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THE USE OF SCRAP SUBSTITUTES LIKE COLD / HOT DRI AND HOT METAL IN ELECTRIC STEELMAKING

ZASTOSOWANIE SUBSTYTUTÓW ZŁOMU TYPU ZIMNE/GORĄCE DRI I CIEKŁEGO METALU PODCZAS PRODUKCJI STALI W PIECACH ELEKTRYCZNYCH

In the last decades, scrap quality got worse and scrap contamination with undesirable elements increased accordingly. Consequently the use of scrap substitutes such as Cold / Hot DRI or HBI, Hot Metal and pig iron became more and more important in electric steelmaking.

Not only scrap quality, but also limited scrap availability, which increases the scrap prices worldwide, pushes the new EAF installations in the direction of high percentage melting of above mentioned substitutes in the EAF.

In order to cover this market request, Siemens VAI MT developed such a flexible and high productive EAF which uses up to 40% of hot metal. As an example, we want to show the 180t EAF which is installed in the steel plant of MMK in Magnitogorsk / RUSSIA.

Additionally, some technical data from the new 70t EAF in the steel plant Chengdu Iron & Steel Co. in Chengdu / PRC which is currently in the installation and commissioning phase, are presented.

As example for the use of up to 100% Cold and Hot DRI, the results of the new EAF at HADEED / Kingdom of Saudi-Arabia will be presented, whereas the Hot DRI is fed to the EAF directly from the DRI plant.

Finally, it will be given an outlook on the future development of this trend by showing some upcoming EAF installations of Siemens VAI MT for ESISCO / Egypt and Al Atoun Steel / Kingdom of Saudi-Arabia.

Keywords: EAF; Hot Metal; DRI; Oxygen Injection; High Productivity

W ostatnich dekadach, widoczna jest stale pogarszająca się jakość złomu, oraz wzrost ilości niepożądanych zanieczyszczeń w złomie. W związku z tym zastąpienie złomu substytutami typu zimne/gorące DRI lub HBI, ciekły metal i surówka będzie odgrywało coraz większe znaczenie w produkcji stali w piecach elektrycznych. Nie tylko jakość złomu, ale także zwiększająca się jego niedostępność na rynku, powodująca wzrost światowych cen zmusza do instalowania nowych pieców mających możliwość większego udziału we wsadzie substytutów złomu.

Aby podążać za rynkowymi trendami, firma Siemens VAI MT opracowała niezwykle elastyczny i bardzo wydajny EAF, w którym można zastosować w roli wsadu do 40% ciekłego metalu. Jako przykład zaprezentowano 180t piec łukowy, uruchomiony w stalowni MMK w Magnitogorsku (Rosja). Dodatkowo przedstawiono pewne dane techniczne 70t pieca łukowego, który aktualnie jest oddawany do użytku w stalowni Chengdu Iron & Steel Co. w Chengdu (Chiny).

Jako przykład zastosowania 100% zimnego i gorącego DRI jako wsadu przedstawiono osiągnięcia nowego pieca łukowego w stalowni HADEED (Arabia Saudyjska) gdzie gorące DRI jest bezpośrednio ładowane do pieca. Na zakończenie przedstawiono perspektywy dalszego rozwoju tej technologii na przykładzie najnowszych instalacji Siemensa: VAI MT dla ESISCO (Egipt) i Al Atoun Steel (Arabia Saudyjska).

1. Introduction

In the last decades, scrap quality got worse and scrap contamination with undesirable elements increased accordingly. Consequently the use of scrap substitutes such as Cold / Hot DRI or HBI, Hot Metal and pig iron became more and more important in electric steelmaking. But not only scrap quality, but also limited scrap availability, which increases the scrap prices worldwide, pushes the new EAF installations in the direction of high percentage melting of above mentioned substitutes in the EAF.

The newest product for Electric Steelmaking of Siemens VAI MT – the SimetalCIS Ultimate – is, due to its design, not only the favorable solution for melting scrap, but also for melting up to 100% Cold or Hot DRI as well as up to 40% Hot Metal in order to reach not

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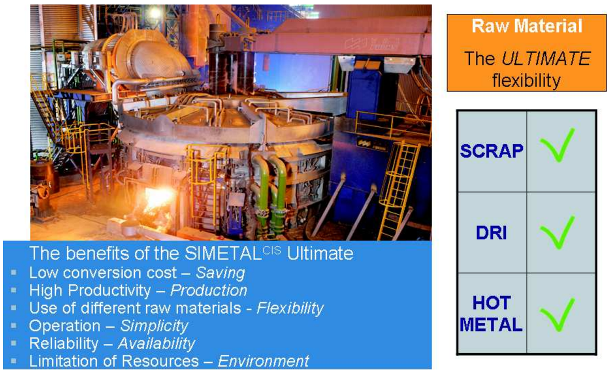
only the extensive request concerning productivity, but also the demand for high quality flat products.

