THE 300-TON "JUMBO-SIZE" FASTARC EAF AT MMK ISKENDERUN NEW DANIELI MINIMILL COMPLEX (TURKEY)[1]

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Abstract

MKK-Atakas joint venture between MMK Magnitogorsk Iron & Steel works, one of the major Russian steel companies, and Turkish Atakas awarded Danieli as sole supplier for the technological supply of a new minimill and cold mill complex to be installed in Iskenderun (Turkey). The minimill production capacity is up to 2,4 Mio liqt/y and includes the installation of a UHP (Ultra High Power) "jumbo-size" AC EAF, with a rated capacity of 300-ton of liquid steel. The new state-of-the-art FastArc™ EAF, served by a 300MVA transformer and equipped with Danarc system for the extensive use of alternative energy sources, will be the most powerful Electric Arc Furnace in operation in the world. In this respect the choice of one EAF has been done in order to provide the best results in term of cost optimisation and process handling. The plant includes also secondary metallurgy equipments (Twin LF and Twin VD) and fume treatment equipment, CSP complex comprising two-strand thin slab caster, hot rolling mill, galvanizing line, and colour coating line. The plant will be located on the sea side; to supply the Iskenderun site with raw and input materials and ship commercial products to customers a sea port will be built directly within the plant's territory capable of receiving ships of up to 80,000 tonnage with integrated harbour, with consequent advantage in terms of logistical material flow from ships to the plant. Plant start-up is scheduled by second half of 2010. This project is of great interest as Turkey is one of the most promising markets. The average annual growth of Turkey's steel consumption over the last 7 years has stood at 15%, while production has grown only 8% annually, with the faster growth of steel consuming sectors generating a steady demand for steel flat products.

Key words: Electric meltshop; Minimill; Electric Arc Furnace; Secondary metallurgy.

FORNO ELÉTRICO A ARCO – FASTARC - "JUMBO" DE 300 T FORNECIDO PARA O NOVA "MINIMILL" DANIELI NA MMK ISKENDERUN, TURQUIA

Resumo

A MKK –Atakas, uma "joint-venture" entre a usina MMK Magnitogorsk, uma das principais companhias siderúrgicas russa, e a empresa turca Atakas, selecionou a Danieli como fornecedora exclusiva das tecnologias que compõem sua nova aciaria "minimill" e o complexo de laminação a frio a ser instalado em Iskenderun (Turquia).

A capacidade de produção será de até 2,4 Mtpa de aço líquido e inclui a instalação de um FEA AC "Jumbo" – UHP (Ultra High Power) - dimensionado com capacidade nominal de aço líquido de 300 t. O novo FEA – FastArc™ - alimentado por um transformador de 300 MVA e equipado com sistema Danarc para uso intensivo de fontes de energia alternativas, será o mais potente Forno Elétrico a Arco em operação no mundo. Neste sentido, a escolha de 1 só FEA foi feita de forma a proporcionar o melhor resultado em termos de otimização de custo e controle de processo. A nova planta também inclui equipamentos de metalurgia secundária (Forno Panela Twin e VD Twin), Planta de Tratamento de Fumos, complexo CSP (Compact Strip Production) incluindo máquina de lingotamento de placas finas (Thin Slab) de 2 veios, laminador a quente, linha de galvanização e linha de revestimento colorido. A usina estará localizada no litoral turco, para prover a usina de Iskenderun com matéria prima e insumos e, para embarcar seus produtos comerciais aos diversos clientes, um porto de mar será construído diretamente dentro da área da planta, com capacidade para receber navios de até 80.000 t na baia integrada, com conseqüente vantagens em termos de logística de fluxo de material entre os navios e a planta. O "start-up" da planta está previsto para o 2o semestre de 2010.

Este projeto é de grande interesse já que a Turquia é um dos mercados mais promissores atualmente. A média de crescimento anual de consumo de aço na Turquia nos últimos 7 anos tem ficado em torno de 15%, enquanto a produção de aço cresceu apenas 8% anualmente, com o crescimento mais rápido dos setores consumidores de aço gerando portanto uma demanda constante por produtos planos de aço.

Palavras-chave: Aciaria elétrica; Mini-usina; Forno elétrico a arco; Metalurgia secundária.

