THE USE OF SCRAP SUBSTITUTES LIKE COLD / HOT DRI AND HOT METAL IN ELECTRIC STEELMAKING[1]

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Abstract
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. 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. 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.
Key words: EAF; DRI; Oxygen injection; High productivity.

USO DE SUBSTITUTOS DE SUCATA COMO DRI FRIO/QUENTE E GUSA EM ACIARIA ELÉTRICA

Resumo
Nas últimas décadas a qualidade da sucata piorou e a contaminação por elementos indesejados aumentou na mesma proporção. Conseqüentemente o uso de seus substitutos como DRI quente/frio e ferro gusa tornou-se cada vez mais importante na aciaria elétrica. Afim de atender esta demanda de mercado, a Siemens VAI MT desenvolveu um Forno Elétrico flexível e de alta produtividade que pode utilizar até 40% de ferro gusa. Como exemplo gostaríamos de citar o Forno Elétrico a Arco de 180t que foi instalado na usina da MMK em Magnitogorsk / Rússia. Como exemplo para o uso de até 100% de DRI quente e frio, os resultados do novo EAF em Hadeed – Arábia Saudita – serão apresentados, visto que o DRI quente alimenta o forno diretamente da planta de DRI. Enfim, será apresentado um contexto do desenvolvimento futuro destas tecnologias, mostrando algumas instalações de Fornos Elétricos Siemens VAI MT para ESISCO (Egito) e Al Atoun Steel (Arábia Saudita).
Palavras-chave: Forno elétrico a arco; DRI; Injeção de oxigênio; Alta produtividade.

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

2 SIMETALCIS ULTIMATE

2.1 Features of SimetalCIS Ultimate

The SimetalCIS 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 SimetalCIS Ultimate has demonstrated the same productivity, or, in other words, production capacity increases of up to 50% for EAFs with the same tapping weight.

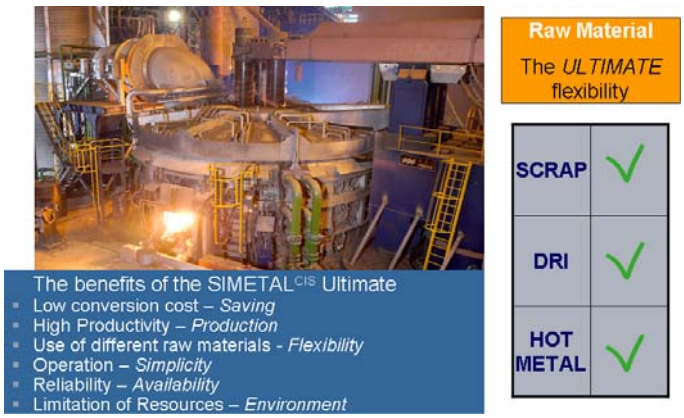

Figure 1: Benefits of the SimetalCIS Ultimate

The two main reasons for this are:

- The possibility of a higher electrical power input (Figure2), and
- A far higher efficiency of chemical energy, decarburization and scrap preheating compared to a standard furnace of the same capacity.

