WAYS TO REDUCE CO$_2$-EMISSIONS AT SSAB LULEÅ WORKS

by

Jan-Olov Wikström*, Carl-Erik Grip**, Mikael Larsson*** and Sten Ångström*

* MEFOS, Box 812, SE-971 25 Luleå, Sweden
** SSAB Tunnplåt AB, SE-971 88, Luleå, Sweden
*** Luleå Tekniska Universitet, SE-971 87, Luleå, Sweden

Key words: CO$_2$-emissions, steelmaking, ironmaking, blast furnace, energy efficiency, alternative iron- and steelmaking

ABSTRACT

Possibilities to reduce the CO$_2$-emissions from SSAB Tunnplåt AB’s ore based steel production in Luleå, have been studied, looking at alternative process routes as well as potential reduction in todays production system.

The CO$_2$-emissions from Luleå Works are in general lower than from other ore based steel plants. This is partly due to lower emissions in the pellet production and high iron content in the pellets, resulting in exceptional low slag rates in the blast furnace operation.

There are today no new smelting reduction processes, either established or under development, that will lead to a substantial reduction of carbon dioxide emissions from the iron- and steelmaking. New process concepts under development are mainly focusing on usage of cheaper raw materials.

An analysis of potential possibilities to reduce CO$_2$-emission from the steel production system in Luleå shows that improvements in process optimisation, improved balance in liquid flow and higher yields, gives the strongest effect. Slag granulation, followed by slag cement production would substantially decrease the emissions. This reduction will take place at the location of the cement producer.

SSAB Tunnplåt AB has a product programme with a high percentage of high strength steels. A great part of the products are for vehicles, containers, cranes, e.g where the high strength steel contributes to a low energy consumption, and low CO$_2$-emissions, in the usage of the final product.
1 INTRODUCTION

In the year 2004, the annual global production of steel will, for the first time, exceed 1000 million tonnes. During the last 30 years the steel production has been quite constant in Europe and Japan and slightly declined in North America. The last couple of years, steel production has increased in Asia, especially in China where 222 million tonnes were produced in 2003, i.e. 41 million tonnes more than 2002. Chinese experts estimate that the steel production will continuously increase for some years in the near future, based on a huge domestic market. The estimated production of steel in China for 2004 is 260 million tonnes, which is still 20 million tonnes lower than the domestic consumption [1].

The rapid increase in steel production in China has had a strong influence on the market for raw materials, resulting in a high price for coal, coke, scrap and iron ore. At some location there is a lack of metallurgical coke, which to some extent has become a strategic raw material.

There are basically two different production systems dominating, i.e. the integrated route (iron ore based) and electro steel (scrap based). For the integrated plants the blast furnace and basic oxygen furnace will keep their strong position for a foreseeable future. Roughly 35% of the steel is produced in electric arc furnaces, based on recirculated scrap and electricity.

According to the Kyoto protocol, the emissions of green house gases, especially carbon dioxide, is one of the major problems for the future of mankind. Globally, 7% of the emissions of carbon dioxide originate from the production of steel, mainly due to the usage of coal and coke as reductant in the iron ore based production. The European joint research will strongly focus on identification of methods to substantially reduce the CO2-emissions from the steel production, especially through the ULCOS-project, aiming at cutting the emissions from steel production by 50%. Similar programs will also start in other parts of the world.

This paper deals with an investigation of possibilities to reduce the CO2-emissions from SSAB Tunnplåt AB’s ore based steel production in Luleå, looking at alternative process routes as well as potential reduction in today’s production system.

2 STEELMAKING AT SSAB TUNNPLÅT AB

![Diagram of steelmaking process]

Fig 1. Lay out of SSAB Works in Luleå.
A layout of the production units at SSAB Works in Luleå is shown in Fig 1. In the year 2000, SSAB stopped the operation in two old blast furnaces and all the hot metal production was concentrated to one new 11.4 m (hearth diameter) furnace. Just some years earlier a new coal injection plant was erected, replacing the earlier one, erected in 1985. Coal injection capacity is in the range of 160-180 kg per tonne of hot metal, depending on production level. Coke is produced in an own coke oven plant from 1975, which has been revamped in 2003. Additionally 15 % of imported coke is used.