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PLANT CONCEPT

The technological solution have been selected in order to have the most innovative system and highest quality level, by which it is possible to achieve extremely efficient operating results with low manpower and specific energy consumption, thereby making the plant highly competitive.
In this respect, the production is realized with a single jumbo size Ultra^3 High Power EAF (250 tons tapped steel in 47 min tap-to-tap time) and single bay concept meltshop layout, which provides the best results in term of process handling and cost optimization.
The choice of single unit, high-capacity EAF is in line with the latest steelmaking technological trends that represent a considerable step ahead if compared to the present situation where comparable productivities, until now, are normally achieved by installing at least two electric arc furnaces.
Furthermore, the defined layout allows the optimization of the required spaces and contributes to an extremely compact and efficient plant general arrangement.
The refining of the steel quality is performed by the Secondary Metallurgy equipment, that includes a Twin design 250 ton Ladle Furnace (LF) and a Twin Tank vacuum station with five stages steam ejectors vacuum pump (VD).
The meltshop includes also an Integrated Material Handling System (IMHS) and a powerful Fume Treatment Plant equipped with twin pulse jet bag filter (FTP).
The steel is then cast with a twin strand Thin Slab Caster (TSC), which feeds the Hot rolling mill and Cold mill complex downstream.
All equipment will be controlled and optimized by an innovative and fully integrated Automation System.

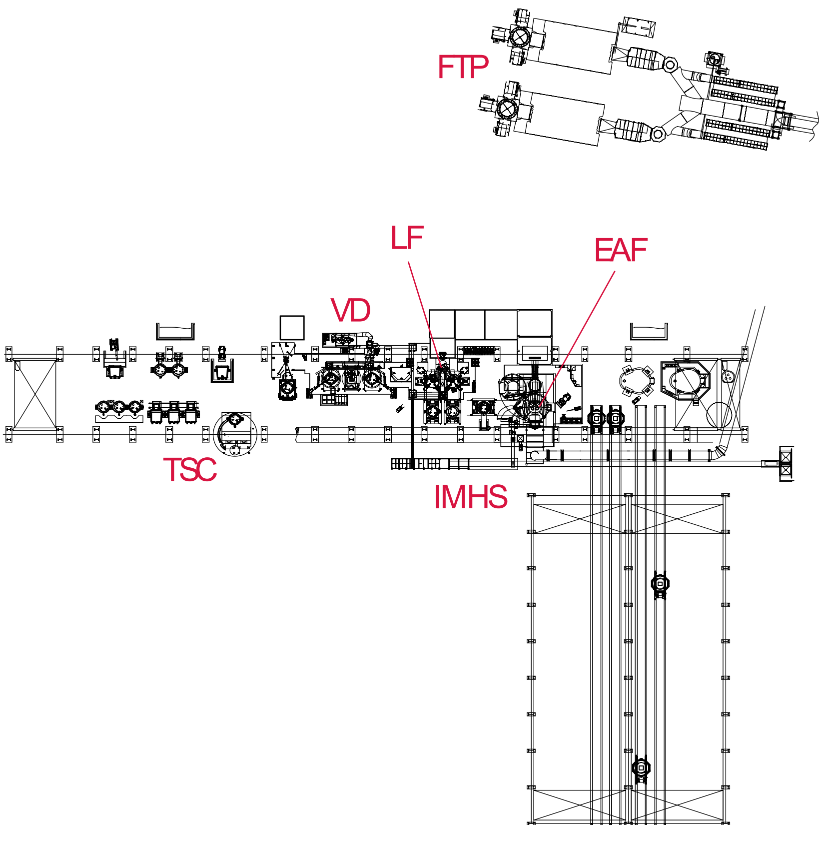

Figure 1. Plant Layout

PLANT PRODUCTIVITY

The furnace is designed to produce Low Carbon, Medium Carbon and HSLA steel grades with the following performances:

- → Productivity; 320 ton/h
- → Tapped steel: 250 ton
- → Charging mix 80% scrap; 20% pig iron
- → Tap to tap time; 47 min
- → Installed power: 300 MVA

EAF DESIGN FEATURES

The required productivity, considerably high for a single EAF, is assured by the state-of-art technology including Fastarc™ module system for the extensive use of alternative energy sources, Hireg®Plus electrode regulation system and with a 300 MVA transformer capacity.

