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PQS

PFC in the Plastics Industry

Power Quality Solutions

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Foreword

Finding the appropriate PFC-system for a specific application is always a job that demands experience. Especially in the plastic industry with its high number of various loads caused by a broad range of production equipment, an in-depth evaluation of existing conditions needs to be performed. The more accuracy is paid to find a tailor-made solution, the shorter the pay-back-period will be for the user. Conventional PFC-systems are most certainly not suited for applications like present in the plastic industry – de-tuned or dynamic PFC should be considered as the appropriate solution.

EPCOS offers all key components out of one source for all kind of applications – carefully harmonized to each other. Customized PFC-systems will pay out: not only in terms of power quality, but also with regard to a responsible usage of natural resources.

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PFC in the Plastics Industry

The plastics industry is one of the most important suppliers to all other industries: its products are used in the automotive, communications, multimedia, domestic appliance and healthcare sectors. This market has consequently experienced tremendous growth during the last few centuries.

1. Fundamentals

The basis for the plastics industry of today is **pure nature**: during the 17th and 18th centuries natural scientists brought an elastic substance extracted from milky tree fluids from Malaysia and Brazil back to Europe. Out of "gum", as it was then called, the plastics of today emerged. In 1839, Charles Goodyear found that vulcanizing the gum with sulfur allowed it to retain its flexibility permanently. A follow-on patent was ebonite – a thermosetting material known as duroplast that created **a new industry** whose importance grew very quickly. The famous "Trabant" car, for example, which is a collector's item today, had a shell made of duroplast.

Fig. 1: The Trabant P50, produced in the late 1950s with a plastic shell

Looking at our surroundings today, there is hardly anything that comes without some kind of plastic part: plastics reach all areas of life, extending even to operating theaters and the faces of Hollywood beauties.

2. Characteristics

No wonder that the plastics industry is booming. **New methods** of processing and new applications are an everyday occurrence, requiring new machines and technology for their sophisticated production processes.

The plastics industry is characterized by **heavy electricity consumption:** many items of machinery operate in non synchronized mode with a **diverse range of electrical behaviors**. Of course, all this has a negative impact on the power quality: the power system is highly stressed during bottlenecks, a **large number of switching operations** causes high inrush currents, bringing **additional burdens** to both the power line and its connected equipment.

3. Countermeasures

Power factor correction (PFC) systems in industrial applications have become a proven countermeasure against voltage drops and negative effects on the production process. However, a conventional PFC system cannot fulfill all the requirements, especially in the plastics industry.

Air compressors, air dryers, material hopper dryers, granulators, mixers, autoloaders and water chillers are **typical items of equipment** use in this industry.

Fig. 2: Typical equipment used in the plastics industry

Auxiliary processors for granulating and melting plastic raw materials combine many motor operations with heating resistors, which results in a **fast-changing power factor**.

Plastic molding injectors use electrically driven hydraulic pumps. All of them are in intermittent operation because the manufacturing process creates fast-changing power factors and reactive energy consumption.

Due to the **tough competition** on the market, shift working is common in this business, so that all equipment runs 24 hours a day, often 7 days a week. Product conveyors used in nearly all the various stages of the manufacturing process run without interruption - mainly driven by variable-speed drives.

Fig. 3: Product conveyor

Plastic film is produced by an extrusion process. The material is pushed and/or drawn through a die of the desired profile shape. Extrusion may be continuous (for indefinitely long material) or semi-continuous (for the production of many short pieces); some materials are hot drawn, others cold drawn. In any case, the equipment used requires many **variable-speed motor drives**.

Fig. 4: Production of plastic film

4. Special requirements

The wide variety of equipment in combination with different kinds of processes is **hard to synchronize**. Not to mention that the natural power factor is usually at a low level – with a negative impact on energy costs.

Most plastics producers use three-phase power control for their manufacturing processes. This usually results in a **high content of the 5th harmonic** or above. The given conditions with fast-changing loads and the unavoidable presence of harmonic pollution makes conventional PFC almost useless due to its slow response.

In these cases, it is recommended to install PFC systems whose **harmonic filter reactors** have a detuning factor of 7% or lower to correct the power factor. This helps to control the harmonic content flowing into the capacitor and also avoids parallel resonance. Detuning may also partially filter out a certain amount of the 5th harmonic. As these applications are characterized by fast-changing loads, the detuning PFC systems should be designed with **dynamic PFC technology** allowing a response in real time.

5. Design of a PFC system

The design of an appropriate PFC system for the plastics industry must start with an examination of the prevailing conditions. Analysis of the main power-line parameters such as the definition and variation of loads and the presence and content of harmonics allows the **applicable PFC technology to be determined**. This should be done by skilled personnel as the design must be **customized** to the specific application. Selection of the right components means a shorter **payback period** for the customer.

A **conventional PFC system** normally consists of a PFC capacitor, capacitor contactors with pre-charge resistors and a PFC controller that switches the capacitor stages in and out as required.

Fig. 5: Components for conventional PFC

A **detuned PFC system** basically comprises a PFC capacitor in series with a detuning reactor to modify the parallel resonant circuit (transformer/capacitor) that can be excited by harmonic currents generated by the load. This causes resonance, dangerous overvoltages and harmonic current overload of the capacitor bank and transformer. In a detuned PFC system, the reactor takes over the job of the pre-charge resistors – so contactors without these resistors should be selected.

Fig. 6: Components for a detuned PFC system

In a **dynamic PFC system,** the capacitor contactors are replaced by electronically controlled fast-switching thyristor modules combined with an appropriate dynamic PFC controller. **Ultra-short reaction times** allow capacitors to be switched on and off within milliseconds, thus delivering real-time behavior. **Additional detuning** of the system helps to improve the overall power quality by reducing harmonic pollution, avoiding voltage sags and assuring protection against sudden breakdowns in the production process.

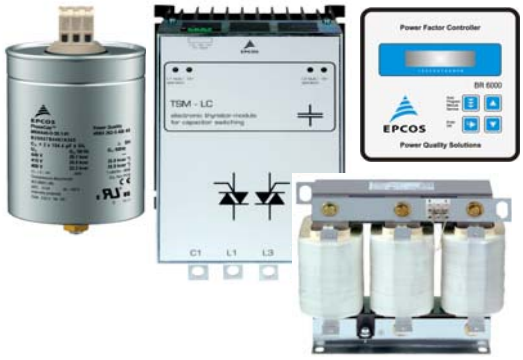

Fig. 7: Components for dynamic detuned PFC

Case studies from other industrial applications have revealed another positive effect. By improving the power factor with an appropriate PFC system, the **superfluous reactive power can be significantly decreased** to such an extent that it has a positive impact on energy costs.

As modern industries such as the plastics sector are given much of the blame for the negative features of **climate change**, it should be mentioned that PFC also helps to **protect the environment** by reducing energy consumption: natural resources are saved and **CO_2 emissions reduced** by making power more efficient.

6. Conclusions

Conventional, detuned or dynamic PFC: the appropriate choice of PFC system is of major importance for success. Power Quality Solutions from EPCOS offer all key components for customized Power Factor Correction from a single source – along with our qualified and experienced partners all over the world, they will help you find the appropriate technology for your needs!

7. 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. These include:

- IEC60831: LV-PFC Capacitor Standard
- IEC61921: Power Capacitors in 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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