The sintering plant in Luleå was taken out of operation already 1978, due to old equipment and strict environmental regulations. Since then the hot metal production is based on 100 % pellets. After the introduction and optimisation of olivine pellets (MPBO, KPBO) from LKAB in the mid 80’s, the slag volume has been in the range of 150-170 kg per tonne hot metal, and the reductant rate among the lowest in the world. In plant fines are recirculated to the blast furnace as cement bounded briquettes, to a volume of ~50 kg per tonne of hot metal. Some operational data from 2003 are shown in Table 1.

Table 1. Averages of operational data of BF No 3 in Luleå 2004 January-May.

<table>
<thead>
<tr>
<th>Pellet ratio</th>
<th>100 wt%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPBO</td>
<td>57 wt%</td>
</tr>
<tr>
<td>KPBO</td>
<td>43 wt%</td>
</tr>
<tr>
<td><strong>Additives</strong></td>
<td></td>
</tr>
<tr>
<td>Lime stone</td>
<td>41 kg/ tHM</td>
</tr>
<tr>
<td>BOF slag</td>
<td>46 kg/ tHM</td>
</tr>
<tr>
<td>Manganese slag</td>
<td>5 kg/ tHM</td>
</tr>
<tr>
<td>Dust briquettes</td>
<td>37 kg/ tHM</td>
</tr>
<tr>
<td><strong>Reducing agents</strong></td>
<td>468 kg/ tHM</td>
</tr>
<tr>
<td>Coke</td>
<td>327 kg/ tHM</td>
</tr>
<tr>
<td>PCI</td>
<td>141 kg/ tHM</td>
</tr>
<tr>
<td><strong>Blast</strong></td>
<td></td>
</tr>
<tr>
<td>Specific volume</td>
<td>938 m³/tHM</td>
</tr>
<tr>
<td>Blast temp.</td>
<td>1118 °C</td>
</tr>
<tr>
<td>O₂ content of blast</td>
<td>23.8 Volume%</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td>2.51 tonnes/m³/24h</td>
</tr>
<tr>
<td><strong>Hot metal</strong></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4.75 wt %</td>
</tr>
<tr>
<td>Si</td>
<td>0.36 wt %</td>
</tr>
<tr>
<td>Si std dev</td>
<td>0.119 wt %</td>
</tr>
<tr>
<td>S</td>
<td>0.039 wt %</td>
</tr>
<tr>
<td>Temperature</td>
<td>1482 °C</td>
</tr>
<tr>
<td><strong>Slag</strong></td>
<td></td>
</tr>
<tr>
<td>Amount</td>
<td>163 kg/ tHM</td>
</tr>
<tr>
<td>B2 CaO/SiO₂</td>
<td>0.98</td>
</tr>
<tr>
<td>MgO</td>
<td>17.8 wt %</td>
</tr>
</tbody>
</table>

Desulphurisation of the hot metal is made in the ladle, before charging into the two LD-converters (2*107 t). The crude steel is further treated in the alloying processes CASOB and RH-vacuum oven. The steelmaking is followed by two slab casters. The slabs produced in Luleå are transported 800 km south to Borlänge, where the rolling mill is located.
SSAB Tunnplåt AB has a product programme with a high percentage of high strength steel. A great part of the products are for vehicles, containers, cranes, e.g. where the high strength steel, from a CO₂-perspective, contributes to a low energy consumption in the usage of the final product.

3 ALTERNATIVE IRON- AND STEELMAKING PROCESSES [3]

An alternative to the BF / BOF route is the electric arc furnaces (EAF), where scrap is recirculated. The EAF can also be operated by use of direct reduced iron (DRI / HBI) or with a mixture of DRI and scrap. The main energy source is electric power.

The DRI / HBI are produced by reducing iron ore in solid state. The reduction is normally made by natural gas or coal. There are three types of reactors, e.g. shaft furnace, fluidized bed and rotary hearth. The shaft processes (Midrex, Hyl) are the most developed and accounts for almost 85% of all DRI production. The fluid bed reactors are normally operated with natural gas (Finmet, Circored), but can also be coal based (Circofer). Processes based on rotary hearth technology are coal based (Fastmet, Itmk3, Sidcomet). In this study, only processes demonstrated in industrial or pilot plant scale are considered.