The main EAF data are summarized in the following:

- → Process Batch - two buckets
- → Shell Design Split shell with conductive arms
- → EAF volume 330 m³
- → EAF capacity 310 ton
- → Electrode diameter 810 mm

The Chemical Energy module system includes:

- → Nr.8 Oxygen Jet FastArc™ modules with burner phase
- → Nr.5 Carbon Jet FastArc™ modules with burner phase
- → EAF bottom stirring system.

The injectors are installed around the furnace at specified positions and injection angles in order to achieve the maximum performances, in accordance with all the process parameters, as detailed in the sketch.

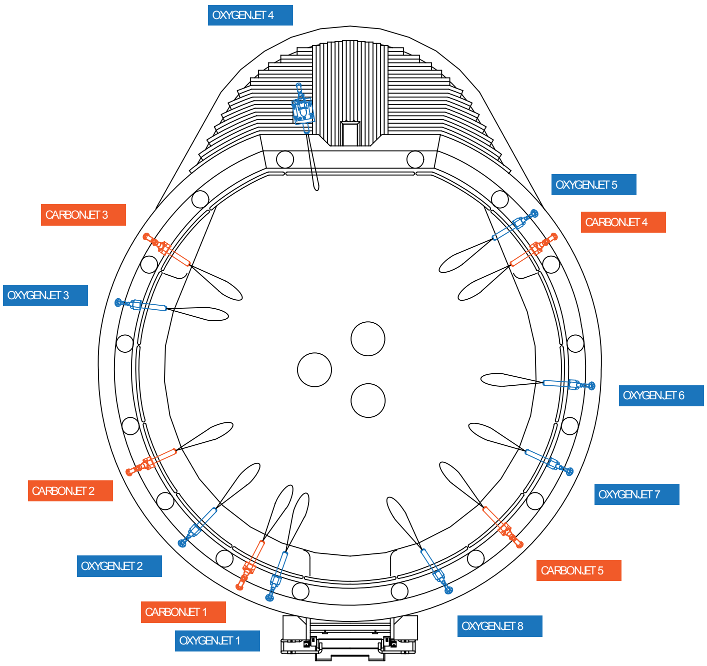

Figure 2. EAF layout with injectors positions

Figure 3. Oxygen Jet + Burner, with shrouding effect

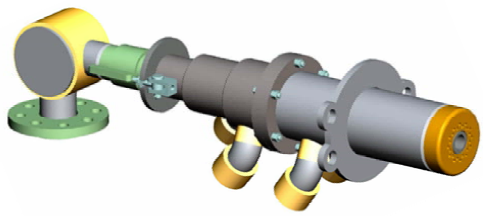

Figure 4. Carbon jet + Burner, with shrouding effect

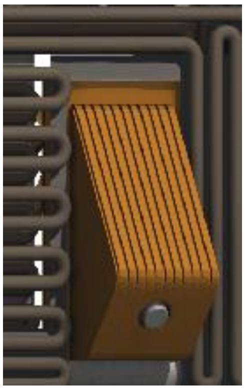

Figure 5. Bulged panel inner view

Figure 6. Bulged panel rear view

Figure 7. Copper block with Oxyjet

The application of FastArc™ Injection Technology introduces following benefits:
a) Process beneficial effects, which can be summarized as follows:
- Reduced electrode consumption;
- More homogeneous bath temperature and chemistry;
- Lower FeO slag content;
- Reduced refractory consumption, furnace shell and ladles.

b) Automation optimization:
The injection is fully controlled by the furnace automation. The furnace activity is totally independent from manual intervention, limiting the operator's function to a mere supervision of the process. Furthermore all variations in working set points are carried out automatically, and, having a fixed injector configuration, the system does not require any manually executed movement to perform its functions.
c) Reduced maintenance impact
The simplification of on board equipment, reduced to a single type of installation, together with the system's fixed configuration, significantly reduce the time allotted to maintenance. Furnace availability is increased, allowing a subsequent pick up in productivity and reduction in costs.
Due to the positive aspects described above, the furnace's performances, in terms of energetic consumption and steel output, are more repeatable. Especially this second point has beneficial effects, considering that standardized furnace output has an impact on the costs of all downstream activities, such as alloying, LF refining and superheating.
An important effect of module operations regards the improvement in arc efficiency with a high degree of repeatability, increasing average power input and lowering power on times.
This aspect is principally related to an earlier and greater foamy slag performance, obtainable with automatic oxygen and coal injection.