2. Simetal^{CIS} Ultimate

2.1. Features of Simetal^{CIS} Ultimate

The Simetal^{CIS} Ultimate combines all of the latest electric steelmaking technologies in the product portfolio of Siemens VAI. MT. This combination results in an electric arc furnace where cycle times can be extremely short and where the corresponding productivity is comparable to the level of larger-sized furnaces. A comparison of a standard 180-t EAF and a 120-t Simetal^{CIS} Ultimate has demonstrated the same productivity, or, in other words, production capacity increases of up to 50% for EAFs with the same tapping weight.



The two main reasons for this are:

• The possibility of a higher electrical power input (figure1), and

• A far higher efficiency of chemical energy, decarburization and scrap preheating compared to a standard furnace of the same size (tap weight)

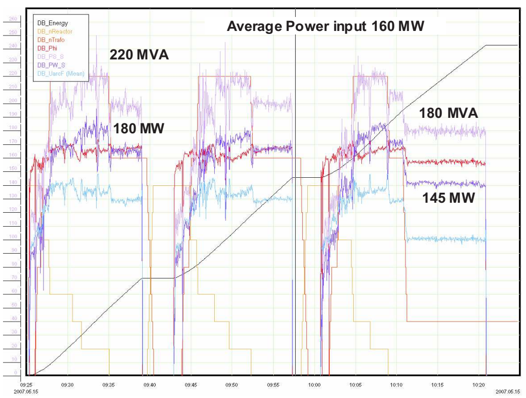


Fig. 1. Curve of electrical Power input

The Simetal^{CIS} Ultimate is a solution that enables increased productivity for a given heat size with low consumption figures. An example is shown in the Start-Up curve (figure 2) of a 300t Simetal^{CIS} Ultimate, supplied to a steelmaker in Middle East.

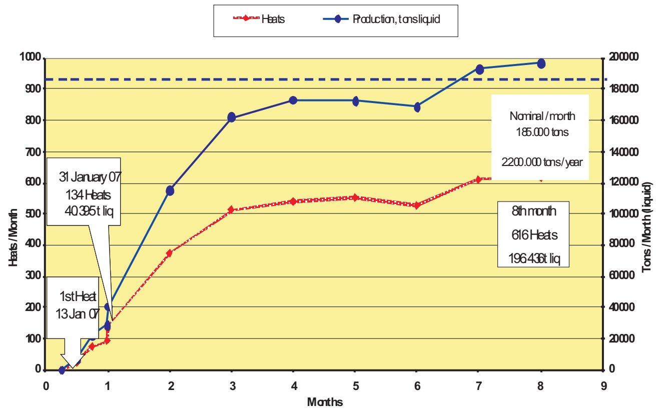


Fig. 2. Start-Up Curve of a 300t Simetal^{CIS} Ultimate

2.2. Features of the SIMETAL CIS RCB

This can be handled because of its several main design features:

– The increased charging volume allows a single bucket operation for a 100% scrap charge with an energy optimized process due to improved post combustion and preheating process inside the scrap during the melting phase using the proven SimetalCIS RCB (figure 3).

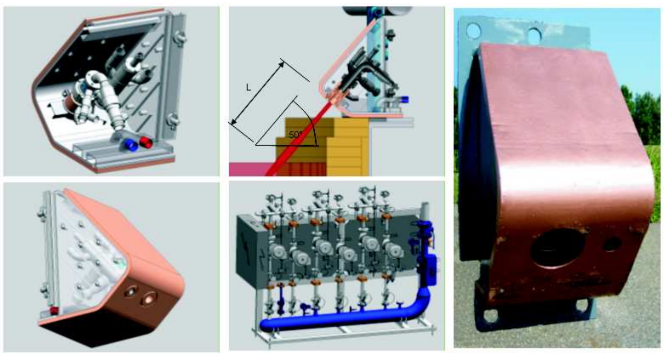


Fig. 3. RCB Technology

– The installed transfomer capacity with more than 1MVA per tapped tons not only allows rapid scrap melting but especially high productive DRI melting.

