”TMT- New Developments for the Cast House and Probes”

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Abstract

Maximizing process efficiency and the blast furnace lifetime is a must today to remain competitive. This paper shows three recent developments pursuing these targets.

The new drill hammer **“HS600”** with adaptive power settings allows to apply automatically the power level required by the taphole condition. This avoids introducing excessive energy during the tap hole opening and increases taphole hearth lifetime.

The new **“3D TopScan”** profilemeter is the only probe capable of continuously scanning the complete burden area, providing a 3-dimensional burden profile every 20 seconds or faster. On-line monitoring of blast furnace charging is now a reality, allowing further to optimize furnace performance and reducing the coke rate.

The **“SOMA”** acoustic-based above burden gas temperature measurement continuously provides a 2-dimensional actual gas temperature profile. Within a short period of time, SOMA has established its position worldwide as a valuable process optimization tool, while at the same time eliminating costly lifetime- and maintenance issues of traditional above burden probes.

Introduction

Maximizing process efficiency and the blast furnace lifetime is in today`s economic environment even more crucial than in the past.

This challenge has led TMT to develop new technologies, helping blast furnace operators in achieving their goals.

- **“TMT-SOMA™”:** acoustic-based 2D above burden gas temperature measurement.
- **“3D TopScan”**3D profile meter for an on-line monitoring of blast furnace charging
- **“HS600 drill hammer”** the new reference in taphole drilling featuring adaptive power settings

All three developments are based on

- highest degree of reliability

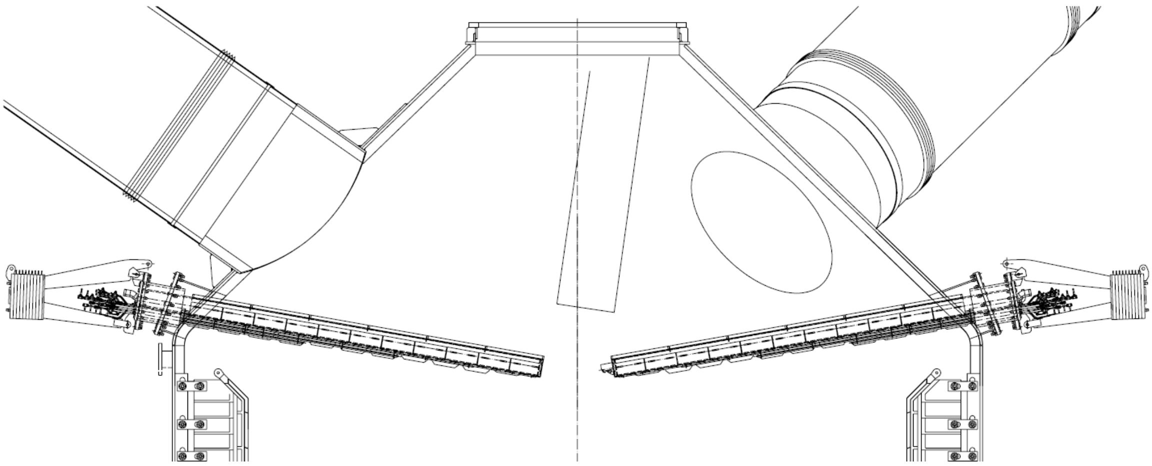
- continuous reduction of production costs for shortest possible return on investment for the customer
- easy maintenance or ideally maintenance free

TMT SOMA™: 2D Top Gas Temperature Measurement

The knowledge of the top gas temperature distribution and gas channel location in the BF top cone is an important feedback for the BF operator allowing adapting the charging program in order to optimize the blast furnace process.

