MODERN TAPPING TECHNOLOGY FOR THE NON-FERROUS AND FERRO-ALLOY INDUSTRY[1]

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Abstract

An important bottle neck for high smelter availability is the taphole area, as this section of the smelter is exposed to a very high heat load. High abrasion of the tapping channel and surrounding area is causing downtimes for repair meanwhile the rest of the refractory lining is still in a good shape. Modern tapping technology can help smelter operators to increase the lifetime of their taphole and by this the productivity of the operations. Actually many smelter-operators are opening the taphole by oxygen lancing or electrode burning, causing unnecessary harm to the taping channel. Closing of the taphole will be done – depending on the product – by just waiting until the metal is slowly freezing within the taphole channel or by use of a plug to stop the metal flow until the taphole is frozen. In some other occasions simple mud guns are used to close the taphole. Besides of this, these practices for opening and closing the taphole do require the operators working directly in front of the taphole – exposed to high heat and danger. A solution for the safety problems is automation of the procedure, a solution to increase the lifetime of the taphole area and by this increase the productivity of the operations is a sophisticated combination of a taphole drill and clay gun. This system is physically protecting the taphole due to a high positioning accuracy and basically the whole taphole channel does have a protective clay lining and abrasion of the refractory can be avoided. Principal of this system is commonly known and accepted in the blast furnace industry for the iron production but needs adaptation to the different smelter technologies.

Key words: Tapping; Tapholes; Safety; Optimization

TÉCNICAS MODERNAS DE VAZAMENTO NA INDÚSTRIA DE FERRO-LIGAS E METAIS NÃO-FERROSOS

Resumo

Um ponto crítico para se viabilizar um alto índice de disponibilidade dos Forno de Redução é a área de vazamento, já que esta é uma área exposta a altas temperaturas. Altos níveis de desgaste do canal de vazamento e áreas circunvizinhas acabam causando altos intervalos de manutenção e reparos, enquanto o restante do revestimento refratário dos fornos, normalmente ainda está em boas condições. Práticas modernas de vazamento podem ajudar a aumentar a vida dos furos de corrida, aumentando assim a produtividade das operações. Muitas operações de abertura de furos de corrida são feitas com auxílio de lanças de O_2 ou eletrodos, causando danos desnecessários ao canal de vazamento. O fechamento do canal muitas vezes é feito, dependendo do produto, apenas aguardando o resfriamento do metal até que comece a solidificar no próprio canal. Em alguns outros casos um canhão de lama simples também pode ser usado. De qualquer forma, estas práticas exigem que o operador esteja diretamente envolvido e exposto em frente ao canal de corrida, exposto a altas temperaturas e perigo. Uma solução para os problemas de segurança é a automatização do procedimento, uma solução para aumentar a vida útil do furo de corrida e, como conseqüência, a produtividade das operações, envolvendo uma combinação sofisticada, compacta e bem elaborada, de uma perfuratriz e uma máquina de tamponamento. Este sistema também atuara protegendo fisicamente o furo de corrida, devido a uma alta precisão de posicionamento que garante o completo preenchimento do canal de corrida com a massa protetora, permitindo que o desgaste do refratário possa ser minimizado. Os princípios deste sistema são geralmente bastante conhecidos e utilizados em altos-fornos, para produção de ferro-gusa, mas precisam de adaptação às tecnologias de fusão/redução de outros materiais e em diferentes fornos.

Palavras-chave: Vazamento; Furo de corrida; Segurança; Otimização.

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1 INTRODUCTION

Market conditions - especially in times of high volatility in price and demand – are challenging the Non-Ferrous and Ferro-Alloys-Producer stronger than ever before in adapting their operations quickly to the current market situation. It is essential for producers to have their smelters in the best condition at times of high price levels to avoid any production-downtimes and to operate it with the lowest maintenance cost at times of lower price levels. Starting up and shutting down is an unloved cost factor and increasing the energy consumption and maintenance work.
One very important bottle neck for high operation availability is the taphole area, as this section of the smelter is exposed to a very high heat load. High abrasion of the tapping channel and surrounding area is causing downtimes for repair while the rest of the refractory lining is still in a good shape. Modern tapping technology can help smelter operators to increase the lifetime of their tapholes and by this the productivity of their operations.