– The increased bath surface allows very high decarburization rates (figure 4) necessary for an increased use of Hot Metal of up to 40% in order to achieve minimum Tap to Tap times.

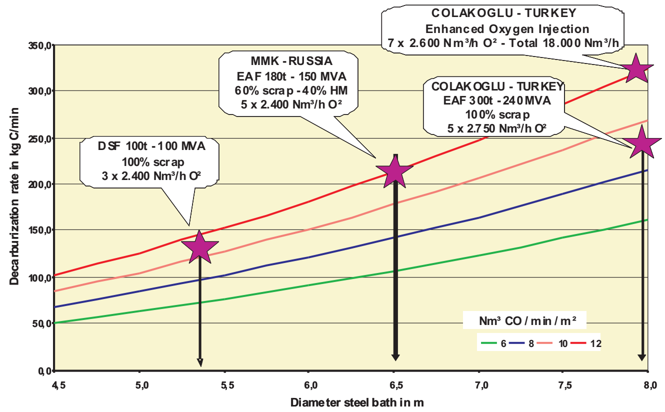


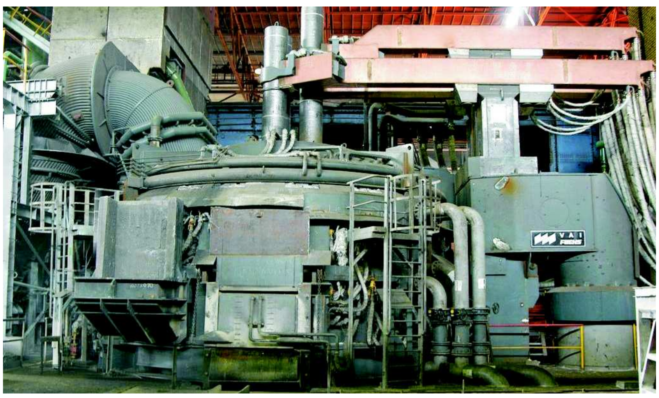
Fig. 4. Decarburization capacity

3. Hot Metal

3.1. Example MMK

3.1.1. Technical Data

The 180 t furnace is equipped with a transformer rated with 150 MVA + 20% and a secondary voltage range from 740 to 1350 V, 5 RCBs & 1 Burner, 2 PC – Injectors and 3 Carbon injection lances. The Hot Metal is charged via a launder through the slag door, whereas the feeding rate is managed by a hydraulic tilting mechanism. The EO-EBT shell diameter is 7.4 m / 24.3 ft, the panel height 3.4 m / 11ft and the roof height 1.2 m / 3.9 ft.



Using the multiple point injection for oxygen via 5 RCB (figure 5), decarburization rates of more than 300 kg C/h/m^2 or 61 lbs C/h/sqft of bath surface were achieved successfully when using 35% liquid hot metal in the EAF. This means, up to 12.000 Nm^3/h / 7.100 scfm of oxygen can be injected into the EAF with 180 t capacity without getting dangerous boiling reactions (above photo 4).

3.1.2. MMK EAF layout

In figure 5, the layout of the injcetion tools can be seen. The Hot Metal is charged via the side wall using a launder with an automatic tilting manipulator.

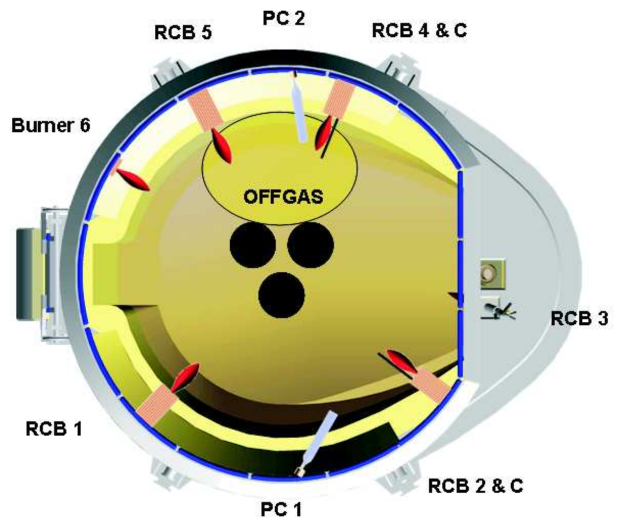


Fig. 5. Layout of MMK EAF

3.1.3. Performance with hot metal

With an input of 22% Hot Metal and 78% Scrap, the actual production record is 32 heats per day. The achieved performance figure for the input of scrap and hot metal can be seen in table 1.

