Controlling the burn

by Dominik Stettler, Märker Zement GmbH, Germany & Alexander Hanf, Powitec Intelligent Technologies GmbH, Germany

Märker Zement was the first company to choose the PiT Navigator, an intelligent closed-loop kiln and preheater control system (NMPC Non-Linear Model Predictive Control) by Powitec in 2001. Due to major process changes this NMPC system was updated in 2009. The challenge for Märker Zement is the constantly high percentage of various secondary fuels (70 per cent) while also ensuring a stable kiln operation with high clinker quality.

Märker Zement is located in the city of Harburg, Bavaria, southern Germany. August Märker founded the company in 1889 as a lime plant and steam brick plant. Over three generations, Märker has developed an excellent reputation as a cement and lime producer in Bavaria and Baden-Württemberg. The product range includes traditional Portland cements (CEM I), Portland slag and Portland composite (CEM II) and blast furnace cement (CEM III). In addition, Märker also specialises in trass cement.

Märker plant basic data

- Kiln capacity: 3000tpd clinker
- Cyclone: four-stage
- Cooler: planetary cooler (10 tubes)
- Fuels: coal, solvents, sludge, fluff, tyres.

Special production challenges are to burn some different qualities of clinker and using a high fraction of secondary fuels. Märker opted for the installation of the Powitec's intelligent closed-loop control system in 2001, making it the first cement customer for Powitec's product.

Recently, Märker decided to carry out a major overhaul of its cement production. This also included an upgrade to the new series of Powitec's optimiser in 2009.

The optimisation system is named PiT Navigator. PiT is an abbreviation for the name of the system producer: Powitec Intelligent Technologies.

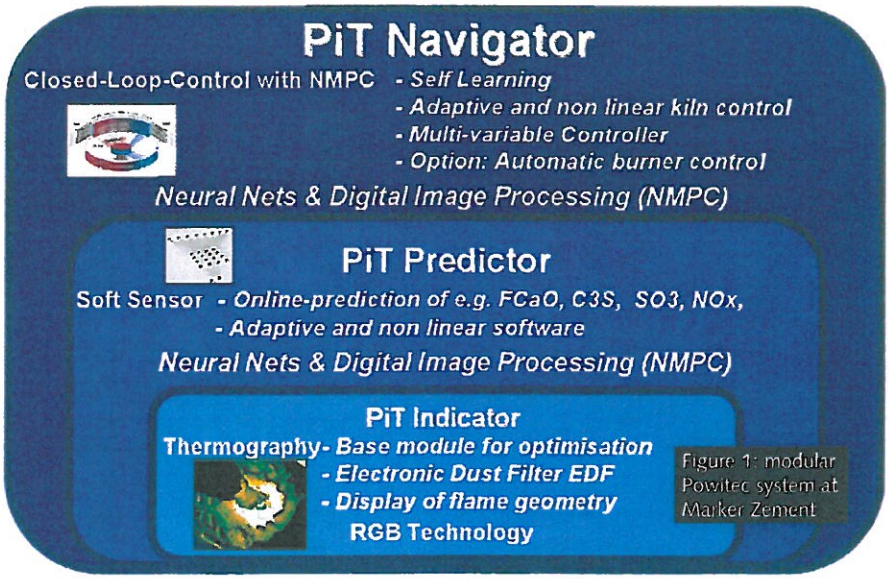


Figure 1: modular Powitec system at Märker Zement

Powitec

German-based Powitec was founded in 2001 and offers optimisation solutions for:

- the cement and lime industry (rotary kilns)
- fossil-fired power plants
- waste-to-energy plants.

Powitec has 45 employees experienced in complex industrial processes and having expertise in Neural Network (NN) and Digital Image Processing (DIP). With about 130 installed references to date, Powitec offers fully developed solutions.

PiT Navigator: innovative optimisation solution

The PiT Navigator consists of three modules (see Figure 1).

The first module is a thermography camera (see Figure 2) generating online characteristics of the sinter zone via DIP. This tool gains information such as:

- flame and sinter zone temperature and flame shape variation
- energy exchange between clinker bed and flame
- plum and fuels combustion properties
- secondary air influence.

The second module is a permanent online prediction of essential process parameters. This so-called Soft Sensor delivers accurate permanent online prediction of eg free lime (FCaO).

