**International Scientific Conference „Natural Disasters in the 21st Century: Monitoring, Prevention, Mitigation“**
**Proceedings, ISBN 978-9941-491-52-8, Tbilisi, Georgia, December 20-22, 2021**

# ON CLIMATE CHANGE MITIGATION MEASURES IN FERROUS AND NON-FERROUS METALLURGY (GENERAL ANALYSIS)

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***Summary:*** *The role of metallurgical carbothermal production processes in the problem of global emission and accumulation of greenhouse gases is analyzed and highlighted. Hence, one of the effective measures to mitigate climate change are identified the need to reduce the risk of carbon sequestration of reactive raw materials (coke, coal, anthracite) to atmospheric oxygen, - reducing of its premature burnout, - reducing of carbon mono- and dioxide emissions, and increasing the degree of carbon beneficial use. The main ways and methods of this problem solving are described. A rational way of solving it are suggested to temporarily passivate the surface of carbonaceous raw materials using such fine-grained metallurgical wastes as industrial oxide-containing dust or sludge.*

***Key Words:*** *Greenhouse gases, Emission, Metallurgy, Coke, Carbothermia, Temporary passivation.*

## Introduction.

The modern world community is one of the most progressive ways to mitigate the threats posed by global climate change is considering a policy of transition to a green, energy-saving, low-carbon economy, where the problem of minimizing greenhouse gas emissions is dominant [1].

According to various sources [2-4], the global emission rate of greenhouse gases was increasing by 60% in the period 1990-2019, from 22.7 up to 36.4 billion tons, calculated in terms of carbon dioxide equivalent. It is noteworthy that in the given period, only the EU is distinguished by the tendency of decreasing greenhouse gas emissions. The total emissions of the EU countries decreased from 3.87 to 2.92 billion t. Emissions from China increased up to 400%, from 2.42 up to 10.17 billion tons, in the case of India, the emission growth rat exceeded 500%, from 0.58 up to 2.62 billion tons. Emissions in the US are relatively stable, with a slight increase of 5.13 → 5.28 billion. According to recent data, a further 5% increase in world greenhouse gas emissions is expected in 2021-2022 [5].

According to the key policy documents on climate change mitigation, by 2030 Georgia will make an unconditional commitment to reduce total greenhouse gas emissions by 35% compared to 1990 levels (2030 greenhouse gas emissions target - 29.655 million ton $CO_{2eq.}$); At the same time, Georgia is committed to reducing its total greenhouse gases emissions up to 50-57% by 2030 compared to 1990 levels if it receives international support. A 50% reduction will be needed if the world community decides to reduce or decrease the average global temperature up to +2℃, and with a policy of +1.5℃ increasing the temperature, it will be necessary to reduce greenhouse gas emissions by 57% [6].

## Contribution of metallurgical industry in greenhouse gas emissions.

The highest carbon demand sector in the world economy is considered to be thermal power generation that is mainly built near large-scale industrial facilities and centers and serves their proper functioning. ≈25% of the generated energy comes from the metallurgy of ferrous and non-ferrous metals that is accompanied by carbon dioxide emitted by its own production. The share of ferrous and non-ferrous metallurgy in the world greenhouse gas emissions according to various sources is 9-13% [4, 7], due it this sector is considered to be the undisputed leader in greenhouse gas emissions.

It is known that from 2023 in the EU the so-called a carbon tax is planned to be introduced [8] that envisages the imposition of an additional duty on the amount of carbon dioxide emitted into the atmosphere in the production of any kind of commodity. This measure will place a particularly heavy burden on industrial enterprises with particularly high consumption of carbon using outdated technologies, including one of the most painful blows that the metallurgy sector will receive. According to the official Geostat data on Georgia's foreign trade [9], the sector of extraction and processing of ferrous and non-ferrous metals (manganese, copper) occupies one of the leading positions in the Georgian economy. Therefore, their impact on the economic development and sustainability of Georgia is crucial. The decision to regulate greenhouse gas emissions will put the future of this field at a high risk.

Carbon is an essential component for the recovery and removal of metals from ores. It is supplied in a burden for carbothermic processing in the form of solid metallurgical coke. Carbon in coke is represented by allotropic modification of graphite, the content of that fluctuates in the range of 82-88% (ISO 18894: 2018). Its flow rate for the production of per ton of ferroalloy makes in average up to 350-450 kg. Solid carbon is also one of the main components for the production of high-capacity graphite or Soderbergh self-annealing electrodes for the delivery of high-capacity electricity to electric furnace furnaces [10]. Carbon, under the conditions of high-temperature, electrothermal processing (softening and melting) of a pre-prepared reaction compound, joins oxygen atoms from the metal oxides present in the ore, thus reducing them to the metal phase, oxidizing itself into carbon monoxide and carbon dioxide and passing through the dust collecting bag filters, is almost unchecked released in the atmosphere [11].

