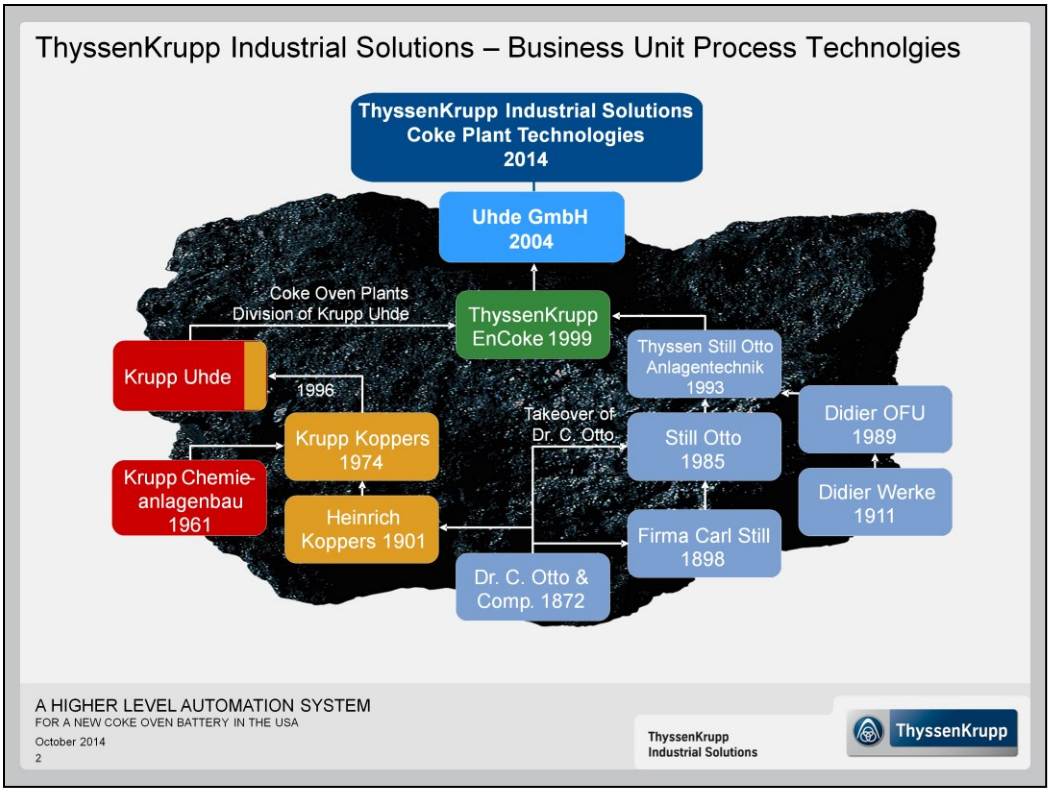
Thank you for the introduction and Welcome Ladies and Gentleman.

US Steel contracts ThyssenKrupp Industrial Solutions to build a new coke oven battery in Clairton (Pittsburgh – Pennsylvania).

This Battery went to operation in November 2012 and was the first new build battery after more than three decades in North America.

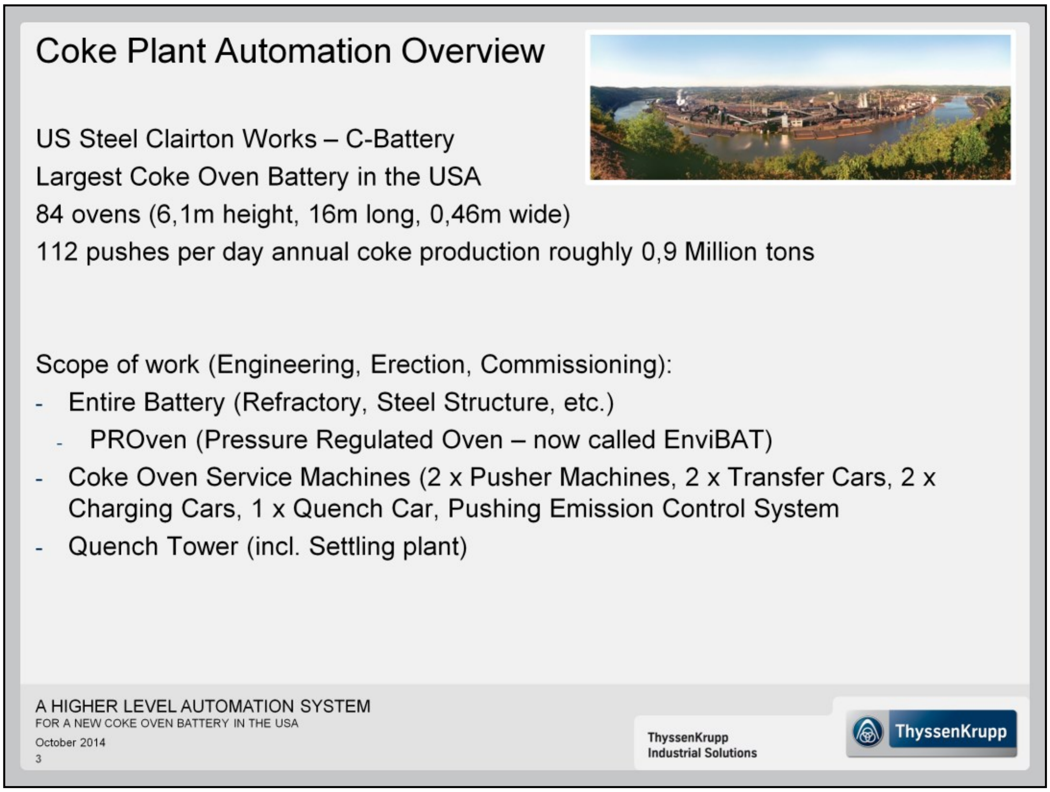
The battery is equipped with state of the art technology and this presentation gives an overview of the implemented automation system and the benefits shown on operation results.



Due to many company internal fusions our name changed in the past years many times.

I guess everybody in this room knows at least one of it.

I do not want to explain the company-tree in detail, but I want to make sure that ThyssenKrupp Industrial Solutions is not new on the market, it is just a new name.



