OWN EXPERIMENTS AND POLLUTION ANALYSIS ON FLOW TECHNOLOGY COMPONENTS SEQUENCES IN OLD 1 SECTION

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The study contains the results of own research and experimentations on decreasing the contents of gaseous and solid pollutants in the ellaboration of iron materials in the oxygen converter at ArcelorMittal Galati. The new established technology drove to about 30% lower emissions as against the classical technology of steel elaboration in the oxygen converter. The personal contributions that have led to this decrease relate to the load component optimization, oxygen intake management and constructive improvements implemented to the aggregate elaboration. The paper presents the results section steelworks with oxygen converters type LD (OLD1).

Keywords: phase flow, pollutants, pollution emissions, pollution technologies, pollution study, and pollution reduction measures

1. Introduction

The primary technological flux of OLD 1 consists in:

a) Cast iron feeding

The cast iron brought in pots from the furnace is loaded for the homogenization of the chemical composition and temperature in two mixers with the storage capacity of 1.500 tons. From the mixers, the cast iron is taken into 155 ton capacity pots and loaded in converters.

In case of steel grades with low sulfur content elaborations, the cast iron is passed through the desulphurization appliance, in which through injecting desulphurized mixtures, the sulfur content can be reduced to values between (0.003-0.005) % [1,2,3].

b) Scrap metal feeding

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The scrap metal prepared in the scrap metal sorting and preparation section is brought in the metal loading hall of the OLD 1 department and loaded into barters with the capacity of 10-12 m^3. The barters are transported by charging machines and unloaded in converters.

c) Iron elaboration, treatment and casting

The elaboration process unfolds in converters provided with combined injection (oxygen from the top and azotes or argon from the bottom), the whole process being computer-aided.

After the elaboration, the steel is evacuated into pots and depending on its destination it is directed to continuous casting or to the ingot casting sector. Depending on the steel prescriptions, before it is directed to the casting sector, it can be treated in two steel special treatment appliances – RH and VAD types.

d) Resulting products from the technological processes

After the manufacturing processes inside the OLD 1 department, steel grades are obtained within four quality groups depending on the alloying elements that compete in the attainment of the specific grade, presented in table1.

Table 1

Steel grades - quality groups

GROUP I	C<0,12 %	Mn<0,5 %	With or without Al
GROUP II	C<0,18 %	0,5<Mn<0,9 %	With or without Al
GROUP III	0,12<C<0,18 %	0,9<Mn<1,4 %	With or without Al
GROUP IV	0,18<C<0,25 %	Mn>0,9 %	With or without Ni, Cr, Mo, Cu, V, Ti, Nb, Al

A part of the drawn steel is cast into bars and grouped in categories according on their weight: 19 tons, 20 tons, 22.5 tons and 23 tons.

In the TC 1 department, the steel grades produced in OLD 1 are cast in slebs and divided in groups according to their thickness and slab width.

The gap dimensions have a wide range, with the following values:

- 150-300 mm thick
- 700-1900 mm wide
- 3500-9500 mm long

2. Research and experimentations

2.1. Research, experimentations and results regarding pollution study in the cast iron reception and treatment sector (cast iron desulphurization)

This sector consists of: mixers, steel ladle transfer carriage, steel pot stand, torpedo wagon, iron transfer pot chariot, cast iron pots (155 tons), and bridge crane.

The cast iron reception sector is equipped with two storage appliances (mixers) provided with CH_4 and air injection devices for maintaining the cast irons’ temperature.

Also, through the constant reception on cast iron from the furnace, the homogenization of the temperature and chemical composition of the iron is performed in the mixers, with the following characteristics shown in table 2:

Table 2

Technical characteristics of the mixer

Capacity		Degree of filling	Mentaining temperature of the cast iron	Fuel	Fuel flow Nominal
Nominal	Maximum				
1500 t	1900 t	0,81 %	(1300-1400) °C	CH_4	1500 t

Cast iron treatment sector is equipped with desulphurization equipment with the technical characteristics presented in table 3, used in cases where steel grades with low sulfur content are programmed for elaboration. Through the injection of the desulphurization mixture into the liquid cast iron, the sulfur content can be reduced to values as 0.003% S, after which the desulphurization cast iron is used in converters.

