

Applications & Cases



Power factor correction

February 2009

Strong partners in steel

Rolling mills for the production of steel require huge amounts of energy to shape the hot metal into sheets, bars and other profiles. The Thai Steel Profile Company is no exception. In order to manufacture high-quality reinforcing steel at its capacity of up to 320 000 tons, Thai Steel's power supply consists of six transformers for a total output of 15 MVA. While two of the transformers (transformers 5 and 6, see Table) serve linear loads, four transformers (transformers 1 to 4) with a total output of 11 MW are dedicated mainly to the nonlinear loads of the mill's inverter-driven DC

motors.



TABLE: TRANSFORMER DATA AND LOADS

Transformer 1	22/0.64 KV, 3 MVA 3 units with 250 KW DC motors
Transformer 2	22/0.64 KV, 3 MVA 2 units with 350 KW DC motors
Transformer 3	22/0.64 KV, 2.5 MVA 3 units with 250 KW DC motors 2 units with 350 KW DC motors
Transformer 4	22/0.64 KV, 2.5 MVA 1 unit with 250 KW DC motors 3 units with 350 KW DC motors
Transformer 5	22/0.4 KV, 2.0 MVA 1 unit with 172 KW DC motors
Transformer 6	22/0.4 KV, 2.0 MVA AC motors with and without frequency converters
	AC motors and plant facility

In order to guarantee the quality of its products, which are used in the construction of high-rise buildings, industrial plants, roads, bridges, highways, dams and airports, among other things, Thai Steel not only invests in high-quality machinery, but also in process development. Therefore, early on Thai Steel installed its own power factor correction (PFC) system in order to improve power quality and save energy.

The key aims were to:

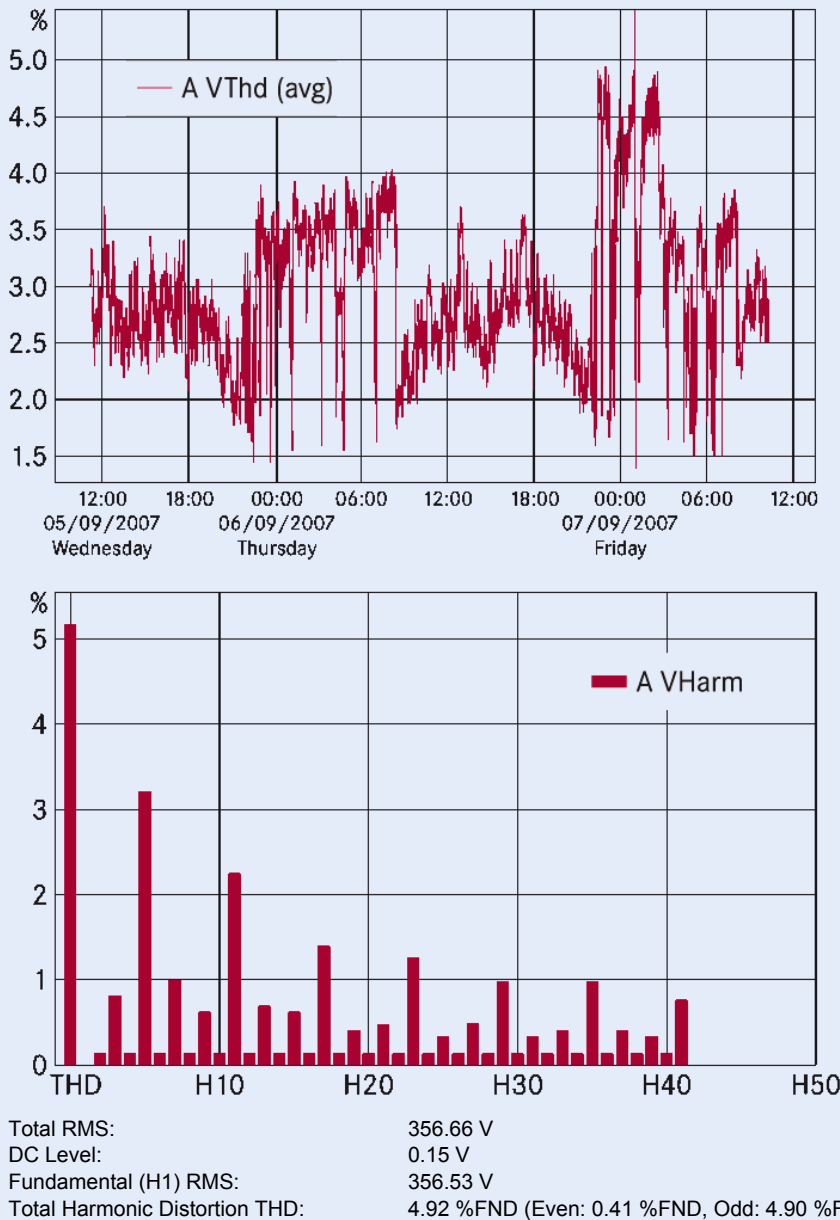
- prevent resonance and reduce harmonics,
- prevent voltage drops and increase voltage stability,
- reduce reactive power,
- reduce transformer and cable losses,
- reduce power consumption,
- increase the service life of electrical equipment, and
- improve utilization of available power, thus increasing production capacity.