Process Design

The requirements of present project are extremely high from a technological process design point of view.
Three are the main constraints that have to be matched to:
1. The final product quality demands for low residuals, low carbon and high purity (inclusion level)
2. The meltshop productivity states a power on as short as 36 minutes implying a melting rate of **9.3 t/min**

3. All the metallurgical reactions have to be fulfilled within such short time in terms of uniformity (distribution of oxygen input) and homogenization (stirring and mixing of the bath).

During design we preferred since the beginning a “large furnace” concept approach, in order to permit longer arcs to be applied as well as more oxygen injection units to be placed around the furnace.

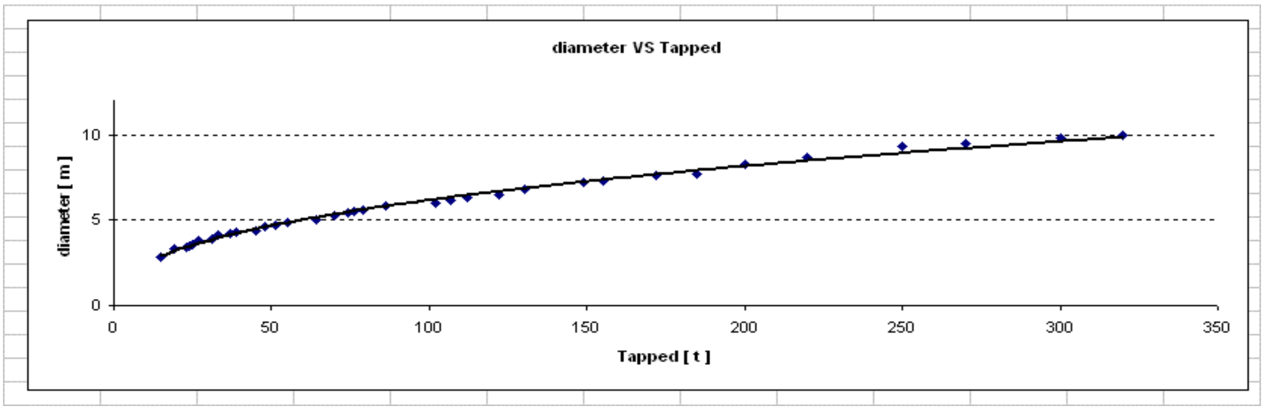

Figure 8. EAF diameter versus heat size

In order to obtain the steel required to the Secondary Metallurgy, a proper charge mix has to be provided. To different solution have been considered:

a. Scrap blended with 20% Pig Iron
b. Scrap blended 35% DRI

In the first case the deC speed has to be considered as the limiting factor while in the second one the power consumption is the critical point.

Particular attention has been placed in the selection of the TRANSFORMER to obtain the required melting rate.

Beyond the needed apparent power of **300 MVA (1200 kVA/t)**, overcoming the limit of present technology, the selected range for the secondary tap-voltages meets the requirements of flexibility in operation during the process: fast power growth during boring, melting at a maximum active power with long arcs and refining at a maximum current with covered arcs by foaming slag.

The current conductive arms and the secondary bus have been designed to conduct the maximum allowed current of 110 kA.

Particular attention has been placed in stiff design of the electrode masts and arms in order to prevent resonance and anomalous vibration affecting the stability and robustness of electrode regulation.

