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EFFECTS OF FOUNDRY INDUSTRY ON THE ENVIRONMENT

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Integrating environment development, as the objective of the research in this paper, is to define a model to implement and monitor the key indicators of energy use efficiency as an instrument of an effective environmental and energy management in the metal sector in Bosnia and Herzegovina (B&H). The used environmental data contribute to a more efficient use of energy as well as to a reduction of emissions and effects on the environment.

Key words: foundry, iron, steel industry, environment, climate changes

INTRODUCTION

Climate changes have a negative influence on water and food production but, on the other hand, they are necessary for human existence. Sustainable development is the basic approach to the environment in modern times. Energy consumption and environmental issues with climate changes are global problems, and industry influencing it is the foundry industry.

There are relatively permanent earth atmosphere components: O_2, N_2, CO_2, H_2O and other gases. However, emissions of pollutants of anthropogenic origin may drastically change proportions at the local and global level.

The climate changes influence the food production, water quality, and pollution and it is necessary to develop an adequate strategy for protection [1]. Industrial corporations in B&H spend significantly more energy on every product in comparison to similar corporations in other countries, which is important from the point of view that more than 50 % energy is spent in metal industry. Integration of the environment in the developmental question is of a special importance in this work, therefore the goals of this work are to research, define application models, and monitor the key efficiency indicators in energy use, as the instrument of an efficient environmental and energy management. [2]

FOUNDRY INDUSTRY

The interest for this matter originates not only from the above mentioned reasons, but also from the ones listed below:

- It is possible to enlarge profitability by decreasing the energy costs.
- Every sustainable development strategy is a vision to improve security in providing energy and its consumption.
- With the assistance of energy indicators, it is possible to connect human activities, changes in energy, and effects measures.
- Castings are a very propulsive industry branch.
- Foundry industry is the key factor in ferrous and non-ferrous metal recycling of waste, which can be re-melted into new products and used 100 %.[3]
- Castings are intensive energy consumers. [4]
- Intensive environmental pollutants of: soil, air, and water. [5]

Environmental influences of the casting processing are mainly related to waste gases, and for reuse or as disposal of mineral residues.

METAL AND FOUNDRY INDUSTRY IN B&H

Production of B&H foundry industry for the years of 2009-2011 is presented in Figure 1, which consisted of vehicle parts. They consist even 45 % of the total production, while the smallest production of nodular castings for the locomotive and wagons parts, except for road vehicles and machines and ferrous parts for other purposes (2 % in both cases).

In 2011, the production structure expended in relation to the year 2009, by two new product groups. While the parts for road vehicles dominate still (33,2 % production), second in the line by percentage (32 % production) are parts of grey cast transmittable axle or parts made of cast iron for different parts for automotive industry, that is product clusters that were not introduced in 2009.

GLOBAL AND B&H PERSPECTIVES OF FOUNDRY INDUSTRY BY 2020

Global castings production has shown that EU countries are the first in non-ferrous and second in ferrous

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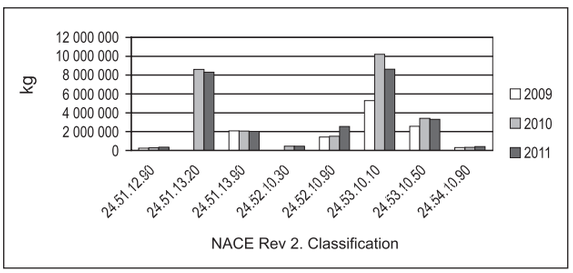

Figure 1 Production in foundry industry, 2009-2011 [6]

castings production. EU foundry production is around 50 % castings production for the automotive industry, and the other major ordering party is from the area of machinery production. Regardless of the dramatic changes, perspective of the EU countries in middle-term program, by the year of 2020, are rather good and relate to castings for the automotive industry and electro unit castings. According to the aforesaid EU development program, castings production for the automotive industry will grow due to the overall growth of the global vehicle production. It has to be noted that the regional production and cast production structure will continually change (Table 1). The remaining transportation areas, such as air and sea, anticipate large investments; therefore the EU foundry industry will stay stable until 2020. It is estimated that market castings share in the four BRIC countries will be up to 60 % in 2020 (Figure 2).

Table 1 **CAEF estimations in castings production until 2020 [7]**

Metals	Structure or types of castings for Industries / %			
	Vehicles	Machinery	Construction	Other
Ferrous basis	56	27	3	17
Non-ferrous	63	9	4	24

All data show the great possibilities of foundry industry in B&H, provided it must be supported by legal regulations, as well as financial support. The basis for the structure of castings in B&H until 2015 is basically founded on the current foundries' capacities: 3 for iron, 5 for grey, nodular or vermicular cast iron, and 4 for non-ferrous. In the period until the year of 2015, the B&H foundry industry must be focused on the issues within its scope of activities, primarily on drafting a study that will determine the target markets within the EU and other markets, incorporate it into the projected markets of casts or search for appropriate market „niches", that would be the best possible solution for specific B&H castings. On the other hand, achieving the economy in casting production and quality of cast require significant investments for equipment and also an increase in the investment in R&D.

