Boosting glass quality with electrically optimised heating

When it comes to glass melting systems, rising energy costs in conjunction with demand for consistently high glass quality are an issue due to the generally required high energy input. Frank Schlieper explains how Advanced Energy Industries came up with a powerful yet low grid impact solution.

Glass, depending on its composition, only forms a uniform mass at temperatures of around 1100°C-1500°C. Therefore, the issues of energy supply, energy distribution and ultimately energy costs are of utmost importance.

Although many melting tanks are still heated by fossil fuels, additional electric heating systems are increasingly being used to improve glass quality and melting performance, while simultaneously reducing emissions. Since glass becomes electrically conductive starting at about 800°C, heating electrodes for the so-called boosting are installed directly in the melt. This means there are hardly any losses and controllability is much more precise than with fossil heating systems.

Forehearths are either exclusively heated electrically or consist of a combination of gas heating with additional electrical heating, in order to further homogenise the mass.

Electrically optimised heating

In the glass industry, regulating transformers are often used to control the electrodes in the boosting range but they have considerable disadvantages as they are too heavy, too expensive and ultimately too space consuming. In addition there is generally a higher risk of environmental pollution and high maintenance due to oil cooling.

Based on the disadvantages of regulating transformers described above and customer feedback gained from installations worldwide, the Advanced Energy Industries (AEI) team came up with the idea to use SCR (silicon controlled rectifier) power controllers in combination with smaller step transformers for boosting, because they can act much more dynamically in control processes. This enables multiple use even with unstable supply grids, since the process can react quickly to any potential fluctuations in the mains voltage.

Power controller

AEI's Thyro-PX SCR power controller series is characterised by a wide range of operating and control modes and has the ability to communicate with various modern control systems. The devices are available with currents up to 2900A and voltages up to 690V.

Employing a Thyro-PX power controller in a Voltage Sequence Control (VSC) circuit significantly reduces reactive power and harmonic distortion, thus increasing the overall power factor of the boosting (see figure 1). The special feature of the resulting heating system is therefore the integrated two-stage VSC technology (figure 2).

VSC differs from the widely used phase-angle control method (VAR). Figure 3 shows the power factor curve for a two-stage VSC connection. In this instance, the power factor is at ≥ 0.9 from a load control of > 53 %, with the result that no grid usage fees are incurred for reactive power. For high performance systems, this is a serious cost factor.

At the same time, harmonics are also reduced considerably. The high edge of the grey line in figure 4 shows a high ratio of harmonics to (expensive) reactive power during VAR phase control. The orange line illustrates the advantages of the VSC mode: It achieves the same

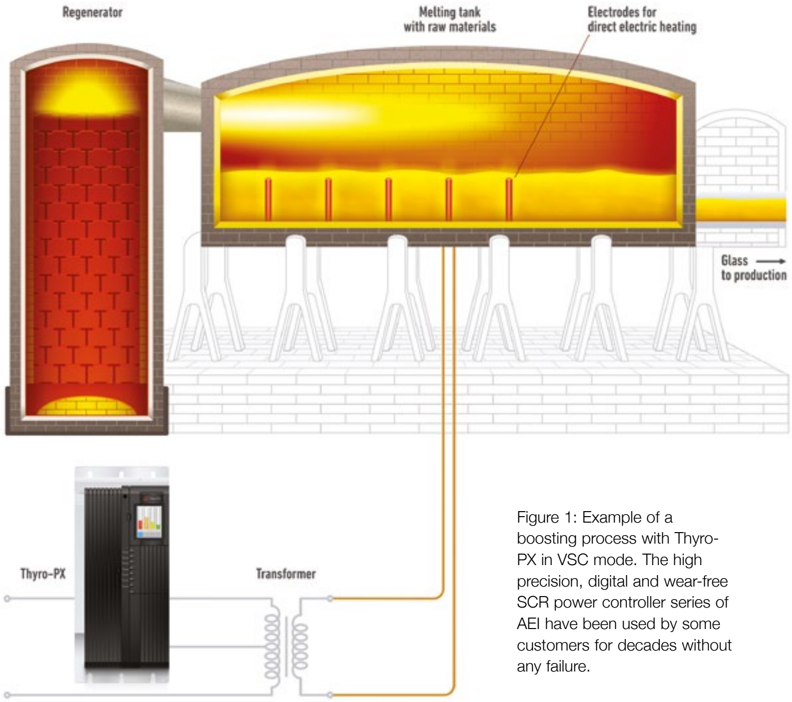

Figure 1: Example of a boosting process with Thyro-PX in VSC mode. The high precision, digital and wear-free SCR power controller series of AEI have been used by some customers for decades without any failure.

