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Advanced Plant of Hot Metal Out-of-Furnace Desulfurization in Large-Capacity Ladles

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Process and layout solutions for new advanced automated plant of hot metal ultra-deep desulfurization by injection of granulated magnesium without impoverishing additives are considered. Plant output is 6.5 mln. tons of hot metal per year. Magnesium injection intensity is up to 26 kg/min. Sulfur content reduces to ≤0.005 % and ≤0.002 % at initial sulfur content in hot metal 0.02-0.05 %.

Keywords: DESULFURIZATION, HOT METAL, MAGNESIUM, INJECTION

Introduction

Current demands of steelmaking need improvement of technological and design solutions in out-of-furnace desulfurization of hot metal with maintenance of high efficiency and carrier power of desulfurization plant, the maximum efficiency at the stage of construction and operation, increase of intensity of desulfurization processes and minimization of refining cycle time, stable ironmaking with sulfur content ≤0.002 %.

Results and Discussion

Z. I. Nekrasov Iron & Steel Institute of National Academy of Sciences of Ukraine (Dnepropetrovsk), State Research and Design Titanium Institute (Zaporizhzhya), "Infocom" (Zaporizhzhya) and Desmag High-Tech Co. (Peoples Republic of China) have been solving the specified problems within for 10 years mainly for plants of Peoples Republic of China [1, 2].

During this time 61 plants of hot metal desulfurization and slag practice with total power more than 75 million t/year are implemented and being constructed on 26 integrated iron-and-steel works of Peoples Republic of China under Ukrainian technology with total capacity more than 75 mln. tons of desulphurized hot metal per year (**Table 1**).

Desulfurization is carried out in 40-300-ton ladles with reduced sulfur content in pig-iron to 0.002-0.010 %. The union Iron & Steel Institute - State Research and Design Titanium Institute - "Infocom" - Desmag expanded the volume of investigation in the area of creation of deep desulfurization plants (<0.002 % sulfur) with high intensity of magnesium injection (to 26 kg/min) for the last years. We solved this technological problem for company China Steel Corporation (CSC, Taiwan).

As of 2007, steel-smelting company CSC made approximately 11 mln. tons of steel per year and was in the top 20 largest world steel manufacturers [3]. Two steel works with converters 160 and 300 tons are a part of the company. Steel work No. 2 equipped with larger converters has 3 stands for out-of-furnace desulfurization (one - for injection desulfurization in torpedo ladles, two - for desulfurization in ladles by KR-process). This plant is also involved in steelmaking and continuous casting of flat blank for production of low-carbon sheet in the volume of approximately 6.3 mln. t/year.

Increase of steelmaking with low and especially low content of sulfur is provided with

production of desulfurized pig-iron to 6.5 million t/year (sulfur content to <0.005 % and <0.002 %) in the new plant of desulfurization and slag practice on the basis of Ukrainian technology of granular (granulated) magnesium injection without additives through a submersible lance.

Key design parameters of the plant

The new deep desulfurization plant includes two stations of hot metal treatment. Pig-iron desulfurization, slag practice, correction of physic-chemical properties of ladle slag, sampling of pig-iron and indication of its temperature are carried out on each station. Key design parameters of this plant are presented in **Table 2**.

Shown specific charges of magnesium are guaranteed, in practice the actual charge of magnesium is lower by 10-35 % (**Figure 1**). The plant works in an automatic regime, if necessary it is possible to use half-automatic step-by-step control mode.

Technological and layout solutions

Desulfurization technology includes new regimes of magnesium air feed in the lance, special parameters of separation of two-phase magniferous canal, new conditions of injected magnesium dispersion in the refined melt and additional measures of effect on the ladle slag. It enabled to increase intensity of magnesium supply to 26 kg/min with the use of only one lance instead of two lances and two injection systems as it is carried out by ESM method at JSC "Severstal" [4].

