ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome VI (Year 2013) – FASCICULE 3 [July–September]
ISSN 2067–3809

[1.] Šefket GOLETIĆ, [2.] Nusret IMAMOVIĆ, [3.] Heidy SCHWARCZOVÁ

THE DUST EMISSION CONTROL IN PRODUCTION OF FERROALLOYS BY APPLICATION OF BEST AVAILABLE TECHNICS

[1,2.] FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF ZENICA, BOSNIA & HERZEGOVINA
[3.] UNIVERSITY OF CENTRAL EUROPE IN SKALICA, KRÁL'OVSKÁ 386/11, 909 01 SKALICA, SLOVAKIA

ABSTRACT: In the production ferosilicon alloys produced as a byproduct of a very fine gray dust, which consists of spherical amorphous particles non cristalic silicon dioxide (SiO_2). Created in the process of reduction of quartz in the metallic silicon electrical furnace by adding a reducing carbon materials (wood chips, coal, metallurgical coke and coal) at a temperature of about 2000^0C. This paper presents the results of application of best available techniques to control dust emissions in the production of ferroalloys in the example plant "Steelmin BH" in Jajce, Bosnia. The new technical solution drainage and purification of flue gases is reduced emissions of dust behind the filters below 5 mg/m^3, which is the threshold limit values for emissions of SiO_2 and its connections to the national environmental standards and BAT EU recommendations.
KEYWORDS: ferroalloys, the emission of dust, the filter system

INTRODUCTION

In the production ferosilicon alloys produced as a byproduct of a very fine gray dust, which consists of non cristalic spherical particles of amorphous silicon dioxide (SiO_2). Created in the process of reduction of quartz in the metallic silicon electrical furnace by adding a reducing ugljeničkih materials (wood chips, coal, metallurgical coke and coal) at a temperature of about 2000 ^0C [1].

BiH has a centuries-old tradition in the production of ferroalloys and another from 1908 it was present on the European market as a significant producer of Silicon. The company "Elektrobosna" Jajce was one of the major European manufacturers of Silicon (FeSi) and silicon metal (Si-metal) until the termination of the 1992. As part of this company was the production of ferro-alloy plant with electric-furnace 4 and 5, which was built and put into operation during the period between the 1970 and 1973. Electric-furnace 4, installed power 30 [MVA] and the construction of "Ing Leone Tagliaferri" of Milan, was put into operation 1971. Electric-furnace 5, power 48 [MVA] and the construction of "ELKEM" from Oslo, was put into operation. The maximum annual production capacity totaled 41,000 tons of ferro-alloys.

Investment capital through the company's Steel Minerals (Steelmin), Perth, Western Australia purchased a drive with electro-reductive furnace 4 and 5 in order to start production of ferroalloys in the newly formed company "BH Steelmin" Jajce.

This company has initiated activities to revitalize this facility provided that the application of efficient waste gas dedusting solutions based on the best available techniques (BAT recommendations of the EU). The goal is to achieve the emission of dust behind the filters below 5 mg/m^3, which is permissible emission limit value for SiO_2 and its connections to the national environmental standards and recommendations of the EU BAT [2].

Feasibility study and study on the effects on the environment have shown a technological, economic and environmental revitalization of the justification of this facility and existing facilities, the application of specific measures for the technological and environmental improvements, the production of ferroalloys has perspective and important area of product placement in the European market. The existing industrial infrastructure, natural stocks of raw materials in the environment, human resources and acquired a tradition in the production of ferro-alloys constitute a solid basis for the revitalization and start production in the respective facility for the production of ferroalloys. Applying the most effective technical solutions for waste gas treatment based on BAT for the non-metal industry towards achieving this goal.