Table 3

Desulphurization appliance technical characteristics

Cast iron treatment pot capacity	Injection time	Material used	Specific intake	Desulphurization degree
155 t	(12-18) min	CaD 8020	9 kg/tona fontă	80

2.1.1. Pollution source determination

In this sector (cast iron reception and treatment) there are workstations in which releases of gases and dust that pollute the atmosphere take place:

1. Loading of the cast iron into the mixer
2. Unloading of the cast iron from the mixer
3. The desulphurization of the cast iron zone

Currently, workstation 1 and 2 help the release of gases and dust, which spread in the atmosphere not being captured and purged.

Workstation 3 has functioning equipment for capturing polluting emissions which substantially reduces the atmospheric pollution.

2.1.2. Pollution types determination

The determinations and the measurements conducted in the area have revealed the presence of gases and dust.

- The main identified gases were: CO; CO_2; SO_x; FeO; NO_x
- The prevailing dusts are: Fe; FeO; Carbides.

In the case of the desulphurization sector that has pollution emissions intake and purge equipment, we have the following characteristics and average values resulted from the 10 determinations, presented in table 4 and in Figs. 1 and 2.

Table 4

Determined results

Det. No.		1	2	3	4	5	6	7	8	9	10	Average value
Desulphurized dust concentrations, [mg/Nm^3]	In	280	290	260	270	275	265	260	265	275	260	270
	Out	45	46	44	46	45	45	44	45	46	44	45
Mixer dust concentrations, [%]	Dust on ground	90	85	95	80	95	95	85	85	95	95	90
	Air emissions	10	9,9	10,1	10	10	9,9	10	10,1	10	10	10

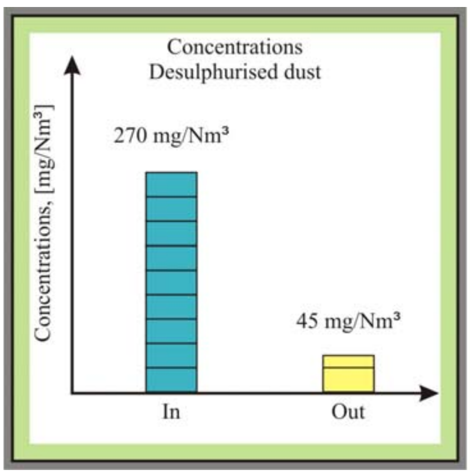

Fig. 1. Changes in the dust concentration during desulfurisation

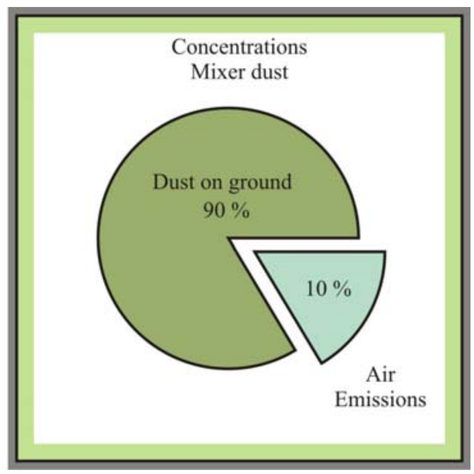

Fig. 2. Mixer dust concentration distribution

The slag resulted from the desulphurization process is about 3-20 kg/ton liquid iron and has the following chemical composition shown in table 5.

Table 5

The chemical composition of the slag resulted from the desulphurization process

CaO, [%]	SiO_2, [%]	Al_2O_3, [%]	MgO, [%]	FeO, [%]	MnO, [%]	P_2O_5, [%]	Cr_2O_3, [%]	S, [%]	CaO/SiO_2, [%]	Cu, [%]	Fe_{met}, [%]
27	18	8	10	15	0,5	0,2	0,1	5	4	1,5	20

In the cast iron storage area (mixers area) there is no emission filtration intake system, which causes 90% of the dust from this sector to deposit on the ground, and the remaining 10% to be trained by the air currents.