2 GENERAL ASPECTS OF TAPPING PROCEDURES

Actually many smelter-operators are still opening the taphole by oxygen lancing or electrode burning, causing unnecessary harm to the tapping channel.
Closing of the taphole is oftentimes done – depending on the product – by just waiting until the metal is slowly freezing within the taphole channel or by using a plug to stop the metal flow until the taphole is frozen. In some other installations simple mud guns are used to close the taphole – but only in the first sections of the channel, the channel section towards the inside of the smelter is still filled with hot metal.
These practices for opening and closing the taphole do require the operator to work directly in front of the taphole – exposed to high heat and danger. Hot liquid metal and/or slag is splashing out of the taphole and serious injuries and accidents are happening all over the world. Consequently local authorities are more and more requesting safe solutions to eliminate these dangerous operations. Globalization is bringing social responsibility of big companies into the public focus and even smaller companies are requested by their worldwide operating customers to comply with their safety standards.
A solution for the safety problems is automation of the tapping process. A solution to increase the lifetime of the taphole area and by this increase the productivity of the operations is a sophisticated combination of a taphole drill and clay gun.
This system is physically protecting the taphole due to a high positioning accuracy. Basically the whole taphole channel does have a protective clay lining and abrasion of the refractory can be avoided. The principal of this system is commonly known and accepted in the blast furnace industry for the pig iron production but needs adaptation to the different smelter technologies.
TMT as a joint company of the companies Dango and Dienenthal in Siegen, Germany and Paul Wurth in Luxemburg is consolidating the many years experience of both parent companies in the field of tapping and measuring technology for the metallurgical industry.

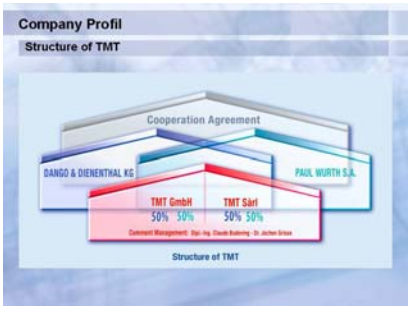

Figure 1: Structure of TMT.

As a major driving force of innovation in these applications, TMT's proven worldwide installations are representing a successful philosophy of a safe and controlled tapping process by use of reliable and sophisticated tapping equipment.

3 PHILOSOPHY

The philosophy of modern tapping technology is quite similar for the ferrous and the non-ferrous industry.

Figure 2: Concept of tapping technology.

Requirements can be subdivided into safety, lifetime, repeatability, reliability, customized design and optimal operation. The philosophy is to develop equipment fulfilling these requirements as well as a quality procedure for a proper day to day. All this combined with the possibility of a high level of automation adapting the system to each specific situation.

4 SAFETY

The smelting operation is mainly includes 2 dangerous operational areas. One is the feeding and stocking of the material into the smelter, the other the tapping procedure.

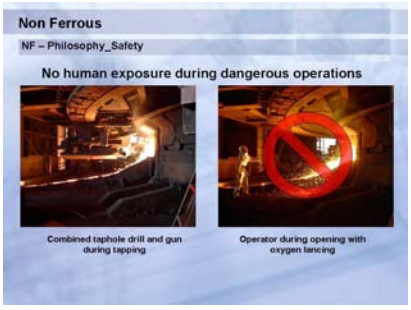

Figure 3: Safety philosophy.

Meanwhile the manual charging by use of charging cars and stocking machines is – depending on the product - replaced by automatic feeding systems, bringing the raw material directly into the right place of the smelter, the tapping on many occasions is still done by use of oxygen lances or carbon electrodes. These manual operations have to be done directly at the taphole and are of high risk for the operators as hot metal splashes all around the tapping area and depending on the process, blow-offs with high temperature can cause serious accidents to the operators - not mentioning the damages to the refractory and surroundings of the tapping area.