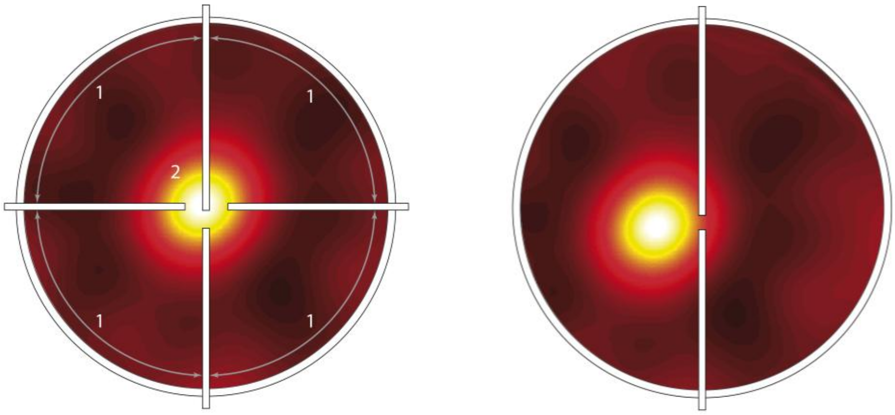
Conventional Technology

Blast furnaces equipped with conventional gas temperature measurement technology typically operate with two or four pieces gas temperature probes.



Typical layout with conventional temperature probes

Even with four conventional probes being installed, the “measurement coverage/density” over the burden surface is low and very irregular. As a matter of fact this technology does neither provide a complete picture of the gas temperature distribution, nor does it allow for the tracking of the central gas channel.



Low measurement coverage on the blast furnace border even using four Above-Burden-Temperature-Probes (1) with a centre gas channel (2) (a).

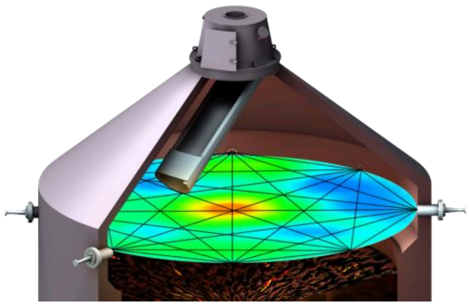
It is not possible to have a clear gas channel tracking using either two or four Above-Burden-Temperature-Probes (b).

Description of the latest TMT SOMA™ gas temperature measurement technology

The TMT-SOMA™ is an innovative, robust blast furnace top gas temperature measurement system. The operational principle of this system is based on acoustic temperature measurement completed with a 2D tomography data evaluation.

The obtained 2D temperature distribution provides blast furnace operators with new process analysis capabilities, which are not possible with the common multipoint temperature probes. Also, this equipment is perfectly suited to be combined with intelligent blast furnace process and monitoring expert systems.

Measurement principle: Multiple transceivers, each operating as transmitter and receiver, are installed on the circumference of the top cone. Each transceiver emits sound, recorded in turn by the other transceivers. The time-of-flight is measured. The speed of sound is directly proportional to the actual gas temperature.



A high performance processor calculates the actual gas temperatures in-between transceivers after each sound emission. A tomography algorithm, specifically developed for blast furnace conditions, computes all measurements to reflect a complete 2D isothermal view of the absolute top gas temperature. This view is updated every 4-6 seconds.

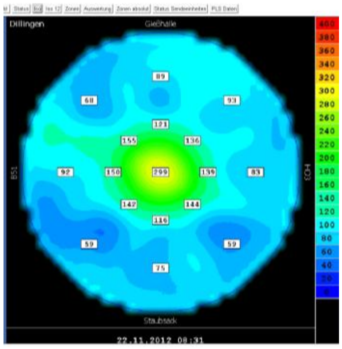
Today, the system is in operation on a variety of blast furnaces around the globe.

Advantages of the new technology and potential cost savings

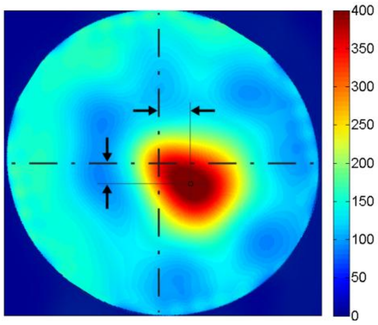
The TMT-SOMA™ system has numerous advantages compared to conventional above-burden temperature probes.