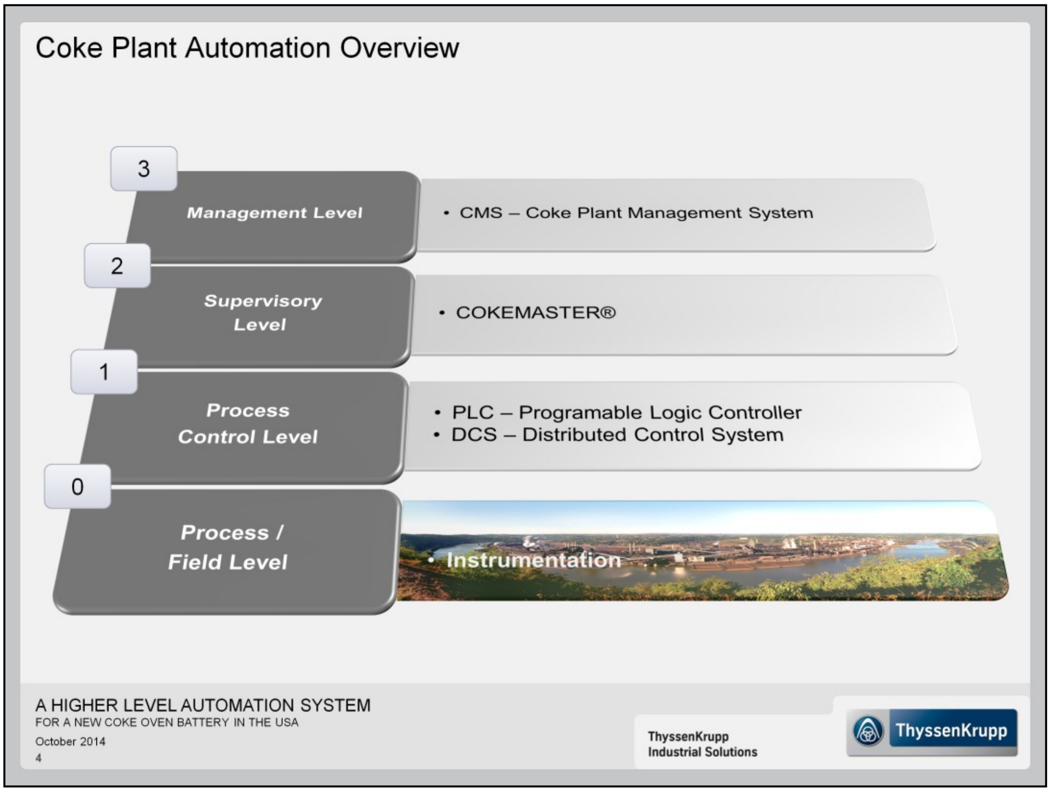
The built Battery is the largest coke oven battery in the USA,

it consist of 84 ovens each covers 30,5 tons of metric coal and produces 21,8 tons of metric coke p. push

112 pushes a day leading to an annual production of 0.9 million tons of coke

The scope of ThyssenKrupp Industrial Solutions was the Battery itself – the Coke Oven Service Machines and

a wet quench tower – all on the base of best available technique and of state of the art technology to ensure optimum production and environmental compliance.



Coming to my majors – The Automation of coke plants

In this presentation I want to highlight especially the Level 2 portion.

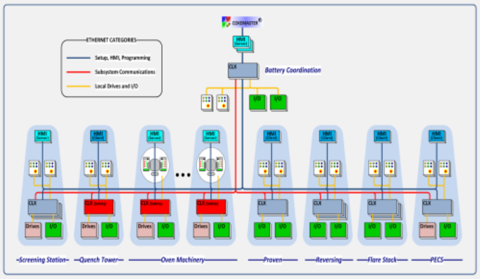
The automation hierarchy Level 0 describes the field level where plant data are acquired, transferred into a PLC which belongs to the Level 1, where the direct control of actuators, motors, etc. takes place.

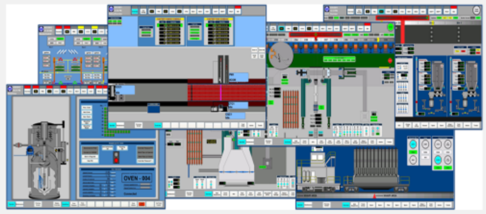
All this data is available in the higher level, so routines on the Level 2 layer can be installed to evaluate and manipulate those plant data and give back optimized production objectives to the process and balances of inputs/outputs to the management level.

PROCESS CONTROL - Level 1 System

Consists of

- Rockwell ControlLogix PLCs & Safty PLCs,
- Drives,
- I/Os
- coupled with Schneider's Citect HMI.