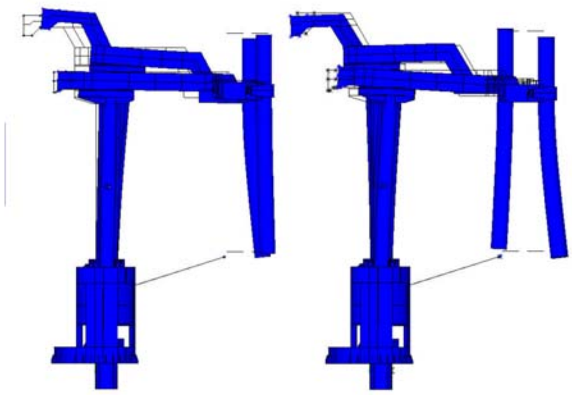

Figure 9. Electrode masts stiffness analysis

All the best improvements of last years' experience have been integrated in the electrode control package "HiReg® Plus" to guarantee power delivery in stable and reliable conditions.
In particular, the integrated ability to evaluate the arcs stability and covering by real-time harmonics monitoring sets-up an efficient supervisor of the preset operating point and a performing foaming slag controller.
The high melting rate in this peculiar process and dimension of bath required to properly distribute the incredibly high amount of oxygen and coal along the furnace walls.
We ended to place 8 oxygen and 5 coal injectors in order to have the following advantages and functions:
1. bath covering: oxygen and coal will be evenly distributed over the bath surface to permit as high as 300 kg/h/m2 of deC and promote the steel homogenization.
2. hot and cold spots balancing
3. equipment availability and reliability

Raw material in charge

The final product quality requirements will be reached by playing with the proper charging material. In this respect the EAF has been designed in order to have the full flexibility in term of selection of raw material mix, starting with 80% scrap and 20% pig iron, but also ready to operate in future with variable percentages of DRI/HBI.
The short power on time available requires fast overheating, as well. For such a reason we will provide a bath stirring system by Bottom Porous Plugs, which will guarantee the best melt temperature homogenisation.
The following pictures depict a typical melting profile as forecast in the case of a 2 bucket heat charging Scrap and Pig Iron

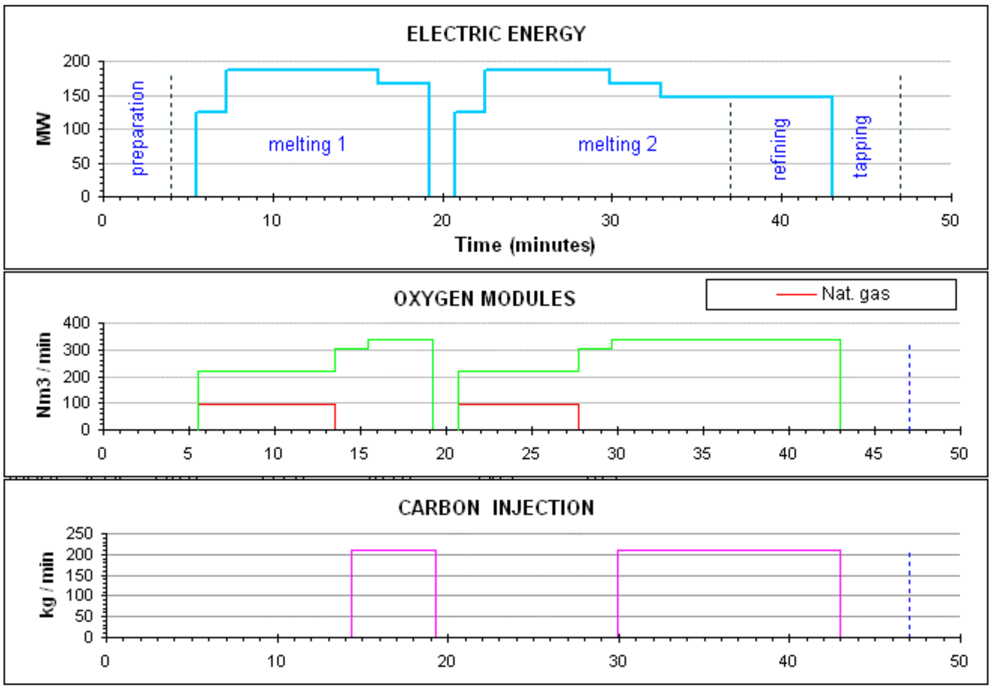

Figure 10. Typical Melting Profile

The corresponding expected performance figures are:

- Productivity	up to 320 ton/h
- Power On time	36 min
- Maximum installed power	210 MW
- Electrical consumption	340-390 kWh/ton, based on several charging mixes
- Oxygen consumption	up to 40-45 Nm³/ton

HIGHLIGHTS OF SECONDARY METALLURGY EQUIPMENT

The final quality of the steel is obtained by means of a powerful Twin position ladle furnace and a Twin tank vacuum station, with deslagging facilities to easily remove the slag before starting the vacuum process. The twin execution increase the production cycle flexibility in accordance to the short tap-to-tap required.