For production of liquid hot metal from iron ore, Corex is so far the only process that has come to a commercial use. Four units, all of the size C-2000 (2000 tonnes per day), are in operation at 3 different sites. Corex is today a well developed process, but the coal consumption is high and a sophisticated usage of the energy rich export gas is necessary, to justify the process. This is today made through production of electricity, combination with direct reduced iron (DRI) production, and could be combined with blast furnace tuyere gas injection.

Several smelting reduction processes are under development and some of them will be demonstrated in pilot plant or industrial scale. As far as can be seen today, none of them will, in the present stage of development, lead to a substantial decrease in CO₂-emissions.

4 COMPUTER MODEL AND CALCULATION PRINCIPLES FOR ESTIMATION OF CO₂-EMISSIONS

The analysis of CO₂-emissions was conducted in a mathematical simulation model, derived for the steel plant system of SSAB Luleå Works. It consists of one process module calculating the mass- and energy flows in the system, and one CO₂-module using the mass- and heat balance to calculate the CO₂-emissions, Fig 2.

The process module includes simulation models for the different process units in the existing production system. New alternative processes can be included by a mass balance sheet. All models are governed by an interface controlling the different sub models. For the study of new alternative technologies, process data have been adapted to fit into the existing steel plant system.
In an industrial energy and production system, such as the integrated steel plant, the different processes are connected by primary and secondary products, affecting each other. Raw materials used for the iron- and steelmaking have generated CO₂-emissions in their preparation. There are processes generating CO₂-emissions inside the steel plant border that is emitted in by-products (e.g., process gases) outside the steel plant border. The use of by-products might also result in a global decrease of the CO₂-emissions, due to replacement of fossil fuels. There are principally three ways of making the analysis (Fig 3):

- as an inventory analysis, including only direct emissions from the system.
- as an effect-oriented analysis, also including indirect upstream emissions from raw material preparation or products used in the production, as well as downstream emissions related to by-product use.
- as an LCA analysis, taking into consideration the total emissions during the total life cycle of the product.

In order to take the specific aspects of the current system into consideration, an effect-oriented calculation philosophy is chosen. The LCA analysis is not applicable since the life cycle emission of
the product is of no relevance to this study. The analysis methodology is based on the method proposed by Aichinger et al [2], and is based upon the following principles:

- Relevance: the system boundary chosen should appropriately reflect the greenhouse gas emission from the system.
- Completeness: the calculation should include all emission sources and activities within the system.
- Consistency: the result should allow for meaningful comparisons of emission performance over time.
- Transparency: the analysis should be conducted in a factual and coherent manner, based on a clear audit trail.
- Accuracy: the emission calculations should have the precision needed for the intended use, and provide reasonable assurance on the integrity of the calculated emission.

Besides the direct emissions within the system, the indirect emissions from the preparation of raw materials and the use of process gases in the combined heat and power plant (CHP) are included. The specific CO₂-emission from the process step divided by the production volume from each primary process product is calculated stepwise. The CO₂-emission is calculated as the carbon entering the system subtracted by the carbon leaving the system in products and compounds other than the primary and carbon dioxide. The indirect emissions are then added by multiplying the actual material use by its specific emission, Table 2. This implies that the first process in the production chain is calculated first (i.e. the coke oven) and gradually the other processes are calculated on the basis of the earlier calculated emissions.

Table 2. CO₂ emission factors used for indirect emissions from processes outside the system boundary (kg CO₂/t).

