46th Ironmaking
17th Iron Ore
4th Agglomeration
ISSN 2176-3135
abm week 2016

TMT-BBG HS 600 – OPTIMIZATION OF TAPHOLE DRILLING IN ECONOMICAL AND PERFORMANCE POINTS OF VIEW*

Claude Bodeving[1]
Marc Flammang[2]
Mark Kruessmann[3]
Daniel Bastos Martins Cruz[4]

Abstract
The present steel economy drastically increases the financial strain on blast furnace operators. As a consequence, the importance of reliable cast floor operations is increasing drastically, which has a direct influence on the required clay mass and tapping equipment performances. When using modern high performance clay masses, pneumatic taphole drilling machines quickly reach their performance limits, which has made fully hydraulic drill hammers a standard in modern cast house operation. Besides the well-established hydraulic TMT hammers with high impact energy, an alternative version with lower impact energy, but high impact frequency was developed by TMT in the past, in order to achieve improved taphole protection. TMT's recent research has shown that the drilling requirements inflicted by the taphole condition change over the taphole length, which has triggered the development of a new hammer, capable of switching between a high impact frequency mode and a high impact energy mode.
Keywords: Taphole; Hammer; Drilling machine.

1 *Managing Director, TMT Tapping Measuring Technology, Luxembourg, Luxembourg.*
2 *Engineer, TMT Tapping Measuring Technology, Luxembourg, Luxembourg.*
3 *Sales Manager, TMT Tapping Measuring Technology, Luxembourg, Luxembourg.*
4 *Business Development, Paul Wurth do Brasil, Belo Horizonte, MG, Brazil.*

ISSN 2176-3135

1 INTRODUCTION

The present steel economy drastically increases the financial strain on blast furnace operators, forcing them to look for highest process efficiency and lowest operational cost at minimal investment cost. As these demands tend to partially contradict each other, solutions providing the biggest ROI are generally favored.
In ROI calculations for iron making, process benefits typically have the biggest impact, which is why optimized Blast Furnace processes are given highest priority.
As a consequence, for the cast house operation the demands are:

- Extend the duration of the BF campaign
  - Protect BF hearth
  - Maintain taphole mushroom
  - Prevent oxygen lancing
- Protect the taphole structure as best as possible
  - Reduce the number of taphole openings / heat cycles
  - Minimize the energy introduced into the taphole for the opening process
  - Avoid non necessary hammering
  - Avoid drill misalignments
- Minimize the operational cost
  - Reduce consumption of clay mass and drilling tools
  - Minimize the equipment maintenance cost for this purpose.

The highest impacts to achieve these objectives start with the clay mass. The strive to reduce the number of taps automatically calls for higher performance clay masses, resulting in longer tapping times with fewer heat cycles and thus improved blast furnace efficiency.
However, high performance clay masses also require a higher drilling performance, without sacrificing reliability or increasing equipment maintenance cost.
When using modern high performance clay masses, pneumatic taphole drilling machines quickly reached their performance limits, leading to unacceptably long opening times. Often the drilling process had to be combined with oxygen lancing, resulting in damages of the taphole and hearth carbon structure, leading to extremely high maintenance cost.

3 RESULTS AND DISCUSSION

The solution to these problems proved evolved through time and today hydraulic drilling is considered to be “state-of-art” in how to deal cope with today’s demand of the modern clay masses according to Dienenthal [2]. These facts have led to the worldwide acceptance of full hydraulic hammers as of the beginning of this century.
One example of advanced hydraulic drill hammers for blast furnace tapholes is the well-known TMT-BBG HS 571 fully hydraulic reverse hammer, having fitted several hundred tapholes, since more than 15 years. This hammer generates high impact energy at a normal frequency – a maximum power output which can still be considered as state of the art to today’s standards.
The strive of many Blast Furnace operators to extend the hearth and taphole lifetime as much as possible, has led to a development of an alternative drill hammer, using a higher hammer frequency, allowing to reduce the impact energy for reduced energy introduction into the taphole and maximum taphole protection. The result was the TMT-BBG HS 573 fully hydraulic reverse hammer which favored frequency over impact energy.

ISSN 2176-3135

In the course of the years, those two fully hydraulic hammers have been upgraded to become the HS581 and HS583 hammers, which significantly improved ease of maintenance, however without changing the hammering performance.
With the HS571 / HS573 and the HS581 / HS583 on the market, BF operators still had to choose between the following two drill hammer philosophies:

- Low frequency / High impact energy hammering – for maximum drilling performance
- High frequency / Low impact energy hammering – for better taphole protection & potentially longer taphole lifetime

While analyzing the drilling process further, TMT has shown that the drilling requirements inflicted by the taphole condition change over the taphole length, so that the optimal hammer must be able to change the performance parameters during the drilling operation.
TMT-BBG has developed the new HS 600 drill hammer that combines the two philosophies in one single hammer and 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 as explained in Figure 1, and described below.