Each of two stations of desulfurization plant (**Figure 2**) has pig-iron treatment chamber 1 in which ladle 2 with pig-iron is delivered on moving hot-metal ladle truck 3. Moving hot-metal ladle trucks 3 are equipped with ladle tipping system

Table 1. Desulfurization plants implemented and under construction by Ukrainian technology with granulous magnesium injection at integrated iron-and-steel works of Peoples Republic of China (during 2002-2009)

Number of integrated iron-and-steel works	26
Number of steel works	33
Number of pig-iron treatment facilities	61
Unit capacity of facilities, million t / year of pig-iron	1 – 6
Mass of treated pig-iron in the ladle, t	40 – 300
Total power of facilities, million t / year of pig-iron	76.4
Intensity of magnesium supply, kg/min	6.6 – 21
Sulfur content in pig-iron, initial, %	0.018 – 0.099
Sulfur content in pig-iron, final, %	0.002 – 0.010
Rate of reagent consumption, pig-iron kg/t	0.274 – 0.971
Rate of Mg consumption on removed sulfur (β), kg/kg	1.26 – 2.46

Table 2. Key design parameters of desulfurization plant

Amount of treated pig-iron, mln. t/year	6.5
Sulfur content in pig-iron, %:	0.010–0.050
- before treatment	≤0.005 (in the whole pig-iron)
- after desulfurization	≤0.002 (in the part of pig-iron)
Weight of hot metal in the ladle, t	275
Initial temperature of pig-iron, °C	1250–1420
Specific charge of magnesium, kg/t	0.25-0.79 (depending on initial and specified final sulfur content in pig-iron)
Intensity of magnesium injection, kg/min	14–26
Duration of magnesium injection, min	3-8 (in average 4–5)
Drop of pig-iron temperature, °C/min	< 1
Extent of pig-iron desulfurization, %	80-96