BASIC TECHNICAL AND TECHNOLOGICAL CHARACTERISTICS OF FERROALLOYS PRODUCTION IN FACILITY "BH STEELMIN" JAJCE

Ferroalloys production will take place in two existing electro-reduction furnace that will revitalize and improve the technological application of efficient technical systems for sewage and waste gases. Otherwise, the electric reducing furnace is a complex *technical and technological system for the production of ferroalloys, which contains the following basic technological equipment:*

1. *Equipment for supplying electricity and electrical equipment to create a network port, which encompasses a system of electrodes and electrode carrier,*
2. *Equipment to add (dosage) of feedstock, such as quartz, reduction material and other necessary components,*
3. *The body of an electric arc furnace with Shaft, bushing and cap that protects the furnace equipment toplotng of radiation,*
4. *Equipment for removal of dissolved material and slag from the furnace,*
5. *The system of sewerage and waste flue gases from the furnace.*

Ferroalloys production begins by preparing raw materials (quartz, wood chips, coal, coal, metallurgical coke, iron filings, etc.). Raw materials are mixed together in previously technology defined stoichiometric relationship. Mixed batch is added to the electro-reduction furnace in which the reagents warm up to temperatures around 2000°C by passing electric current through a batch furnace. The melting furnace is made of quartz at a temperature of about 2000°C using three graphite electrodes powered electricity, ie electric arc that forms between the electrodes (by passing electricity through a batch furnace).

Ferroalloy production process is based on the direct reduction of quartz or quartzite in the furnace by adding carbon materials: wood chips, coal, lignite mining and metallurgical coke. When raw materials are heated to the required temperature chemical reactions take place with quartz reduction of carbon from carbon materials. The production process takes place in the oven continuously dosing (filling) mixtures of feed materials from the furnace through the dosing silo tubes arranged around the rim caps furnace. Obtained ferroalloys (eg. Silicon) is collected at the bottom of the furnace and electrical discharges into the transmission pan. Then drain opening in the furnace is closed with a clay cap, a process in the furnace continues to cyclic and continuous dosing of raw materials into the furnace creates a new volume of the product (liquid ferro-alloys) which is fed back to the aperture opening oven for about an hour. During this time, drain the pot is filled with liquid and shipment of ferroalloys in the cooling and processing of commercial grain. The technological processes of production are added is shown in Figure 1.

In the process of melting quartz ore in a reducing furnace electro-generated waste flue gases with high content of fine dust, which is taken in the ventilation system in order to bag filter dust separation from gases. Makes a very fine dust dispersed, amorphous SiO_2. Individual particles of SiO_2 are extremely small, 50-100 times smaller than cement particles and have an average size of 0.1 to 0.2 µm. If these particles are removed from waste gases, can cause significant environmental and health effects in humans and ecosystems in the region.

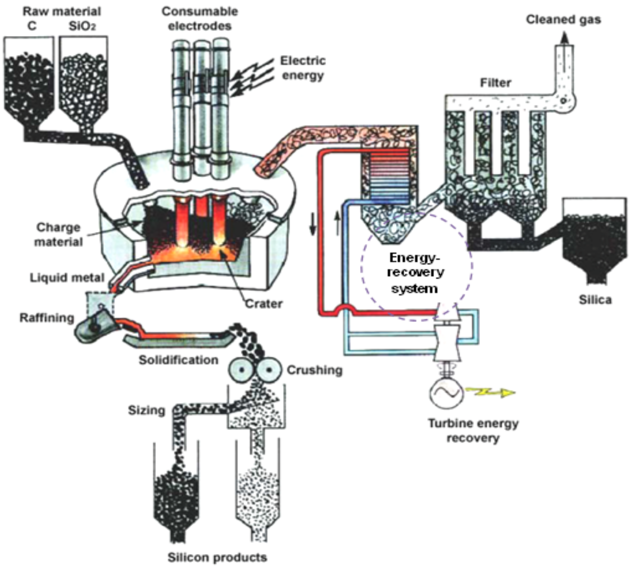

Figure 1. Elements of electro-reduction process ferro-silicon [2]

It is assumed that emissions of dust and gases from the electric furnace are about 94% of the total emissions from the plant for production of ferroalloys. Unloading, internal transportation and manipulation of raw materials may appear uncontrolled emissions of dust, which can have an impact only in the workplace [2].