TABLE 1
MMK Performance with 22% Hot Metal

Tapping weight	175.2 t	193.1 sht
Oxygen Total	34 Nm^3/t	1108 scft/sht
Gas	4.2 Nm^3/t	135 scft/sht
Electrical energy	223 kWh/t	205 kWh/sht
Power On Time	31.4 Min	31.4 Min
TTT	45 Min	45 Min
Productivity	233 t/h	257 sht/h

3.2. References

Siemens VAI MT has several references where new furnaces have been supplied for hot metal charge.

- Above mentioned MMK has two identical 180 t EAF, which have been installed in order to replace the Open Hearth furnace production route.
- In China, the three 80/100t shaft furnaces at Zhangjiagang and the shaft furnace at Anyang are working with Hot Metal input.

- Again in Russia, the two 120t shaft furnaces of Severstal are producing steel with an input of up to 35% of Hot Metal.

3.3. Outlook Chengdu

Actually, a 70t EAF with Hot Metal charge is under construction in Chengdu, PRC, where it is foreseen not only to charge 100% scrap, but also up to 20% Hot Metal.

This EAF is equipped with

- a 50 MVA Transformer and
- 3 RCB and 2 Carbon Injection Lances in order to reach a Tap-to-Tap time of 55 min.

In case of the 20% Hot Metal is used, the furnace will be charged with only one scrap basket and the Hot Metal will be poured into the furnace via a launder through the slag door.

4. DRI

4.1. Example HADEED

4.1.1. Technical Data

In March 2007, the first heat was tapped from the new 150 t EAF at HADEED. This EAF is feeding a LF and a Slab Caster and is equipped with a 130 MVA Transformer, 3 RCB, 3 Carbon injection lances as well as bottom stirring system and a 3-point lime injection system through the roof.

The EAF can be charged with 100% scrap, but the optimised process for this EAF design is charging from 75% Cold DRI to 100% Cold and Hot DRI.

4.1.2. HADEED EAF layout

In figure 6, the layout of the injection tools can be seen. The DRI is continuously fed via the roof out of bunkers, whereas the Hot DRI is coming into the EAF with a temperature of approx. 650°C via a conveyor from the MIDREX plant (figure 7).

The new DRI plant is installed to produce around 1.760.000 t/year Hot DRI with the quality mentioned in table 2.

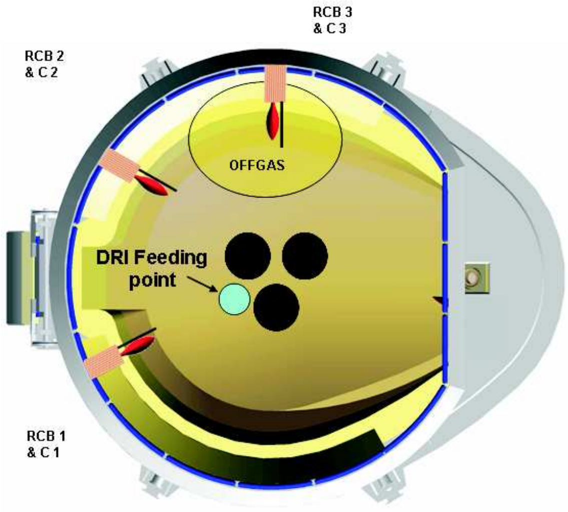


Fig. 6. Layout of HADEED EAF

4.1.3. HADEED DRI Transport

In figure 7, the transportation concept for the Hot DRI is shown: the Hot DRI is coming via an inclined belt from the DRI plant to an intermediate hopper above the furnace, from where it is gravity feed into the EAF. All the way from the DRI plant into the EAF, the material is inertised with nitrogen in order to avoid carbon losses by oxidation.

