ETIKROM INC. WASTE GAS HEAT RECOVERY PROJECT AND OPPORTUNITIES FOR RUSSIAN FERROALLOY SMELTERS

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ABSTRACT

Bulk ferroalloy production with pyrometallurgical methods actually needs a high temperature to provide appropriate conditions for chemical reactions. Reduction reactions which are carried out by carbothermic, metallothermic (silicothermic or aluminothermic) process generate a high temperature of flue gas. This off-gas holds a huge quantity of heat energy which is going to be wasted in the atmosphere simultaneously.

Recently, these heat recovery recycling process has become popular among bulk ferroalloys producers. As an example, Turkish ferrochrome smelter Eti Krom Inc. has been working on a pioneering project in its high carbon ferrochrome production plants to implement a dedusting and energy recovery system. Mainly the unit consists of a waste-heat boiler, a filter bag station, a fan and a clean gas stack. The excess heat is estimated to produce more than 35 tons per hour of steam which is then fed into a system to drive a steam turbine to generate 5,5 MWe of electrical power. This is then either fed back to the plant or loaded onto the national grid.

Similarly, Russian ferroalloy industry holds 2 million tons of production capacity with 85 electrical furnaces and 1121 MVA transformers power capacity. Accordingly, this paper shows the reasonable waste heat energy recovery and dedusting opportunities for Russian ferroalloy smelters [1,2,3]

1 INTRODUCTION

Ferroalloys are mainly used as master alloys and additive material for special treatments in the iron-steel and stainless steel industry.

Depending on the production rate, ferroalloys can be divided into two main categories, bulk alloys and special (or noble) alloys. Especially in the European Union, bulk ferroalloys (ferrochrome, ferrosilicon, ferromanganese, silicomanganese and ferronickel) account for about 90% of the total production of ferroalloys. Compared to bulk ferroalloys, the production rate of special ferroalloys (ferrovanadium, ferromolybdenum, ferrotungsten, ferrotitanium, ferroboron, and ferroniobium) is rather small.

This paper will focus on the assessment relevant to bulk ferroalloys industry. Generally, bulk ferroalloys are principally produced either by the carbothermic or metallothermic (silicothermic or aluminothermic) reduction of oxidic ores or concentrates. Carbothermic reduction as reducing agent requires coke (metallurgical coke), coal, charcoal or anthracite. The metallothermic reduction is mainly carried out with either silicon or aluminium as reducing agent. [1]

During bulk ferroalloys smelting, reduced oxides generate metal phase and unreduced oxides generate slag phase. As an output of reduction reactions, huge amount of the energy wastes in the flue gas and disappears in the atmosphere.

As global perspective, considering consumption quantity and cost of electrical power, nowadays capturing waste heat energy and recycling it back to the process have been becoming more important.

On the other hand, while capturing the waste energy, off-gas filtering and dedusting are also crucial operations as a next step of the integrated energy recovery process to achieve the minimization of carbon footprint and improvement for environmental standards.

2 HEAT RECOVERY PROJECT OF ETI KROM INC. [3]

2.1 Project Description

Turkish ferrochrome smelter Eti Krom produces high carbon ferrochromium which is an iron-chromium alloy consisting 50-70% of Cr and 4-10% of C. Pyrometallurgical high carbon ferrochrome process is carried out through submerged arc furnaces (SAF). Total 4 submerged arc furnaces of Eti Krom holds a 140,000 mt annual capacity and a secondary treatment facility holds 10,000 mt annual metal recycling capacity. Transformer capacity of each furnace is given as below.

- 2 x 17 MVA opened type SAF has total annual capacity of 50,000 mt (**Figure 1**),

- 2 x 30 MVA semi-closed type SAF has total annual capacity of 90,000 mt.

Figure 1: Opened type submerged arc furnace, Eti Krom Inc.

Required heat source for carbothermic reduction reactions is supplied by electrical arc. The arc generates a temperature between 2,500 °C and 3,000 °C at the reaction zone. Simultaneously, a blend containing raw materials and reductants in the furnace charge are smelted by consuming excessive quantity of electrical energy.

Eti Krom has been commissioning a pioneering project with SMS SIEMAG AG in its high carbon ferrochrome production plants to implement a dedusting and energy recovery system.