Figure 4: Safety for operator.

Modern tapping equipment allows operating the tapping process from a safe distance, either by remote control, or even radioing remote control in case of multiple tapholes.

5 LIFETIME

Oxygen lancing is still a common procedure to open the taphole at the smelter, but the problem is that the oxygen lancing is an uncontrolled process. The operator has no mayor influence on how the lance is burning through the wall and therefore causes damages to the refractory lining at the taphole area. This procedure makes the lining vulnerable to spontaneous breakouts and washing out starts in the tapping area. Finally it causes a shut down for repair of the taphole area although the rest of the refractory is still in good condition.
Closing of the taphole is done by either just putting a plug on the taphole and wait until the metal freezes inside the tapping channel or, in case of silicon metal just trusting that due to the low viscosity and flow rate, the material is stopping anyhow in case that no rodding operation is used to keep the material flowing.

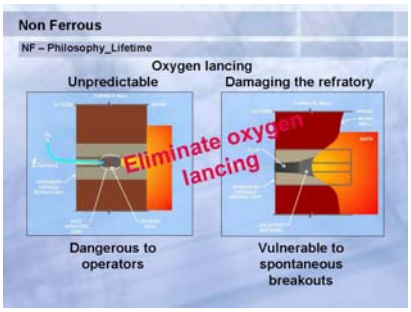

Figure 5: Lifetime philosophy.

Because of the consequential damages caused with electrode burning or oxygen lancing, operators in the Silicon-Metal production for example, keep a taphole open as long as possible and therefore do not operate the whole smelter symmetrically.

Modern tapping equipment consisting of a taphole drill and clay gun is the solution to these problems.

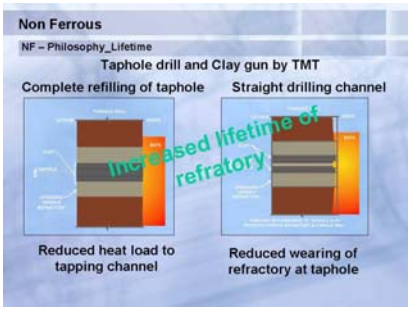

Figure 6: Increased lifetime of taphole.

The taphole drill is opening a straight tapping channel without causing any harm to the refractory lining. Closing will be done by use of a modern clay gun. This claygun is always filling the complete tapping channel with clay mass and thereby pushing back the hot metal back towards the bath. The combination of drilling inside the previously filled channel and closing the same again with clay mass reduces wear of the taphole and consequently increases the lifetime of the smelter.
In short terms: Only drill, what was plugged before!
Some people also say: Using a clay gun and taphole drill is continuous taphole repair.

6 EQUIPMENT

6.1 Clay Gun

The attached pictures show a typical clay gun used in the Non-Ferrous industry. It consists of a clay barrel, a nozzle cone and the ramming cylinder at the back side. On top is the opening to fill the barrel with the clay mass.

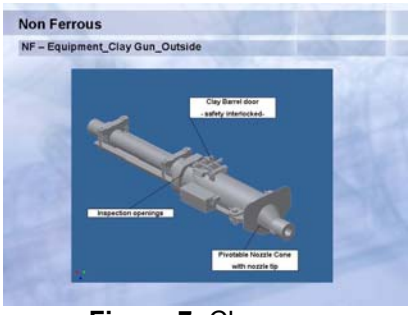

Figure 7: Clay gun.

In order to control the filling grade of the taphole, the volume of the filled clay into the taphole has to be controlled by use of an appropriate measuring technique.

6.2 Taphole Drill

The taphole drill is consisting of a boom where the drill is moving to and from the taphole and a feed motor to move the drill forward and backward. The drill rod including the drill bit and a heat & splash cover can be seen as well.
The drill itself is running on wheels along the drill boom.

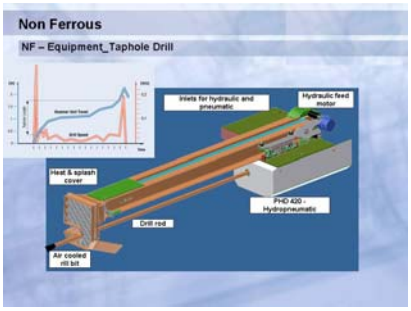

Figure 8: Taphole drill.