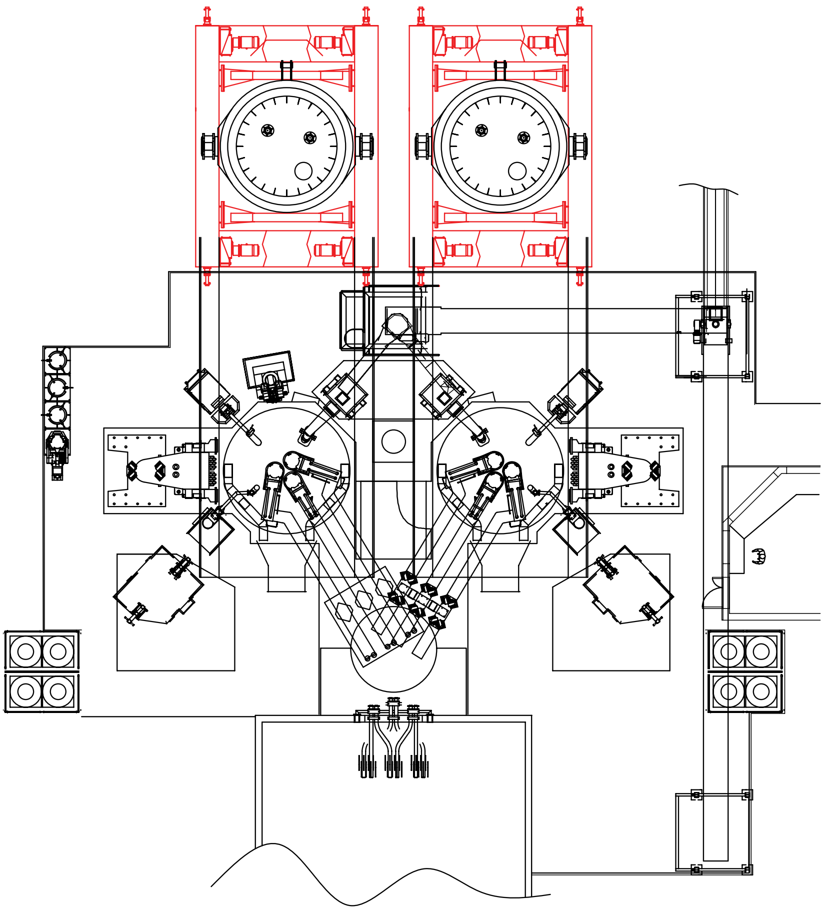

Figure 11. Twin position Ladle Furnace

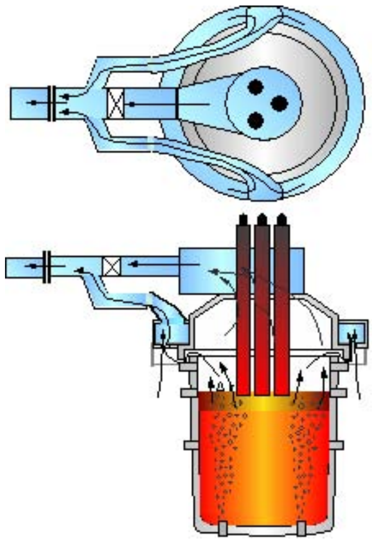

Figure 12. Ladle furnace Inert roof

The ladle furnace is equipped with:

- Swivelling electrodes system and double inert roofs.
- 48 + 20% MVA transformer
- Two ladle cars
- Automatic sampling equipment for each working position
- Wire feeding system for each working position

The Ladle furnace is equipped with an "inert roof" where a small positive pressure (or neutral) is kept inside the furnace via a pressure damper in the hood suction line. This reduces the air infiltration to the furnace and thus minimises the:

- Side oxidation of the electrodes and thus the electrode consumption
- Oxidation of the slag and thus the FeO content and consequently the oxygen content in steel
- Hydrogen pick-up from the furnace atmosphere
- Nitrogen pick-up from the furnace atmosphere

The table below on pick-up of gases from the atmosphere proves the advantages with this type of roof and separate suction hood design.

