J. Mater. Environ. Sci. 2 (S1) (2011) 501-506 *Abedghars et al.*
ISSN : 2028-2508
CODEN : JMESCN
Colloque International « Journées des Géosciences de l'Environnement »
Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ».

Monotoring of air quality in an iron foundry (Case of NOx, SO_2, benzene and dust)

M. T. Abedghars [1, 2], A. Hadji [2], S. Bouhouch [1]
1. Research Unit on iron and steel industry URASM/CSC, Annaba Algeria.
Mail: abedghars@yahoo.fr, bouhouche11@yahoo.fr
2. Laboratory of Foundry, Badji Mokhtar University, Annaba - Algeria
Mail: hadji_alidz@yahoo.fr

Abstract
The requirements as regards ecology are imposed more and more by the legislator. The cast iron foundries, using the cupola furnace like means of fusion and several other materials for the clothes industry of the moulds and the cores, produce a great quantity of noxious gas and dust. These pollutants are discharged into the atmosphere and are very harmful for the human health of the workers and the environment bordering the sites of production. So, our study relates to the monitoring of polluting gases such as: the so_2 , nox and btx continuously during a working station by passive sensors and to measure the dust level reigning in the various workshops of the foundry by the method of decantation (method of bergeroff). All these pollutants are known for their harmful effect on human health. The strategic aims had by this study is to index the atmospheric emissions, to determine the level of the air pollution generated by the activity of a manufacturing unit of castings out of cast iron using like moulding the traditional process, to determine the peaks of concentration of polluting gases (so_2 nox and btx), to quantify and analyze pollution by the suspended particles, to work out a cartography of the air pollution) and to compare the values obtained relating to the current situation with limiting values who. The results of taken measurements showed a very strong pollution reaching of the values 236.6 $\mu g/m^3$ for benzene (c6h6), 508.2 $\mu g/m^3$ for the dioxide of sulfur (so_2) and 722.4 $\mu g/m^3$ for oxides of nitrogen (nox). The concentrations of dusts are in on this side limiting value of who. Their chemical analysis showed the presence of much silica and iron.

Key words: cast iron foundry, gaseous polluant, atmosphere, dust, values who.

Introduction
Today fast industrialization, the growth of the cities in the world, the energy production and deficiencies in the regulation of planning and the environment are as many factors having contributed to disasters as well on health as on our environment.

The management of the quality of the air contributes to the control of a better knowledge of the pollution generated by the metallurgical industrial activity.

This study constitutes an approach undertaken at the national level in the assumption of responsibility of the environmental problems on an industrial scale and more particularly in the field of the foundries.

The impact of the air pollution on the ecosystem was shown by several scientific works [1]. This form of pollution is caused by various industrial activities, amongst other things the foundry. The measured impact relating to the activity of the foundry is the air pollution (gas and dusty rejections).

The requirements as regards ecology, even if one disregards moral obligation, are imposed more and more by the legislator [2]. But the need for producing with a maximum of economy became inescapable. In this direction, the foundry is the most advantageous branch by comparison with the other processes of development [3].

2. Experimental methods

The realization of the monitoring of polluting gases (SO_2, NOx and BTX) and the suspended particles rest on the identification of the fixed sources of pollution (various workshops), the development of the sampling design and the chemical analysis of the samples gas and dust in suspension.

Means used

The means implemented for the realization of the project are as follows:

- Plan of mass of the cast iron foundry;
- Samplers (sensors) passive with box; carries samples for gases: NOx, SO_2 and BTX (Figure 1);
- Devices of recovery of dust by decantation;
- Statistical models
- References of WHO.

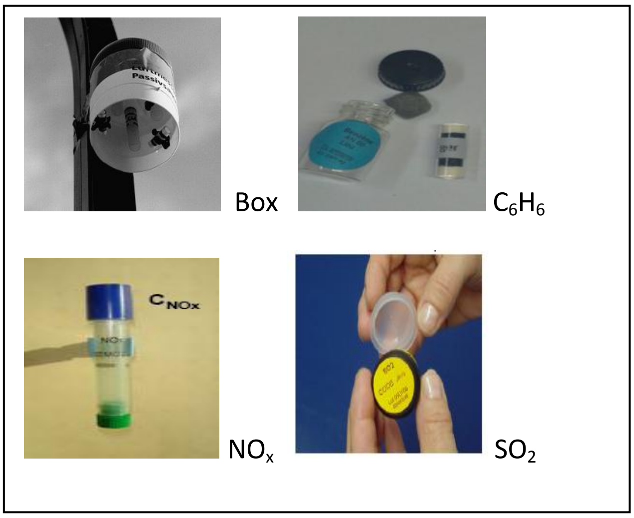

Figure 1: Carried box samples (Passive sensors: Passam)

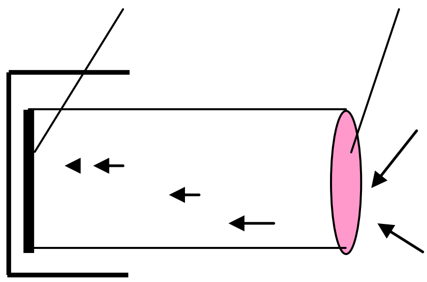

Figure 2: Principle of diffusion (samplers)

This method enables us to evaluate the spatial distribution of the polluants. The sensors do not consume energy. This kind of taking away presents the method of measurement the most adapted for the knowledge of pollution at the scale of the studied zone.