2.2. Pollution study in the iron elaboration sector

This sector consists in: LD converters, the RH equipment, the VAD equipment, the iron and slag ladle transfer carriage, charging machines, slag pots, iron pots, gantries.

The iron elaboration sector contains:

- 3 combined injection converters that consist in O_2 injection from the top through the lance, corroborated with the injection of N_2 and Ar through nozzles installed at the bottom of the converter. These converter characteristics (table 6) allow the possibility of obtaining miscellaneous steel ranges and grades.

Table 6

Converter technical characteristics

Type of injection	Capacity		Injection flow	
	Nominal	Maximum		Nominal
Combined	160 t	180 t	Combined	160

- a vacuum degassing plant through iron recirculation, type “RH”(with the characteristics from table 7), through which the reduction of the gas quantity remained in the steel is ensured.

Table 7

"RH" equipment technical characteristics

Capacity		Treatment duration	Vacuum characteristics	
Combined	160 t		Combined	160 t
160 t	180 t	(15-25) min	160 t	180 t

-VAD type steel treatment plant with heat input with the characteristics in table 8. The equipment has the possibility of heating and maintaining the steel temperature being able to provide a special deoxidation, alloying and degassing treatment.

Table 8

"VAD" equipment technical characteristics

Capacity		Transformer characteristics	Vacuum characteristics	
Nominal	Maximum		Nominal	Maximum
160 t	180 t	10MVA; 6KV	160 t	180 t

This sector also consists in auxiliary equipment maintenance, such as:

A)-Charging machines. Two charging machines that serve the three converters and their scrap metal feeding.

The machines are electrically operated so they are not polluting and are moved to the elaboration platform zone by rail. They ensure the scrap metal barter transport from the metal cargo zone to the elaboration zone.

B) -The gantries (225 tf). The three gantries serve the converters and the adjacent stream in the area. They are electrically operated, thus not polluting, and running on rails situated on support beams at +18.000 mm altitude level. The action zone is 72 meters long with a 21 meter opening between the beams.

C) -Valve and pots transfer carts. The three transfer carts serve the converters. They are electrically operated and run on rails at ground level “zero” altitude.

2.2.1. The influence of the development of pollution technologies and classes of steel produced

As producer, the refracted steelworks unit supplies a large variety of steel groups according to current standards and marketing requirements.

These form four quality groups, value differentiated through their alloying elements content (table 9).

Table 9

Quality groups

GROUP I	C<0,12 %	Mn<0,5 %	With or without Al
GROUP II	C<0,18 %	0,5<Mn<0,9 %	With or without Al
GROUP III	0,12<C<0,18 %	0,9<Mn<1,4 %	With or without Al
GROUP IV	0,18<C<0,25 %	Mn>0,9 %	With or without Al, Ni, Cr, Mo, Cu, Ti, Nb, V

Elaboration technologies are adequate according to the group the respective steel is in, being compatible and respecting steel elaboration international rules regarding the limitation of source pollution (in the converter).

There have been developed green elaboration technologies for:

- Low carbon steels, aluminum cooled in combined injection converters;
- High carbon steels, aluminum cooled in combined injection converters;
- Silicon or silicon and aluminum cooled steels in combined injection converters;
- Steels poured into ingots;
- Cold strip steel manufacturing for pressing;
- Steel for steel plates thicker than 40 mm;
- Steel for steel plates with U.S. control prescriptions;
- Steels that receive only primary aluminum;
- VAD treated steels;
- RH treated steels;
- Steels with sulfur prescriptions.

Of particular importance in establishing technologies is auditing the materials and the quality of the used materials. Intake rules have to be calculated according to the steel grades prescriptions, and the misconduct coefficients must register in the permissible limits.

The elaborated steel grade falls into quality group III, being mild steel for which the proposed technology has been established and experimented with.

The values of the performed emission measurements and the structure of these emissions for two big converters elaborated steel groups (mild steels and alloy steels), globally analyzed, and are presented in table 10.