Applications & Cases

Unfortunately, the capacitors originally installed in the PFC system (10 x 150 kvar, 760 V for TR1, TR2, TR3 and TR4) either burst or were damaged after a few years of operation. Therefore, Thai Steel needed to find an explanation for the premature failure and implement a new reliable solution as quickly as possible. For this reason the steelmaker turned to ITM, a Thai-based electrical engineering company that specializes in PFC products and power-quality solutions from EPCOS. ITM is one of the very few local engineering companies with the necessary engineering expertise and equipment to run measurements and analyze the grid and the quality of the power and voltage.



FIGURE 1: NET ANALYSIS REPORT



Grid analysis and extract from the net analysis report according to EN 50160.


Applications & Cases

Custom solution

ITM general manager Thumrongdej Mungcharoen, who has more than 20 years of experience with reactive power compensation and the reduction of harmonics, was called on to identify the root cause of the failures. In order to check the power quality in general, and the harmonics in particular, he installed a real-time power analyzer and gathered as much data as possible (Fig. 1). When evaluating the measuring data, ITM found very high values for the total harmonic distortion of the current (THD-I) as well as a strong fluctuation of the total harmonic distortion of the voltage (THD-V). THD-I showed values from 35 to more than 200 percent, while the average values of THD-V varied between 2 and 6 percent. In order to protect the capacitors and also to decrease the harmonic pollution, ITM proposed a detuned PFC solution for Thai Steel.

“Based on our analysis, we recommended that the original 760-V capacitors be replaced with 800 V MKK capacitors of the PhaseCap® premium series from EPCOS,” explains Mungcharoen. The new heavy-duty capacitors were to be installed alongside the system’s original reactors, which were developed specifically for applications with high loads and which – in contrast to the capacitors – were working properly.

“ QUOTE



“A PFC system that meets all requirements under even the hardest conditions can only be designed with the right know-how and reliable components.” Thumrongdej Mungcharoen, general manager of ITM, Thailand

Thai Steel thus placed an order with ITM to install fourteen steps of 170 kvar at 800 V, each equipped with six PhaseCap premium MKK800-D-25-11 capacitors and one PhaseCap premium MKK800-D-20-11 capacitor.

The PhaseCap premium series, which has been used successfully in wind turbine and industrial applications for many years, offers several key features and benefits:

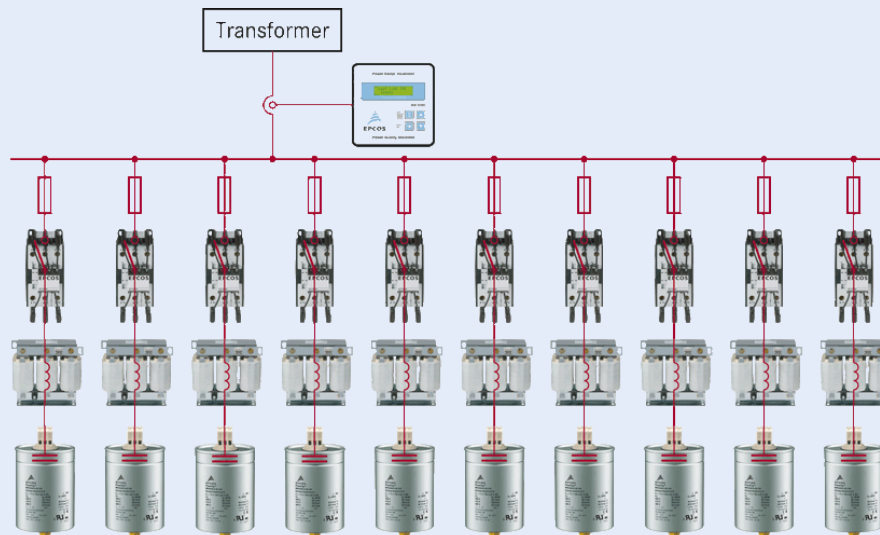
- extremely high inrush current capability of up to 300 times the rated current,
- service life of up to 130 000 hours,
- dry capacitors gas-impregnated with nitrogen,
- long-term approved MKK technology, and
- triple safety system.

After installation in 2007, ITM repeated their measurements, demonstrating that the PhaseCap premium capacitors not only significantly enhanced the cos phi, but also the total harmonic distortion values. THD-V decreased to 1 to 5 percent and the fluctuation range for THD-I dropped to between 20 and 80 percent. Because of the success of the installation and operation of the PhaseCap premium capacitors, in July 2008 TSC decided to equip additional seven steps of with capacitors with 800 V rated voltage.