The free lime prediction at Märker (see Figure 3) is highly accurate and in line with the laboratory values which are provided one hour later.

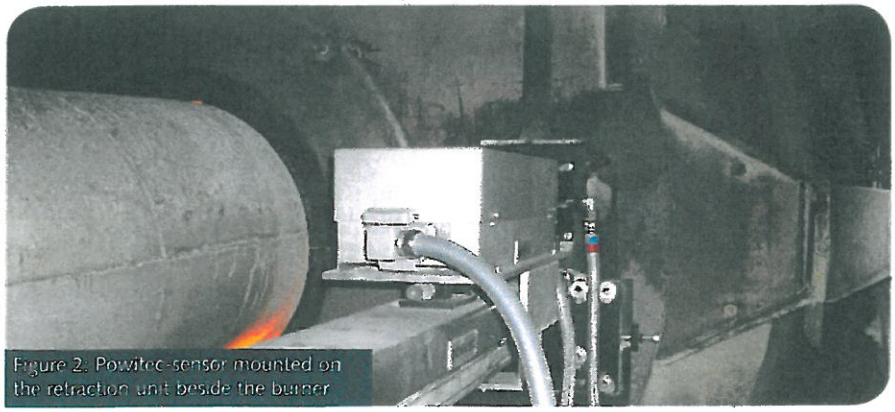


Figure 2: Powitec-sensor mounted on the retraction unit beside the burner

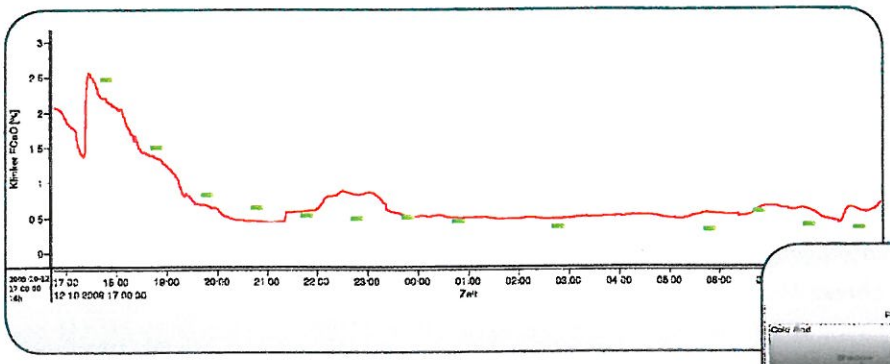
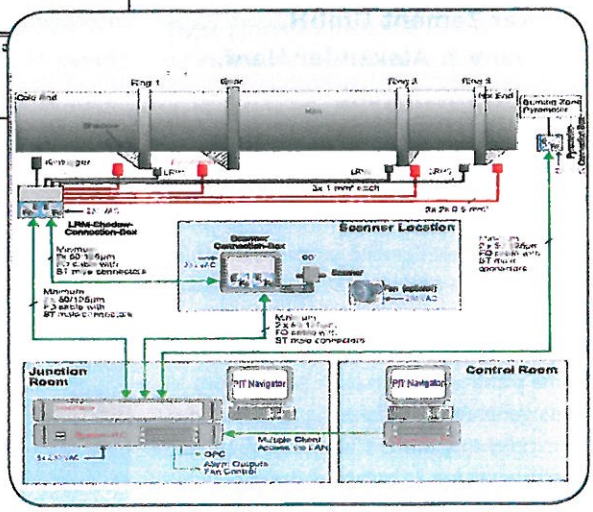


Figure 3 left: Free lime prediction (red) and lab values (green)

Figure 4 below: principle scheme of kiln shell scanner integration



The third module is the closed-loop control via non-linear model predictive control. This system is:

- self-learning
- adapting to varying process situations
- a non-linear optimiser
- based on artificial NN
- using optical information generated by the thermography camera.

Powitec's NMPC system learns autonomously and on a continuous basis. This NN is able to recognise, among other things, changes caused by wear-and-tear and fluctuating calorific values in the primary and secondary fuels. The software re-adjusts its optimisation strategy independently and continuously, based on a set of optimisation targets.

To optimise the process, the flame information is combined with conventional plant data obtained via process interface. This enables a continuous process result prediction and developing an optimisation strategy.