Table 1. Atmosphere gases pick-up range

Type of gas	Pick-up in ppm during normal heating	Remarks
N	< 5 ppm	Slag thickness must cover arcs, measured in a 100 tonnes LF
H	0.22 ppm	Average value over 24 heats, measured in a 130 tonnes LF

The Vacuum station is equipped with:

- Twin tank with switchable suction line
- Single cover
- Automatic sampling manipulator for Temperature, Oxygen, probe and Hydrogen sampling
- Wire feeding system
- 5 stages steam ejectors vacuum pump with suction capacity up to 500 kg/hr

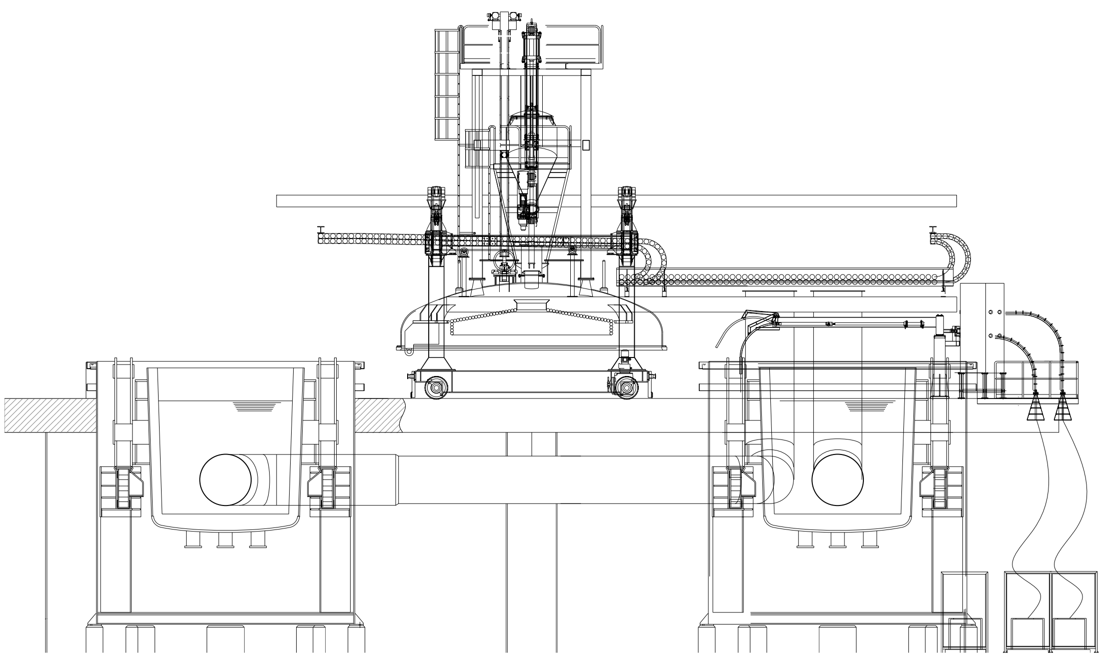

Figure 13. Twin-tank vacuum station

HIGHLIGHTS OF FUME TREATMENT PLANT

The extremely powerful melting process requires a proper fume de-dusting plant, able to process a flow rate up to 430.000 Nm³/hr from the primary and almost 3 Mio m³/hr in total. The huge flowrate leads to a twin design pulse jet filter with six M.V. powered fans with high efficient design. Along the suction line an extensive cooling is provided by a natural twin-type cooler coupled with two spark arresters, cyclone type.