<table>
<thead>
<tr>
<th>Material/energy</th>
<th>Specific emission</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pellet (hematite ore)</td>
<td>154</td>
<td>kg CO₂/ tonne</td>
</tr>
<tr>
<td>Pellet (magnetite ore)</td>
<td>51</td>
<td>“</td>
</tr>
<tr>
<td>Ore</td>
<td>26</td>
<td>“</td>
</tr>
<tr>
<td>DRI, Carbon based</td>
<td>1790</td>
<td>“</td>
</tr>
<tr>
<td>DRI, Natural gas based</td>
<td>586</td>
<td>“</td>
</tr>
<tr>
<td>Scrap</td>
<td>18.7</td>
<td>“</td>
</tr>
<tr>
<td>Burned Lime</td>
<td>1346</td>
<td>“</td>
</tr>
<tr>
<td>BOF slag</td>
<td>149</td>
<td>“</td>
</tr>
<tr>
<td>Limestone</td>
<td>428</td>
<td>“</td>
</tr>
<tr>
<td>Oxygen</td>
<td>1283</td>
<td>“</td>
</tr>
<tr>
<td>Steam</td>
<td>224</td>
<td>“</td>
</tr>
<tr>
<td>Power</td>
<td>0.6</td>
<td>kg CO₂/ kWh</td>
</tr>
<tr>
<td><strong>Transports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boat (coal/coke)</td>
<td>51.4</td>
<td>kg CO₂/ tonne</td>
</tr>
<tr>
<td>Truck</td>
<td>0.072</td>
<td>kg CO₂/ tonkm</td>
</tr>
<tr>
<td>Train</td>
<td>0.020</td>
<td>“</td>
</tr>
</tbody>
</table>

For carbon, leaving the system in other forms than CO₂, a credit is given in the analysis. The carbon is therefore only debited the process where it is used. For re-circulated materials, credits are given if they replace materials with a related CO₂-emission. The electricity produced in the CHP is credited the system. Since the blast furnace slag is not granulated, this has not been included as a credit in the analysis. The stepwise calculation gives the total accumulated emission for all processes in the Luleå Works system.
CO₂-EMISSIONS FROM SSAB LULEÅ WORKS

Comparison with other integrated steel plants

Aichinger et al presented in 1999 a study of CO₂-emissions related to ore based steel production for three modern European plants [2]. The average emission was 1640 kg per tonne of hot metal. The much lower value compared to other studies is caused by the credit given for energy in the blast furnace top gas, as well as for the usage of granulated blast furnace slag for cement production.

By using the same calculation principle, as earlier described, the emissions for SSAB Luleå Works is 1385 kg per tonne of hot metal, Fig 4. The major difference is the usage of 100 % high quality pellets from LKAB, based on a magnetite type iron ore, which needs much less energy for induration, compared to hematite based pellets, or sinter, Fig 5. Another difference is the usage of 100 % coke oven gas for firing of the coke oven battery.

When comparing emissions per tonne of crude steel the difference is smaller, mainly due to lower scrap rate in the BOF at SSAB.

Fig 4. CO₂-emissions from SSAB Luleå Works, compared to some European plants. (Alchinger et al).

Fig 5. CO₂-emissions from sintering respective pelletising. (Source: LKAB).
Comparison with EAF steelmaking

If the BF/BOF at Luleå Works are replaced by EAF’s the total emission, using the same calculation method as described above, the total CO₂-emission will be 320 kg per tonne of liquid steel, in case of 100 % scrap charging. Charging of 50 % DRI would increase the emissions to 700 kg.

From a strict logical point of view it is not correct to look upon scrap melting as an alternative to ore based metallurgy. Instead they are different steps in the same process chain; an iron unit is created by ore based metallurgy, then scrap is recovered and melted again, e.g. using EAF. As a calculation example look upon one tonne steel that is first created from ore with a specific emission of 1400 kg CO₂. Assume that 75 % of the steel can be recovered as scrap and re-melted with a CO₂ emission of 320 kg CO₂. Then in the second life cycle we will get 0.75 tonne and a total emission of 0.75*320 = 240 kg CO₂. The third life cycle will give 0.56 tonne steel and 180 kg CO₂, etc. If all re-melting cycles are summed up (using standard formula for geometric series) they give back 3 tonne of steel and 960 kg CO₂. Totally in all life cycles 4 tonnes of steel and 2360 kg CO₂ are produced, i.e., the mean for the sum of all life cycles is 590 kg CO₂/tonne steel. If the recovery rate is lower the emission is higher, e.g., 50 % recovery would give a mean emission for all life cycles of 860 kg CO₂/tonne steel.

Comparison with alternative technologies

Corex is so far the only alternative to the blast furnace for production of liquid hot metal. If the blast furnace in Luleå is replaced by a Corex plant the CO₂-emissions will be around 2170 kg per tonne of liquid steel, if high quality raw materials are used. With poor raw materials the emissions will be more than 3000 kg. Combination of Corex with other processes might lower the emissions to some extent, although not down to the same level as the blast furnace.