A HIGHER LEVEL AUTOMATION SYSTEM
FOR A NEW COKE OVEN BATTERY IN THE USA
October 2014
5

ThyssenKrupp
Industrial Solutions

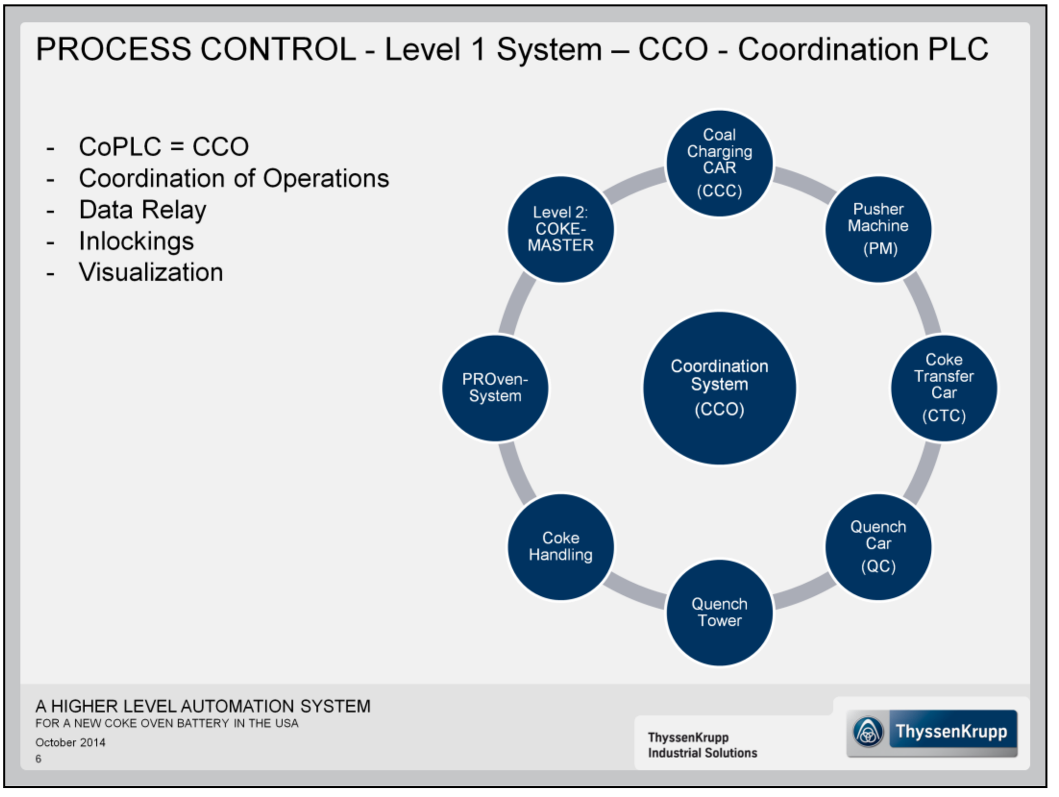
ThyssenKrupp

The Level 1 system consist of Rockwell Control Logix components

PLCs / Safety PLCs of the sub-systems are connected in a clustered network and data of all the systems are available at all over the place.

As HMI System a Schneider´s Citect system was implemented.

A concept which allows access to all plant data on any place was installed to give advanced operators the chance to train unskilled colleagues on the job, even if they are not on the same location. This concept helps for error analysis and production supervision. Each sub-system has an engineering station, to make sure that specialists have access as quick as possible in case of any disturbance.



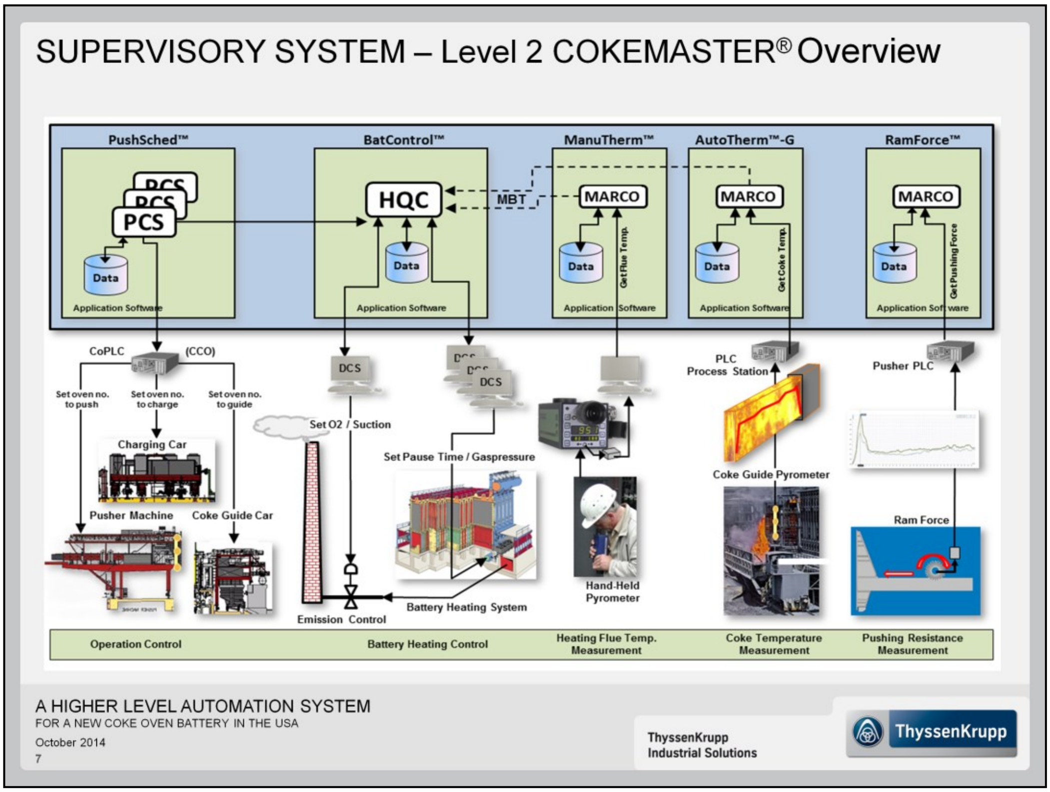
The heart in the automation concept and the „relay“ between Level 1 and Level 2 is the coordination system called CCO.

The main task of the CCO is the coordination of the oven service machines and the interlocking to ensure safe operation conditions for human and machine.

The CCO gets production set points automatically from the higher automation level or by manual input of an operator. This information is forwarded to the respective machines for the given operation.

In case of „pushing an oven“ the CCO receives the oven no. and timestamp from the COKEMASTER Pushing Schedule system and forwards this to the Pusher Machine, Transfer Car, and Quench Car.

The Cross-Battery interlock ensures that no pushing operation starts before all machines are in place and all necessary conditions are given.



The Level 2 framework COKEMASTER is developed by TKIS and was installed on more than 30 Batteries in the last 10 years.

COKEMASTER® is a modular automation framework that mainly serves to optimize the coke plant operation.

It is structured as a Level 2 System and is usually suited between a DCS and higher level management systems, in U. S. Steel's case called CMS.

The COKEMASTER® framework for U. S. Steel Clairton contains the following modules:

Production Supervision and Planning:

PushSched™: the dynamic pushing and charging schedule

Controlling of the Heat Input to the Battery and supervision of the combustion:

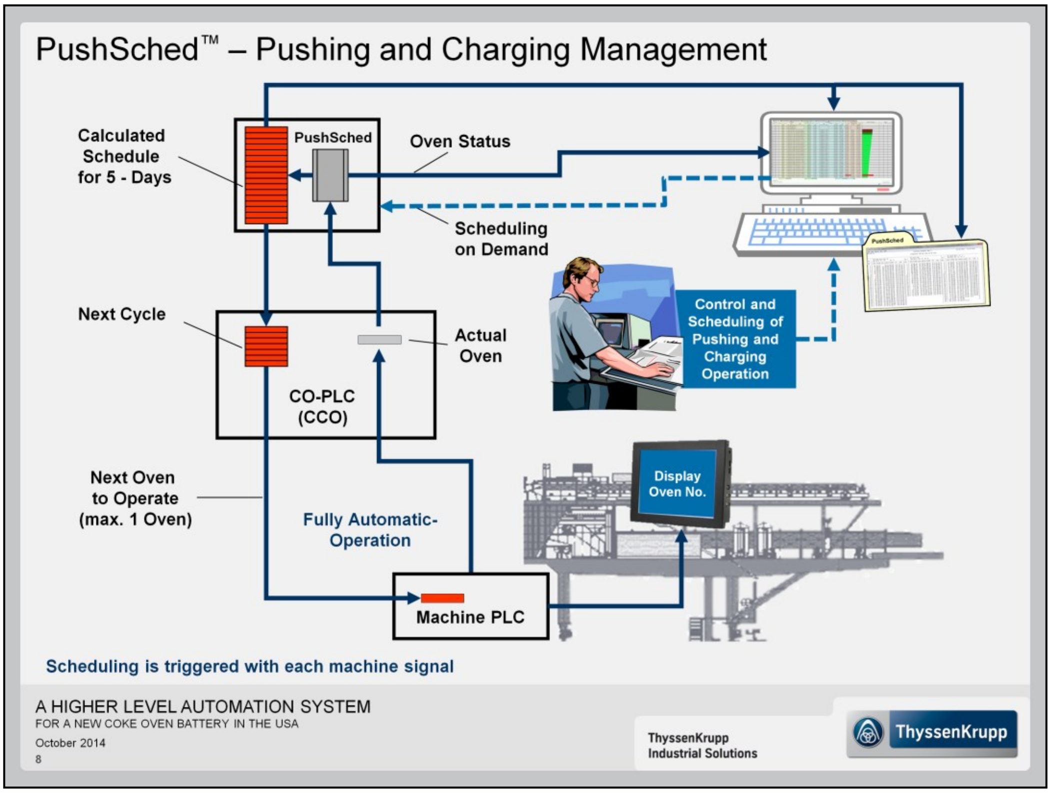
BatControl™: the dynamic heat quantity calculation

Maintaining the Battery Temperature and oven conditions with:

ManuTherm™: the manual heating flue temperature measurement

AutoTherm™-G: the automatic coke cake temperature measurement

RamForce™: the recording of forces during the coke push



PushSched is designed as a Client/Server Architecture,

the client displays all necessary information to the operation team and allows manual interaction to the calculation model.

The client is the HMI system and the model is installed on the server.

The server is connected via an OPC connection to the CCO where all oven machine information is available. This interface is used for receiving and sending data from/to the machines.

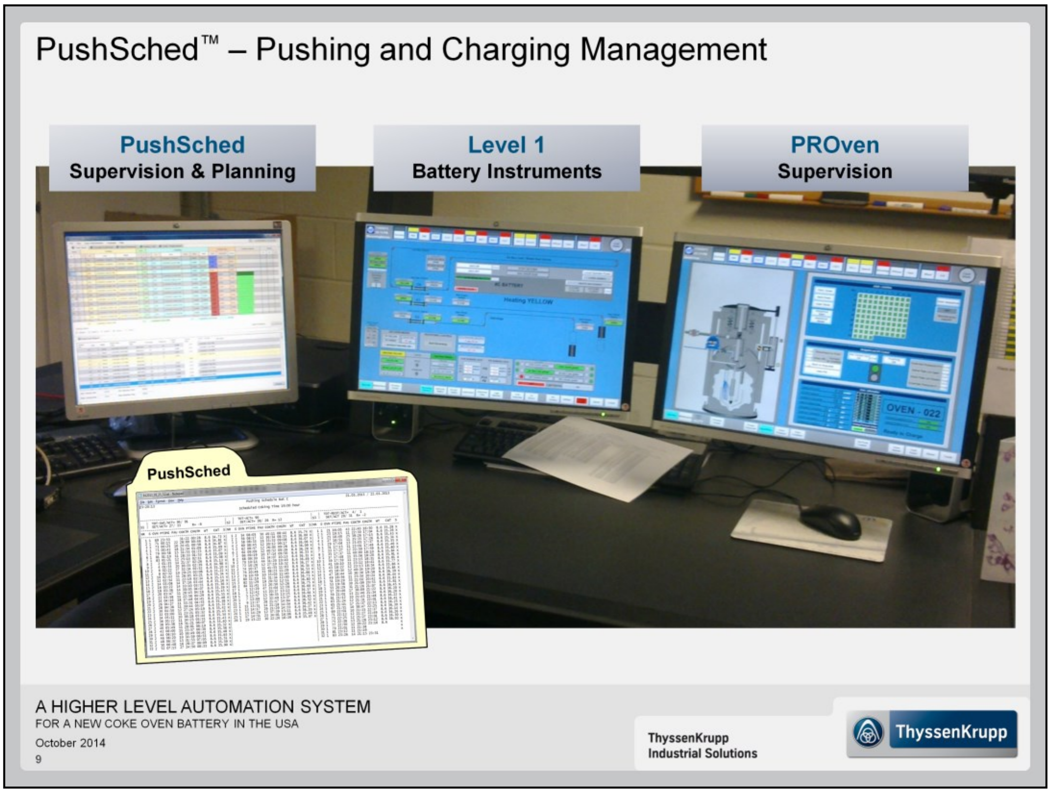
The operator is able to schedule special ovens, such as disturbed ovens, via the HMI and the model takes this changes under consideration in the next automatic calculation or it can be triggered by the operator.

Automatic means trigger by a received machine signal such as “pushing finalized” or “charging finalized”.

The pushing and charging model calculates on this base a schedule for the next 5 days and stores this in the COKEMASTER database.

The changed schedule with the next 20 pushing and charging operation steps will be sent to a buffer in the CCO

and the next operation step is immediately available on the respective machines.



The PushSched Client is located in the main control room, but can be also implemented via a plugin to the most SCADA systems.