The PiT Navigator also uses the kiln shell scanner at satellite cooler and kiln end (see Figure 4). This leads to significant increase of free lime prediction and kiln torque prediction since the NN can read the drift of the sinter zone at high secondary fuels.

The PiT Navigator software issues, on the basis of the objectives and priorities specified by the plant management, selected actuating signals via the interface to the control system. The continuous feedback of the new results with the input variables helps to make the process model autonomous in its learning capability.

Considering the actual plant and process conditions respectively, the PiT Navigator determines the ideal combination of process control parameters out of a multitude of possible kiln operation modes and feeds the set points to the process control system.

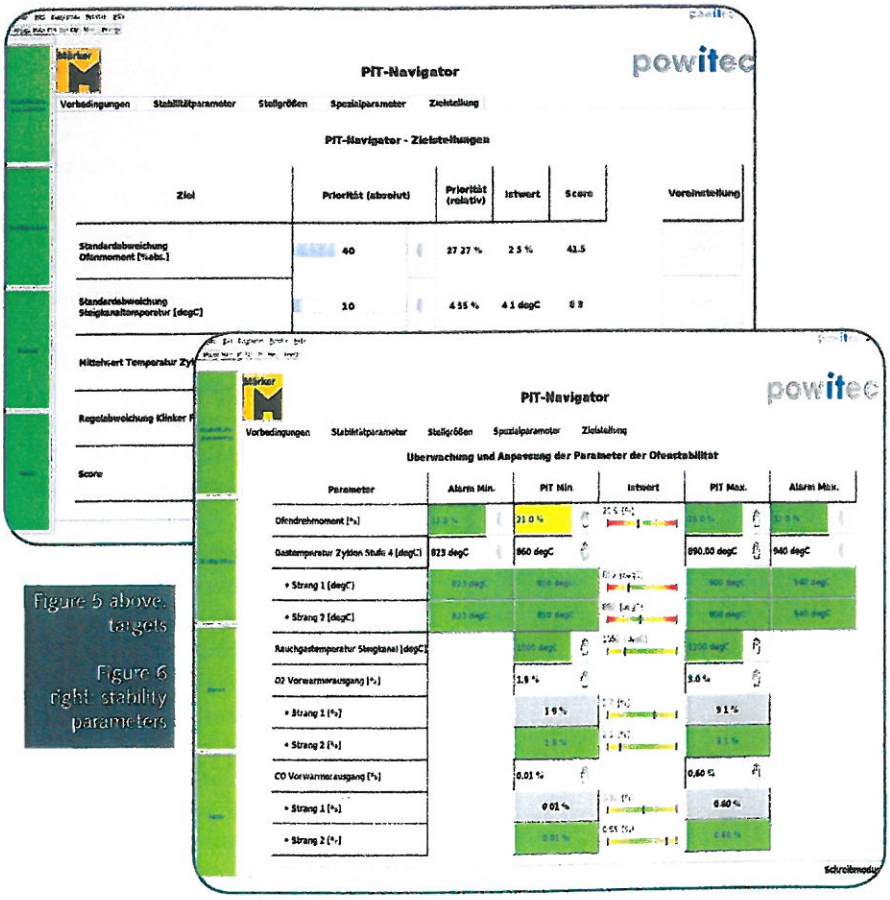


Figure 5 above: targets

Figure 6 right: stability parameters

PiT Navigator optimisation targets

PiT Navigator follows a prioritised target combination, being set by the plant management. During a target finding process this targets and priorities are worked out together with Powitec. Currently, the focus at Märker Zement lies on kiln stability and clinker quality.

Mean value temperature of cyclone No 4	36%
Control deviation free lime	32%
Standard deviation kiln torque	27%
Standard deviation temperature rising duct	5%.

If Märker's plant management's targets do change later on (ie towards energy consumption reduction and/or production increase), these targets can easily be changed by the plant management itself.

The current target combination (see Figure 5) aims at stabilising the process. Stability parameters with its borders are shown in Figure 6.

