Intelligent Solutions for Ferroalloy Production of Paul Wurth

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ABSTRACT

Paul Wurth, Luxembourg is the market leader in the design and supply of complete solutions for blast furnaces, coke oven plants, and environmental protection systems for the iron & steel industry.

This paper will highlight the potential applications for sinter plants, blast furnaces and slag granulation systems in the ferroalloy industry. Furthermore, the industrial application of a revolutionary dry slag granulation pilot plant will be presented. This technology not only avoids the presence of water but also allows the recovery of parts of the sensible heat out of ferroalloy-based slags.

When it comes to submerged arc furnaces and electric smelters, the Paul Wurth Group supplies modern equipment, clay guns and drilling machines, slag and metal granulation system and pig casting machines.

Paul Wurth also delivers reliable refractory lining concepts for electric smelters. The latest trends of the products related to submerged arc furnaces will be presented and discussed.

1. FERROALLOY PRODUCTION THROUGH THE BLAST FURNACE ROUTE

For the production of FeNi and FeMn today the rotary kiln-SAF route is mostly used. Alternatively Paul Wurth has developed the route using rotary hearth furnace – SAF, which eliminates the problems due to the carryover of dust from the rotary kiln. However, the blast furnace route, combining a mini sinterplant and a mini BF has also to be considered as a production route for the production of ferro- alloys, for instance Ni pig iron and FeMn. Especially in regions where the infrastructure is not well developed, the BF route may be advantageous. If a continuous supply of electricity is not guaranteed, the availability of the SAF is reduced and thus the rentability may not be high enough. Also in regions where the electricity is expensive, the BF route may be used.

Especially low Ni and low Mn ores can be treated very efficiently through the BF route.

Nowadays, 60% of Ni production is based by on the use of sulfide ores and 40% on the use of laterite ores. As 70% of the land based Ni ores are contained in laterites, an increase in production will be mostly based on the use of laterite ores.

The rise in the prices of high Ni ores has created a trend to use limonite ores which contain less Ni compared to the saprolite ores. With a mixture of limonite and saprolite ores the BF route is used to produce Ni pig iron (NPI) with a Ni content of less then 6%. NPI can be used for the production of stainless steels of the grade 200 series which has lower Ni contents (0-6%) than the more common 300 series. A production of NPI directly at the mine will reduce the transport costs. The BF route at the mine is also an attractive solution for mines for example in Indonesia which are no more allowed to export raw ores due to a ban by the government.

Due to the relatively small scale of the plants compared to the steelmaking industry, they are referred to as “mini sinterplants” and “mini blast furnaces”

1.1. Mini Sinter Plants by Paul Wurth

Paul Wurth is offering big-sized sintering plants to the steel producers as well as small scale plants for the non-ferrous, ferroalloy and merchant pig iron producers. In many cases the sintering process is very interesting since it allows, with a relatively small investment, reducing the operating cost of the downstream reduction and smelting aggregates due to the use of poorer raw material qualities.

In this context, Paul Wurth provides up-to-date technological solutions combining high standards of engineering and a high degree of automation. One of the key advantages is the modular design of the plant which matches the sinter plant capacity to the customers-specific requirements at the time of the project yet allows for an easy capacity increase in the future. In Figure 1 a typical layout of a 1 mini sinter plant consisting of 1 sinter strand module with a production capacity of typically 200,000 to 500,000 tpy is illustrated.