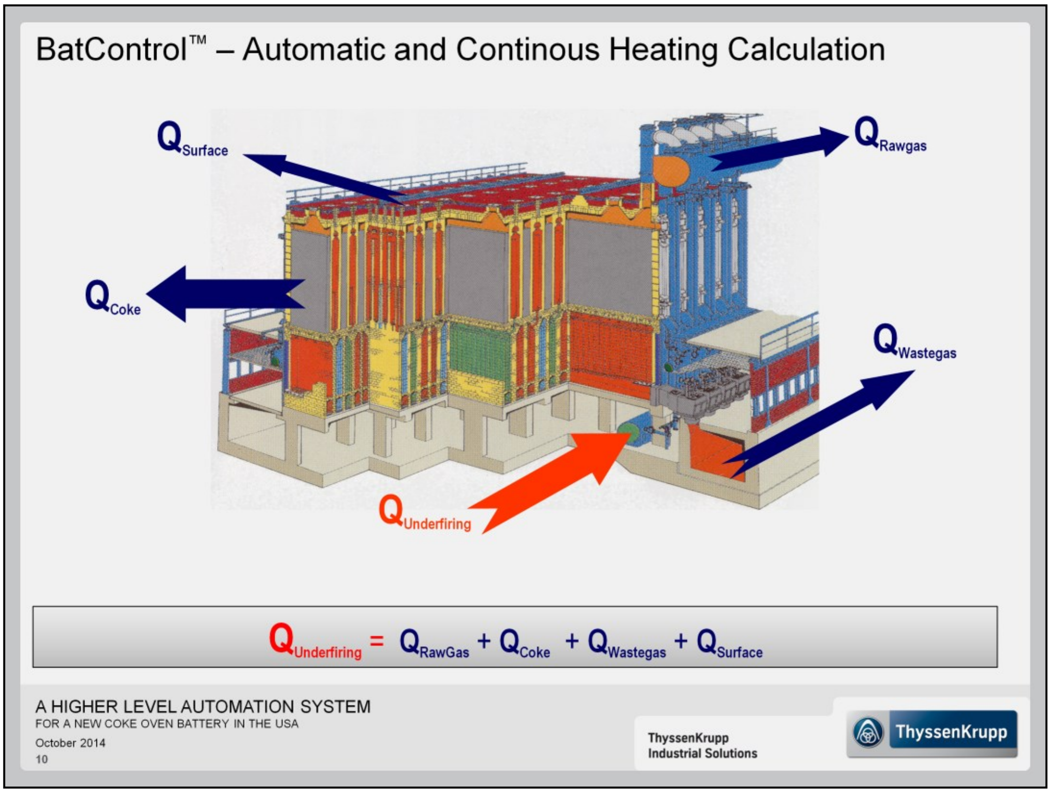
This slide shows the setup at the US Steel facility where the PushSched HMI is all the time supervised by the control room operators.

Daily production reports with all necessary information can be printed and are stored in the COKEMASTER database for later evaluation as well.

Oven conditions, like the actual coking time of all ovens are forwarded to different sub-systems.

Here shown to the PROven system, which requires the actual and scheduled coking time to control the optimum pressure steps inside the oven chamber for the respective coking-condition.

The Level 1 Battery Instrumentation HMI, in this case the heating system, shows the inputs of COKEMASTER to control the heat input and combustion.



The next model of the COKEMASTER framework is BatControl.

BatControl stands for Automatic Battery Heating Control and can be adopted on plants using „pause time“, „pressure regulation“ or regulation of the heat balance by enriching the gas or lowering the heating value to control the heat input to the Battery.

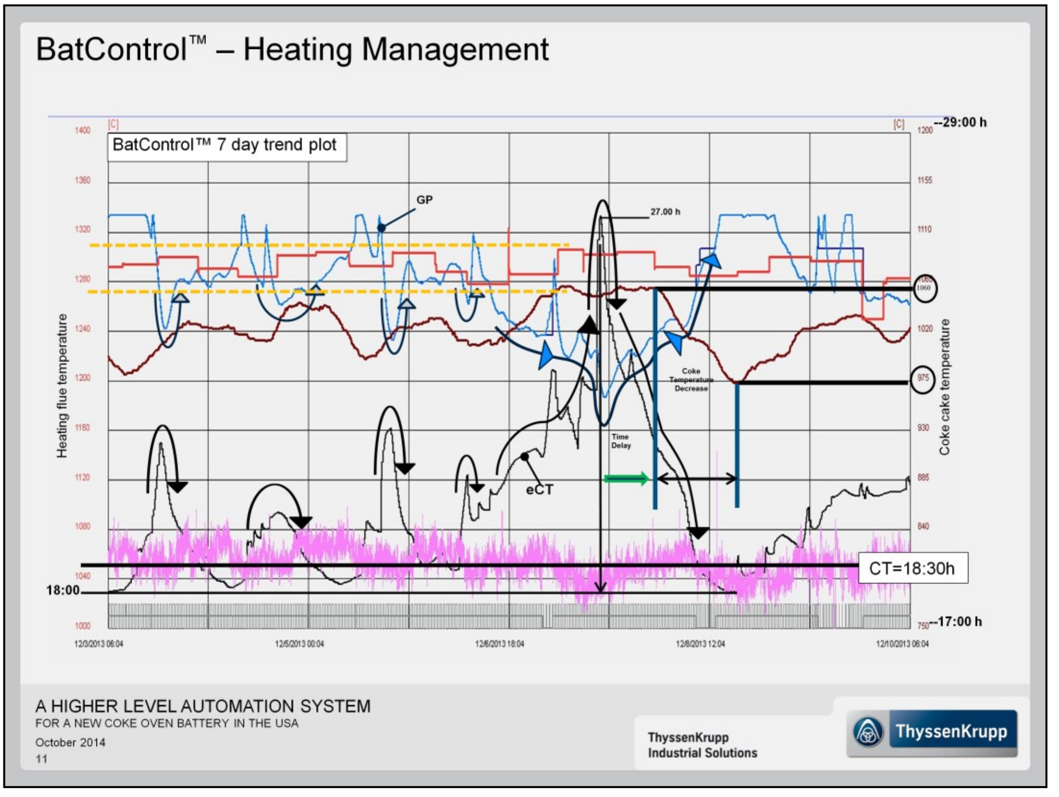
The sophisticated model calculates the required heat in dependence to the expected coking time calculated and received by PushSched and takes all thermal losses under consideration.

The calculated heat requirement is checked and corrected by the temperature feedback of the battery.

At the Battery in Clairton the heat input is adjusted by varying the underfiring gas pressure.

Each automatic change of the underfiring gas pressure causes an automatic adjustment of the waste gas suction to ensure the right relation between oxygen and underfiring gas for the combustion.

In addition there is an automatic wobbe monitoring system, means the calorific value of the underfiring gas is supervised and the system response on fluctuations in increasing or decreasing the gas pressure to ensure a constant heat balance.



This operation example of BatControl shows the influences of the coking time to the required heat for the battery. The black curve shows the expected CokingTime (eCT), the blue line shows the gas pressure (GP).