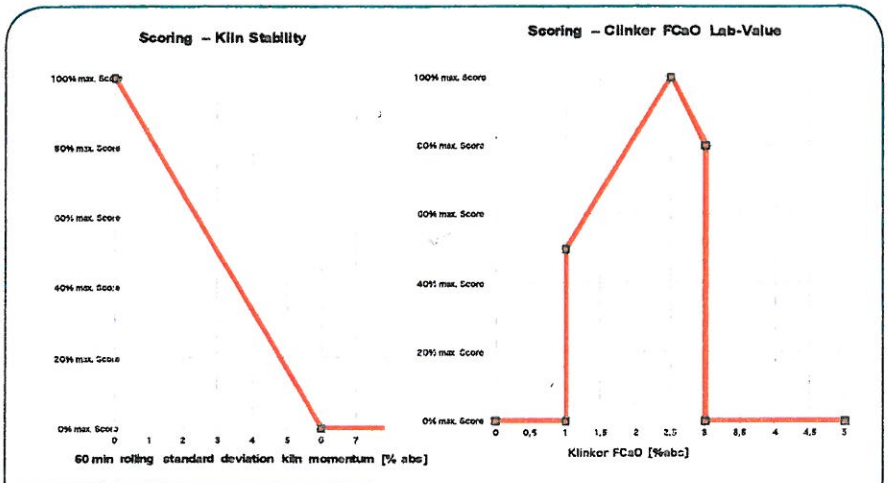


Figure 7: Two example scoring functions

Scoring model

To control the PiT Navigator and to measure the optimisation results under consideration of multiple targets with different priorities (complex target matrix) Powitec installed the scoring tool with the following steps:

- Target function: Märker and Powitec set up a benefit function for each individual target (see Figure 7)
- Priority: each target received an own priority/weighting
- Overall score: weighted sum of individual benefits integrated over a predefined period of time
- Comparison of the scores with and without PiT Navigator.

Results

The challenge for Märker is the high percentage of secondary fuels and at the same time to ensure a stable kiln operation with a high clinker quality.

The PiT Navigator has the additional task to handle extraordinary situations including compensation of secondary fuel outages, heating value changes etc.

Free lime stabilisation

The first result of the installation at Märker was a free lime stabilisation:

1. The free lime value was stabilised and the average free lime prediction error is always < 0.1 per cent abs
2. The free lime was kept on a high quality level.

Powitec produces a constant online and real-time prediction of FCaO by the usage of online data from the Process Control System and the digital image processing information. The accuracy of this free-lime prediction is very exact and shows 95 per cent prediction accuracy.

Results performance test

The comparison of PiT Navigator online and non-optimised operation under same conditions shows operating efficiency of the system. The control deviation of the free lime is significantly better with the PiT Navigator, although less energy was consumed (which was no target and thus no scoring benefit was achieved for this). The comparison as well shows the capabilities to keep the temperatures at cyclone stage 4 on a low, non-critical level. The kiln stability (which is the major target) was increased by 15 per cent.

Further optimisation potential will be launched in 2010 by expanding the control limits for the kiln torque so that the PiT Navigator has the possibility to burn the material less harder.

Conclusion

After the implementation phase and the then gained experience with the updated Powitec system, the kiln is now extensively controlled by the PiT Navigator autonomously.

During the optimisation phase special parameters have been implemented in the system which are designed to provide additional stable kiln operation (eg compensation for fuel for secondary fuel outages, compensation for calorific change, air volume adjustment at raw mill start and stop, checking the transmitted data on meaningfulness etc).

These additional parameters allow a tailored system for every operation mode.

The always good cooperation between Powitec and Märker has helped to implement a system that guarantees stable kiln operation, consistent clinker quality, continuously-taken corrective actions on process parameters, comparable furnace operation and system transparency.

The PiT Navigator at Märker has significantly and measurably optimised the clinker production process, targets have been fulfilled:

- 34 per cent improved and stabilised (controlled) clinker quality
- stabilisation of the cyclone stage 4 temperatures
- 20 per cent better kiln operation than in non-optimised mode
- plus advantages through process stabilisation by automated and not individual operator-dependent control.

Table 1: results process variables from non-optimised versus optimised operation

		Process values		
	Target priorities	*Non-optimised operation*	*PiT Navigator online*	*Difference*
Standard deviation kiln momentum	27%	2.50%	2.45%	-2.0%
Standard deviation of temperature rising duct	5%	5.90°C	5.40°C	-8.5%
Mean value temperature cyclone No 4	36%	867.6°C	863.9°C	-0.4%
Control deviation free lime lab values	32%	0.28%	0.22%	-21.4%
Mean value CO		0.41%	0.41%	0%
Specific energy consumption		100%	98.7%	-1.3%