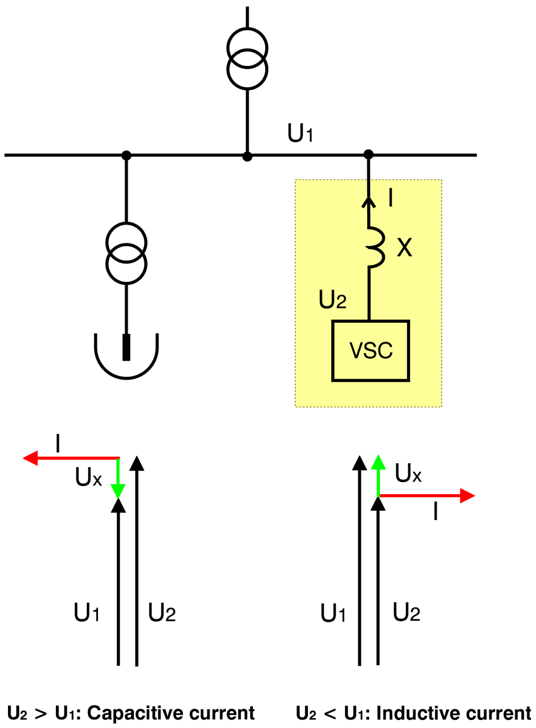

Figure 2 : VSC: a controllable voltage source.

The output of the VSC is connected to the AC system by means of a small reactor. By control of the VSC voltage (U_2) in relation to the bus voltage (U_1), the VSC will appear as a generator or absorber of reactive power, depending on the relationship between the voltages. To this controlled reactive power branch, an offsetting capacitor bank is added in parallel, enabling the overall control range of the SVC Light to be capacitive.

The controllability of IGBTs enables SVC Light to be directly connected to voltages in the tens of kilovolts range. Thanks to this, it becomes unnecessary to parallel converters in order to achieve the power ratings needed for arc furnace compensation (typically tens of MVA).

Uddeholm Tooling installation

Uddeholm Tooling at Hagfors in mid Sweden is a steel producer based on scrap melting and refining in an electric arc furnace (EAF) rated at 31,5/37,8 MVA and a ladle furnace (LF) rated at 6/7,7 MVA. Both furnaces are fed from a 132 kV grid via an intermediate voltage of 10,5 kV (Fig.3). The grid is relatively weak, with a fault level at the P.C.C. of about 1000 MVA. This is unsufficient to enable operation of the two furnaces while upkeeping reasonable power quality in the grid.

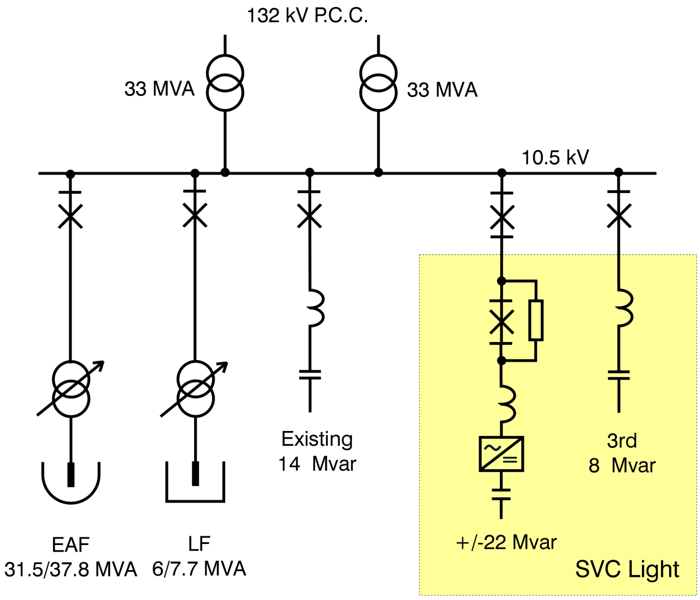

Figure 3: Single-line diagram of EAF feeding network and compensation

The SVC Light is rated at 0 - 44 Mvar, continuously variable. This dynamic range is attained by means of a VSC rated at 22 MVA in parallel with two harmonic filters, one rated at 14 Mvar existing in the plant initially and one installed as part of the SVC Light undertaking, rated at 8 Mvar. Via its phase reactors, the VSC is connected directly to the furnace bus voltage of 10,5 kV.

The targeted residual flicker level at the 132 kV point of common coupling with the SVC Light in operation has been aimed not to exceed $P_{st}(95) = 1$. The compensated power factor at the point of common coupling will be better than P.F. = 0,95. The SVC Light (Fig.4) will become operational in 1999.

Figure 4: The Uddeholm Tooling SVC Light

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