Due to commissioning work and other delays, in this case the production is fluctuating between 18:00 hours minimum and 27 hours maximum.

If the coking time increases (i.e. due to a delay in production), the heat input to the battery has to be decreased.

If the coking time is decreased (i.e. to speed up the production), the heat input to the battery has to be increased.

So the black and the blue curve course has to be seen vice versa.

Taking the view to an extreme operation delay which shows again the direct impact between increased coking time and the resulting decreased gas pressure.

This situation was handled by BatControl automatically.

After the big operation break the production was speeded-up so fast (27h – 18:30h CT) that the fresh charged ovens cooled down the battery.

This causes falling coke cake temperatures (shown in the brown curve) , which are detected by the temperature feedback function of BatControl.

The model reacts by increasing the gas pressure, even if the temperature drop is not visible in the heating flue temperatures (shown in the red curve).

The reason for this is the inaccuracy of the heating flue temperature measurements, mostly done at gas outlet where the temperature change is moderate, because it is an indirect measurement.

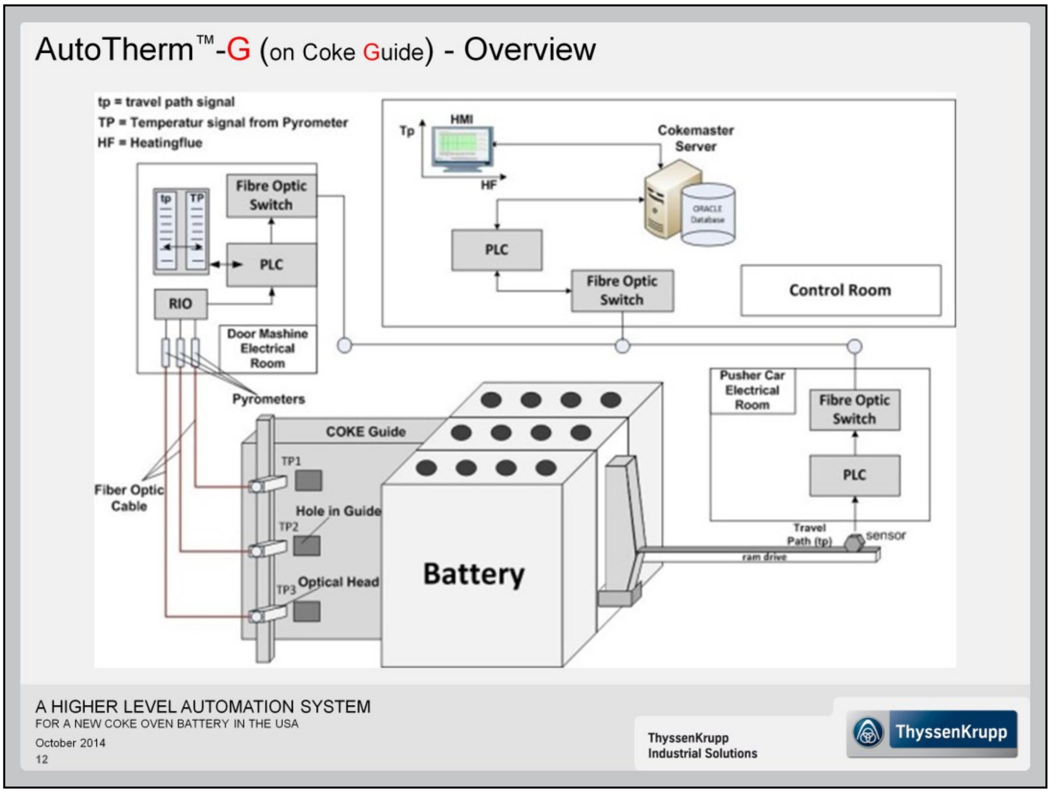
The other point is the heat-accumulation property of the refractory. All the fresh charged ovens taking more heat from the walls then supplied. This leads to the result that at the end of the coking process this coke hadn´t see the required heat over the complete cycle.

The result will be a high pushing and travel emissions.

Our experience shows that the coke cake temperature should not fall below 980°C, to keep the environmental compliance.

In this case the only option was an operation break, because it was not possible to bring more heat to the Battery due to the limitation of gas pressure. The maximum pressure was already reached and the value was clamped by the system.

Summarized: The heating-flue temperature is to slow to provide the necessary information to detect the falling coke cake temperatures early enough to ensure environmental compliance. The continues measurement of the coke cake temperatures is a much better indicator to allow the possibility of counter actions. Therefore the COKEMASTER heating system is using the coke temperature measurement of AutoTherm as a control input.



AutoTherm stands for Automatic Temperature Measurement on coke ovens.

On this slide the basic design of the AutoTherm-G assembly is shown – which US Steel has decided to use.

Three optical lenses in different heights are installed on side of the guide in an air purged case. Those are looking through slots into the guide to the coke cake surface.

The lenses are connected via fiber optic cables to pyrometers which are installed in a protection box on the machine in a location which is not as rough as the place beside the guide. (temp / dust)

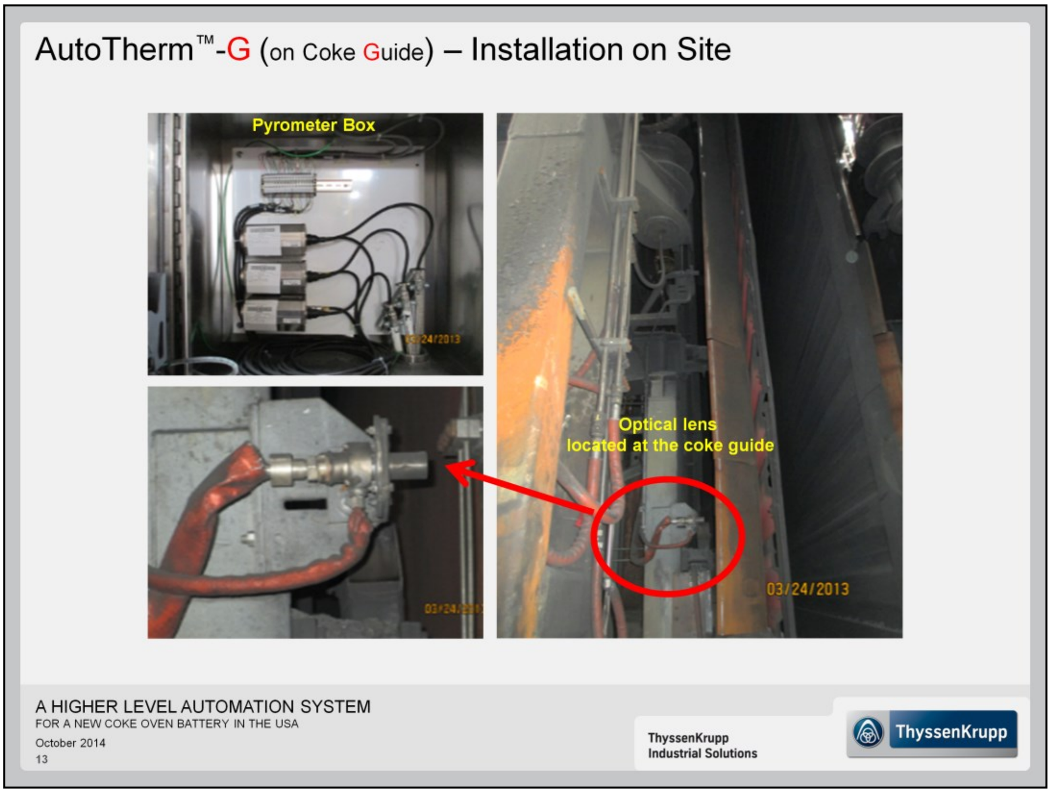
Those pyrometers are connected to the AutoTherm PLC and are processed while the coke is being pushed through the guide.

