TOWARDS CLEANER STEEL INDUSTRY: REQUIREMENTS AND ACHIEVEMENTS

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Abstract

The European Union is in the forefront of environmental and climate protection; steel companies are strongly involved in this activity. A short review is given on the changing EU regulations and on the most recent developments in emission trade. Reactions of the steel industry will be summarized including the increase of waste utilization, reduction of CO2 emission, life cycle analysis for the better understanding of the environmental impacts of producing and utilising steel.

Keywords: steel industry, environmental protection, waste utilization, CO2 emission, life cycle assessment

1. INTRODUCTION

Because of its nature steel industry is among the branches considered to generate heavy environmental burden. Despite spectacular improvement of its environmental performance this image could not be improved very much in the last decade.

The European Union – realizing its responsibility as one of the most developed regions – is continuously aggrevating its environmental regulation. To follow the tightening regulation steel industry must continuously develop its basic and environmental technologies; the costs of this activity may influence its international competitiveness.

As a result of the developments the steel industrty of the EU is regarded now as leader on the field of environmental and climate protection. An overview of the changing EU regulations especially important for the steel industry will be given in the paper; information on the improvement of the environmental performance of the steel industry will be shown, and, lastly, the role of steel industry in sustainable development will be demonstrated.

It should be noted here that in the paper the protection of environment and climate will not be separated, because of their common origin, although in the last decade climate protection started an autonomous life getting sometimes more interest than classic environmental protection.

2. THE ENVIRONMENTAL AND CLIMATE REGULATION IN THE EU

Regulations accepted by the European Parliament are compulsory for member states, so national regulations have to be conform with them. The activity of the European Commission is especially spectacular in the field of environment: yearly 200-300 new or modified regulations are introduced. For the steel industry the most important items are Industrial Emission Directive together with BAT documents, the new waste regulation and the Emission Trade System (ETS).

2.1. Industrial Emission Directive (IED) and Best Available Techniques (BAT) documents

Main point of IED, Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control recast) is that companies that belong under the scope of the directive (steel companies are among them) can be operated only according to the environmental permission issued by the appropriate environmental
authority. In the regulations emission limit values are given that are based on emission values in the BAT documents.

From among steel technologies coking, sintering, ironmaking, steelmaking and continuous casting are listed among processes belonging to IED regulation. First BAT documents for the steel industry were published at the beginning of the 2000’s. Decision on renewing them was made in 2007; in this activity experts of member countries were invited. The first draft was issued in 2010, the final one in 2012. Because of its full title (Best Reference Document on Best Available Techniques) they are often referred to as BREF documents [1]. In the rather voluminous document (more, than 400 pages) emission values of up-to-date solutions are given for each production phases, together with a short description of the technique. Main conclusions are separately edited (BAT conclusions) [2].

As an example BAT conclusions for the dust emission of EAF steelmaking are given below.

<table>
<thead>
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<th>Example for BAT conclusions: Reduction of dust emissions from sinter strands</th>
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| **20. BAT for primary emissions from sinter plants** is to reduce dust emissions from the sinter strand waste gas by means of a **bag filter**. BAT for primary emissions for **existing plants** is to reduce dust emissions from the sinter strand waste gas by using **advanced electrostatic precipitators** when bag filters are not applicable. The BAT-associated emission level for dust is \(<1 – 15 \text{ mg/Nm}^3\) for the bag filter and \(<20 – 40 \text{ mg/Nm}^3\) for the advanced electrostatic precipitator (which should be designed and operated to achieve these values), both determined as a daily mean value. **Bag Filter** \[\text{Description: Bag filters used in sinter plants are usually applied downstream of an existing electrostatic precipitator or cyclone but can also be operated as a standalone device.}\
**Applicability:** For existing plants requirements such as space for a downstream installation to the electrostatic precipitator can be relevant. Special regard should be given to the age and the performance of the existing electrostatic precipitator.** |

Fig. 1. BAT conclusions for dust emissions from sinter strands [2]

### 2.2. The new directive on wastes [3]

Objective of the elaboration of the new waste directive was to define the transition between wastes and non-wastes. For the steel industry the possibility of transferring ferrous scrap from the status of waste to product was dangerous. For the transfer predefined conditions have to be fulfilled, first of all on the field of quality assurance and it would increase costs of the scrap processors resulting in price increase for steel companies. On the other hand, steel companies were afraid of losing the benefits provided for waste utilization, too. As the transfer is not compulsory, scrap processors agreed in most countries to follow the former practice.

### 2.3. The emission trade system (ETS) of the EU

In 1997 developed countries agreed to reduce their CO2 emission by 8% until 2010 related to their 1990 emission in order to decrease the danger of global warming (Kyoto protocol). It is known that some countries
(including the largest emitter, the USA) did not ratify the protocol and it is still disputed how far human activity does influence global warming.