In many of the non ferrous and ferro-alloy applications a hydro-pneumatic drill-hammer is used. While the rotation of the drill is hydraulic, the hammer is pneumatically actuated. In case there are any obstacles inside the taphole (hard-spots or metal enclosures) the hammer-function can be switched on, but in general only rotational drilling is used for opening the taphole.
For not causing cracks in the taphole due to the impact energy of the hammer, TMT has developed a special hammer-type for the NF-operation with a high rotation torque and low impact energy at a high impact frequency.

7 REPEATABILITY

The combined use of both the taphole drill and the clay gun, does not yet assure that the taphole is always opened and closed at the same position.

Figure 9: Positioning accuracy.

Therefore a sophisticated and precise drive system has to be provided that positions the machine always automatically at the same spot in front of the taphole.
High heat load to the machine suspension, drives and track have to be absorbed by the design in order to guarantee an exact and repeatable positioning of the machine, providing that the drill is always drilling inside the previously filled clay mass channel and the gun is always positioned correctly in front of the opening for filling the complete tapping channel with clay mass.

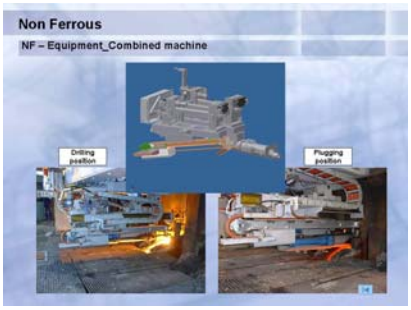

Figure 10: Combined machine.

The combination of the taphole drill/clay gun and the accurate drive system is the perfect symbiosis to properly maintain the tapping channel instead of provoking serious damages by using oxygen lancing or carbon electrodes.

8 RELIABILITY

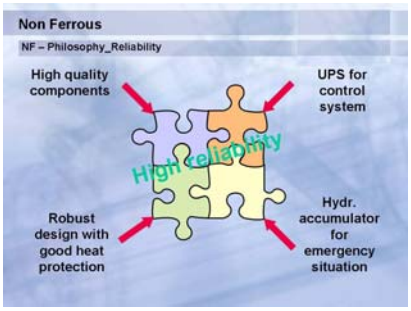

Figure 11: Reliability concept.

The relevancy for safety, lifetime and repeatability of tapping equipment is consequently requesting a high reliability of the equipment, considering the mostly dusty working conditions as well as high heat load to the equipment. Even in case of power loss at the plant, the tapping equipment must be able to at least close the opened furnace.

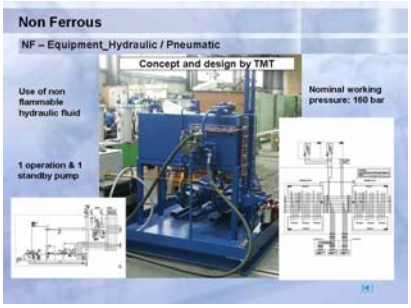

Figure 12: Hydraulic control system.

Therefore the electric control and hydraulic system operating the machine have to be an integral part of the complete machine concept. Adapted to the local requirements the equipment has to consist of the most reliable parts available for this kind of application.

9 CUSTOMIZED DESIGN

As each smelter situation is different and different types of smelters exist, amongst others SAF-; ISA-; AUSMELT- or Flash-Smelter, it is necessary to adopt the tapping equipment to the different situations.

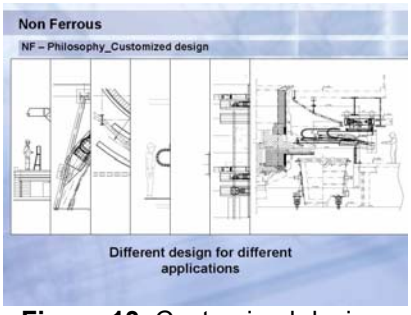

Figure 13: Customized design.