To assign the measured temperature to a position of the ram, means to assign the right temperature to the respective part of the cake, a communication to the travel path encoder of the pusher machine is established.

The temperature values are averaged for a certain wall span (width of heating flue) by a designated PLC, so that 32 temperature measuring values in correspondence to the heating flues are available for each coke mass measurement and measuring point.

The values combined together with the pushed oven number are transmitted to the COKEMASTER® database for storage and evaluation by the operator.

Additionally this values are processed and transferred to BatControl.

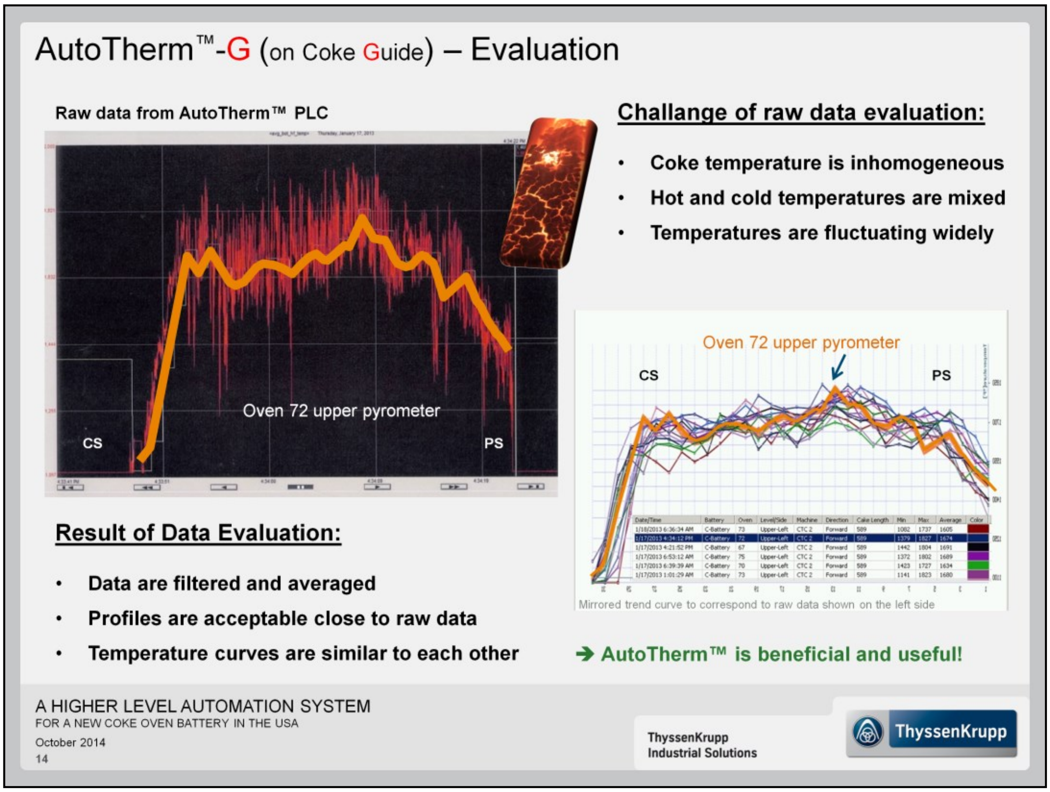


The pyrometers are installed in a protection box away from the hot guide.

The fiber optics and its protection hoses are shown right of the pyrometer. The pyrometer are connected via a remote IO to the AutoTherm PLC located in the electrical room of the machine.

The guide itself is slotted in three heights to enables the lenses to look inside the guide. The lenses are mounted in special air purged cases to ensure an overpressure inside to avoid dust to infiltrate.

The fiber optics are designed for rough environments and are protected against dust and additionally isolated against heat by special protection hoses.



Coming to an operation example of an AutoTherm-G measurement.

The biggest challenge is the spreading of temperatures in the raw data caused by the inhomogeneous coke surface – dust and flames.

The wide fluctuation is compensated by a high ratio of samplings and through processing algorithms.

The raw data are recorded and trended chronologically, means the first value is of the coke side, the last value is of the machine side.