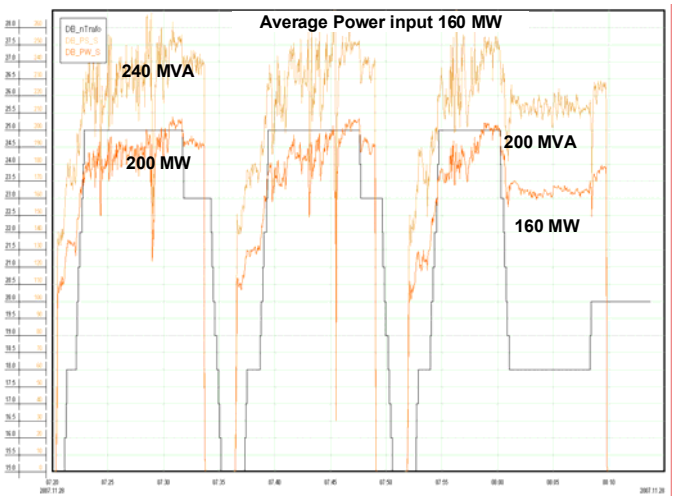

Figure 2: Curve of electrical Power input

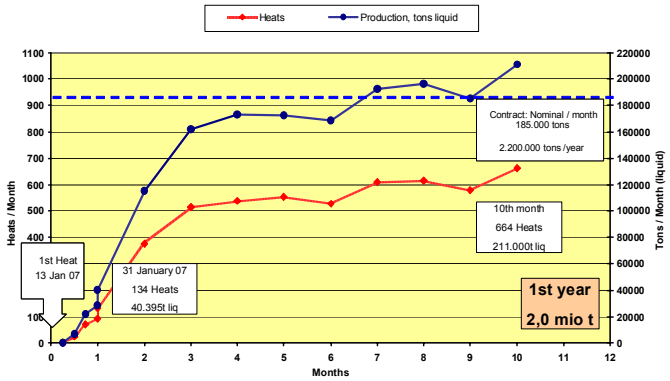

Figure 3: Start-Up Curve of a 300t SimetalCIS Ultimate

The SimetalCIS Ultimate is a solution that enables increased productivity for a given heat size with low consumption figures and good reliability. An example is shown in the Start-Up curve (Figure 3) of a 300t SimetalCIS Ultimate, supplied to a steelmaker in Middle East.

2.1 Equipment of SimetalCIS Ultimate

All these challanges 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 4).

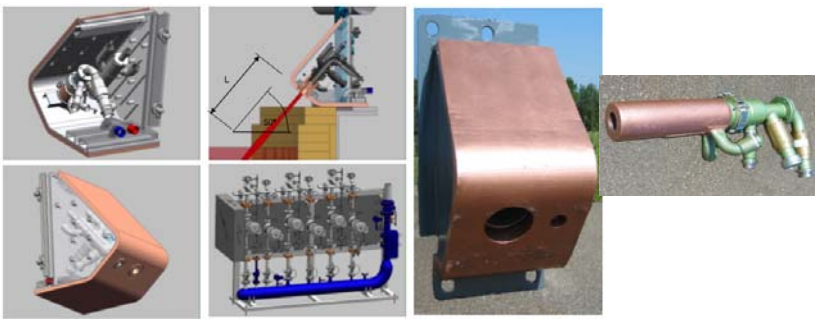

Figure 4: RCB Technology

- 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 5) necessary for an increased use of Hot Metal of up to 40% in order to achieve minimum Tap to Tap times.

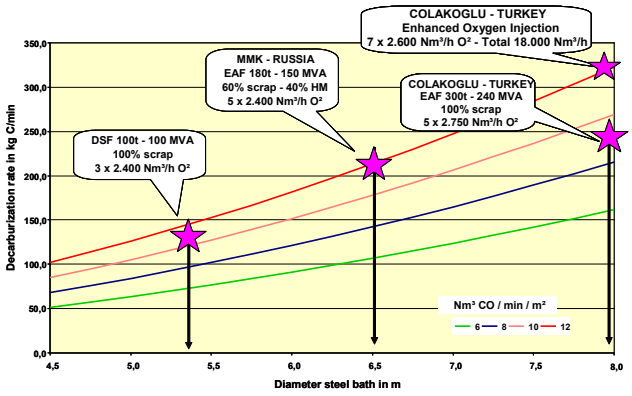

Figure 5: Decarburization capacity

3 HOT METAL - EXAMPLE MMK

3.1Technical Data

The 180t furnace is equipped with a transformer rated with 150 MVA + 20% and a secondary voltage range from 740 to 1.350 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 7,4m, the panel height 3,4m and the roof height 1,2m .

Figure 6: Picture of the EAF at MMK

Using the multiple point injection for oxygen via 5 RCB (Figure 6), decarburization rates of more than 300 kg C/h/m² of bath surface were achieved successfully when using 35% liquid hot metal in the EAF. This means, up to 12.000 Nm³/h of oxygen can be injected into the EAF with 180t capacity without getting dangerous boiling reactions (Figure 5).

3.2 MMK EAF Layout

In Figure 7, the layout of the injcetion tools can be seen. The Hot Metal is charged via the slag door using a launder with an automatic tilting manipulator (Figure 8).

