SHARC - Shaft arc furnace
with efficient scrap preheating concept provides low conversion costs

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Is productivity the main goal driving the meltshop operator or is a cost-oriented strategy the better one? A combination of both may be the most competitive and powerful tool. The 100 t electric arc furnace at Hellenic Halyvourgia in Greece is a practical example of how such a strategy may be implemented. Here, a basic concept and idea was transformed into a mature, extremely flexible and highly efficient low-cost scrap recycling facility.

Introduction

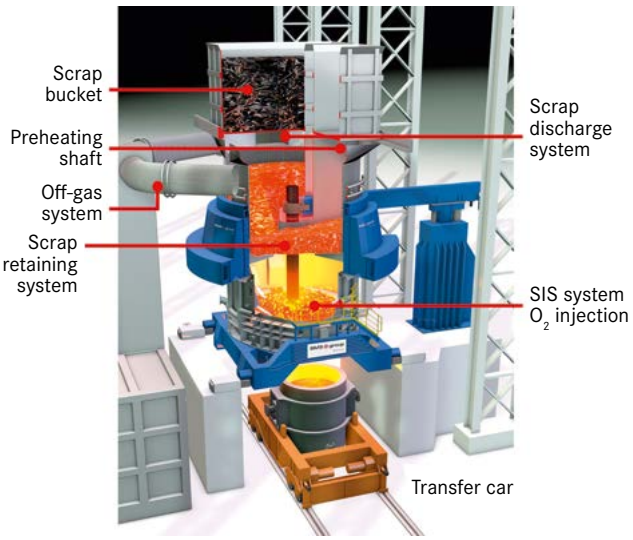
With the SHARC (shaft arc furnace) concept, the Greek steel producer Hellenic Halyvourgia SA (HLV) and SMS group have developed a unique process for scrap preheating. The utilization of scrap in general consumes less energy compared to producing steel from ore. The SHARC saves even more natural resources by using a minimum amount of primary energy for preheating and by utilizing maximum the hot off-gases of the furnace. The electric arc furnace below the shafts is equipped with modern burner and injection technology. The preheating effect is optimized by the efficient use of chemical energy. Thus, the SHARC furnace is highly productive, economically efficient and easy on the environment.

Unlike in other scrap preheating systems with asymmetrical scrap charging equipment, in the SHARC furnace the entire furnace cross section over the height of the two shafts is available for energy transfer. The unique design with the symmetrical shape of the hearth with DC high current technology makes it possible. This leads to a longer residence time of the hot off-gases inside the preheating shaft and a more efficient heat transfer. With the SHARC furnace, it is possible to ensure economically efficient and smooth operation even when charging with low-quality scrap (low density) without additional pretreatment. This design is unique worldwide and has the advantage that the scrap is molten highly homogeneously.

The SHARC design

The SHARC furnace consists of an EBT lower shell and a water-cooled upper shell on which two identical preheating shafts are vertically arranged. This symmetrical arrangement of the two preheating shafts results in a homogeneous distribution of the mechanical and thermal loads. The compact and efficient arrangement of the preheating shafts is facilitates thanks to utilizing the proven-and-tested DC high current technology and pin-type bottom electrode developed by SMS group. The off-gas is extracted from the SHARC directly below the closable charging opening. As a result, the hot furnace off-gas is continuously drawn through the scrap column across its entire cross-section and over its entire length.

Water-cooled fingers retain the scrap at the bottom part of the preheating shafts before it is charged into the electric arc furnace at the beginning of a new heat. The 34 fingers can be extended and retracted all together or individually. In this way, the homogeneously preheated scrap is distributed evenly inside the electric arc furnace.



Components of the SHARC furnace design

Thanks to the use of a pin-type bottom electrode, the preheating shafts can be arranged in a compact way

Tapping of the SHARC furnace

The temperature of the water-cooled shaft and wall panels is monitored by temperature sensors. Exact temperature control in the gas cleaning system ensures compliance even with the strictest environmental standards. The EBT taphole gate is operated by means of a pneumatic cylinder. The lower and water-cooled upper shells are installed on a tilting platform; tilting in slagging direction and tapping direction is performed via two hydraulic cylinders on each side. The SHARC furnace is operated with the exchange shell technology developed by SMS group. To change the furnace shell, the complete tilting platform with the lower and upper shell is placed onto an adapter on the tapping ladle car and moved into the operating range of the bay crane. In this position, the shell can be changed and the newly lined shell is brought into its working position. No heavy-duty bay crane is required.

The SHARC process

With regard to the composition of charge materials, the SHARC provides high flexibility while keeping production costs low. The scrap is charged into the two shafts from the top via scrap buckets. Four buckets are normally charged per heat in two batches. For this purpose, the top shaft covers are opening horizontally.

The first batch of scrap charged is retained by water-cooled fingers installed at the bottom of the shaft and preheated by the off-gases of the previous heat inside the furnace. After the previous heat has been tapped, the first two preheated buckets of scrap are charged into the furnace from the fingers. The contents of buckets three and four are then charged directly onto the preheated scrap of the first two buckets.