The European Union decided to motivate large emitters to decrease their emission using market instruments; the solution was introducing the emission trade system (ETS). According to the system large emitting branches (power stations, steel industry, construction materials industry, pulp industry) are allowed to emit a predefined amount (quotas) of CO2 free of charge; surplus quotas can be sold and the missing ones have to be purchased on the quota market. Each member country received a certain amount of quotas that was distributed in the country among emitters. Between 2005-2007, 95 %, 2008-2012, 90 % of the quotas was given free of charge.

There were several problems with ETS from the very beginning. In the first period quotas were defined using historical emissions given by the companies. As a result, the amount of free quotas was higher than emission in several branches and oversupply was formed on the market in a short time, resulting in low quota prices. In the second period the Commission tried to correct this problem, however, because of the global economic crisis production (and emission) went down so strongly, that oversupply and low prices were maintained. Up to now EU steel industry was much more a seller than buyer on the quota market.

Basis of the Post-Kyoto ETS (2014-2020) was laid down in 2008 and it was accepted by the European Parliament [4]. It was decided that the distribution of free quotas will be made using the benchmark method (Fig.2.). The benchmark value was proposed to be the average specific emission of the lowest 10 emitters for each technology. The aim was to reward good performers and to punish bad ones. The idea is fine; however, the benchmark values defined by the European Commission are lower than the specific emission of the lowest emitters according to EUROFER (Table 1.).
Table 1. Specific emission benchmark values for the EU steel industry (issued in October 2010)

<table>
<thead>
<tr>
<th>Process</th>
<th>Benchmark given by the EC</th>
<th>Best performers by EUROFER</th>
</tr>
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<tbody>
<tr>
<td>Sintering</td>
<td>171 kg/t</td>
<td>191 kg/t</td>
</tr>
<tr>
<td>Coking</td>
<td>286 kg/t</td>
<td>333 kg/t</td>
</tr>
<tr>
<td>Ironmaking</td>
<td>1328 kg/t</td>
<td>1475 kg/t</td>
</tr>
<tr>
<td>Electric steelmaking</td>
<td>285 kg/t</td>
<td>285 kg/t</td>
</tr>
</tbody>
</table>

EUROFER started a process against the Commission to modify the values; up to now without any result.

The 2014-2020 ETS system is different from the earlier ones also at other points. Air traffic will be involved in the system. A more important point is that the free allocation of quotas for power stations will be stopped. As power stations are in the position of transferring the increased costs to their clients, electricity prices will increase and this will affect steel companies (first of all EAF steel mills). As a result of the protest of branches strongly hit by this rule, a compromise is forming now: the Commission will allow governments to give financial support to companies for compensating their losses due to the problem mentioned above. (Remember: up to now state aid of steel companies was strongly prohibited).

The hottest debates are carried out recently at EU level is the revision of the ETS accepted in 2008. Namely, as a result of the global crisis steel production in the EU was dramatically reduced and according to experts it will never more reach the peak in 2007. So, the emission reduction required (20% related to the 2005 emission) can be achieved without stronger efforts and quota prices will not much increase, so the objective of the system (urging companies to reduce their emission) will not be effective. The European Commission tries to solve the problem by the temporary withdrawal of a certain amount of the already distributed quotas (backloading) and so demand and prices will be increased at the quota market.

The idea of backloading resolved a violent opposition of the branches hit by the change (energy intensive branches): they say high quota prices will destroy their international competitiveness. The discussion is still going on; EUROFER is in the forefront of the struggle.

3. ACHIEVEMENTS IN THE DEVELOPMENT OF CLEANER STEEL TECHNOLOGIES

3.1. Reduction of emissions

Objective of the Industrial Emission Directive — as it was shown — is to reduce the concentration of the harmful materials in the emission, because the harmful effects are also related to the concentrations. Required emission limits can be guaranteed by using effective end-of-the-tube techniques (separating and removing harmful materials from air or water). Air and water cleaning technologies and equipments are continuously developing and the amount of impurities emitted to the air or water has been spectacularly reduced in the last decades (Fig.3.).
3.2. Utilization of wastes

Beside the steel products other materials are also arising at steel companies during production. Three groups of them are as follows:

- materials separated during air and water cleaning (dusts, sludges)
- unnecessary or harmful components of the charge materials that are removed during production (slags)
- materials that are not utilized during production or processing (splashes, scales, etc.)

Depending on the technologies used their specific volume may be rather large. Because of their chemical composition and physical properties most of them can be utilized and so not only the costs of their storage can be reduced but their utilization may be a profitable activity, too. That is why the amount of wastes sent for dumping is continuously decreasing and the implementation of „zero waste” technologies is a reality now.
The amount of dusts, sludges, and scales in the steel industry of Germany is given on Fig. 4.