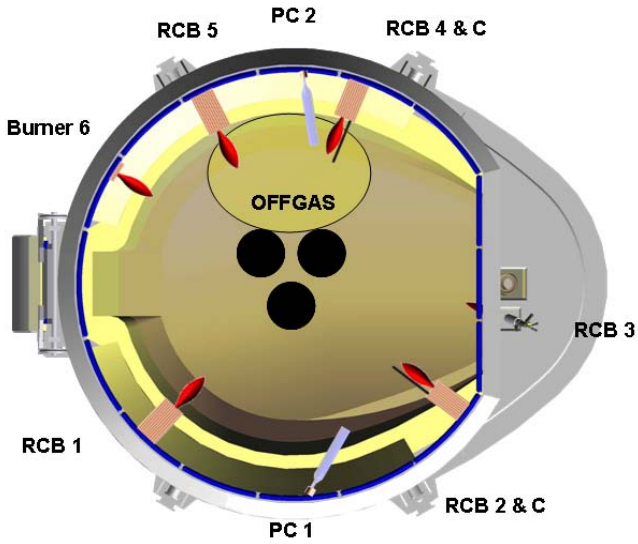

Figure 7: Layout of MMK EAF

3.3 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**
Oxygen Total	**34 Nm³/t**
Gas	**4,2 Nm³/t**
Electrical energy	**223 kWh/t**
Power On Time	**31,4 Min**
TTT	**45 Min**
Productivity	**233 t/h**

Figure 8: Picture of Hot Metal Charge with door launder

3.3 References

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

- Above mentioned MMK has two identical 180t 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.
- In March 2008, a 70t EAF with Hot Metal charge have been commissioned in Chengdu, PRC, where not only 100% scrap is charged, but also up to 20% Hot Metal.

3.4 Outlook DONETZKSTAL

Actually, a 150t EAF with Hot Metal charge is under contract in Donetzk, Ukraine, where it is foreseen not only to charge 100% scrap, but also up to 40% Hot Metal. This EAF will again replace an Open Hearth furnace. This EAF is equipped with:

- a 120 MVA Transformer and
- 5 RCB, 2 Burners, 4 O2 Post Combustion Injectors and 3 Carbon Injection Lances in order to reach a Tap-to-Tap time of only 38min.

In case 40% 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.

3.5 Outlook NTS

For the customer NTS – member of the Tata Steel group – SVAI is supplying a system and the process for the use of Hot Metal in the existing EAF. In detail, the Hot Metal ladle is placed in a charging turret with tilting mechanism, where Hot Metal is poured in a launder and fed through the slag door into the EAF.
The system will be commissioned end of 2009.

4 DRI - EXAMPLE HADEED

4.1 Technical Data

Figure 9: Picture of DRI and Steel Making plant

In March 2007, the first heat was tapped from the new 150t EAF at HADEED. This EAF is feeding a LF and a Slab Caster and is equipped with a 130MVA Transformer, 3 RCB, 3 Carbon injcetion 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 using four buckets per heat, but was designed and optimised for charging various input mixes ranging from 75% Cold DRI / 25% scrap over 100% Cold DRI to 100% Hot DRI.

4.2 HADEED EAF Layout

In Figure 10, 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 9).
The new DRI plant is installed to produce around 1.760.000 t/year Hot DRI with the quality mentioned in Table 2.