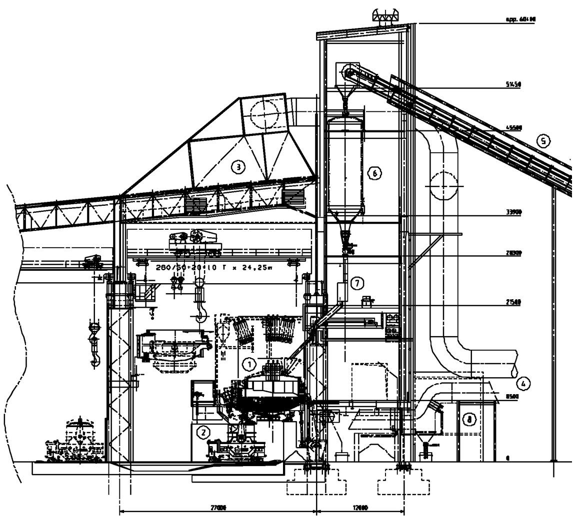


Fig. 7. Layout of HADEED Hot Link DRI

4.1.4. Performance with DRI

During the 48h Performance test which was done with the input of 75% DRI and 25% scrap, a HADEED record of 27 heats in 24 hours was achieved with the figures in table 3. The DRI quality was: 94% Metallization and 2,4% carbon.

TABLE 2
HADEED performance with 75% Cold DRI

Tapping weight	150 t	166.7 sht
Oxygen Total	22.6 Nm^3/t	798 scft/sht
Gas	2 Nm^3/t	70.6 scft/sht
Electrical energy	492.8 kWh/t	447.1 kWh/sht
Power On Time	45.8 Min	45.8 Min
TTT	54.5 Min	54.5 Min
Productivity	165.1 t/h	182 sht/h

In table 4, the envisaged production figures for 100% Hot DRI are shown.

TABLE 3
HADEED performance with 100% Hot DRI

Tapping weight	150 t	166.7 sht
Oxygen Total	30 Nm^3/t	1060 scft/sht
Gas	2.5 Nm^3/t	88.3 scft/sht
Electrical energy	430 kWh/t	387 kWh/sht
Power On Time	42 Min	42 Min
TTT	51 Min	51 Min
Productivity	176.5 t/h	196 sht/h

4.2. References

Siemens VAI MT has several references where new furnaces have been supplied for DRI or HBI input.

- Above mentioned HADEED has another EAF, commissioned in 1998, which is fed with mainly 75% DRI and 25% scrap.
- In Rocky Mountain Steel Mills, Colorado / USA, the 110 t EAF, commissioned in 2005, is working with an input of 20% HBI and 80% scrap, charged together in only one basket.
- At NASCO, Kingdom of Saudi-Arabia, DRI is charged into the EAF with a ratio of up 100%. This operation was started in 2007 after revamping the EAF in order to allow continuous DRI feeding through the roof.

4.3. Outlook ESISCO and Al Atoun Steel

Siemens VAI MT has several new orders for DRI furnaces, whereas two of them are mentioned afterwards:

- One 160 t EAF, using up to 100 Cold and Hot DRI, will be supplied to ESISCO, Egypt, reaching a Tap-to-Tap time of 52 min. This furnace will be equipped with a 140 MVA, 4 RCB and 3 carbon injection lances. The equipment will be commissioned in 2009.
- One 80/100 t EAF will be installed for Al Atoun Steel, Kingdom of Saudi Arabia. This EAF will be charged with 100% scrap in the beginning, with a tap weight of 80 t. In a second step, a DRI production facility will be installed and the EAF will use up to 100% Hot DRI, tapping 100 t in max. 46 min. This EAF will be equipped with a 105 MVA, 3 RCB, 2 burners, 2 Post-Combustion oxygen injectors and 3 carbon injection lances. The quipment will be commissioned in 2010.

5. Conclusion

Siemens VAI Metals Technologies is glad in offering a High-End solution to meet the request for increased productivity in electric steelmaking whether charging scrap, but also up to:

- 40% Hot Metal
- 100% Cold DRI and 100% Hot DRI

With the design of the Ultimate furnace using in-house technologies such as the Simetal Simelt electrode control system for the control of the electrical power input, RCB for the input of chemical energy and the Foaming Slag Manager to control the carbon injection, Siemens VAI has developed a new generation of electric arc furnaces, which meets the steelmakers demand for increased productivity and low conversion costs. Both technologies offer a major potential for steelmakers to boost productivity and slash costs in the production of both carbon and stainless steels.

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