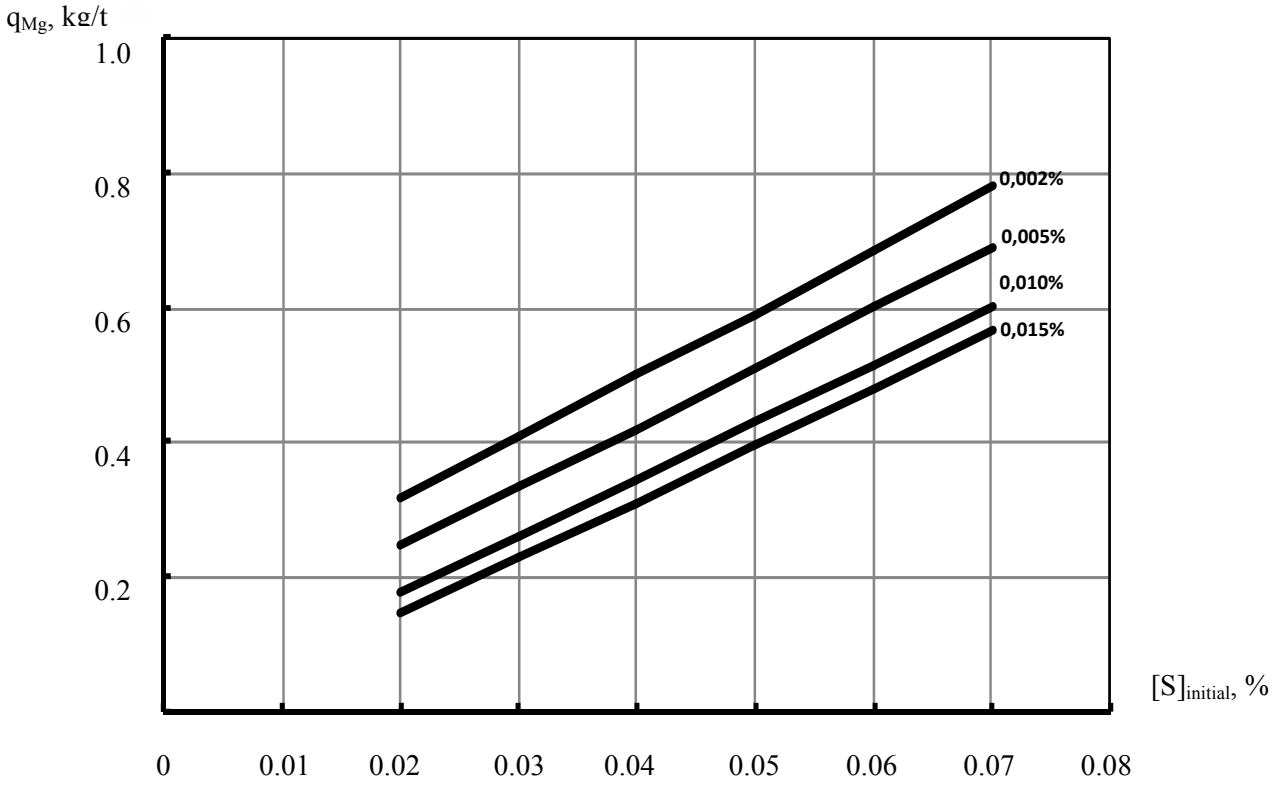

Figure 1. Dependence of specific charge of magnesium (q_{Mg}) on initial sulfur content in pig-iron ($[S]_{initial}$) at grained magnesium injection in 300-ton ladle of company CSC. Figures on lines indicate sulfur content in pig-iron after desulfurization (%)

which makes it possible to carry out all operations on one station including slag skimming.

Desulfurization station is equipped with one mobile lance feeder into melt 4 with two lances 5.

Each ladle is treated by one lance (the second lance is used for treatment of the next ladle). This technology is accepted and implemented proceeding from the least capital input and the greatest carrying capacity of desulfurization station. Ladled and run supply of magnesium in hot metal is provided by module-dozer 6 (**Figure 2**). One module-dozer is applied on one station and injects magnesium through several lances alternately (irrespective of their quantity).

There is stand 7 of reserve and replaceable lances, on which lances are repaired and served, on the operating floor of desulfurization plant (**Figure 3**) near the lance feeder in the melt 4. Jib 8 (**Figure 3**) carries out load handling on transportation and change of lances.

Loading module 9 (**Figure 2**) is used for rapid and automated loading or additional loading of modules-dozers with magnesium. This loading module is located on the distance to 200 m from modules-dozers 6. Rate of magnesium overloading from loading module 9 into modules-dozers 6 is 200 kg/min. One loading module is applied (irrespective of quantity of modules-dozers) and contains 2-6 tons of current and consumed stock of magnesium. The loading module is filled with magnesium from transport basket 10 (**Figure 2**).

Ladle slag correction is carried out by addition of bulk materials from nonutilizable waste of refractory and roasting manufactures in amount of 1.5-2.0 kg/t from silo 11 (**Figure 2**).

For slag skimming the ladle is inclined by hot-metal ladle truck tilting mechanism 3. Slag skimming machine 12 removes slag from pig-iron surface in the slag pan 13 (**Figure 3**). When nitrogen blowing of pig-iron through device 14 (**Figure 3**) bubblering takes place, slag is pushed aside towards the ladle lip which reduces time of slag practice and increases the level of pig-iron purification from slag.

The control of all operations is carried out from the main control panel by means of personal computer and PLC in both automatic and discrete regimes. The control system is connected with

external control systems of the plant.

Data about composition of magniferous reagent, pig-iron weight in the ladle, temperature, intensity of chemical agent injection, sulfur content in pig-iron before desulfurization and specified after treatment are fed into computer. The necessary charge of chemical agent, injection time and other parameters of the process are automatically computed. All the subsequent operations are carried out in the automatic regime.

The new desulfurization plant is rather compact and needs small working area.