The **measurement density** over the complete blast furnace section is more homogeneous than for above-burden temperature probes, which makes the measured temperatures not only more representative and reliable, but also helps the BF-operators to maximise production or process efficiency.

For this purpose the integrated **tomography algorithm** opens a vast array of new gas temperature evaluation methods useful for the blast furnace operation that have not been available until today with the classic gas temperature measurement probes.



Isothermal view



Gas channel tracking

Typical examples of customisable HMI screens of the TMT-SOMA system

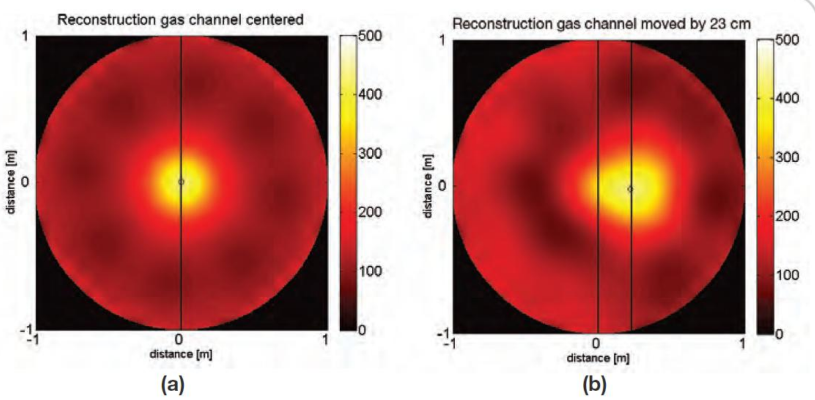
The system has **no inertia**, so gas temperature variations are detected instantaneously. Contrary to that, conventional temperature probes cannot detect rapid increase which might give an early indication of an ongoing or imminent abnormal operation.

The components of the TMT SOMA™ system are very robust, and there is no need to exchange components on a regular basis (as it is the case with conventional temperature probes).Consequently maintenance requirements for the SOMA are very limited and maintenance costs are drastically decreased.

In order to maximize the efficiency of the process, BF operators try to charge the burden as precisely as possible. The transceivers of the TMT SOMA system are installed in the blast furnace wall, therefore without any components penetrating into the burdening area. This way, unlike with conventional temperature probes, no disturbance of the charging pattern appears.

The TMT SOMA™ system is able to track the gas channel position without any limitation and source of misinterpretation. In addition, the system provides the possibility to monitor the border temperatures with a good resolution.The BF operators can assess the relationship between the gas flow through the BF central chimney and along the wall, thus enabling an optimization of productivity and BF lifetime.

Conventional temperature probes protruding into the furnace proper are affecting the charging of the burden



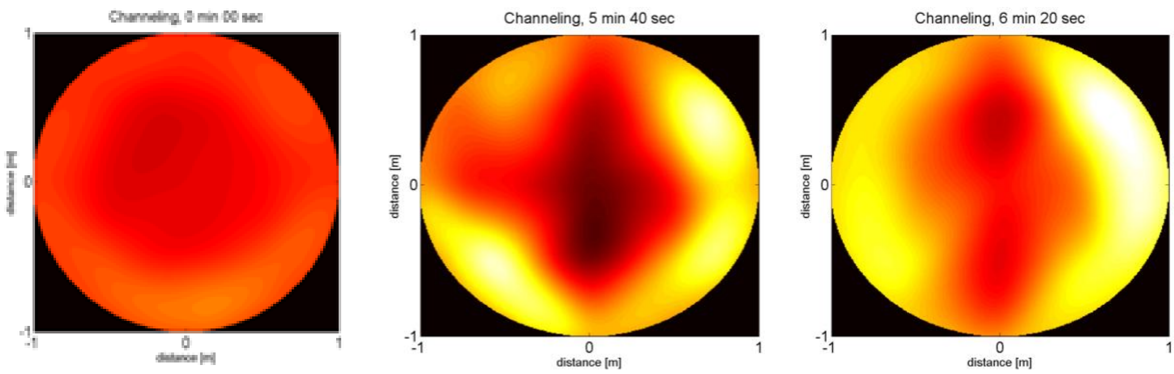
Gas channel tracking:

(a) perfectly centred gas channel

(b) gas channel drifting off centre

It is possible to detect secondary gas channels or wall channels and even to detect the position where those appeared.

This is shown in the following sequence of pictures, where instances with blast furnace channelling were identified The temperatures begin to increase rapidly in the border region along the blast furnace circumference (Figures b and c).



(a) (b) (c)

This sequence of 2D temperature profile recorded with the TMT SOMA system shows the rapid appearance of a wall channel during blast furnace operation.

Conclusions

The acoustic temperature measurement is superior in performance, precision, reliability and provides process feedback which is not available with classic temperature probes.

Camera systems, oftentimes promoted for temperature measurements, can only provide a qualitative statement of the surface temperature they see.The gas temperature being the important indicator for the process efficiency cannot be measured.It must also be taken into consideration that the quality of data provided by camera systems deteriorate with decreasing temperatures until they become virtually blind when temperatures fall below 300 [°C].

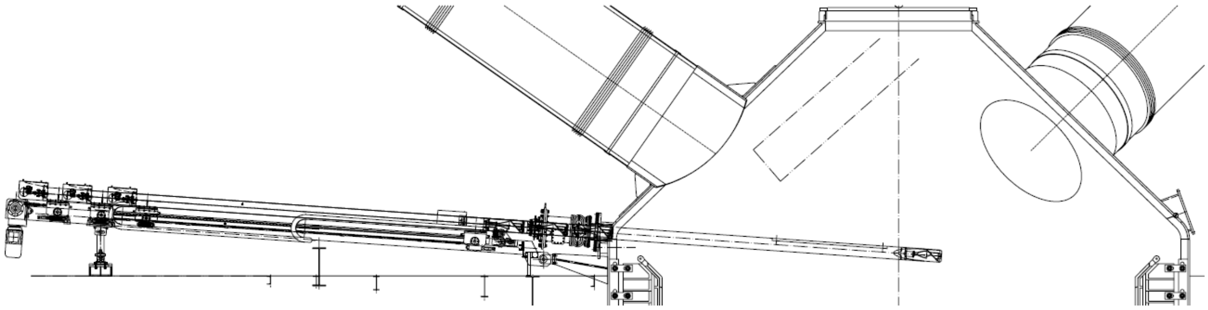
3D Top Scan: True Surface Profile Measurement

Profile meters are used to allow for an assessment of the burden surface. It is this knowledge of the burden distribution which allows the BF operator to adapt the charging matrix when trying to decrease the coke rate, and consequently minimize the operating costs.

A trend for collecting more data has not only emerged regarding the measurement of the temperature distribution with the TMT-SOMA™ system. With the introduction of the3D Top Scan it became possible for the first time to measure a complete surface, in high resolution, in real-time.

Conventional Technology

A conventional profile meter is essentially a vertical single point radar distance measurement that is linearly moved along a BF radius by a horizontal lance.