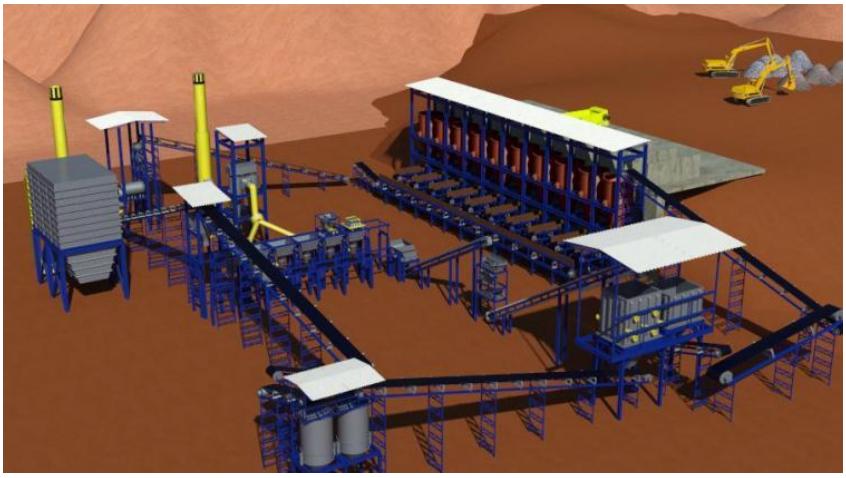

Figure 67: Mini sinter plant, typical layout

Beyond the typical iron ore, other sorts of non-ferrous ores and waste materials can be sintered. Paul Wurth has experience and references in sintering various materials including ferroalloys and even exotic materials such as desulphurisation agents which are applied in the steel works. Paul Wurth relies on a pilot plant in order to test these materials that allows making optimum plant concepts for the client's situation.

Figure 68: Paul Wurth pilot plant for sinter tests

Flexibility does not only apply for the metallic burden but also for fuel fines in the sinter "cake" and ignition gases. Charcoal, coke fines, biomass, coal fines and BF dust can be mixed in the sinter cake as fuel for the sintering process. Coke Oven Gas, Blast Furnace Gas, LPG and NG can be burned in the ignition furnace, generating the initial flame for the whole process.

Figure 69: Ignition furnace

1.2. Mini Blast Furnace Plants By Paul Wurth

Through its extensive experience in blast furnace design for the traditional iron making industry, Paul Wurth is in a perfect position to adapt the blast furnace for the specific requirements of the ferroalloy production. A well designed blast furnace for ferroalloy production should have the following main characteristics:

- High flexibility to charge a variety of raw material and fuels
- Cost effective yet precise top charging equipment
- High flexibility in terms of production rate
- Capacity to handle highest slag flows

In order to adapt the blast furnace for the ferroalloy production, the furnace profile is revised in reducing the height of the stack and increasing its angle.

The high amount of slag requires a repositioning of the tuyeres and an adaptation of the number of tuyeres. This will reduce the turbulence in the bosh area, optimizing the heat exchange and facilitating the drainage of liquid. Furthermore, two slag tapholes are foreseen additionally to the hot metal taphole, allowing regular operation as well as emergency drainage of the slag. These slag tapholes are executed with cooled copper jackets.

When it comes to top charging equipment, Paul Wurth provides two options to its customers: Single Bell Pressurized Top (SBPT) or Mini- Bell Less Top (Mini-BLT).

The SBPT solution is very cost-efficient, with lower investment cost and very moderate maintenance cost. While the SBPT uses a rotary charging chute for equal material distribution, a dynamic burden distribution can be achieved by adding a movable throat armor.

The Paul Wurth BLT is the worldwide reference when it comes to blast furnace top charging equipment. The Mini-BLT has been designed specifically with smaller blast furnace sizes in mind. It provides even greater precision to the charging of the furnace, improving the operation efficiency and reducing the fuel rate. The precise charging allows further controlling the heat load at the furnace walls, improving the lifetime of the refractory.