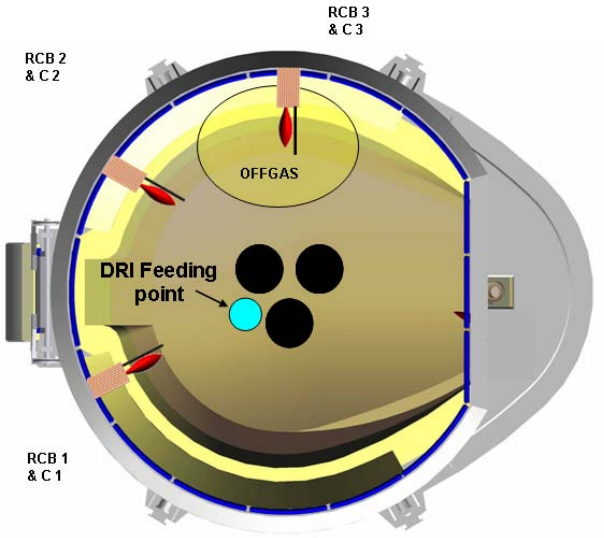

Figure 10: Layout of HADEED EAF

4.3 HADEED DRI Transport

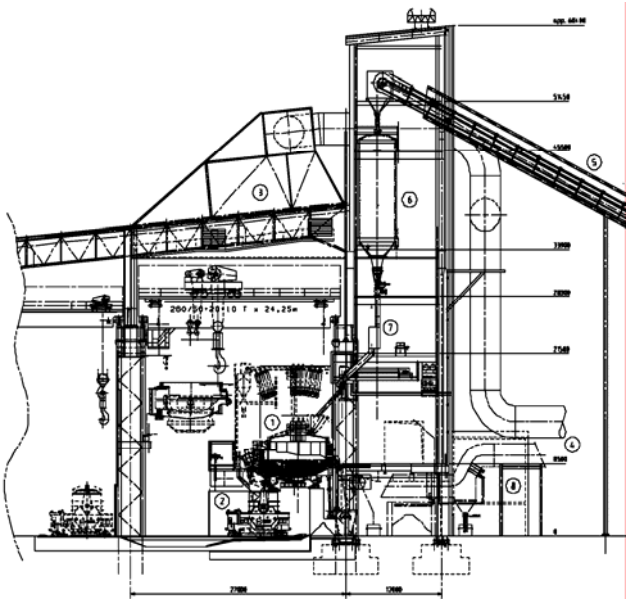

Figure 11: Layout of HADEED Hot Link DRI

In Figure 11, the transportation concept for the Hot DRI is shown: the Hot DRI is coming via an inclined belt (Figure 12) from the DRI plant to an intermediate hopper above the furnace, from where it is gravity fed 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.

Figure 12: Conveyor system for Hot DRI

The system for the Hot transport is designed with sealed special bucket-type apron conveyors.

4.4 Performance with Scrap and Cold DRI

During the first 48h Performance test which was done with the input of 75% DRI and 25% scrap in September 2007, a HADEED record for this input mix of 27 heats in 24 hours has been achieved with the figures in Table 2.
The corresponding DRI quality has been: 94% Metallization and 2,4% Carbon.

Table 2: HADEED performance with 75% Cold DRI

Number of heats	**50**	**Contract**
Tapping weight	**150 t**	**150 t**
Oxygen Total	**22,6 Nm³/t**	**30 Nm³/t**
Gas	**2 Nm³/t**	**3 Nm³/t**
Electrical energy	**492,8 kWh/t**	**495 kWh/t**
Electrodes	**1,1 kg/t**	**1,35 kg/t**
Power On Time	**45,8 Min**	**46,5 Min**
TTT	**54,5 Min**	**58,5 Min**
Productivity	**165,1 t/h**	**153,9 t/h**

4.5 Performance with Hot DRI

During the second 48h Performance test which was done with the input of 100% Hot DRI in May 2008, a new HADEED overall productivity record of 30 heats in 24 hours has been achieved with the figures in Tables 3. During this test, the EAF was even not running on maximum productivity due to limited Hot DRI availability.
The corresponding DRI quality has been: 95% Metallization and 2,1% Carbon.

Table 3: HADEED performance with 100% Hot DRI

Number of heats	**60**	**Contract**
Tapping weight	**152 t**	**150 t**
Oxygen Total	**26 Nm³/t**	**30 Nm³/t**
Gas	**1,4 Nm³/t**	**2,5 Nm³/t**
Electrical energy	**385 kWh/t**	**430 kWh/t**
Electrodes	**0,8kg/t**	**1,3 kg/t**
Power On Time	**39,6 Min**	**42 Min**
TTT	**48,6 Min**	**51 Min**
Productivity	**187,7 t/h**	**176,5 t/h**

Reviewing these figures, the EAF with the HOT DRI input can achieve even better productivities and consumption figures compared to scrap based processes. These figures are also benchmark for Hot DRI input worldwide

4.6 References

Siemens VAI MT has several references with the input of DRI or HBI.

- 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 110t 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.

4.7 Outlook ESISCO and Al Atoun Steel

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

- One 160t EAF, using up to 100 Cold and Hot DRI, will be supplied to ESISCO, Egypt, reaching a Tap-to-Tap time of 52min. This furnace will be equipped with a 140MVA, 4 RCB and 3 Carbon injection lances. The equipment will be commissioned in 2009.

• One 80/100t 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 80t. In a second step, a DRI production facility will be installed and the EAF will use up to 100% Hot DRI, tapping 100t in max. 46min. This EAF will be equipped with a 105MVA, 3 RCB, 2 burners, 2 Post-Combustion oxygen injectors and 3 Carbon injection lances. The equipment 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
- Mix of Scrap, Hot Metal and 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 cut costs in the production of both carbon and stainless steels.