According to our data, the metallurgical sector of Georgia emits an average of 0.5-0.6 mln. ton carbon-containing gas with a greenhouse effect. The total amount of greenhouse gases emitted, including ancillary enterprises and logistics services, is approaching up to 1 million tons of carbon dioxide equivalent.

**Analysis of the possibility of reducing greenhouse gas emissions.**

In the electrometallurgy of ferrous and non-ferrous metals, electrocarbonothermal production of ferroalloys is characterized by a particularly low rate of carbon useful use. Here, the coefficient of target uptake of carbon does not exceed 0.80-0.85, the rest of it burns in vain with atmospheric oxygen, on the surface of the shaft top of the smelting furnace, which is irretrievable losses of economically valuable and ecologically harmful carbon. Thus, in order to exclude carbon deficiency, coke dosing is always carried out in excess of the stoichiometric amount of carbon required for recovery processes by 15-20%. This technical solution is an ecologically and economically harmful, but technologically necessary measure. The problem is exacerbated in the cast iron industry. World average production of ferrous cast iron (1,200 million tonnes) averages 50 times that of ferroalloys. The electrometallurgy of primary copper and aluminum is also a significant problem in terms of solid carbon consumption and greenhouse gas emissions. The issue of the high "carbon capacity" of the metallurgical industry is somehow already in the world's attention, and a number of well-founded studies and reports on the need to address it have been published [12, 13, 14], although studies on mitigation and prevention measures are still in their infancy.

Thus, from the all of above mentioned, solving the problem of coke reaction surface insulation from atmospheric oxygen, eliminating its waste combustion and increasing the target carbon utilization rate should be considered as one of the key issues with the potential to mitigate the harmful effects on the environment by the metallurgical industry.

**Effective measures to reduce greenhouse gas emissions.**

Based on the main principles of energy saving recommended by the concept 3R [15] "Reduce, Reuse, Recycle", the rational way to solve this problem is to pre-cover (temporarily passivate) the coke porous surface (passivation) emits in the ferroalloys production process by thin dusts or slime (1-3 mm) layer. This measure involves closing the pores opened at the surfaces of the coke granules by pre-annealing them with light dust by pelletizing them or extruding them into briquettes [16]. As a result of this measure, the solid coke supplied with the raw material in the furnace is protected from contact and reaction with atmospheric oxygen that will significantly reduce its in vain combustion. On the other hand, the close contact of coke and metal oxide dust will maximize the kinetics of the recovery-removal process of metal elements from this rear end, thereby increasing the rate of useful use of processed ore and recyclable metal-bearing secondary resources. In addition to reducing of vain combustion and thus mitigating the effects of adverse environmental impacts, this measure will significantly increase charge's electrical resistance, thus reducing the intensity of short circuits and power overloads, which in turn will significantly reduce electricity consumption per ton of products produced. It is noteworthy that the reduction of the volume of exhaust gases from the furnace also reduces the heat losses of the furnace, which will further improve the technical-economic and ecological characteristics of the melting process.

Accumulation of carbon dioxide (CO) emitted from the reaction zone and return to reverse for initiating the effect of plasma according to the scheme presented in the study [17] is also a rational solution in terms of reducing the intensity of greenhouse gas emissions. In terms of minimizing heat loss, a rational approach would also be to set up and operate special two-chamber duplex furnaces [18]. Technically just as rational, but economically relatively high-cost approach is the replacement of AC furnaces with hermetically sealed DC furnaces of the new generation [19]. There is no doubt that for enterprises with large-capacity production of widely demanded metallurgical products (silicon and manganese ferroalloys, pig iron, copper, and aluminum), our proposed approach of coke passivation is the most optimal.

**Conclusion.**

Thus, from the stated above brief analysis, it would be concluded that one of the rational and techno-economically justified ways to reduce the contribution of ferrous and non-ferrous metal metallurgy to global greenhouse gas emissions is to isolation/safeguarding a solid carbon contained in the used in cabothermal recovery processes reactive raw materials, from atmospheric oxygen. The process by which we ensure this operation is called as temporary carbon passivation.

Temporary passivation of carbonaceous raw materials is also an effective technical solution for improving the technical-economic index of recovery-extraction of target metals from ores and for the secondary use of physical-chemical energy of gases and dust released from the crucible of furnace.