The operation of passive samplers based on the principle of diffusion expressed by Fick's law:

$$C = \frac{(Q \times I)}{(D \times A \times t)} - \frac{Q}{SR \times t}$$

C = (Q * I) / (D * A * t) – Q/ SR * t); with:

- C: concentration (µg / m^3);
- I: diffusion distance (cm);

- D: diffusion coefficient (cm^2/min.)
- SR: sampling rate (ml / min.)
- Q: amount absorbed (mg);
- A: diffusion surface (cm^2);
- t: transmission time.

With regard to the suspended particles, the method considered to be interesting is the bergerhoff method whose principle rests on the collection of dust by decantation in a container of 1.5 liters suspended to a height lower than two meters simulating the maximum height of a man.
To highlight the probable sources of this pollution, we supplemented our experiments by the casting of the grey pig iron samples while making a follow-up of the metallurgical process and qualities of the charged loads. The chemical analysis of the cast iron test-tubes testifies to the quality of the loads and the level of pollution obtained especially for gases.

In all the loads, the quantity of return and scrap-metals are constant, only the quantity of flux and fuels (coke) varied.

3. Results and discussion

The air pollution currently constitutes a major concern of the organizations of the environmental protection and in particular the safeguarding of human health. Thus the effects on a planetary scale are the reheating of the atmosphere and thus of the ground and/or the destruction of the layer of ozone. The air that we breathe today is a mixture more or less polluted according to places' where we are. That it is in the vicinity or far from the sources, this mixture of polluants generates attacks sensitive and durable with the health of the man, particularly the respiratory problems.

3.1. Suspended particles
The small quantity of suspended particles collected by decantation according to the method of Bergerhoff did not enable us to carry out a granulometric analysis to classify it according to its smoothness PM_{10} and $PM_{2.5}$.

The chemical analysis carried out at the physicochemical analysis laboratory of the direction of industrial research in iron and steel industry, assembled us that this dust is made up mainly of silica and of alumina in addition to some oxides like MnO and CaO. These compounds penetrate in the cells of the lungs and create a chronic asphyxiation or diseases (e.g. silicosis).

This pollution is the result of various handling of the matters in circulation in the foundry such as sand, limestone and the scrap-metals.

3.2. Benzene
Emissions of volatile organic compounds, which include mainly solvents (the BTEX: benzene, toluene, ethyl benzene and xylems) and other organic materials, come mainly from the use of the residues of combustion of coke, the resins, of organic solvents, or of the coatings at organic base during the manufacture of the moulds and the cores and fusion.

The examination of the results of chemical analysis of the passive samplers shows that contents very high benzene respectively equal to 236.6 µg/m^3 and 229.2 µg/m^3 were obtained at the station (foot of the cupola) and with the loudmouthed the cupola . These values show that pollution by benzene comes primarily from the combustion of coke to the cupola furnace at high temperatures (Figure 3):

The other measurements taken with a portable apparatus of measurements of gas (OLDHAM-MX21 plus) during the second cast are presented on figure 4. These measurements were carried out with a two minutes step.

We Remarque that the content of COV on the foot of the cupola furnace is constant some is the duration of measurement, that measured in medium of chains increases gradually with time to reach high values. This is

J. Mater. Environ. Sci. 2 (S1) (2011) 501-506 *Abedghars et al.*
ISSN : 2028-2508
CODEN : JMESCN
Colloque International « Journées des Géosciences de l'Environnement »
Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ».

with the outburst of gases at the time of the contact of the molten metal during casting with solvents and the mineral black used in the sand of moulding and cores.