IMPROVING THE EFFICIENCY OF TECHNICAL SYSTEMS WASTE GASES TREATMENT

Technical system for purification of waste gases generated in the electric furnace is a reducing type CEAG - dust collector with a conventional filter bags in which to perform purification of waste gases before their release into the ambient air. The efficiency of this filter system does not meet the new regulations on the allowable emission limit values. The values for emissions during operation of the plant usually varied between 50 and 100 mg/Nm^3, which is well above the allowable emission limit value presented from 5 mg/Nm^3. In order to improve the efficiency of the existing technical system for dedusting the waste gases (bag filter with the preliminary separators for separation of larger particles and sparks) and reduction of dust emissions below the specified limit access to a new conceptual design solutions to upgrade certain structural elements and improve the technical efficiency of existing treatment systems waste gases generated in a reducing electric furnaces.

A new technical solution drainage and purification waste gases is based on applying the best technical solutions given in the BAT for non-metallic industry. New technical systems for waste gas purification have the following main technical characteristics:

- *total volume of the exhaust flue gases is Vo = 589 000 Nm^3/h,*
- *load on the filter surface is 30.51 m^3/m^2 x h,*
- *flue gas temperature is max. 240 °C*
- *P_{gas} = 5016 Pa,*
- *NMct = 3 MW,*
- *filter system has 14 chambers and each chamber was built at 288 filter bag measuring 149 m^2 per bag,*

- *filter bags are manufactured from materials provided by a mixture of glass fibers with a PTFE membrane (Microporous Teflon Membrane), which have a guaranteed minimum efficiency of 99.99%, because their membranes have a pore size below 2 µm,*
- *length is 10.5 m and each sack was supplied with 10 rings, which give the bag shape,*
- *the life of the bag is about 10 years,*
- *lower power consumption,*
- *such a filter chamber was provided container for collecting dust, which is transported in the pneumatic pipeline tower pelleting and storage to loading into trucks for delivery to customers as a secondary raw material,*
- *dust collection hopper holds approximately 225 m^3,*
- *accumulation of dust is provided for approximately 16 h,*
- *cleaned gases from the filter system drains through the stack into the surrounding air,*
- *content of dust in the rest of the purified gases behind the filters is max. 2-5 mg/Nm^3*
- *control dust emissions is done by installing automatic measuring device for the continuous registration of dust concentration in the stack,*
- *management of work filter system is fully automated and computer driven.*

Waste gases resulting in a reducing electric furnaces is transported 160 pipeline length of his specially designed filter system in front of which there is a cyclone separator. Each furnace has its own pipeline to transport of smoke (waste) gases into the filter system and on the two pipelines is one cyclone for preliminary separation of larger particles and sparks (as it would damage the bags).

The pipeline is made by cooling the gas. Gases due to pass through the filter system of bags and cleaned so it drains through the stack into the ambient air. Bags are made of glass fiber and virtually retain the smallest particles of dust, so that the concentration of particles on the mechanical output from the filters below 5 mg/m^3, which is the projected value of this type of technical systems for dust collection.

Limit values for emissions of SiO_2 and its compounds is 5 mg/m^3 at a mass flow rate greater than 25 g/h, according to national regulations and BAT for non-metal industry.

The dust is retained in the bag and shakes the bag with air-powered fan (who shall in turn release and withdrawal of air) and deposited in a receiving tank for collecting dust each chamber (14 chambers). From these tanks the dust is still transported via screw conveyors in the plant for palletizing. Pelleted dust, known as microsilica, is used as secondary raw materials.

Performance management systems filter is fully automated. The degree of efficiency of the new (improved) CEAG technical system for dedusting of smoke gases is very high and under normal conditions is approximately 99.99%.

Emission of dust behind this filter is 2-5 mg/m^3, which is below the limit values according to national regulations and BAT [2,3]. The total dust emission varies between 0.2 and 0.3 kg/t of ferro-alloys, which is within the limits specified in the Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December, 2001.