Fundamentally, the facility consists of a waste-heat boiler, a filter bag station, a fan and a clean gas stack. The waste gas which holds 600°C temperature is recovered by evaporative cooling and transformed into steam to be used for transformation of mechanical energy to the electrical power generation. The excess heat is estimated to produce more than 35 tons per hour of steam which is then fed into a system to drive a steam turbine to generate 5,5 MWe of electrical power. This is then either fed back to the furnaces or loaded onto the national grid (**Figure 2**).

Dedusting unit will be synchronized for 4 of Eti Krom furnaces and waste heat energy recovery will be applied only for 2 of 30-MVA semi-closed furnaces. Therefore, purpose and objective of the project is not only to recover the waste heat energy but also to eliminate off-gas dusts and reduce carbon footprint of overall 25.000 tons CO_2 emission per annum which means less requirement for global and domestic fossile based energy production.

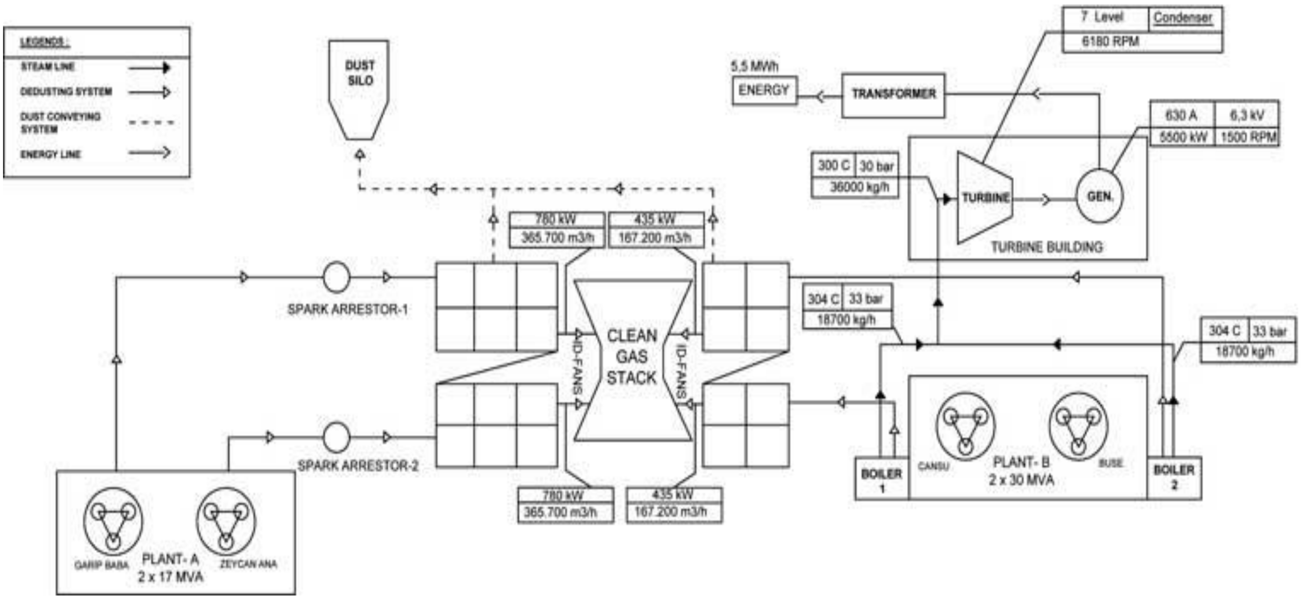

Figure 2: Eti Krom dedusting and heat recycling project flow chart.

2.2 The Waste Heat Boiler

The boiler mechanism instruments contain economizer, evaporator, super heater, screen, steam drum and blowdown tank. Inlet temperature of the flue gas into the boiler (steam generator) is approximately 600°C and the outlet temperature is approximately 200°C. The process that takes place inside the boiler can be described as an evaporative cooling system through water vaporization. Flue gas temperature can be reduced significantly through the phase transition of liquid water to water vapour (evaporation), which can cool air using much less energy than refrigeration.

2.3 Power Generation System

The power generation system consists of the steam turbine package including the condenser turbine, gear box, generator and condenser. The steam turbine is able to generate 5.5 MWe of electrical energy. The package is a compact unit and fits on a turbine table. A special spring system is installed between the turbine table and the ground.