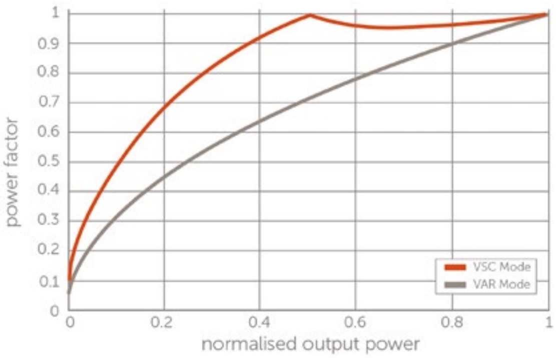

Figure 2: Diagram of a two-stage VSC circuit.

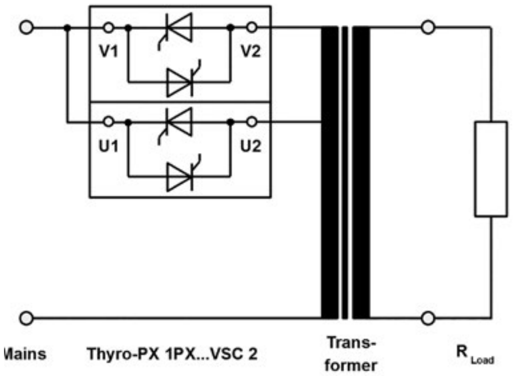

Figure 3: Power factor rated to output effective power (modulation of a two-stage VSC connection).

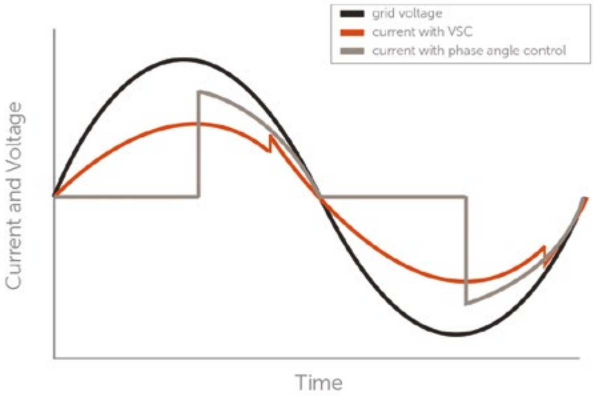

Figure 4: Comparison of phase angle control (VAR) and VSC (Voltage Sequence Control) with the same RMS current value.

RMS value as the phase angle control but with an approximately sinusoidal [sine wave oscillation] shape. The resulting small edge is so marginal that, as a result, a high power factor with low harmonics and equally low reactive power arises.

Not only are reactive power, space requirements and installation costs optimised with AEI's solution but also, the costs of the transformer. Modern static transformers with water cooling increase the savings potential as well.

Reactive power does not mean invisible costs

The power factor, a calculation variable, can quickly increase operational costs if not managed correctly. A hypothetical calculation shows the differences in the use of the operating modes phase angle control (VAR) and voltage sequence control (VSC). Consider reasonably realistic system values of a heater with an output of 1000 kW. If this heater was operated with a power factor of λ = 0.83, annual costs for the reactive power of about €15,000 [£13,340] per year would be incurred, as shown in figure 5. An increase to λ = 0.9 eliminates these additional costs. Thus, saving €15,000 per year. The figure shows an example of normalised reactive power costs.

However, that is not all. Due to lower apparent power, the transformer can be dimensioned correspondingly smaller. The same applies to various other electrical system components, of which smaller models may be sufficient. Switchgear can also be made smaller. ●

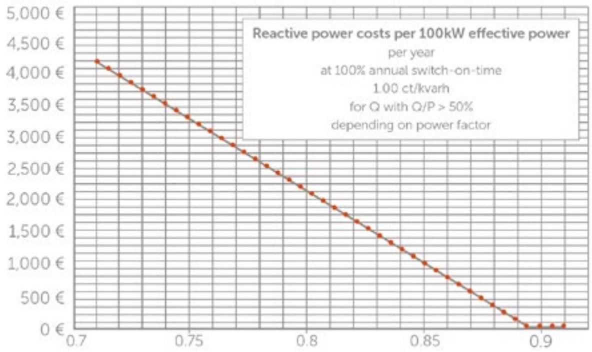

Figure 5: Example of normalised reactive power costs.

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