The prescribed criteria for the emission of dust 5 mg/m^3 as a matter of good practice in facilities that operate in the European Union, such as: FERROATLANTICA, ELKEM, FESIL, VA POCKING, etc.). This criterion is taken as a national standard for the emission of dust SiO_2 in B&H [3].

Fabric filter systems are widely used and recommended within the industrial sector for the production of ferroalloys, due to their high efficiency in controlling emissions of fine particles that are produced in the smelting operations. Numerous commercial filters designed using different types of filtration bags which in principle should realize low emission levels below 5 mg/m^3. It primarily depends on the filter mode, filtering surface, the way of maintenance, as well as the temperature of smoke gas that filters the quality is up to max. 280^{o}C. Providing better maintenance prolongs the working life of the bag about 10 years, and the pressure drop is about 2.5 kPa.

Featured in the bag filter dust is gray, which consists of very fine dispersed, amorphous SiO_2 particles, size <45 um. This dust is happiness in the literature under various names: mikrosilica, condensed silica fume (CSF), silica fume (SF), etc. Microsilica is actually a commercial name for SiO_2 dust. It consists of a non cristalic spherical particles of amorphous SiO_2. Because of the fineness of particles, large surface area, and high content of SiO_2, microsilica is highly valued secondary raw materials used in the manufacture of cement, concrete waterproofing, special materials for the repair of damaged buildings, refractory materials and other specialty building materials. Quality Microsilica specified in ASTM C 1240, the Norwegian Standard NS3045, CAN/CSA-A23.5-M Canadian standards and European standards.

Amounts of dust (microsilica) that separates the process of production of ferro-alloys is about 200 to 300 kg SiO2/1.000 kg, depending on the type of raw materials, products and technology of applied. Thus, for maximum production of 41 000 t/y of ferro-alloys can be expected around 8200-12300 t/microsilica, which is prepared and used as a secondary raw material for production of construction materials.

Since the gaseous pollutants are emitted dominantly CO_2 in ambient air and the exhaust flue gases do not contain significant quantities of SO_2, NOx, CO, HF, polycyclic aromatic hydrogen (PAH) and volatile organic compounds (VOCs). Air emissions can be significantly reduced by improvements (process redesign) the production of ferroalloys [4,5].

CONCLUSIONS

The following table shows the air emissions in relation to the design techniques of charging electric furnace.

Table 1. Air emissions from the standpoint of design techniques to fill according to BAT [2].

Pollutant	Emission (per ton of product)			
	Unit	The standard technique of filling	Improved technique of filling	Improved technique of filling + High temperature gas drainage
CO	kg/t	4.8	3.5	0.5
PCDD/F	µg/t	5.5	1.1	0.2
NOx	kg/t	-	7	8.3
PAH	g/t	1.21	0.01	0.01

The presented results show that the use of technological improvements and controlled management process significantly reduces the emission of gaseous pollutants.

REFERENCES

[1.] Goletić, Š., Imamović, N.: Plan aktivnosti sa mjerama i rokovima za postupno smanjenje emisija odnosno uticaja na okoliš i za usaglašavanje sa najboljom raspoloživom tehnikom za pogone i postrojenja za proizvodnju ferolegura firme “Steelmin BH“ Jajce, Univerzitet u Zenici, 2011.

[2.] Integrated Pollution Prevention and Control (IPPC): Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, European Comission, December 2001.

[3.] Pravilnik o graničnim vrijednostima emisije zagađujućih materija u zrak (“Službene novine Federacije BiH“, broj: 12/05).

[4.] Smjernice za najbolje raspoložive tehnike-mjerenje emisija i korištenje podataka o emisijama, Mjerenje emisija i korištenje podataka o emisijama, Projekt CARDS 2004.

[5.] A Driver for Environmental Performance in Industry, European Conference on “The Sevilla Process, Energy use and process integrated BAT measures illustrated by examples from the Non Ferrous Metals Industries BREF Ludwig Finkeldei European IPPC Bureau Stuttgart, 6 and 7 April 2000.

ACTA TECHNICA CORVINIENSIS - Bulletin of Engineering

ISSN: 2067-3809 [CD-Rom, online]