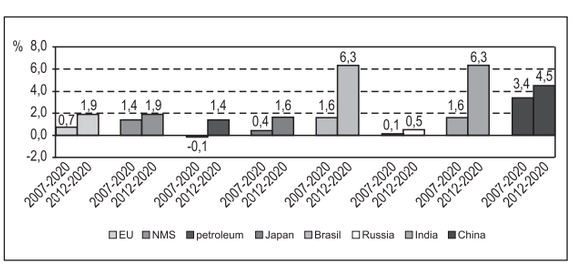

Figure 2 Global castings production in the period between 2007– 2012 and estimations until 2020 [7]

THE WASTE AND THE EMISSIONS

With regard to the hypothesis of this paper and reasons mentioned earlier on, a selection of business systems representing the propulsive branch of the B&H metal sector has been conducted, which also amount to a challenge from the aspect of managing the environment and energy, because they are intensive energy users, but at the same time they are big environmental pollutants.

For the purpose of this work, a survey was conducted in 9 foundries using a general questionnaire based on the ESCO Company questionnaire. Based on this, information about the foundries' consumption of electricity is shown in Table 2.

Table 2 **Consumption of electrical energy in foundries in question per annum / kWh**

Characteristics	Foundries			
	CIMOS TMD Casting doo	Zenica P.J. Novi zivot	Bosnia Vales Tuzla	Foundry Visoko d.d.
	L1	L3	L4	L5
Shop	18 524 147	4 000 000	2 400 000	86 000
Technology process		100 000	100 000	
Heating		600 000	800 000	
Lighting	4 705 853	300 000	300 000	
Total	23 230 000	5 000 000	3 600 000	86 000
Shop & Technology	18 524 147	4 100 000	2 500 000	86 000
Percentage / %	79,74	82,00	69,44	100,00
	Jelšingrad d.d.	Foundry Turbe d.d.	Iron and steel works Ilijaš d.d.	
	L7	L8	L9	
Shop	13 440 000	93 676		
Technology process			3 500 000	
Heating	960 000			
Lighting	1 600 000		36 000	
Total	16 000 000	93 676	3 536 000	
Shop & Technology	13 440 000	93 676	3 500 000	
Percentage / %	84,00	100,00	98,98	

TECHNOLOGICAL PROCESS OF METAL CASTING

Foundry is well famous, very old and very concurrent and efficient production process. Besides, casting of metal is very complex process, because of compounding of great number of variables that must be controlled. If it is added, that demands bringing the technological process of casting in context of environmental protection, because of the fact that the process is significant pollutant, respecting the advances and mistakes of the process (Table 3).

The following tables present:

- Technological casting process
- Potential soil pollution originating from iron and steel casting industry raw materials
- The basic characteristics of melting furnace and emission levels
- Average data on emissions from induction furnaces for melting steel and iron
- Air emissions by phases of the process in iron and steel castings

Table 3 **Average data on induction furnace emissions for iron and steel melting (2011)**

	IP
Capacity Number of furnaces x ton/ module	(2 x 10) + (3 x 3)
Waste gas collection	Side-draught
Flow / m³/sat	54 000
Flue gases cleaning equipment	Bag filters
Dust / mg/m³	5
SO_2 / mg/m³	No data available
CO / mg/m³	No data available
NO_x / mg/m³	No data available
HF / mg/m³	No data available
O_2 vol / %	21

Emission measurements related to CO and SO_2 and foundries L1 and L3 are presented in Tables 4 and 5 below.

Table 4 **Average values of measured characteristics of all foundry L3 gases**

Measured characteristics	Units	Values
O_2	/ %	5,77 ± 0,03
CO	/ ppm	3,25 ± 0,50
CO_2	/ %	11,24 ± 0,03
CO_2 - IR	/ %	10,43 ± 0,01
NO	/ ppm	89,74 ± 1,15
NO_2	/ ppm	-0,30 ± 0,35
Temp. fluida	/°C	242,65 ± 5,45
NO_x	/ ppm	89,00 ± 1,15
SO_2	/ ppm	41,25 ± 33,63
H_2	/ ppm	3,25 ± 2,22
EffN	/ %	88,23 ± 0,17
EffG	/ %	83,08 ± 0,22
Rati		0,00 ± 0,00
Amb, temp.	/ °C	21,98 ± 1,49
Device temp.	/ °C	21,18 ± 0,96
Oild		0,00 ± 0,00
Dewpoint	/ °C	47,83 ± 0,05
Pump flow	/ l/m	0,77 ± 0,02
O_2 ref	/ %	3,0 ± 0,00
CO_2 max	/ %	15,5 ± 0,00

Average values of measured characteristics of foundry L3 gases for four measuring of gasses from boiler room is presented on Table 4.