## References


1. Paris Agreement. United Nations, 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
2. Center for Sustainable Systems, University of Michigan. 2020. “Climate Change: Policy and Mitigation Factsheet.” Pub. No. CSS05-20
3. Fekete H., Kuramochi T., Roelfsema M., Elzen M.D., Forsell N., Höhne N., Luna L., Hans F., Sterl S., Olivier J., Soest H.V., Frank S., Gusti M. A review of successful climate change mitigation policies in major emitting economies and the potential of global replication. // Renewable and Sustainable Energy Reviews, № 137, 2021, pp. 1364-0321. https://doi.org/10.1016/j.rser.2020.110602

4. Ritchie H., Roser M. $CO_2$ and Greenhouse Gas Emissions. (2020) Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions [Online Resource]
5. IEA, Global Energy Review 2021. //IEA, Paris. https://www.iea.org/reports/global-energy-review-2021 (Accessed 07.09.2021)
6. Samkharadze I., Chitanava M., Janashia N., Vardosanidze K. Impact of Climate Change Mitigation Policy on the Labor Market: Context, Possible Future Development Scenarios and Recommendations: The Example of Georgia. // Short research paper, Tbilisi, 2021, 70 p. (in Georgian)
7. Muller S., Lai F., Beylot A., Boitier B., Villeneuve J. No mining activities, no environmental impacts? Assessing the carbon footprint of metal requirements induced by the consumption of a country with almost no mines. // Sustainable Production and Consumption, Elsevier, 2020, https://doi.org/10.1016/j.spc.2020.02.002ff.
8. State and Trends of Carbon Pricing 2021. International Bank for Reconstruction and Development / The World Bank. https://openknowledge.worldbank.org/handle/10986/35620
9. External Trade of Georgia 2020. // Statistical Publication, Tbilisi 2021, 44 p. https://www.geostat.ge/media/39340/External-Merchandise-Trade-2020_publication-2021.pdf
10. White J.F., Rigas K., Peter Andersson S. et al. Thermal Properties of Söderberg Electrode Materials. // Metall Mater Trans B 51, 2020, pp. 1928-1932. https://doi.org/10.1007/s11663-020-01890-0
11. Jandieri G., Sakhvade G. Smelting of Alumosilicomanganese from Technogenic and Secondary Resources Mining-Metallurgical Industry of Georgia. // X International Congress Machines, Technologies, Materials 2013 (September 18-20 2013) Varna, Bulgaria. pp. 107-110 http://mtmcongress.com/winter/1-2013.html
12. Simonyan L.M. Analysis of the methodology for determining $CO_2$ emissions on the territory of the Russian federation in respect to the ferrous metallurgy. // Izvestiya VUZov. Chernaya Metallurgiya = Izvestiya. Ferrous Metallurgy, Vol. 61. No. 9,2018, pp. 721-730. https://doi.org/10.17073/0368-0797-2018-9-721-730 (in Russian)
13. Gates B. How to Avoid a Climate Disaster. // Penguin, Allen Lane, 2021, 272 p.
14. Together, Let's Speed up the Energy Transition to Create a Carbon-Neutral Society by 2050. // Corporate Communications, TOTAL SE, 2020, 60 p.
15. Srinivas H. The 3R Concept and Waste Minimization. GDRC Research Output - Concept Note Series E-093, 2015. Kobe, Japan: Global Development Research Center. Retrieved from https://www.gdrc.org/uem/waste/3r-minimization.html
16. Jandieri G., Jishkariani G., Sakhvadze D., Tavadze G. Technologies of Rendering Harmless and Regenerating Solid and Liquid Inorganic Industrial Wastes. // The Jubilee Conference on Modern Technologies and Methods of Inorganic Materials Science. Dedicated to the 100 Anniversary of Acad. Ferdinand Tavadze. Tbilisi, 2012, pp. 304-318
17. Janelidze I., Jandieri G., Tsertsvadze T. Thermodynamic analysis of interaction of components in the $SIO_2$-C system: improvement of technical silicon production technological process. // Physics and Chemistry of Solid State. 22, 2, Jun. 2021, pp. 345-352. https://doi.org/10.15330/pcss.22.2.345-352
18. Jandieri G., Sakhvadze D. Duplex-Furnace for Processing Manganese-containing Technogenic Waste with the Possibility of Obtaining Low-Phosphorus Manganese Ferroalloys. // International Conference: Key Aspects of the Development of the Metallurgical Industry, At: Kyiv, Ukraine, 2014, pp. 41-44 (in Russian)
19. DC Submerged ARC Furnace (SAF). Tenova Pyromet. Electronic resource, access mode (09.08.2021): https://www.tenova.com/product/ac-submerged-arc-furnace-%28saf%29/