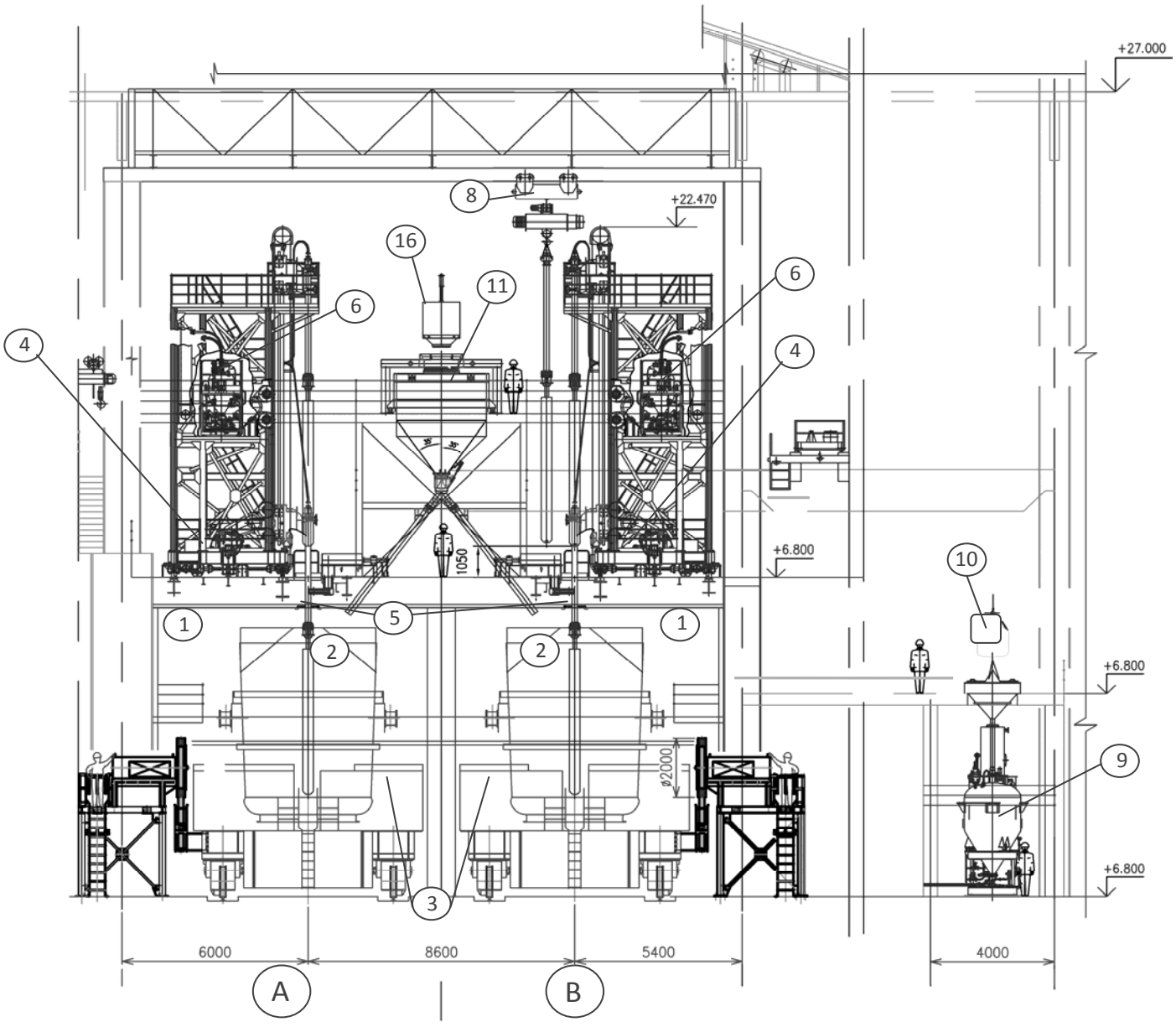

Figure 2. Desulfurization plant with grained magnesium injection (cross-section of stations A and B): *1* - pig-iron treatment chamber; *2* - ladle with hot metal; *3* - moving hot-metal ladle truck; *4* - lance feeder into melt; *5* - lances for magnesium injection; *6* - dozer of grained magnesium; *8* - jib for motion and change of lances; *9* - magnesium loading module; *10* - transport container with magnesium; *11* - silo of ladle additives; *16* - container with correcting additives