Average values of measured characteristics of foundry L 1 for three measurements of waste gases within one hour is presented in Table 5 below.

Table 5 **Average values of measured characteristics of foundry L 1**

Measured characteristics	Units	Values
O_2	/ %	20,95 ± 0,02
CO	/ ppm	3,67 ± 1,15
Fluid temperature	/°C	29,03 ± 0,47
NO_x	/ ppm	0,00 ± 0,00
SO_2	/ ppm	0,00 ± 0,00
H_2	/ ppm	0,00 ± 0,00
Amb, temp.	/°C	18,73 ± 0,21
Device temp.	/°C	21,67 ± 0,06
Oild		0,00 ± 0,00
Pump flow	/ l/m	0,82 ± 0,25
O_2 ref	/ %	5,10 ± 1,82
CO_2 max	/ %	11,9 ± 0,00

EXPLANATION

- Harmful emissions caused by casting melting and production are basically related to the use of additives and fuels or raw material impurities. The use of coke or oil might cause the emission of the product of burning. The use of additives in the process generates a reaction. The presence of impurities in waste that blend by melting may cause the formation of a product with incomplete combustion or a recombination and dust. Dust from the process might consist of metal and metal oxides. During the melting process, elements evaporate and tiny metal dust particles are released. Metal particles appear during the final processing [8].
- Emission of pollutants from cast iron foundries [9]
  Having conducted a research on 20 field castings, it has been established that the total annual emission of dust pollutants in the atmosphere is between 0,1 and 94 kg or averagely 4,7 kg/t, the annual emission of waste gases basically consists of SO_2, NO_x and CO from these castings in the quantity of 0,1 up to 108 kg/t, that in average amounts to 5,4 kg of gases/t. In many cases the presence of NO_x is not even measured at all.
- Emission of pollutants from cast steel foundries
  Research has shown that the total quantity of dust in steel castings production is from 6,65 to 35,55 kg/t, while Si dust composes between 3,46 and 21,09 kg /t. The annual emission of gases SO_2, NO_x and CO from production is from 0,01 up to 20 kg. The largest sources of NO_x emission are electro- furnaces, in some castings even up to 90 %, while the remaining part originates from induction furnaces, etc. CO emission in the production process amounts up to 18 kg /t. Basically, this gas emits from electric arc furnaces and induction furnaces, while the emission of SO_2 originate from different resources and furnaces, etc.
  Application of a developed indicator method to estimate and evaluate the EI in castings.

Statistical data processing

Statistical method served as a tool based on which the collected data provided a series of information on the EI movement on the basis of which it is possible to make decision and undertake necessary activities to improve the process on the grounds of regulations and laws to define mass processes.

Application of the developed indicator method to estimate and evaluate EI in castings

- Castings energy intensity [EI] is calculated with the following formula:

$$EI = \frac{K_e}{Y} \quad (1)$$

As:

EI – energy intensity of castings

K_e – use of electrical energy in MWh

Y – total casting production

THE GIDDENS' CLIMATE CHANGES PARADOX

Vehicles are the main sources of benzene emission in the environment. In addition to food, humans absorb benzene into their organisms through the air, where high concentrations exist that vary from 3 through 160 μg/m^3. Benzene is a hematological toxin. Behavior of NO_x in the atmosphere shows that its high chemical reactivity has an important role. NO_x and C(OH) accumulate in the atmosphere at night and at day NO_x transforms into NO_2 through photolytic cycles.

There is sufficient knowledge on a possible apocalyptical scenario and insecure future regarding the global climate changes. Eco-pathological sociology of this is the fact that it is dealing with abstract and elusive dangers, however potentially devastating they may be. This is called the Giddens' paradox. [10, 11]

ECO ACTIVISM

When the pollutants (CO_2, SO_2, NO_x) are in the atmosphere, their existence depends on the physical and chemical processes that are being developed all the time. It is not simple to find the correlation between the emission and acidity of the atmospheric layers. The implementation of the legislation on air pollution would bring many changes in the regulation of climate changes, and protect the area from its negative consequences. [12]

CONCLUSIONS

Through the existing technology, electro-metal and foundry industry pollute, to some degree, the air, water and soil, which affects the climate. Although generating a moderate pollution, the foundries in B&H, due to their obsolete equipment in terms of emissions, such as CO_2 or SO_2, or expulsion of air pollutants, affect the climate change, as well. By increasing the total production and fuel consumption, no drastic contamination is anticipated but an increase in environmental pollution only. On the grounds of the above considerations and the theory, it is possible to calculate the energy intensity. Higher pollution is associated with higher castings production, but it is possible to improve it by obtaining the so-called *ideal foundry*.

Recent research on energetic efficiency in the B&H metal sector has offered the following recommendations: special methodology that must be involved in the legislation and pre-legislative acts, formation of the EE Agency (anticipated by the draft of Legislation on EE in FBiH, formation of the net MEEIBH, etc.)

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