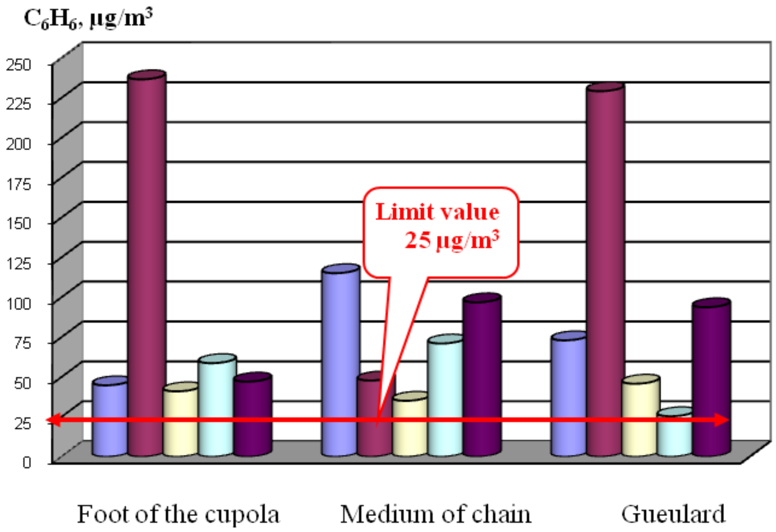

Figure 3: Variation of pollutant benzene concentration

Figure 4 shows that the station of measurement (medium of chains) is exposed more to the gas benzene than the foot of the cupola furnace

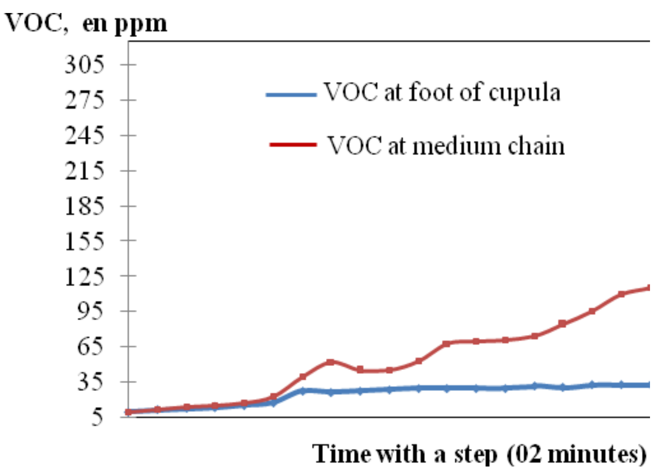

Figure 4: Values of organic fuels volatile over time.

3.3. Nitrogen oxides (NOx)

Emissions of nitrogen oxides ($NOx = NO + NO_2$) are caused by the high temperature furnace and the oxidation of nitrogen. Monitoring of NOx through the three selected positions during all flows, showed that there's strong gas NOx pollution. The measured values are alarming. We recorded a peak of 722.4 µg/m3 during the second cast in the first position (Figure 5). All measured values except for the middle chain are important; this confirms the hypothesis of combustion reactions taking place inside the cupola.

ISSN : 2028-2508
CODEN : JMESCN
Colloque International « Journées des Géosciences de l'Environnement »
Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ».

This type of combustion air that contains 79% nitrogen produces a reaction between a nitrogen molecule and a molecule of oxygen resulting in the emission of nitric oxide (NO) unstable. Nitric oxide reacts with oxygen in the oxidizing zone to give NOx.

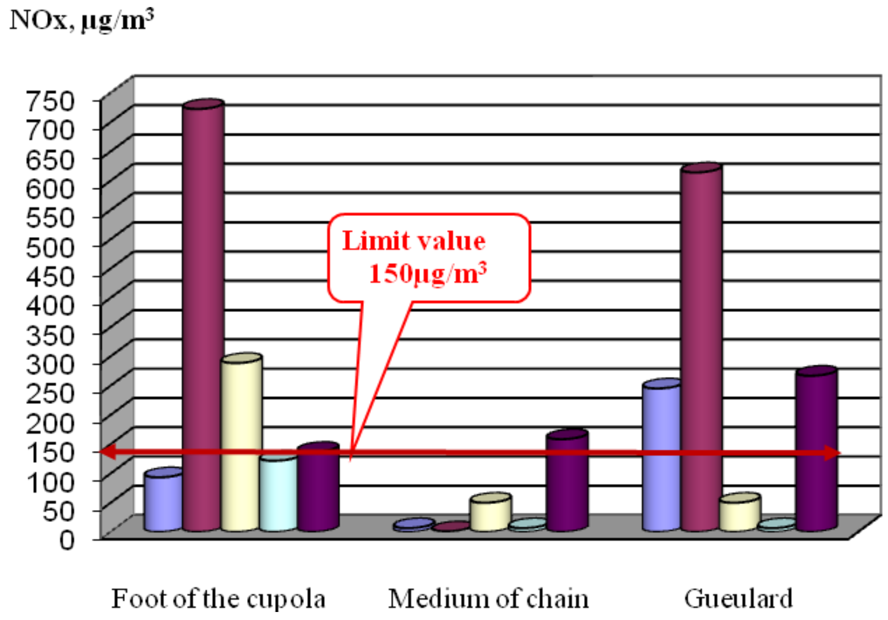

Figure 5: Variation of concentration NOx pollutant.

