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Application Notes

PQS

Strong Partners in Steel

Power Quality Solutions

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Foreword

The steel processing industry has gained increasingly in importance during recent decades. Nowadays almost no new construction can dispense with steel. The higher a building, for example, the more its safety depends on the quality of this material.
The Thai Steel Profiles Company (TSC) is dedicated to manufacturing high-quality products for a broad range of customers. In order to maintain its high standards, TSC not only invests in production equipment but also in reducing its use of natural resources and in environmental protection.

Manufacturing a range of parts for the automotive industry is a very important activity, as the driver's wellbeing depends on their functionality and reliability. So the production equipment must guarantee a high degree of precision and quality.

The decision to invest in power factor correction was already taken some years ago. However, the originally chosen solution turned out not to be the best one. Therefore TSC contacted ITM, the EPCOS partner for PQS (Power Quality Solutions) in Thailand. The following case study shows that this was a very wise decision!

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He has run numerous technical training sessions and seminars for utilities, panel builders, consultants and customers around the world.
Lukas Motta was previously responsible for product marketing for medium voltage/low voltage (MV/LV) switchboards and MV/LV power factor correction and harmonic filtering at Schneider Electric.

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Power Factor Correction

Strong Partners in Steel: PFC and TSC – Thai Steel Profile Company

Living in the 21st century, we still admire ancient monuments such as the Great Wall of China, the pyramids of Giza, Notre Dame… the list could be continued indefinitely. But all these monuments have one thing in common – they were constructed without a building material which seems to be indispensable today, namely steel.

Although iron was already known in the 2nd century BC, it took another 1000 years before a simple kind of steel could be produced. But only in the 19th century did new inventions boost it use. The steam engine brought the first form of automation, and railroads and steamboats began to transport goods to fast-growing markets. The Eiffel Tower – presented during the 1889 World Expo in Paris – illustrates the increasing importance of this material. Nowadays, we cannot imagine constructions without steel. The new Olympic stadium in Peking, called the “Bird’s Nest” on account of its appearance, is wire-woven with more than 42 tons of steel braces, and is hugely impressive.

The steel-producing nations created a new kind of industry, namely steel-working, to process the raw material (1131.8 million tons of crude steel were produced in 2005 alone). This sector includes rolling mills where billets are transformed into sheets, tubes, bars or poles.

1. The company

THAI STEEL PROFILE CO., LTD

The **Thai Steel Profile Company, Ltd.** Thailand, was founded in May 1994. With capital of 1000 million Baht (approx. €21 million), it has developed to become a leading manufacturer of high-quality reinforcing steel in the form of round and deformed bars. Its products are used for the construction of high-rise buildings, industrial plants, roads, bridges, highways, dams and airports – just to mention a few. With a production capacity of up to 320,000 tons per year, TSC is dedicated to a **high level of quality,** confirmed by regular quality tests and certification to standards such as TIS and ISO.

Fig. 1: TSC products

TSC not only invests in high-quality machinery made in Europe, but also in **process development**. Several years ago, the company implemented a detuned power factor correction system aiming to:

- **improve power quality**
  - prevent resonance and reduce harmonics
  - prevent voltage drops and increase voltage stability
- **save energy**
  - reduce kvar loads
  - reduce transformer and cable losses
  - reduce KWh and demand loads
  - increase the service life of electrical equipment
  - release system kVA and increase production capacity.

2. Initial situation

For the power supply of the plant, TSC uses six transformers with a total output of 15 MVA.