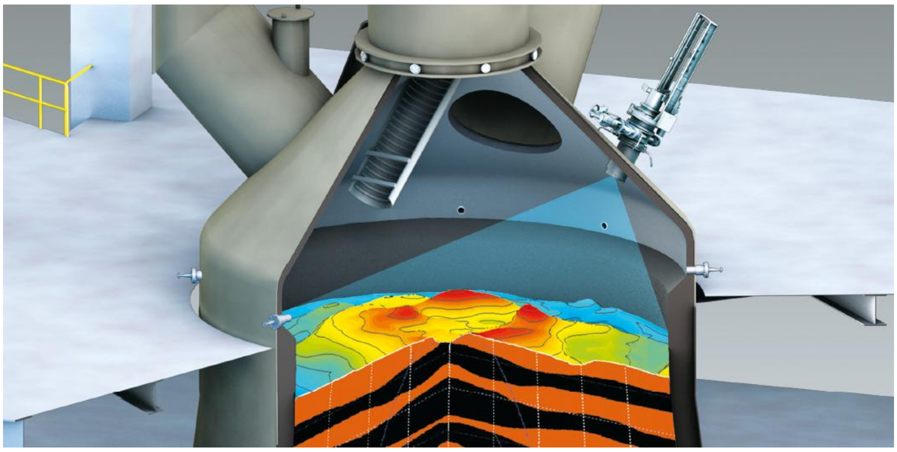
Conventional Profile meter

When using conventional technologies it is only possible to record one predefined radius of the burden surface. Also, typically, only one profile is measured per charging, and the charging is interlocked during the measurement. Other existing measurement concepts even measure only individual points and interpolate these to simulate a profile.

As it is known that the surface of the charged burden is unlikely to be symmetric, i.e., that the radial profile is not the same at every position, the goal for a new development was to determine the complete burden surface topology to include information on asymmetries.

Description of the latest 3D Top Scan technology

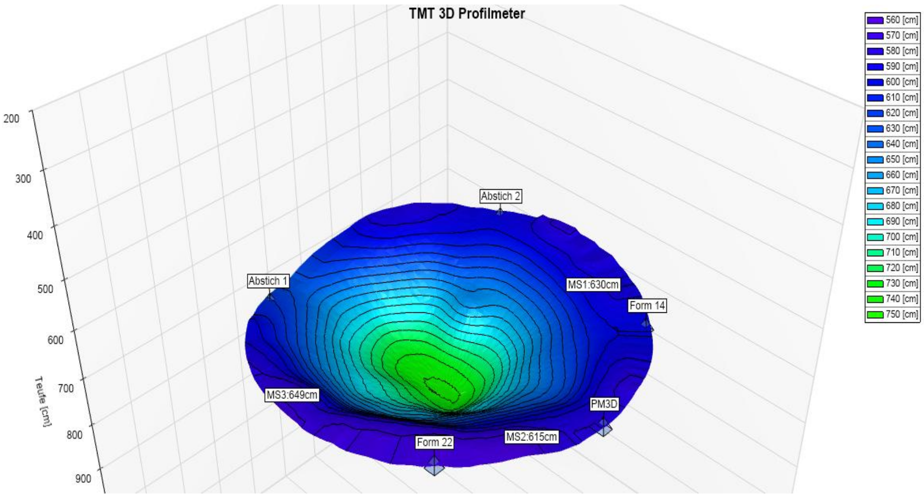
The 3D Top Scan is installed in a fixed location at the top cone where it conducts the measurement continuously. As no mechanical parts protrude inside of the top cone area it can neither interfere with the rotating chute nor the charged burden.



3D Top Scan installation on a BF cone

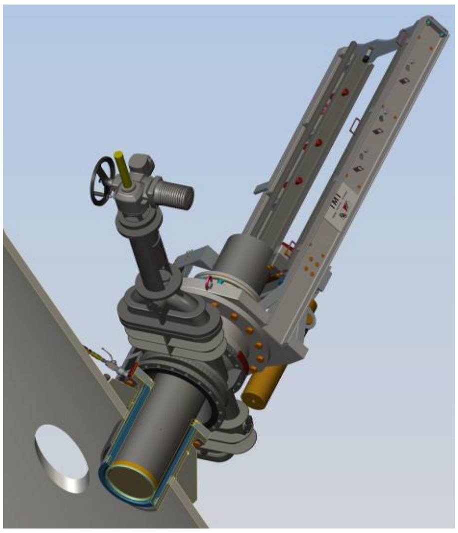
In order to enable the system to collect more process data in a short time frame and on a continuous basis, the 3D Top Scan™ uses the latest in radar- and antenna technology and provides a surface scan with **multiple thousand data points within a few seconds.**