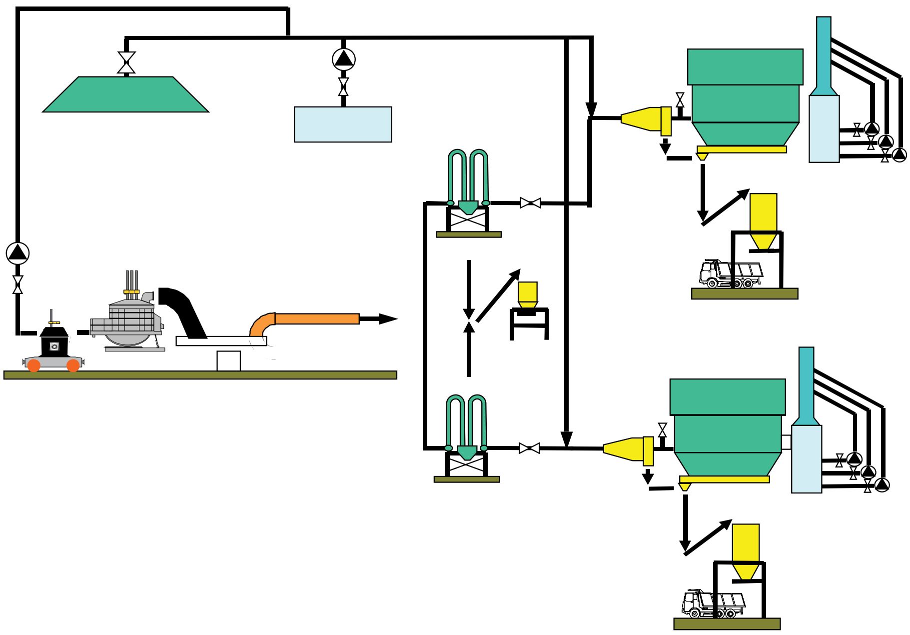

Figure 14.Fume Treatment plant

ELECTRICAL AND AUTOMATION SYSTEM

The automation system proposed, covering both equipment control (Level 1) and process control (Level 2), is based on state of the art hardware and software platforms, while the application software is the well proven DANIELI AUTOMATION package, result of over 40 years of experience in the steelmaking field. The system characteristics are common for the entire plant. In order to achieve the best performances for the EAF, Danieli automation is featured with Hireg®Plus system, which improves arc regulation in the EAF. The Hireg®Plus system, thanks to the analysis of the harmonic content in the power circuit, can evaluate the arc stability and arc coverage indexes, thus increasing the efficiency of the electric arc.

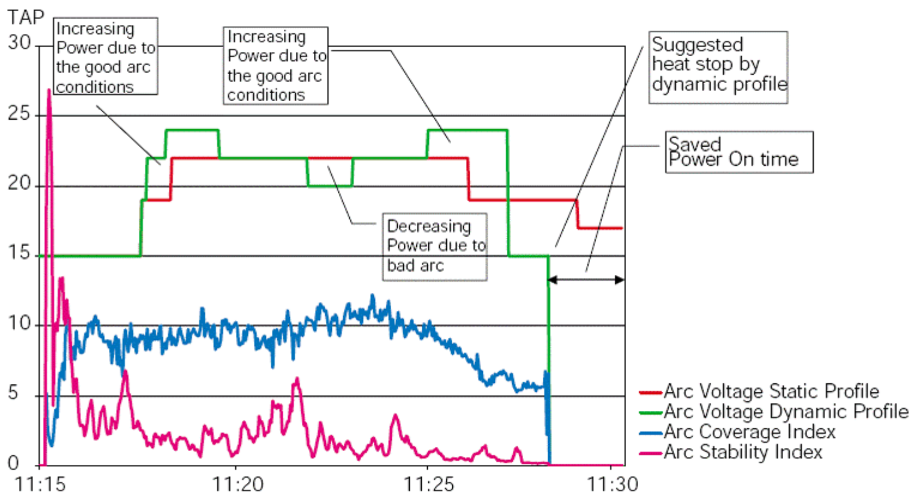

Figure 15. Hi_reg analysis curves

In other words the arc is kept protected by foaming slag and with maximum stability, providing high power without increasing refractory wear.
The improvements are:

- minimum power on time
- maximum average power
- reduced energy consumption (electrical energy and carbon injected)
- reduced electrode consumption

The on-line monitoring of process data and recording of process data for subsequent analysis will also improve the knowledge of arc behaviour, which is particularly important considering the extremely high power input.

CONCLUSIONS

The evolution in steel and energy market in last period has progressively brought the steel producers to focus more and more on the increase of the meltshop productivity and efficiency, as well as following the market tendency in high quality steel products.
The productivity increase must be accomplished with limited investments, in order not to affect the margins with high fixed production costs and/or depreciation.
This tendency brought to a considerable increase of the meltshop heat sizes and to a simultaneous reduction of the cycle times (tap to tap), having as an immediate consequence a sensible increase of the power usage.
The new meltshop described in the paper is perfectly representative of this market trend; the fully integrated steel production complex is based upon a state-of-the-art huge, powerful and fast EAF equipped with an advanced alternative energy package and fed by an impressively powerful electric system and transformer,