At integrated steel mills – where the main raw material is iron ore with ~ 60% iron content – the specific amount of these wastes is more than the double of the one at EAF steel mills (6).

Fig. 4. Generation of Dusts, Sludges and scales in Germany, 2010 [5]

Fig. 5. Value potentials of dusts and sludges [5]
One of the important problems of EU steel industry is the lack of raw materials; most of the iron ore and coking coal is imported from third countries. Utilization of the useful components of wastes is so an important point. In dusts and sludges first of all their iron content is remarkable, and in some cases their C-content can also be utilized (Fig. 5).

Main place for the utilization of the iron content is sinter strand. Appropriately prepared wastes will be mixed to the sinter charge. With the addition of high CaO slags part of the lime can be also replaced. This solution, however, can not be used in some cases. Dusts and sludges of iron and steelmaking may contain heavy metals (first of all Zn); oil content of rolling mill scales may cause problems in air pollution. For the utilization of the Zn content different technolofgies are used; they produce valuable charge materials for the production of Zn.

The specific amount of slags is several times larger than that of other wastes: in integrated steel mills it is about 400 kg/t crude steel (ironmaking + steelmaking slags), in EAF mills about 170 kg/t crude steel.

Fig. 6. Utilization of slags in Germany [6]

Because of their chemical and physiscal properties slags can be utilized for different puropses. Their composition is exploited in the cement industry; using them instead of lime CO2 emission of the cement industry can be strongly reduced. Because of their mechanical and physical properties slags can be used as construction materials, replacing natural rocks (they are often regerded as artificial rocks). For the different utilization slags have to be appropriately prepared (cooled from liquid state, milled to predefined grain size, etc.).

The share of landfilled slag is rather low now (Fig.6). There are companies already processing and utilising the total amount of their slag.

4. STEEL INDUSTRY AND SUSTAINABLE DEVELOPMENT

Steel industry is still accused of strongly endangering the environment and using a huge amount of energy and raw materials; all these items are contradicting the idea of sustainable development. This is a very
superficial view, because only the production phase is considered; if the real environmental performance has to be defined, the whole life cycle must be investigated (Life Cycle thinking, Fig. 6).

![Cradle to Grave (Life Cycle)](image)

**Fig. 7.** Boundaries at life cycle analysis [7]

A life cycle assessment (LCA) of a steel product looks at resources, energy and emissions, from the steel production stage to its end-of-life stage, including recycling. Steel can be recycled over and over again, indefinitely, without any loss of its inherent properties. LCA is a sensitive issue especially when comparing different, competing materials (e.g. steel, plastic and Al car bodies); results depend strongly on the methodology applied. That is why ISO standards have been developed:


LCA activity of steel is lead by World Steel Association; methodology has been worked out with the participation of several experts from steel companies and steel institutions all over the world. Work is going on. Some interesting results:

- the use of innovative steel products (in the vehicle industry, in power generation, etc.) instead of conventional materials may save much more energy than needed for the production of the steel (Fig.8).
- the use of high strength steels in Europe in vehicles could reduce CO2 emission by 8000 kton.
Innovative use of steel saves six times as much CO$_2$ as is caused by the production of the steel

Fig. 8. Contribution of innovative steels to climate protection [7]

4. SPECIAL SOLUTIONS FOR THE REDUCTION OF CO2

The European Union is strongly insisting in keeping its pioneer position in climate protection. After introducing the ETS a long-term strategy has been elaborated and published in 2012 (EU Roadmap to Low-carbon Economy). The objectives formulated in this document are extremely ambitious: the required reduction of CO2 emission in industry compared to the 1990 emission values are as follows:

- until 2030: 34 – 40 %
- until 2050: 81-87 %

Recently no steel technology is known that could fulfill this requirement.

Acknowledging the continuous pressure a program for finding and elaborating innovative methods was launched by WSA: Ultra low CO2 Steel Making (ULCOS). Beside realistic aspirations research is going on solutions that can be regarded now futuristic (Fig. 9).
Fig. 9. Breakthrough technologies investigated in the ULCOS project

5. CONCLUSIONS

a) Environmental efficiency of the steel industry was strongly improved in the last decades by
   - EU regulations
   - Strong R&D input
   - New technical solutions

b) Zero waste steelmaking is now close to realization.

c) Life cycle analysis is a useful tool for the objective evaluation of the environmental performance of steel

d) Innovative steel solutions can make the balance of CO₂ emission and reduction positive for the steel industry

e) Newest EU climate protection regulations and objectives (2014-2020 and to year 2050) may strongly increase the costs of steel companies and endanger their international competitiveness.

REFERENCES