Every 20 seconds, a well-detailed BF burden surface, comprising a total of ~10.000 reflection points is recorded. The short timeframe is of utmost importance, as the burden surface constantly moves downwards in the operating BF. A longer data acquisition time would affect the accuracy unnecessarily. The complete surface is measured in a highly detailed resolution, such that no assumption of radial symmetry or interpolation is required.



Burden Surface, recorded within 20 seconds on the operating BF

One of the main arguments for the success of the profilemeter has always been its maintenance friendliness. The new 3DTopScan can be maintained independently of the BF process. The radar system is fully integrated and protected inside the lance. As shown in the below picture, the system can be retracted with the BF being on blast and isolated from the process with a shut-off-valve. A service intervention can then take place while the BF remains in operation.



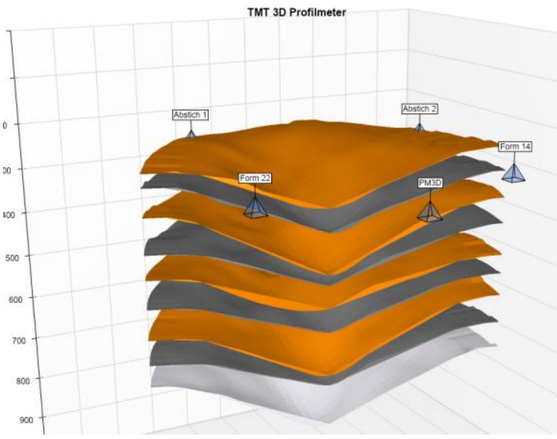
Retractable TMT "3D TopScan" Profilemeter. During operation and during retraction of the lance a stuffing box seal ensures tightness towards the atmosphere. Once the lance is retracted and the isolation valve is closed, the system can be fully withdrawn for servicing.

Consequently no production loss occurs and immediate maintenance is always possible.

Advantages of the new technology and potential cost savings

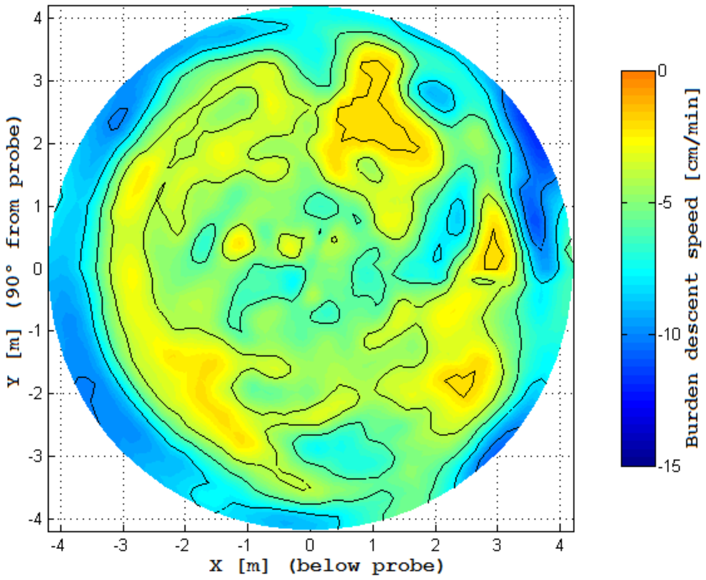
The major benefits for the blast furnace operators are the detection of the complete surface, and this at a very high update rate. Rotational symmetry is no longer assumed while real asymmetries in the surface pattern are detected in all its details.With the charging feedback being drastically increased, process analyses can be taken to the next higher level.