When using low-cost light scrap, the contents of further buckets can be charged without problems and without obstructing the process. Energy losses by charging additional buckets are minimized due to the shaft design. Troubles like overfilling, fireball effect and splashing such as occur in conventional furnaces, do not exist and even the process time will not increase significantly.

This operating practice is not possible with conventional electric arc furnaces. After the scrap in the two shafts has dropped below the level of the fingers, these are extended again to hold the first two buckets for the next heat and the preheating cycle starts again.

At the same time, the previous heat is fully molten in the electric arc furnace, decarburized and, if required, de-phosphorized by means of intense slag work. In a previous process step lime and coal are added directly into the SHARC furnace via a conveyor system and an alloying hopper installed between the two preheating shafts.

In this way, the furnace can also be charged with DRI, HBI and pig iron to be able to produce higher quality steel grades. At a temperature of 1,620 – 1,630°C, tapping is performed via the EBT taphole.

The SHARC at HLV

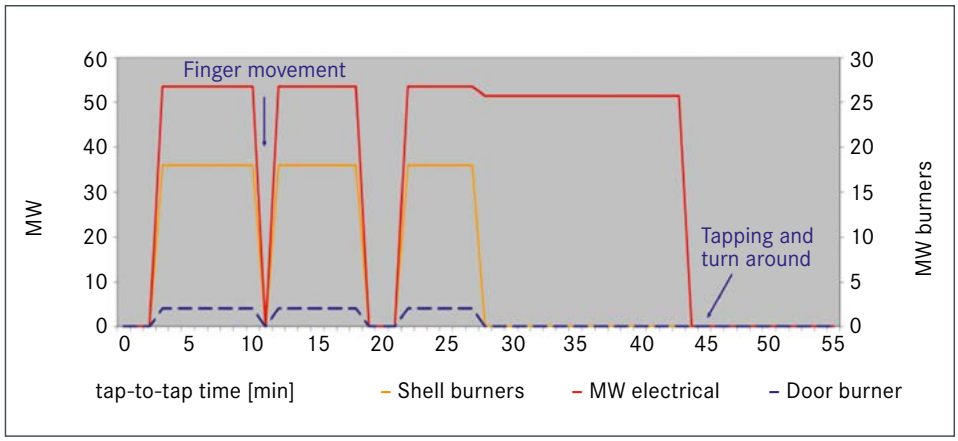
After implementing various developments and modifications, the SHARC at HLV has been operating to the steelmaker's fullest satisfaction. The 100 t/ 54 MW direct-current electric arc furnace features two preheating shafts in which the scrap is dried and preheated. During the last 14 years, it has been operating very reliably.

In the DC furnace, the two shafts are located towards the front and the back side of the furnace with the electrode arm moving in between the two shafts. Different to other shaft furnaces, this guarantees equal scrap distribution around the circumference of the shell. Uneven conditions like one-sided scrap charging usually lead to an imbalance of the system which makes it difficult to control and operate. All systems in nature and physics strive for equilibrium and stable state conditions.

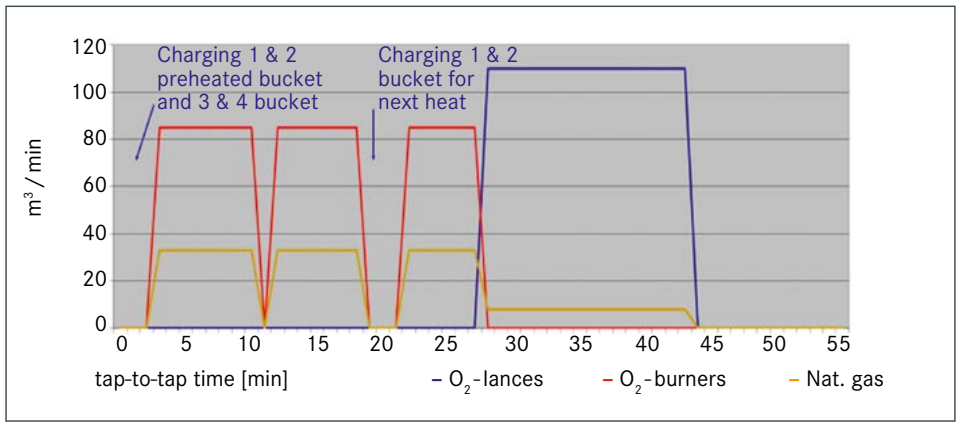
The SHARC DC furnace is made for easier and more natural operation. The symmetrical conditions, the all-over distribution of the scrap and the even division of the off-gases into the shafts provide reproducible results as well as uniform and highly efficient operation during melting and the liquid phase. All areas are reliably covered with scrap. While a furnace campaign lasts about 1,000 heats, the bottom electrode has a service life of approx. 3,500 heats. In spite of the discontinuous operation of the furnace (eight hours per day on weekdays and 13 hours on weekend days), the furnace provides convincing results.