3. 4. Sulfur dioxide (SO_2)

Monitoring of SO_2 through the three working stations during the five cast showed that virtually all results are largely higher than the values limits of WHO and to European standards, except for two casts at the station foot of the cupola furnace and three casts in medium of chains. We recorded peaks of 375.5, 508.2 and 502.6 µg/m^3 respectively in workstations foot of the cupola, medium chain and blast tube (Figure 6).

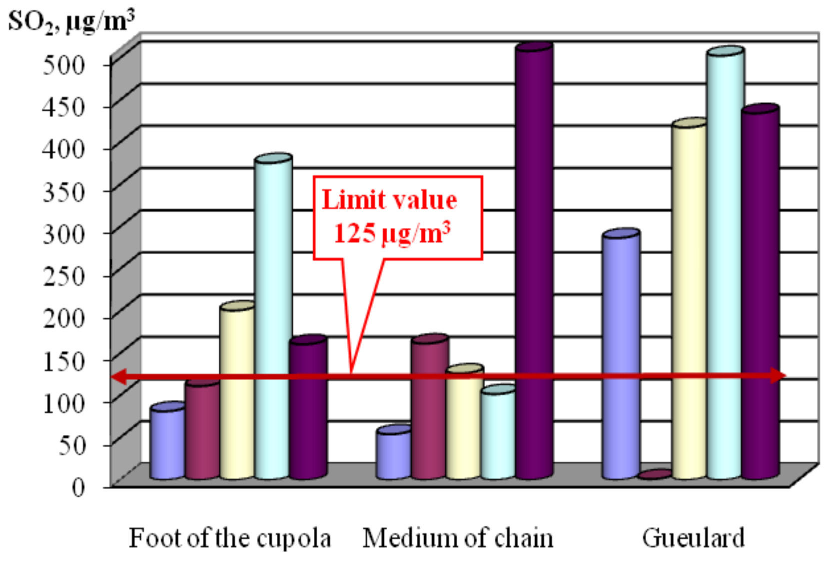

Figure 6: Variation of concentration polluant SO_2.

ISSN : 2028-2508
CODEN : JMESCN
Colloque International « Journées des Géosciences de l'Environnement »
Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ».

The presence of sulfur oxides (SO_2) in waste gases from the combustion of smelting furnaces depends on the sulfur content of fuel which is our case for coke. The sulfur dioxide is also the result of processing metal in the cupola. Other emission sources are, in particular, the curing process natural gas in the manufacture of molds and cores with chemically bonded sand.

WHO as well as the European standards limited the value day to 150 µg/m^3 for NO_2, to 25 µg/m^3 for the benzene and to 125 µg/m^3 for SO_2.

Conclusion

The control of the quality of the air would have a positive incidence on the health of the workers which would be deteriorated by the air generated by this activity and would make it possible to locate the sectors requiring of the interventions that they are specific to the process or in the form of installation of clean technology. Taking account of all these principles, it is convenient to follow the polluants SO_2, NO2, BTX and dust, highlighted after exploitation of various results of investigations.

According to the recorded results, it arises that the measured value of benzene is definitely higher than the limiting value of WHO (236.6 µg/m^3 per 25 µg/m^3, the concentration of the dioxide of sulfur and of oxides of nitrogen is alarming if we compare it with the limiting value WHO. For the dioxide of sulfur, it is 508.2 µg/m^3 per 125 µg/m^3 and for oxides of nitrogen 722.4 µg/m^3 per 150 µg/m^3.

By decreasing the levels of air pollution, one can help the countries to reduce the world load of ascribable morbidity to the respiratory infections, the cardiopathies and pulmonary cancers. Several operations are possible. With this intention, in foundry cast iron, it is imperative to use a fuel with low sulfur content, to carry out enrichment with oxygen in the process of combustion while decreasing the air/combustible report/ratio (reduction in nitrogen in the air). With regard to the sand-preparation plant, it is necessary to use sand without polluting chemical binders.

References

1. Bliefert C.; Perraud R., Chimie de l'environnement air, eau, sols, déchets. Boeck Diffusion, Paris, 359-365, (2008).
2. Grantz D.A., J.H.B. Garner and D.W. Johnson; Ecological effects of particulate matter, Environ. Int. 29 (2003) 213- 239,.
3. Karl B. Schnelle, Jr., Charles A. Brown. Air pollution control technology handbook / Raton : CRC Press, 2nd floor, Information-Reference, 2002.
4. Chunlong (Carl) Zhang, Fundamentals of environmental Sampling and Analysis, Wiley 2007.
5. Kenneth C. Schifftner, Air pollution control equipement, selection guide, lewis publishers, 2002.
6. Signification des valeurs limites d'immission de l'ordonnance sur la protection de l'air, Cahier de l'environnement n° 180/ air, (OFEV), 1999.
7. Nicolas, J. Surveillance de l'environnement et Méthodologie, Academia Bruylant; (1998)