Table 10

Pollution emissions values, [%]

COMPONENTS	MILD STEEL	ALLOY STEEL
Fe tot	25 – 50	30 – 40
SiO_2	1,5 – 5	7 – 10
CaO	4 – 15	5 – 17
Al_2O_3	0,3 – 0,7	1 – 4
MgO	1 – 5	2 – 5
P_2O_5	0,2 – 0,6	0,01 – 0,1
MnO	2,5 – 5,5	3 – 6
Cr_2O_3	0,2 – 1	10 – 20
Na_2O	1,5 – 1,9	0
K_2O	1,2 - 1,5	0
Cu	0,15 – 0,4	0,01 – 0,03
Ni	0,02 – 0,04	2 – 4
V	0,02 – 0,05	0,1 – 0,3
As	0,003 - 0,08	0
CI	1,5 – 4	0
S	0,5 – 1	0,1 – 0,3
C	0,5 – 2	0,5 – 1
Basicity	2 – 6	0
Humidity	6– 16	0

2.2.2. Pollution nature, quantity and source determination

The technological process that takes place in the converter results in gas and dust emissions known as “converter gases” that contain in their structure gases such as: CO, CO_2, SO_x, NO_x that train dust particles in their flow.

From the converter gas emissions, for the 10 elaborated batches, with different load components, the following gaseous pollutants were determined (in volume percentages):

$CO = 72.5$ %; $H_2 = 3.3$ %; $CO_2 = 16.2$ %; $N_2 + Ar = 8$ %

Resulting from the oxide emission:

Al = (0.60 – 0.80) g/t liquid steel
Cr = (0.00 – 0.04) g/t liquid steel
Fe = (2.8 – 83) g/t liquid steel
Mn = (2.7 – 60) g/t liquid steel
Fluorides = (0.008 – 0.01) g/t liquid steel

Also, the values of these emissions were measured and determined in different areas and altitudes (Fig. 3) as follows:

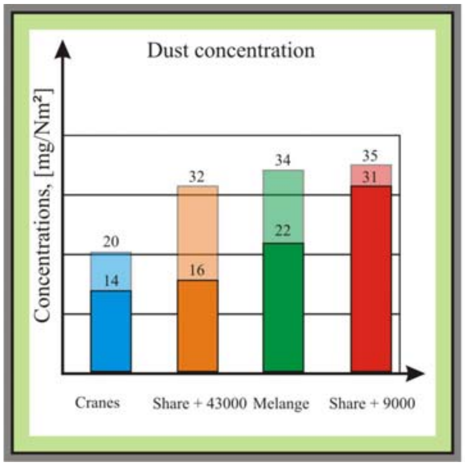

Fig. 3. Polluting emissions values measured and determined in different areas and altitudes

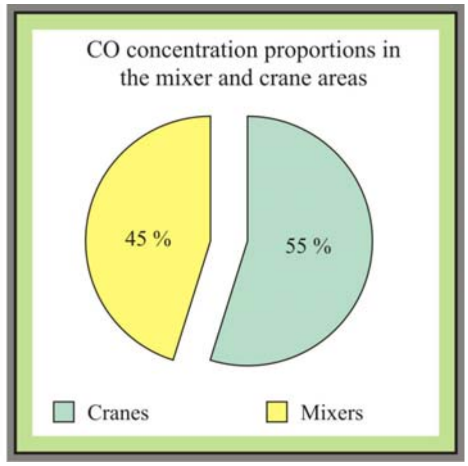

Fig. 4. CO concentration proportions in the mixer and crane areas

Dust area:

-Crane = (14-20) mg/m^3 of air; +9.000 mm altitude = (31-35) mg/m^3 of air

Fig. 4 presents the concentration proportion of CO in the mixer (55%) and crane zones (45%). Also, CO contents were measured having the following values presented below:

CO in area:

- Mixer (30-34) mg/m^3 of air
- Cranes (26-48) mg/m^3 of air.

From the conducted measurements it results that, in full, the values exceed the maximum admissible limit of 0.15 mg/m^3 of air.

The resulting smug from the converter technological processes is 100-130 kg/t liquid steel. It has the chemical structure submitted in table 11.

Table 11

Smug chemical structure

CaO, [%]	SiO_2, [%]	AI_2O_3, [%]	MgO,[%]	FeO, [%]	MnO, [%]	P_2O_5, [%]	Cr_2O_3, [%]	Fe_{met}. [%]	CaO, [%]	(S), [%]	CaO/SiO_2, [%]
50	9	2	3	1	2	15	1	12	7	0	4

In the case of VAD and RH equipment, the technological process creates:

- Gas emissions and dust.