Basically, the steam turbine is a mechanical device that converts thermal energy in pressurized steam into useful mechanical work; this mechanical force is then converted into rotational force, which is then converted to electricity. The electricity generated in the circuit is then fed to the electrical substation, which transfers the power to the furnace transformers or the national grid.

2.4 Bag Filter House (Dedusting System)

Flue gas is introduced to the bag filter house through two ways:

I. Flue gas which comes from the boiler for 2 of 30 MVA furnaces
II. Flue gas which comes from directly from 2 of 17 MVA furnaces

Filter equipment of dedusting system are designed to be used at a temperature not more than 200°C. Thus, the temperature of off-gas from boiler is lowered from 600°C to 200°C in order to be fed for bag filter house. For the flue gas from 2 of 17 MVA furnaces, an additional cooling treatment is not required due to its off-gas temperature is lower than 200°C.

In the filtering process fans push the clean gas through the clean gas stack into the atmosphere, and the collected dust is collected in a dust silo. It is discharged into a truck that disposes of the dust at a landfill site in compliance with environmental regulations.

3 SUSTAINABILITY OF ETI KROM PROJECT

Indeed, this heat recovery and dedusting project is domestically a milestone in the field of ferrochrome production and is globally one of the pioneering enterprises due to holding many profits with environmental, efficiency and social impacts.

3.1 Environmental Impact

Electricity generation through the combustion of fossil fuels is one of the source of CO_2 emissions. For instance, in United States generating electricity through fossil fuels is accounts for about 37% of total U.S. CO_2 emissions and 31% of total U.S. greenhouse gas emissions in 2013 [4].

In Eti Krom project, dedusting system reduces approximately 25,000 mt of CO_2 emissions per year as well as significantly minimizes carbon footprint. In this manner, the project globally purposes to build an awareness among ferroalloys smelters in the field of advanced environmental protection.

Moreover, there is an opportunity to certify this type of projects by Gold Standard. In the last decade, Gold Standard certified projects took 20 million tonnes of carbon out of the atmosphere. In 2015, this figure is expected to reach 65 million tonnes. [5] Eti Krom has also applied and initiated Gold Standard Certification process.

3.2 Efficiency Impact

During energy cycling, per hour 30 tons of produced steam is continuously recovered to drive mechanical turbine in order for generating 5.5 MWe of electrical power. Each 2 of 30 MVA electrical arc furnaces has a nominal 23,5 MWh consumption capacity. If the recovered energy is fed back to the smelters, it would reduce electrical consumption spontaneously. Therefore, this makes the process energy efficient as well as cost-efficient.

3.3 Social Impact

The dedusting project minimizes emissions and saves life cycle onto earth by disposing wastes and diminishing greenhouse gas emissions which influence global climate change. Thus, one of the main purposes is also to save local community settled around the smelting territory.

According to a long-standing approach, waste heat energy recovery is valuable process for sustainability of next generations by saving energy, emitting less gases and consuming less natural sources for electricity generation.

Figure 3: Eti Krom plant site

4 OPPORTUNITIES FOR RUSSIAN FERROALLOY SMELTERS

4.1 Russian Ferroalloys Industry Background

Russia is one of largest ferroalloys producing countries in the world. Russian ferroalloy industry holds 2 million tons of production capacity. Almost half of the industry depends on silicon based alloys. The remaining are ranking as chrome alloys, manganese alloys and others. Sufficient raw material sources and availability of power make the industry sustainable [2].