TR1 – TR4 with mainly nonlinear loads
(DC motors for the rolling mills)

TR5 – TR6 with linear loads

Transformer data

Transformer 1:	22/0.64 KV, 3 MVA
Loads:	Three units with 250 KW DC motors, two units with 350 KW DC motors
Transformer 2:	22/0.64 KV, 3 MVA
Loads:	Three units with 250 KW DC motors, two units with 350 KW DC motors
Transformer 3:	22/0.64 KV, 2.5 MVA
Loads:	One unit with 250 KW DC motors, three units with 350 KW DC motors
Transformer 4:	22/0.64 KV, 2.5 MVA
Loads:	One unit with 250 KW DC motors, three units with 350 KW DC motors, one unit with 172 KW DC motors
Transformer 5:	22/0.4 KV, 2.0 MVA
Loads:	AC motors with frequency converter, AC motors without a converter
Transformer 6:	22/0.4 KV, 2.0 MVA
Loads:	AC motors and plant facility

DC motors are mainly used for the steel rolling mills.

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.

3. Know-how required

Only very few PFC panel-builders in Thailand possess the **technical know-how** and the necessary equipment to run measurements and analyze the grid and the quality of the power and voltage. Several trials to find an explanation for the premature failure of the capacitors failed.

ITM, whose general manager Thumrongdej Mungcharoen looks back on more than 20 years of hands-on experience in the field of reactive power compensation and the reduction of harmonics, has the engineering expertise to identify the root cause by using power analyzers for in-depth measurements.

"We installed a real-time power analyzer to check the power quality, and particularly the harmonics, by gathering as much data as possible", Mr. Mungcharoen says. "When evaluating the **measuring data**, we found very high values of the **total harmonic distortion** of the current (THD-I). We also noted the heavy fluctuation of the values of the total harmonic distortion of the voltage (THD-V)." The average values of THD-V were between 2 and 6%, whereas THD-I showed values from 35 to more than 200%

Fig. 2: Thumrongdej Mungcharoen, General Manager of ITM, Thailand

Evaluation of the extensive measuring data led to ITM's **recommendation** to replace the original 760-V capacitors. The reactors installed in the system were working properly and did not show any failures. Mr. Mungcharoen recommended **800-V MKK capacitors** of the WindCap heavy-duty series from **EPCOS** to be installed together with the present reactors because they were developed specifically for applications with high loads. TSC thus placed an order with ITM to install fourteen steps of 170 kvar at 800 V: each was equipped with 6 x WindCap MKK800-D-25-11 plus 1 x MKK800-D-20-11.

The main features and benefits of the WindCap series, which has now been used in wind turbine and industrial applications for many years, are: a higher **inrush-current withstand capability** up to 300 x I_R, a service life of up to 130,000 hours, long-term approved MKK technology and a triple safety system.

After the installation in June 2007, ITM repeated the measurements, showing that the WindCap capacitors **significantly enhanced** the following values: THD-V decreased to 1 – 5% and THD-I dropped to a fluctuation range of only 20 – 80%.

TSC then decided to place an additional order with ITM to install seven steps of 170 kvar at 800 V in July 2008 after one year's successful installation and operation of the WindCap heavy-duty capacitors.

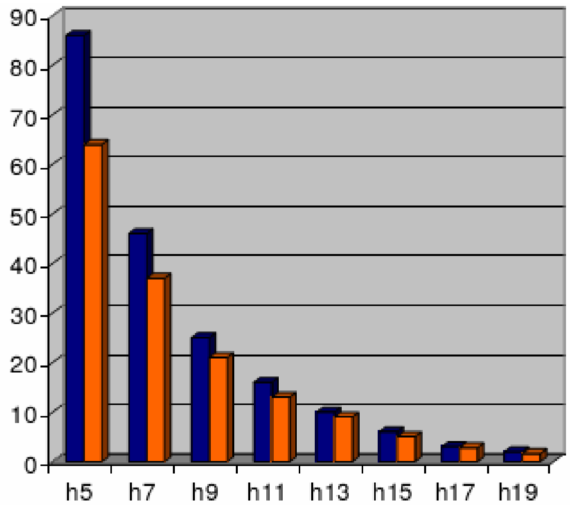

Fig. 3: Simulated harmonic current with and without compensation at a 7% detuning factor