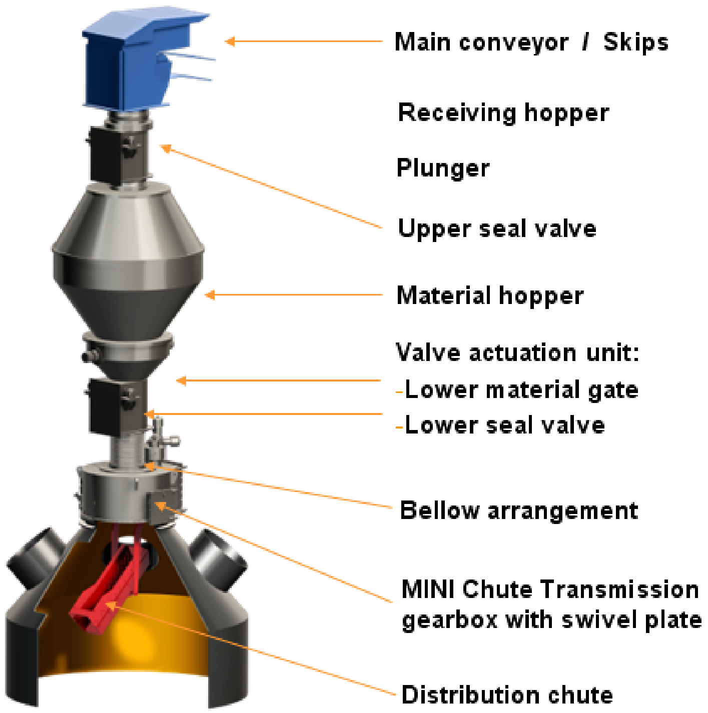

Figure 70: Paul Wurth Mini-BLT

Paul Wurth designs, supplies and installs all other components which are part of the blast furnace plant:

- Refractory linings, either different qualities of different areas or monolithic solution
- Casthouses with runner systems and casthouse machines.
- Gas cleaning systems, wet type.
- Hot stoves
- Pig casters and hot metal granulation systems
- Slag granulation systems (see dedicated chapter in this paper)
- Water treatment plants
- Pulverized coal injection (PCI) systems: Simplified fuel injection facilities, generated fuel fines are easy pre-treated for direct injection in BF process or will be used in sintering process
- Stockhouses
- Blower stations

2. PAUL WURTH TECHNOLOGIES FOR THE TREATMENT OF SLAG IN THE FERROALLOY PRODUCTION

2.1. INBA Slag Granulation System

Over the years Paul Wurth has designed, supplied and commissioned more than 320 slag granulation systems, including 38 systems specifically for the ferroalloy and non-ferrous application.

The main components are the granulation unit, the dewatering system and the storage area. The modular design allows installing these three components either grouped together or at separate locations, depending on the available layout and the requirements of the customer.

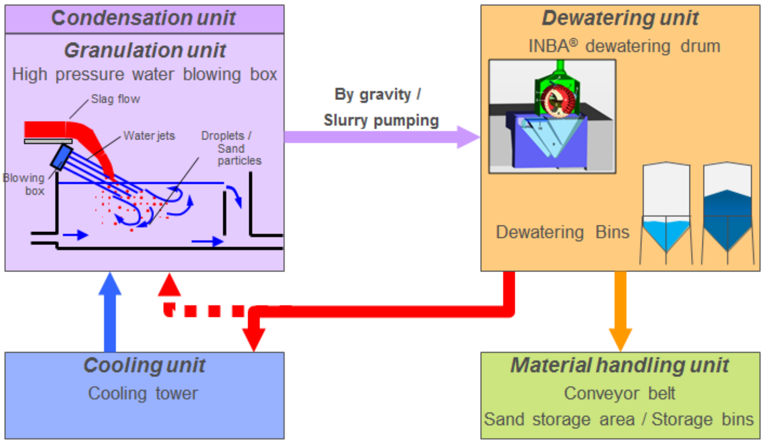

Figure 71: Modular arrangement of slag granulation system

The slag is first quenched with high pressure water in the granulation tank, solidifying the slag and creating slag sand. The mixture of slag sand and water is taken to the dewatering drum where the slag is separated from the water before being taken to the storage area. The water recovered from the slag sand is recirculated to the blowing box and reused in the granulation process. Alternatively the water can be cooled before being recirculated to the blowing box, increasing the quenching effect and improving even further the quality of the final slag sand product. A typical system arrangement for treating a continuous slag flow is shown on Figure 5.