But – regardless of the type of smelter it is essential to always follow the philosophy of safety, lifetime, repeatability and reliability.
The concept of closing the taphole with a claygun, opening it with a taphole drill, combined with an accurate positioning system that is functional even in case of power loss at the plant always remains the same.

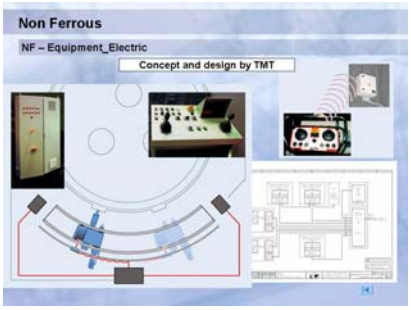

Figure 14: Electric control system.

And of course – all of these operations performed from a safe distance for the operator via the remote control panel.

9.1 Rodding Device

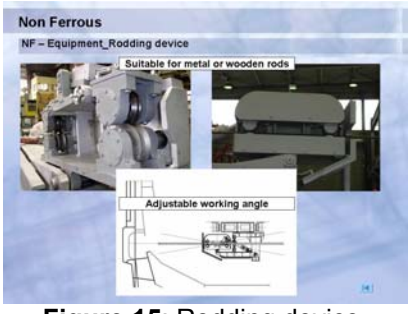

Figure 15: Rodding device.

In case of special situations – for example for FeSi and Silicon-Metal - a rodding device allows the operator cleaning the taphole-channel to achieve a continuous flow of the hot metal. The rodding device is suitable for metal and wooden rods and will be actuated as well from the safe remote control panel, instead of manual operation in front of the taphole.

9.2 Drill Bits

Besides of the machine, different drill bits with different shapes, diameters and cutting edges allow the operator to select a drill suitable for the drilling process for his special situation.

Figure 16: Positioning accuracy.

10 QUALITY

All the best concepts and philosophies for this kind of machinery are of less value if not a complete quality system assures that every process is under control of the equipment supplier.

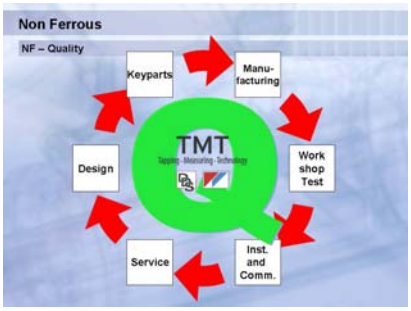

Figure 17: Quality concept.

Especially a complete workshop test and commissioning of the equipment by experts of the machine supplier under full production are essential to guarantee that the machine is properly setup for a continuous and reliable operation.
Qualified service providing the customers with technical assistance and reliable OEM-quality spare parts, wear parts and consumables is keeping the machines always in perfect operation condition.

11 OPTIMIZATION

Continuous contact with operations and experience feedback from different applications, combined with market research, technical innovation and know-how are a must to understand the needs of the producers and develop the best available tapping technology for the non-ferrous industry.

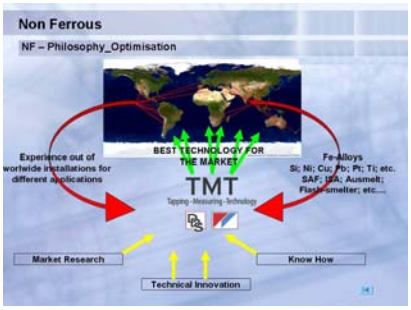

Figure 18: Optimization concept.

12 CONCLUSION

Although there are many more aspects that have to be considered for each type of operation and depending on the different products, locations and smelter types, a detailed clarification is of utmost importance.
The benefits of using modern tapping technology are obvious:
- Reduced refractory wear
- Increased lifetime
- Safe operation

Of course the investment into sophisticated tapping equipment appears to be costly initially. However, by avoiding accidents, by avoiding days of production loss because of a damaged tap hole, by reducing refractory wear and related maintenance costs, the payback for this investment guaranteed within a short time is more than justifying this investment.