The 3D burden surfaces of the individual layers in the charging matrix are processed to a layer model. This model indicates the shape and the thickness of the different layers in the burden column.This data enables the operators to adapt their charging matrix to reduce the coke rate and to prevent perturbing phenomena.



Exemplary layer model, displaying an arbitrary selectable cross section of the burden distribution. (coke layers indicated in black, ore layers indicated in orange)

The obtained measurement data also allow for a calculation of the local burden descent speed. The detection of a nonhomogeneous speed can help to recognize abnormalities in the BF process.



Exemplary graphic ,indicating areas of high and low burden descent speed

Currently, process specialists are working on tools to detect abnormalities early, including burden hanging or slipping and blow-throughs, in order to enable a faster and more appropriate response by the BF operators. This could prevent damage or production loss.

Conclusions

The increased amount of data will be used to supervise the charging process more precisely and more realistically. With the 3D Top Scan, not only the complete burden topography is measured, but also, the burden descent speed is observed on the fly.

It becomes obvious that the experience with this measurement tool will lead to new insights into the BF charging process which will support the efforts to further reduce production costs.

HS 600 New generation full hydraulic drill hammer

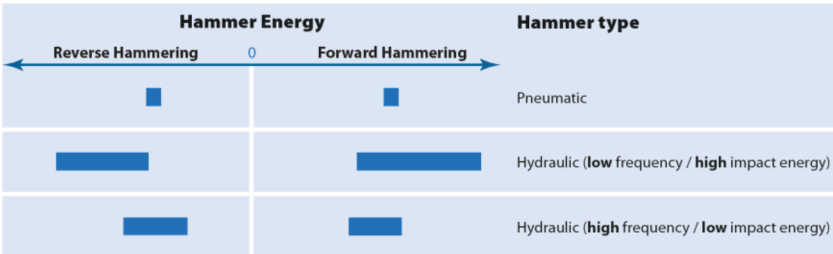
Managing a large blast furnace with high level performance requires efficient and reliable casting equipment. The strive towards highest operational efficiency and the reduction of operational costs has also pushed the development of new hammer technologies, resulting in a new generation of hammers which can switch between various performance ranges for a maximum protection of taphole and BF-hearth.

Conventional Technology

Due to the development of high performance clay masses with excellent abrasion and corrosion resistance, the tap hole itself is no longer the limiting factor in tapping time. These high performance clay masses have significantly increased the demands on tapping equipment.

Pneumatic tap hole drilling machines were quickly brought to their performance limits, leading to unacceptable opening times. Often the drilling process had to be combined with oxygen lancing,resulting in damages of the tap hole and high maintenance costs. The solution to this problem were full hydraulic tap hole drills which can cope with today's demand of the modern clay masses.

Amongst the worldwide references also, the major Indian producers are equipped with the hydraulic TMT drilling technology.



Performance range of conventional TMT drill hammers

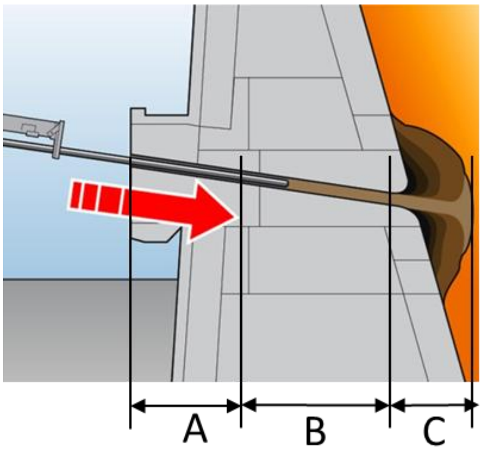
Description of the latest drilling technology

The drilling requirements imposed by the tap hole condition, change over the taphole length.