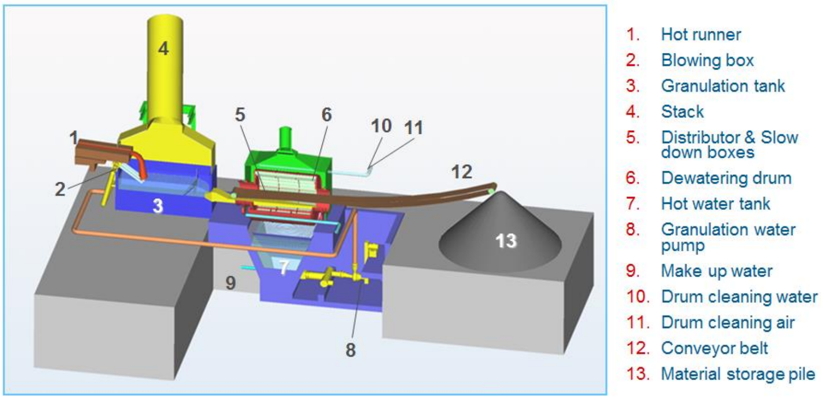

Figure 72: INBA slag granulation system, hot system.

The system presents following advantages compared to conventional systems:

- Compact design
- Continuous filtering and evacuation: The INBA system is a dynamic granulation system; that means online granulation and online dewatering and evacuation of the slag sand. No intermediate storage.
- High flexibility towards slag flow and slag casting duration. The process adjusts automatically to the needs. No influence to upstream operation.
- High reliability
- Measurement of the slag flow either by measuring the torque of the drum or by calculating the thermal balance in the granulation tank (latter possible only probided full steam condensation)
- Closed loop: Limited need of make-up water, environmental advantages
- Air pollution control by steam condensation (next chapter)
- Limited invest compared to other granulation systems
- Low maintenance costs
- Low operation costs

Alternatively Paul Wurth offers slag granulation systems with static dewatering bins, reducing the investment cost even further. These systems particularly well suit for batch processes or applications with smaller slag flow rates.

2.2. Dry Slag Granulation System With Heat Recovery

Metallurgical slag, a by-product from any pyrometallurgical process such as iron and steel making or copper smelting, is usually poured into slag pits or water quenched to assure fast cooling rates and specific material properties. However, the huge amount of thermal energy contained in the liquid slag, seen as the highest single source of energy that is wasted in these processes, is lost to the environment.

Paul Wurth has taken up the challenge to provide a reliable and safe solution to recover this energy, by developing the dry slag granulation system with heat recovery.

The dry slag granulation process is based on the mixing of steel spheres and liquid slag. This allows transferring almost all of the energy of the liquid slag into a mixture at high temperature which is then subject to energy recovery. At the same time, the properties of the slag can be maintained on the same high level as with the traditional quenching by water.

Figure 73: Principle of Paul Wurth dry slag granulation system.

Figure 74: Full scale pilot plant at Dillinger Hütte BF 4.

Following the favourable outcome of several reduced scale test series, Paul Wurth tackled the challenge of building the first ever full scale dry granulation plant at blast furnace 4 of Dillinger Hütte steelworks in Dillingen, Germany. The dry slag granulation pilot plant was successfully commissioned in November 2013 and shows that dry granulation of liquid slag streams of up to 8 t/min can be achieved.

The process was successfully tested with various slag chemistries from the ferrous and non-ferrous industries.

3. PAUL WURTH REFRACTORY COMPETENCE IN FERRO ALLOY PRODUCTION

During the last decades,Paul Wurth has acquired extensive know-how in the area of refractory design, supply and installation. The Paul Wurth expertise was mainly (but not limited to) focused on the iron making industry and developed several refractory lining concepts for Blast Furnace, Hot Stove, Torpedo, bustle main, direct reduction furnaces.

This refractory expertise is now supporting the SMS Group in the Ferro Alloy Production. Paul Wurth is able to design, supply and install refractory linings such as:

2.1. Freezing Lining

An example for a FeMn submerged arc furnace is shown in Figure 8.