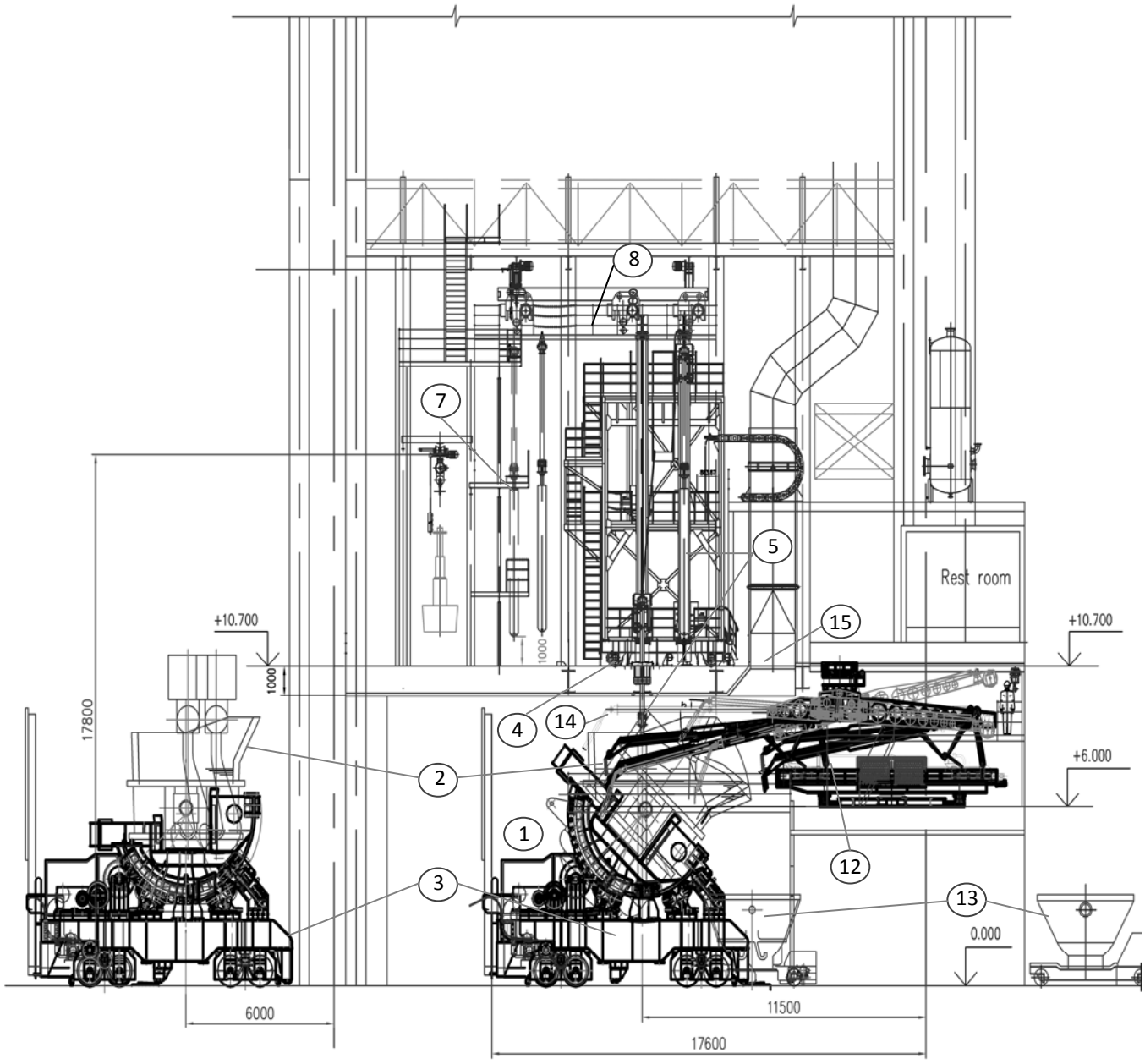

Figure 3. Longitudinal view of desulfurization plant: *1* - chamber of pig-iron treatment; *2* - ladle with pig-iron; *3* - hot-metal ladle truck; *4* – lance feeder in melt; *5* - lances for magnesium injection; *7* - stand of reserve lances; *8* - jib for replacement of lances; *12* - slag skimming machine; *13* - slag pan on the carriage; *14* - babbler; *15* - furnace gas flue

Conclusions

Achievements in adoption of Ukrainian technology of out-of-furnace desulfurization at iron & steel plants are stated. The new plant of out-of-furnace hot metal desulfurization by magnesium designed for company SSS (Taiwan) is presented.

High intensity of magnesium injection (26 kg/min) without any additives and high extent of magnesium recovery provide design of desulfurization plant with the least capital and current operational expenses.

Advancement of ladle slag removal operations (due to nitrogen blowing and correction of slag characteristics) increases the degree of purification from slag and reduces arrival of sulfur to converter as minimum as possible.

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Современный комплекс внедоменной десульфурации чугуна в большегрузных заливочных ковшах

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Представлены технологические и компоновочные решения по новому современному автоматизированному комплексу особо глубокой десульфурации чугуна вдуванием зернистого магния без разубоживающих добавок. Мощность комплекса 6,5 млн. т. чугуна в год. Интенсивность вдувания магния до 26 кг/мин. При исходном содержании серы в чугуне 0,02-0,05 % обеспечивается снижение серы до ≤0,005 % и ≤0,002 %.