4. Detuned PFC systems

Detuned PFC systems consist of a **capacitor and a harmonic filter reactor** detuned in a predefined range. Thus the natural resonant frequency of the system is below the dominant harmonic and not close to it. In the example given below, the natural resonant frequency is 189 Hz: this **PFC system consequently has a detuning factor of 7%.**

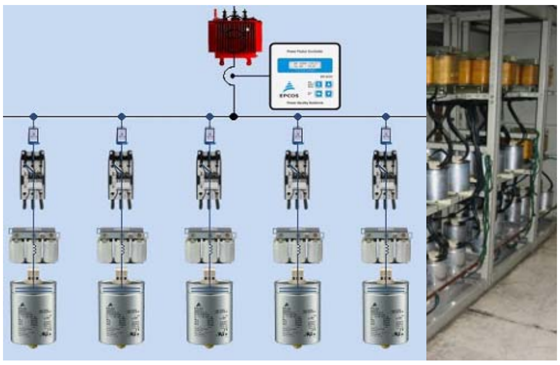

Fig. 4: Principle of wiring diagram for TSC's detuned PFC system

Detuned PFC systems are used in all cases of **high harmonic infestation**. They can reduce the harmonics by **increasing the quality of the voltage** while at the same time specifically combating the **phenomena that decrease its quality**. In addition, the service life of the capacitor and the complete system is increased due to the reduction of the harmonics by detuning.

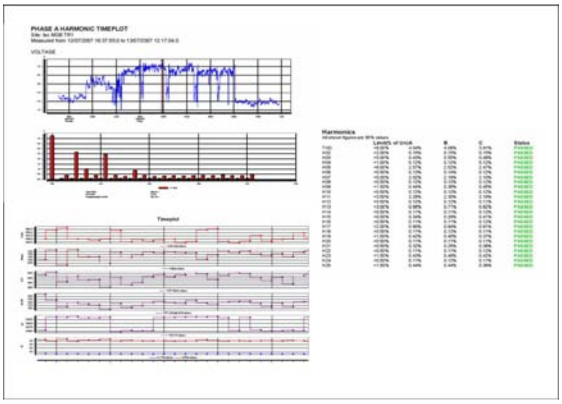

Fig. 5: Grid analysis and extract from the net analysis report according to EN 50160

5. Conclusion

The measurements taken before and after the new installations and the evaluation of the values showed that TSC's targets were fully met: the THD values for current and voltage were significantly improved, resulting in an enhancement of power quality and supply stability. The reduced power consumption will pay off both for TSC and the environment.

The problems that TSC faced clearly showed that 1 plus 1 does not necessarily make 2 – at least in terms of PFC. It takes much more than just combining some key components to make a PFC system effective. The **cornerstones** that ITM built upon to reach TSC's targets were expert know-how, evaluation of existing conditions, measurement of key parameters and customized solutions for specific applications. And these are also the cornerstones of the **EPCOS strategy** for **Power Quality Solutions** – which aims at providing complete solutions instead of mere products. And the success at TSC is yet another proof that this really is the right way!

Fig. 6: PQS components from EPCOS

6. Standards

The recommendations and proposals stated in this Application Note are based (amongst others) on several international standards for PFC capacitors, LV switchgear design and electrical systems:

- IEC60831: LV-PFC Capacitor Standard
- IEC61921: Power Capacitors LV PFC banks
- DIN EN61921: Leistungskondensatoren Kondensatorbatterien zur Korrektur des Niederspannungsleistungsfaktors
- EN 50160: Voltage Characteristics of Electricity Supplied by Public Distribution Systems
- Engineering Recommendation G5/4: Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the United Kingdom
- IEEE Standard 519-1992: IEEE Recommended practices and requirements for harmonic control in electrical power systems
- IEC60439-1/2/3: Low-voltage switchgear and control gear assemblies

The specifications in the standards and manufacturers' data sheets should always be observed.

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