The principle of a freezing concept is to keep the heat inside the furnace. As a consequence, a skull forms in front of the lining which protects the refractory lining from erosion. The advantage of a freezing concept is a high productivity compared to the same-size furnace with insulating lining. The disadvantage is a high heat extraction and therefore high eropex costs through cooling requirement.

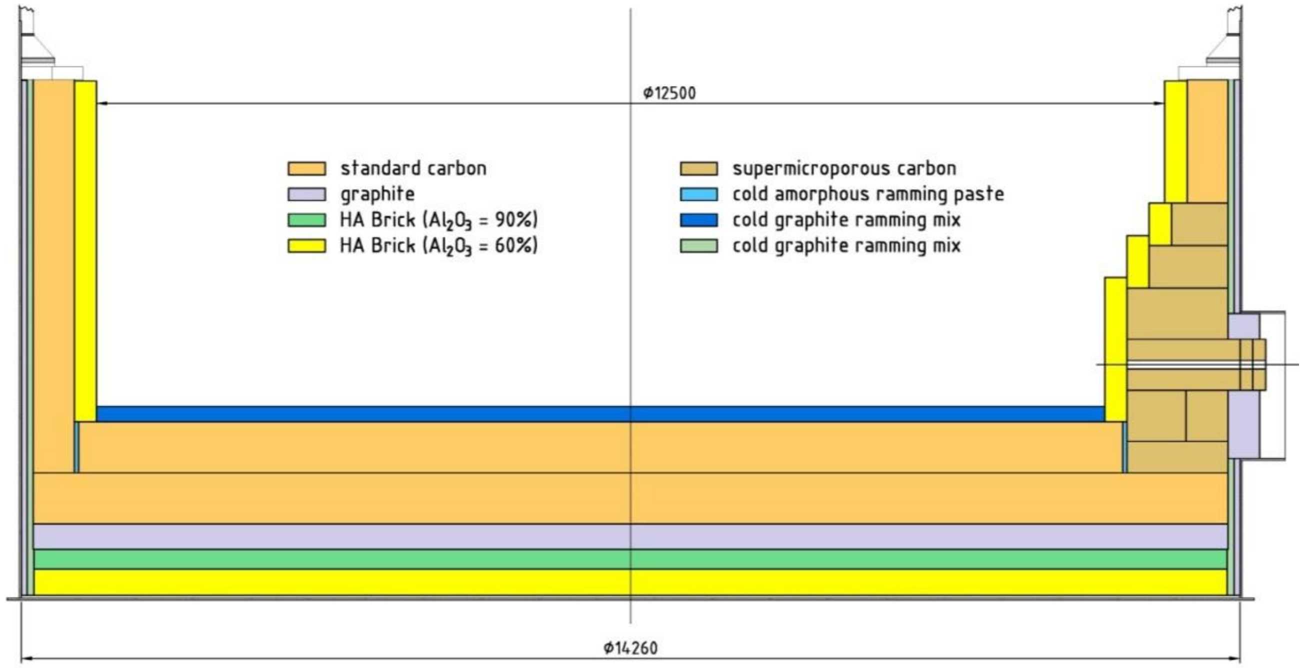

Figure 75: Submerged arc furnace freezing lining concept

2.2. Insulating Lining

An example for a Si submerged arc furnace is shown in Figure 9.

The principle of an insulating concept is to keep the heat inside the furnace. Such a concept is required for certain ferroalloy process where a freezing lining would disturb the process itself. The advantages of an insulating concept are reduced heat lost, no cooling requirement, and therefore lower opex costs.