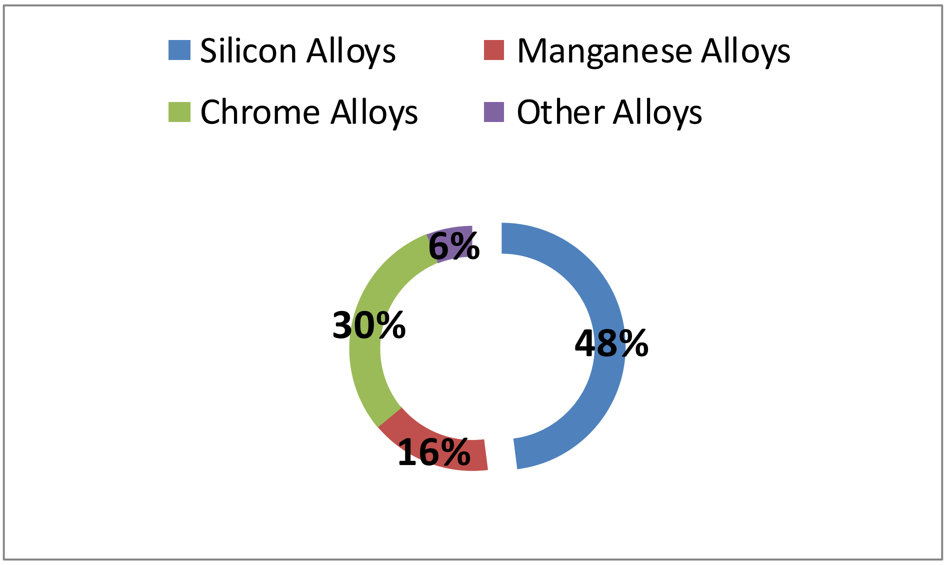

Figure 4: Russian ferroalloy industry [2]

Table 1: Some Russian ferroalloy smelters

Company	**Ferroalloy Products**	**Transformer Capacity - Number of Furnaces**	**Production Capacity**
Serov Ferroalloy Plant	Medium Carbon FeCr, Low Carbon FeCr,	**160 MVA** total capacity for **18** smelting and tilting furnaces	200,000 tpy
ChEMK Industrial Group	FeSi, Low-Carbon FeCr, FeSiCr, SiCa, SiMg, FeMg	**335 MVA** total capacity for **35** electric arc furnaces	700,000 tpy
Kuznetsk Ferroalloys	FeSi	**290 MVA** total capacity for **16** smelting furnaces	380,000 tpy
Yurginskiy Ferroalloy Plant	FeSi	**108 MVA** total capacity for **4** electric arc furnaces	120,000 tpy
Bratsk Ferroalloy Plant	FeSi	**132 MVA** total capacity for **4** electric arc furnaces	150,000 tpy
Tikhvin Ferroalloy	High Carbon FeCr	**96** MVA total capacity for **4** electric arc furnaces	120,000 tpy

4.2 Heat Recovery and Dedusting Availability

In Russia measured carbon dioxide (CO_2) emissions per real gross domestic product (GDP) is 60% higher than the average of IEA member countries. Therefore, it seems that overall carbon footprint in the country needs to be reduced [6].

Russian ferroalloy industry holds 2 million tons of production capacity with 85 electrical furnaces and 1121 mega-voltampere (MVA) transformers power capacity. Thus, these huge quantity of consumed energy in the smelters would have a significant off-gas heat energy which needs to be recovered.

Simultaneously just after the energy recovery treatment, there is an opportunity to filter flue gas as well as significant carbon dioxide (CO_2) emissions reduction together and greenhouse gas emissions.

Economical calculations are not performed in this paper due to complexity of some variable operational and design parameters as given below [8,9,10].

- Variable flue gas heat energy depending on the type of furnace such as opened type, closed type, and semi-opened furnaces,
- Various furnace transformer capacities,
- Variable flue gas temperature depending on each alloy quality,
- Various raw material and reductant types usage.

In this aspect, the paper mainly purposes to build an awareness to encourage efficient and environmentally friendly smelting technologies.

4.2.1 Added values to Russian ferroalloys industry

Environmental Values

- Reducing carbon footprint and CO_2 emissions,
- Minimizing wastes and reducing greenhouse gas emissions,
- Contributing life cycle sustainability,
- International Gold Standard certification opportunity.

Efficiency Values

- Availability of feeding recovered energy back to the process,
- Energy cost reduction,
- As result of utilizing steam, opportunity to have hot water for household requirements,
- Cost efficiency.

Social Values

- Improving awareness for health and life cycle.
- Precaution for global climate change by reducing greenhouse gas emissions,
- Environmentally sustainable society,
- Supporting local communities by providing hot water.

5 RECOMMENDATION

Since energy recovery and dedusting process contribute a better sustainable world, it should be financially encouraged by international organizations such as IFC, EU, EBRD.

6 CONCLUSIONS

Indeed, heat recovery is an efficient technology in order for reducing energy costs and dedusting is an environmentally friendly project for diminishing hazardous emissions and saving the life cycle. Since Russian ferroalloys smelters hold a large waste heat energy potential in the flue gas, there should be more motivation in the country to be an entrepreneur for applying such a valuable technology in many aspects.

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