Until now BF operators had to choose between two drill hammer philosophies:

- Low Frequency / High impact energy hammering – for maximum drill feed
- High Frequency / Low impact energy hammering – for better tap hole protection & longer tap hole lifetime

The new HS 600 drill hammer is capable of switching between a **high impact frequency** mode and a **high impact energy** mode to allow an online matching of the drilling parameters to the varying taphole conditions shown in the below picture.



A: rotational drilling without hammering for maximum taphole protection

B: low frequency hammering with high impact energy for areas with hard inclusions

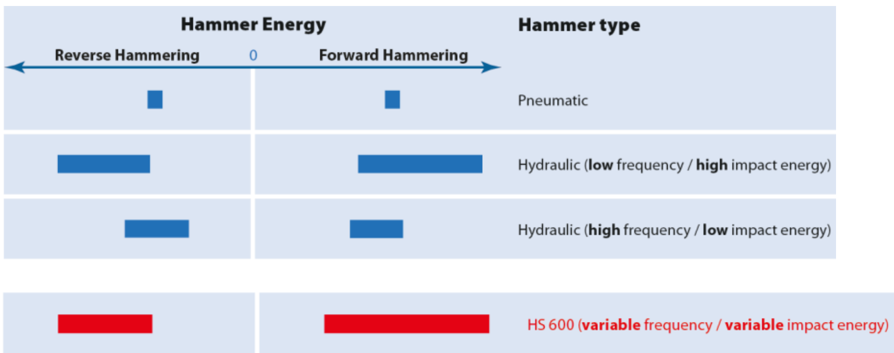
C: high frequency hammering with low impact energy to minimize mushroom break-offs and to maximize the taphole length

Taphole areas with different drilling demands

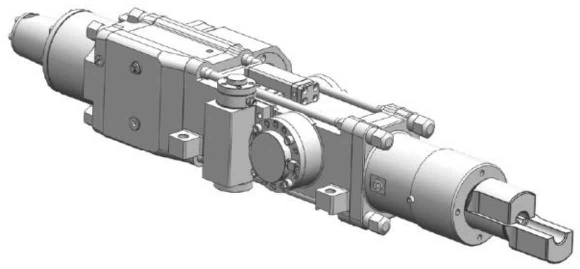
Thus the latest hammer generation offers the combined performance ranges of the best available hammers for both drilling philosophies ensuring that no limitations for the use of existing clay masses occur. As major components from the previous hammer HS 5xx series are used, most of the spare parts can be reused

Current technology

New HS 600



Switching between the different modes can be done either in full automatic or in manual mode. The benefit generated by this technology is typically maximized in the automatic mode, as it removes the human influence on the drilling result.



HS 600 hammer series

Advantages of the new technology and potential cost savings

Switching between the two performance settings is geared to accomplish a maximum protection of the critical taphole area, in order to

- maximize the lifetime of the taphole
- to reduce the number of taphole repairs
- to increase availability of the blast furnace

As this optimized tapping practice protects the taphole as well as the BF hearth it can finally result in a longer blast furnace campaign life.

Beside the benefits resulting from the variable hammering frequency, the HS 600 hammer provides the benefits already introduced with the HS 5xx-hammer series:

- Reliable opening of any taphole without delays
- Smooth taphole channel for less taphole wear
- Minimize O2 lancing for increased operator safety and prevention of damages to taphole structure
- High reverse impact energy for safe withdrawal of stuck drill bar
- Reduced equipment maintenance cost and prolonged hammer lifetime

Conclusions

Especially in the casthouse where huge volumes of pig iron and slag have to be drained from the furnace each day the constant efforts for cost reductions is of utmost importance. The latest hammer technology contributes to these improvements by combining highest drilling performance and low maintenance costs with the ability to protect the tap hole and the BF hearth.

Potential implications of the new technology are hard to estimate. However it is obvious that avoiding costly tap hole repairs, respectively extending the campaign life by only few weeks or months can generate enormous savings.