A: relatively soft clay - rotational drilling only without hammering to achieve smooth, well defined taphole channel surfaces

B: Hard clay with inclusions – only if required, low frequency hammering with high impact energy for areas with hard inclusions

C: hardest clay with inclusions – only if required, high frequency hammering with low impact energy to minimize mushroom break-offs and to maximize the taphole length

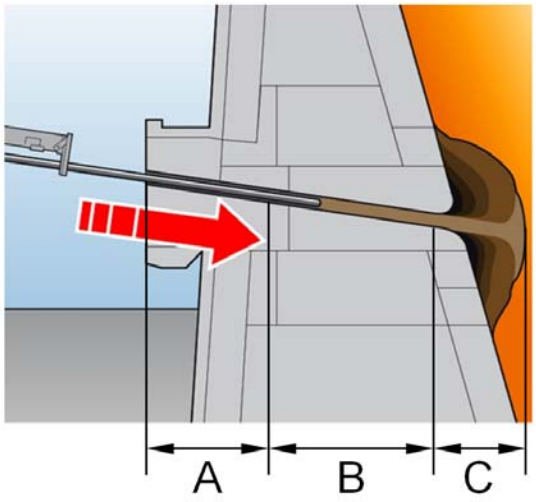

Figure 1. Taphole areas with different drilling demands

A taphole perfectly filled with clay should always be drilled open with rotation only, without hammering. This results in the highest taphole protection level. In reality however, most tapholes show sections with inclusions. These extremely hard inclusions require hammering to allow for drilling progress. Cast house operators should therefore be trained to switch the hammering function on and off while drilling, according to the requirements of the taphole.
While in manual mode it is the operator who controls both hammering and performance level, an ideal solution offered by TMT is “automatic hammering”: Here

the control system senses the taphole's requirements for hammering and automatically switches the hammer not only on and off, but also between performance levels according to the taphole section.
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 HS-series hammers are used, many spare parts are identical, which is advantageous for BF plants already operating HS hammers and wanting to keep using their spare parts stock.
Figure 2 below shows the extended hammering energy range of the new TMT-BBG HS600 drill hammer:

- In low energy mode, it can hammer at about 30% of a pneumatic hammer, offering a protection level far superior to pneumatic hammers.
- In high performance mode it can hammer at about 200% of a pneumatic hammer, capable of drilling the hardest clay masses and inclusions.

The benefit generated by this technology is typically maximized in automatic mode, as it removes the human influence on the drilling result

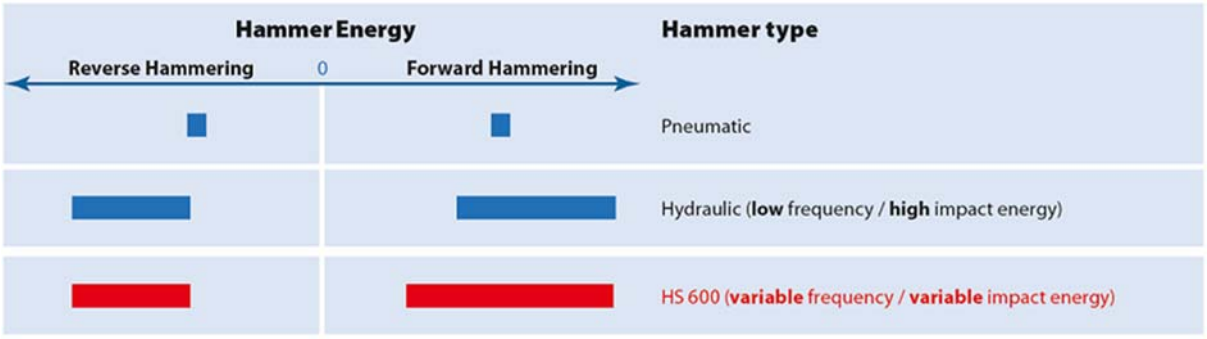

Figure 2. Hammer energy comparison for different hammer types

Figure 2 also shows that the HS600 is a full reverse hammer as well. Experience has shown that blocking drill rod retraction after opening is a quite common phenomenon. When using a forward hammer only, or a so called "retrac hammer" (vibration technology coming with rock drilling hammers but without real impact), a blocked drill bar cannot be freed up, leading in most cases to burned machine components with expensive repairs and longer downtime.
All TMT HS-series hammers feature a powerful reverse hammering capability to prevent this from happening.

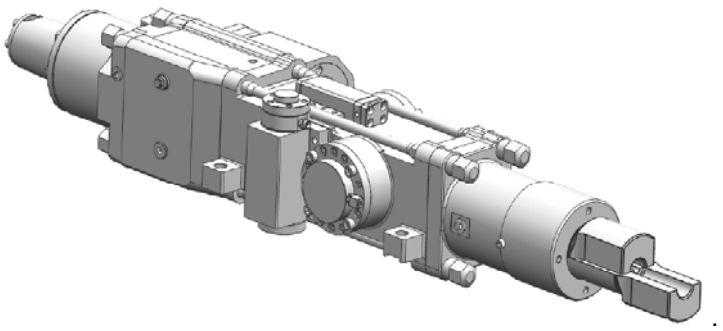

Figure 3. CAD view of HS 600 hammer series

Besides the benefits resulting from the variable hammering performance described above, the HS600 hammer provides the benefits already introduced with the previous HS-series hammers:

- 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

4 CONCLUSION

Typically the hearth condition dictates the end of a Blast Furnace campaign whereas protecting the hearth and taphole to the best possible level is of crucial importance to achieve long blast furnace campaigns.
The ability to reduce power on initial drilling and end of drilling provide improved centering as well as preservation of the mushroom lead to improvement of taphole life and blast furnace campaign.
The generated savings due to lower maintenance, less often taphole repairs, less downtime and lower consumables consumption come as an additional benefit with this technology.

Acknowledgments

We would like to thank the Blast Furnace staff of Voestalpine AG (Linz) for supporting industrial tests of this new equipment.

REFERENCES

1 M. Geerdes, H. Toxopeus and C. vd Vliet, Modern Blast Furnace Ironmaking: An Introduction, ISBN 978-1-60750-040-7, IOS Press, Amsterdam, 2009.
2 A. Dienenthal. A short history of the development of tapping equipment. The Southern African Institute of Mining and Metallurgy Furnace Tapping Conference. 2014.
3 J. A. Rodrigues Pasqual, J. George Drury et al. Evaluation of the Influence of Drilling in the Lifetime of a Blast Furnace. AISTech Conference Proceedings. 2014
.