The resulting dust is characterized by the component oxides: aluminum oxides, iron oxides, manganese oxides, silicon oxides and others.

From the gas emissions the following components were revealed: CO, CO_2, Ar, SO_x. The percentage values of these components are presented below and graphed in Fig. 3.14.

The RH and VAD equipment are provided with high vacuum achievement systems.

The vacuum pump absorbed emissions are taken by the intake and purification plant.

In the dust areas the following values were determined:

Dust
- (8-11) mg/m^3 of air - dust area
- (2-4) mg/m^3 of air - ground area

In Fig. 5, the percentage placement of the dust quantity is presented, with 80% averaje values in the dust area, and 20% values in the ground area.

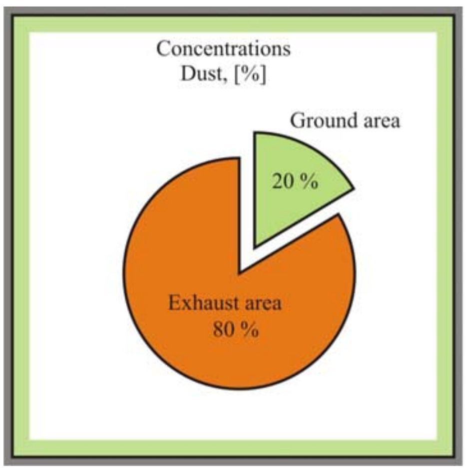

Fig. 5. Dust quantity distribution

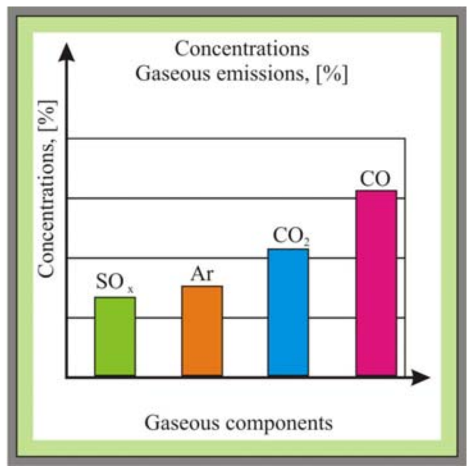

Fig. 6. Graphic representation of the gaseous components

Gases (average values) - CO = 7,25%; - CO_2 < 2%; - Ar = 1%; - SO_x < 1%

Having in mind that the workload of this equipment is 10% at the moment, it can be concluded that the emission contribution is fairly low.

3. Conclusions

In order to reduce air pollution, from conducted experiments, it is revealed that one of the solutions with a maximum efficiency is the one related to constructive improvements of the current intake and treatment of pollutant emissions equipment. The current converters are provided by “Venturi” type emission intake and purification equipment, with variable section and demister. The suction is made with variable revolution exhausts that ensure a 150 g/m^3 dust concentration entry value and a 150 mg/Nm^3 exit value. The converter gas that results from the intake process goes into the equipment with a 1200°C temperature and an approximate 20.000 Nm^3/h flow, namely 115Nm^3/t liquid steel. The converter gas contains (70-80)% CO and has a thermal power situated around the value of 8.8 MJ/Nm^3. The intake equipment is fixed and positioned on the vertical axis of the converter.

To limit the release of dust into the atmosphere, as a constructive solution to the current “Venturi” intake and filtering system, a prefilter duplex type system can be installed upstream, which consists in a dust bag intake device, followed by a “Venturi” type filtering equipment, identical to the existing one but smaller in size. In this manner, a 30% decrease of pollution parameter values measured at initial installation is achieved.The dust bag filtering system is located in an electrostatic field, and at the time the particles pass through this device they charge electrically, being drawn to the filtering bags, thus achieving the retention of a significant part of the polluting emissions. Another possibility of reducing the pollution resulted from the experiments is the one referring to the converter load optimization and the oxygen intake conditions.

R E F E R E N C E S

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