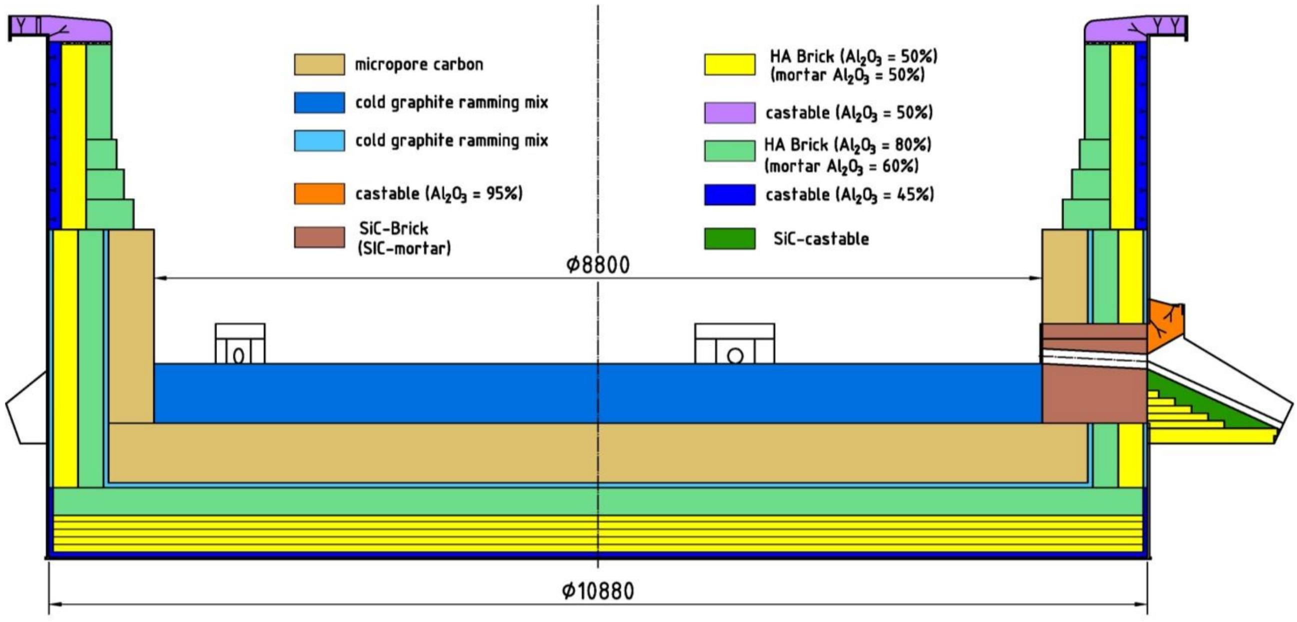

Figure 76: Submerged arc furnace insulating lining concept

Paul Wurth, as an engineering company, is not tied to a specific refractory supplier and therefore can provide a suitable refractory mix for any customer worldwide. The Paul Wurth services comprise:

- Basic and detail engineering
- Thermal calculation
- Finite element simulation
- Refractory quality management

- Cost optimized refractory solution

4. MODERN TMT TAPPING TECHNOLOGY FOR THE NON-FERROUS AND FERROALLOY INDUSTRY

The joint venture company **TMT – Tapping Measuring Technology** combines the experience of both DANGO & DIENENTHAL and Paul Wurth, to contribute to the creation of taphole and BF measurement technology for the future.

The taphole area is one of the most important production bottlenecks on many smelters and furnaces in the non-ferrous and ferroalloy industry. Due to the high heat load and abrasion in the taphole channel, regular downtimes are required for taphole repairs. Modern TMT tapping technology improves the working conditions for taphole opening and closing and helps to significantly increase taphole lifetime, thus resulting in increased productivity of the operations and reduced costs.

Today, many tapholes are opened by oxygen lancing, causing unnecessary exposure of personnel to the dangerous taphole area. Furthermore, the manual guiding of the lance leads to unavoidable damage to the taphole channel. Available tapping equipment is often not adapted to the specific taphole process requirements. Insufficient plugging pressure or injection speed can result in frozen slag or metal in the taphole channel. Drilling machines with low torque are mostly operated with excessive hammering to open the taphole. As the taphole is a sensitive area on each furnace, these conditions lead to premature taphole block damage in many cases. The inevitable consequence is a furnace shutdown for taphole repair, leading to unnecessary production loss and costs.