Operational results

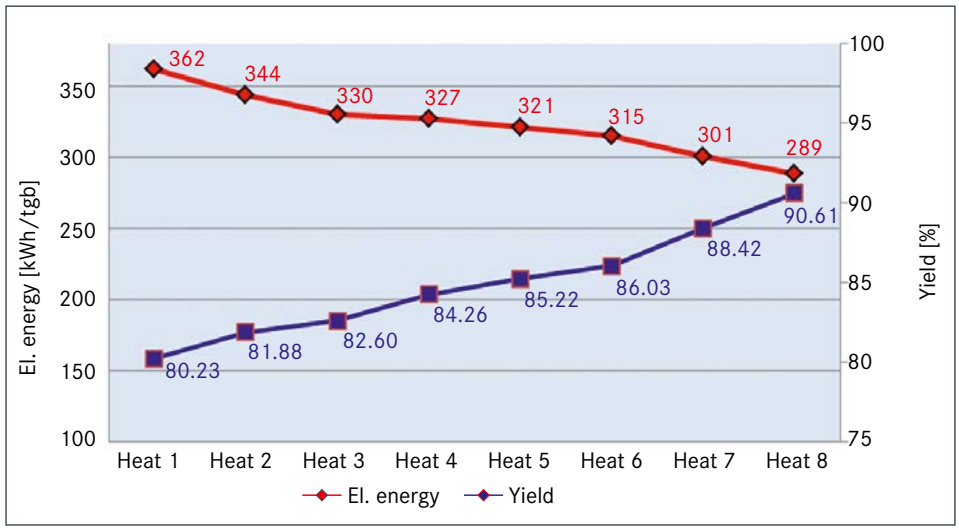
The features of the SHARC furnace provide for high productivity operation. Tap-to-tap time is significantly lower than that of other furnace types with a similar power input. The SHARC furnace at HLV is able to achieve productivity figures of up to 120 t/h and more. Such performance figures are achieved during a production day of eight hours operation and ten consecutive heats.



Operational diagramme for electrical energy input



Operational diagramme for chemical energy input



The impact of the yield on the specific electrical energy consumption – based on real heat data of Hellenic Halyvourgia with different yield rate

The electrode consumption figure given by HLV also includes electrode breakages. In operational practice various measures were taken to improve electrode consumption. However, during 2012 – 2014, electrode consumption still amounted to approx. 0.75 – 0.79 kg/tgb (tons of good billet) on average.

In August 2014, a new electrode arm was installed allowing bigger electrodes with a diameter of 700 mm (28") to be used, replacing the previously used 600 mm (24") diameter electrodes. The larger diameter makes the electrode much more robust. Since the bigger electrodes have been in use, there has been just one electrode breakage and that was due to a wrongly loaded and charged skull. Due to the bigger diameter, electrode consumption has decreased to approx. 0.60 kg/tgb, with weekly figures already being below 0.58 kg/tgb, which is the general target for that period.

When being charged from the shaft into the hearth, the scrap mix has an average temperature of more than 550 °C. In this way, energy consumption values as low as 280 kWh/t can be attained. When producing steel grades with high demands on purity, the scrap can either be preselected or partly substituted with virgin charge material.

The main technical parameters of the furnace operation are as follows:

- charge mix: 100 % scrap
- furnace capacity: 97 t
- shell diameter: 6,100 mm
- tapping weight: 97 t
- transformer power: 78 MVA
- active power: 54 MW
- current: 79 kA
- secondary voltage: 684 V
- consumption of oxygen: 32.1 m^3/tgb (93 % O_2 purity; s.t.p.)
- consumption of natural gas: 6.1 m^3/tgb (s.t.p.)
- electrode consumption: 0.58 kg/t
- energy consumption: 320 kWh/tgb (yield factor of the scrap 81.5 %) or 280 kWh/tgb (with a yield factor of 87.5 %).

All specific figures are related to one ton of good billets (tgb) which is impacted by the yield factor of the scrap and including yield losses at ladle furnace and continuous caster. Specific electrical energy consumption has to be examined based on the above mentioned circumstances and influencing conditions such as the scrap yield factor.

The yield depends on the scrap quality in terms of density, soil and ferrous rate. It has been proven that by using a different and better scrap mix the furnace can achieve 280 kWh/t of good billets which is a tremendous energy benefit. Melting steel has never been more cost-efficient than with the SHARC furnace.

Conclusion and outlook

HLV is a steel company with a long tradition and extensive practical experience. With the SHARC, a completely new and unique process for scrap preheating has been successfully developed. This process minimizes energy consumption and simultaneously generates a significant increase in economic efficiency. The design of the SHARC furnace and the metallurgical process result in high productivity and flexible, cost-efficient furnace operation. The installed environmental technologies comply with the strict requirements on occupational health and safety and environmental protection.

The cooperation between the operating company and the plant manufacturer provides space for innovations, focusing on further technological development and enhanced design features of the furnace. HLV has been passing on its operational know-how, offering trainings and instruction courses and rendering support in the commissioning of new furnaces.

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