Applications & Cases



FIGURE 2: CONFIGURATION OF THAI STEEL'S DETUNED PFC SYSTEM



The complete PFC harmonic filter system consists of 10 steps of 150 kvar, 7 percent detuned. Each step is switched by a capacitor contactor.

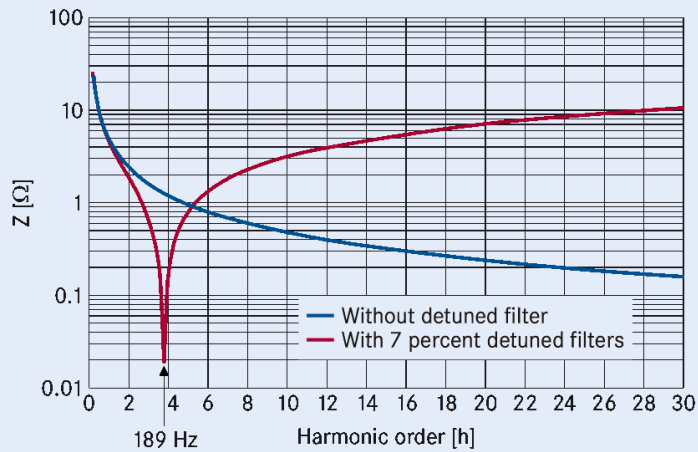
Detuned PFC systems

Detuned PFC systems are used in all cases of high harmonic distortion. In addition to reducing the reactive power, they are also able to significantly decrease the harmonics in the system. The service life of the capacitor and the complete system is also increased thanks to the reduction of the harmonics by detuning. Detuned PFC systems consist of a capacitor and a harmonic filter reactor detuned in a predefined range, which results in a series resonant circuit (Fig. 2). Thus, the natural resonant frequency of the system is below the dominant harmonic and not close to any existing harmonic. In the installation for Thai Steel, the fifth harmonic (250 Hz) is dominant. For this reason, the resonant frequency of the filter circuit is designed for 189 Hz, which means that the PFC system consequently has a detuning factor of 7 percent (Fig. 3).

Applications & Cases



FIGURE 3: IMPEDANCE WITH AND WITHOUT DETUNED FILTERS



Detuned PFC systems could significantly reduce the harmonics in the system.

The detuning factor is calculated according to the following formula:

$$p = \frac{X_L}{X_C} \quad \text{or} \quad p = \left(\frac{f_n}{f_{\text{res}}} \right)^2 100$$

where

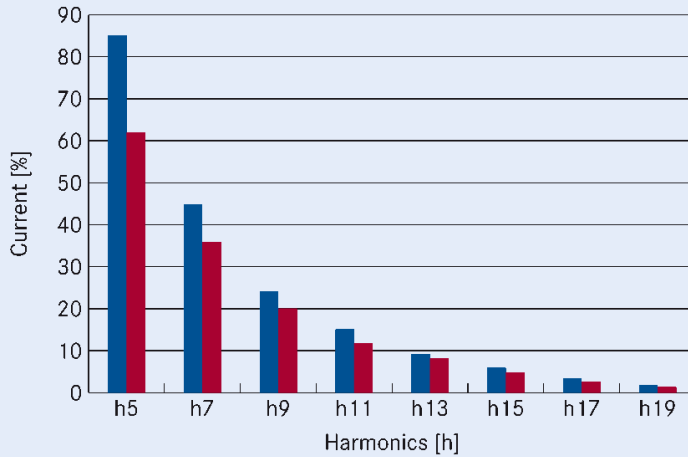
- P Detuning factor in percent
- X_L Reactance of the choke
- X_C Reactance of the capacitor
- f_n Mains frequency
- f_{res} Resonance frequency of the resonant circuit

The measurements taken before and after the new installations and the evaluation of the values showed that Thai Steel's targets were fully met (Fig. 4). The THD values for current and voltage were significantly improved, resulting in an enhancement of power quality and supply stability. Both Thai Steel's bottom line and the environment benefit from the reduced power consumption.

Applications & Cases



FIGURE 4: HARMONIC CURRENT IN A DETUNED PFC SYSTEM



Simulated harmonic current (red) with and without compensation at a 7 percent detuning factor.

The challenges faced by Thai Steel clearly show that it takes much more than just combining some key components to make a PFC system effective. Based on engineering expertise, the evaluation of existing conditions, and the measurement of key parameters, PFC and power quality, specialist ITM has created a custom solution together with EPCOS that is designed to meet the steelmaker's requirements. The success at Thai Steel is strong proof of the benefits of EPCOS' power-quality solutions.

Autor: Lukas Motta, Product Marketing Manager, Power Factor Correction