The design features of TMT combined tapping machines physically protect the taphole from damage. A claygun with adequate clay mass pressure and injection speed allows filling the taphole channel completely with clay after each closing operation, which is one of the most important preconditions for a clean taphole reopening procedure. The opening process can then be realized mainly by rotational drilling, using the separate hammer function only when hard spots in the taphole are detected. This feature reduces the amount of impact energy introduced in the taphole, thus significantly increasing the taphole lifetime.

For reasons of limited space availability and furnace geometry, TMT combined tapping machines are always adapted to the specific project needs. With the experience of design, manufacturing and commissioning of over 400 combined tapping machines installed all over the world, TMT is able to fit tapping equipment to almost any furnace. Reference designs are available for all kinds of special requirements like extremely restricted space availability, high level differences between different tapholes and long distances between different tapholes.

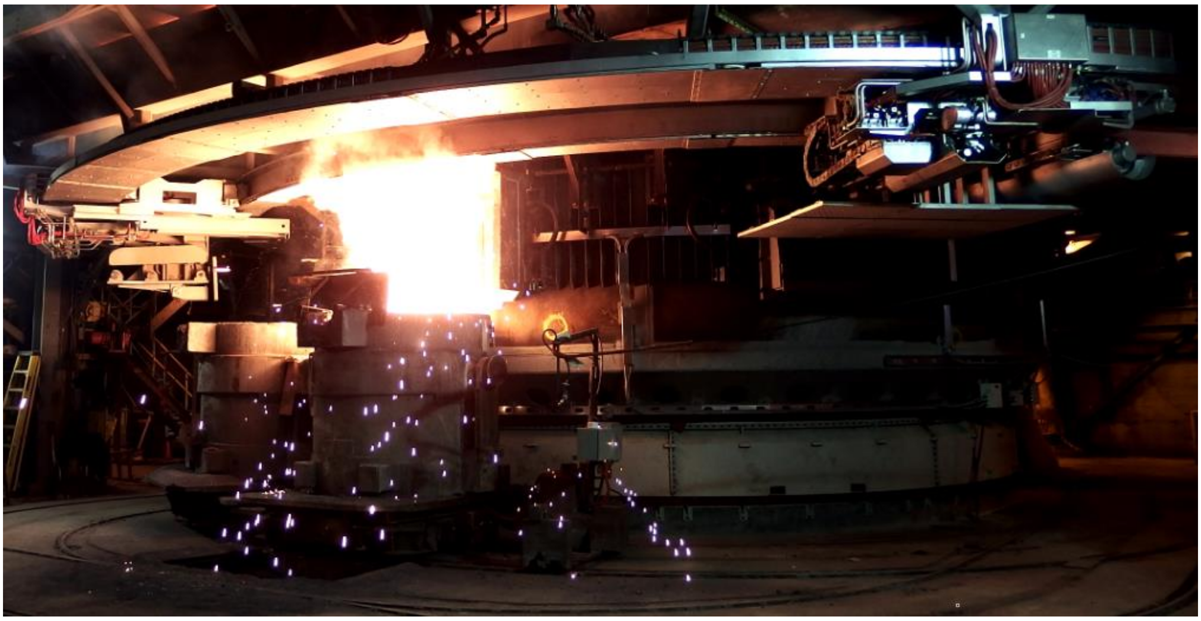

Figure 77: Tapping operation at an Fe-Si smelter

5. CONCLUSION

Paul Wurth, as part of the SMS group, has built up an extensive range of products and solutions for the ferroalloy industry. While some of the solutions are taken over from the traditional iron making industry and adapted to the specific needs of the ferroalloy production, others are specifically developed for this application. Environmental protection, energy recovery and cost efficiency are part of the basic considerations in any project handled by Paul Wurth. Paul

Wurth provides services ranging from plant auditing, process design, plant layout, basic and detail engineering to equipment design and supply, automation system design and supply, erection, commissioning up to operation of the plants.