→click

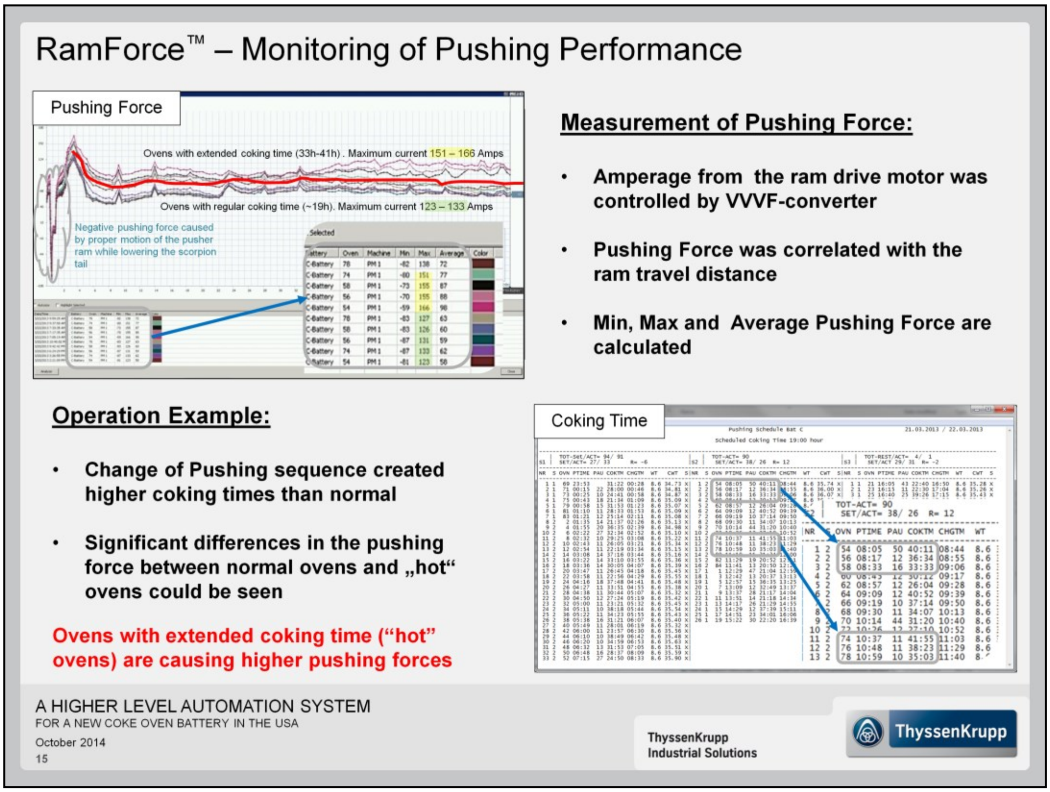
To compare data of the COKEMASTER evaluation, the values have been mirrored, because they are stored in the database vice versa the raw data.

The orange marked curve is selected in the COKEMASTER application and belongs to the selected raw data curve. (upper pyrometer – oven 72).

→click

The profiles of the curves are acceptable close to the raw data and the temperature curves are similar to each other.

The before mentioned benefits in detecting deficits of coke end temperature and the reliability of the results proofs that „AutoTherm is beneficial and useful“ as an automatic temperature measuring system.



Last but not least the RamForce application of the COKEMASTER framework monitors the force the pusher ram drive needs to push out the coke.

The amperage value of the ram drive (variable frequency drive) is sampled and correlated with the travel path to assign the sample to a position inside the oven.

The processing is implemented in the pusher machine PLC and the data are transferred via an OPC connection and stored in the COKEMASTER database for further evaluation and documentation.

→ click

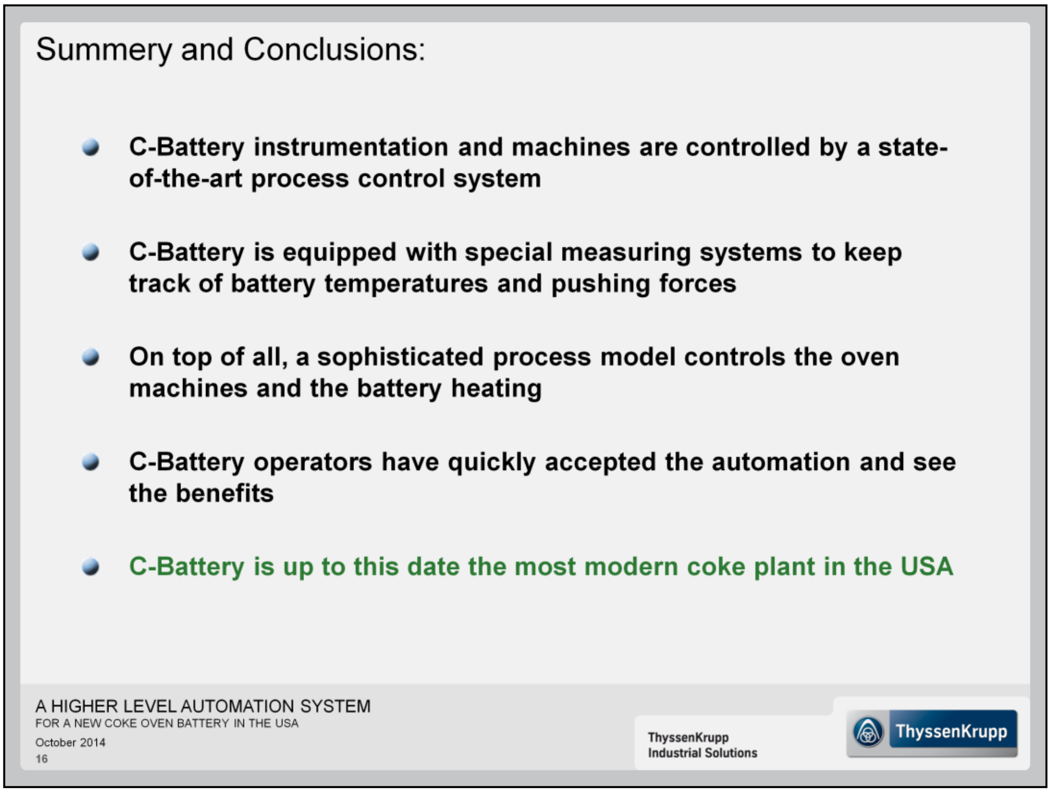
Due to a decision to change the pushing sequence from 5:2 to 2:1 there was a time with many ovens on higher coking time than normal.

All these ovens had the same RamForce characteristic, roughly 20% more force was needed to push the ovens out.

→ click

This is one result which can be taken of the RamForce measurements, additionally RamForce measurements stored in the COKEMASTER database offers the maintenance possibility for long-time evaluation.

The variation of coal blends causes as well different demands to the coking process. Whether the oven is coked out correctly can be easily seen in evaluating the RamForce measurements.



C-Battery instrumentation and machines are controlled by a state-of-the-art process control system

C-Battery is equipped with special measuring systems to keep track of battery temperatures and pushing forces

On top of all, a sophisticated process model controls the oven machines and the battery heating

C-Battery operators have quickly accepted the automation and see the benefits

C-Battery is up to this date the most modern coke plant in the USA

Thank you very much for you attention and feel free to visit our booth in the poster presentation room.