All the smelting reduction processes under development seem to have an estimated coal consumption higher than the blast furnace, or in the same range, which make them less attractive from a CO₂-emission perspective. Many of the ideas that are now being realised originate from the 80’s, when there was no focus on CO₂-emissions and the major objective was to use less expensive raw materials. Calculations for the Sidcomet process show emissions slightly higher than for the blast furnace. The reason for choosing Sidcomet as a representative for rotary hearth processes is that it was close to be industrialised during the time when this study was initiated, and consumption figures were available, estimated from pilot plant operation.

Potential CO₂ reduction for SSAB Luleå Works

An analysis has been made to identify possible potential ways of reducing the CO₂-emissions, without replacing any of the production units at Luleå Works. The results are as follows:

- Increased iron yield. If the yield from hot metal to liquid steel can increase by 1 %, the CO₂-emissions are reduced by 14 kg per tonne.
- Increased crude steel yield. If the yield from liquid steel can be increased by 1 % (for example through reduced slag losses, reduced slopping from the BOF or reduced losses from the continuous casting), CO₂-emissions can be lowered by 21 kg per tonne.
- Improved balance in the liquid flow. During process disturbances in the steelmaking, pig iron is cast as an alternative to modification of the hot metal production. The solid pig iron is later charged to the BOF. The method reduces the yield from hot metal to liquid steel and is also reducing the usage of external scrap, causing higher CO₂-emissions. If pig casting could be com-
pletely avoided emissions would be reduced by 88 kg per tonne. On the other hand, changing the production level of the blast furnace, to avoid pig casting, is not a good solution, as emissions will increase due to an increased blast furnace reductant rate.

- **Increased ratio of external scrap.** For each percentage of scrap charged to the BOF, CO$_2$-emissions are decreased by 11 kg per tonne. Initially, scrap can be charged as a coolant instead of iron ore, and for higher ratios scrap can be preheated. An increased charging of external scrap will probably not reduce CO$_2$-emissions globally, as an increased scrap ratio at SSAB will lead to a reduced scrap charging in another plant, due to limited available amount of scrap.

- **Coal injection into the blast furnace.** At BF No 3 in Luleå normally 140 kg of pulverised coal is injected per tonne of hot metal. Process calculations show that when going from all coke operation to an injection level of 60 kg, CO$_2$-emissions are substantially reduced. Above this level the effect of higher PC rate is marginal. The reason is that below 60 kg PC, moisture is added to the hot blast for flame temperature control. Above 60 kg, oxygen is added for the same reason, Fig 6.

![Figure 6](image-url)

**Fig 6.** Effect of coal injection rate (PCI) in Luleå BF without credit for BF-gas (upper) and with credit for BF-gas (lower).

- **Reduced reductant rate in the blast furnace.** If the coke rate is reduced by 20 kg per tonne of hot metal, CO$_2$-emissions are reduced by 66 kg per tonne of liquid steel. It should be pointed out that the reductant rate at SSAB has been more or less unchanged since the mid 80’s, and is among the lowest in the world. Although there are theoretically options, like using coke and coal with a substantially lower ash content.

- **Recirculation.** SSAB is already applying recirculation of BOF-slag into the blast furnace. The BOF-slag has a fairly high iron content and the chemical composition is almost ideal for the blast furnace process. BOF-slag reduces the need for limestone and has been given a credit of 142 kg CO$_2$ per tonne of slag.

- **Reduced flaring of process gases.** Because of unbalance in gas production and gas utilisation, sometimes the process gases are flared. Through an improved planning of the total energy system a reduction of the gas flaring is possible. It is important to make sure how to use the gases when there is a low need for hot water production.
- **Firing of the coke oven battery.** More efficient firing of the coke oven battery can reduce CO₂-emissions to some extent.

- **Heat exchangers for the hot stoves.** By heat exchanging of the off gases from the hot stoves to the combustion air, energy consumption can be reduced. Although, the effect on CO₂-emissions is not very high.

- **Top pressure recovery turbine.** Installation of a turbine to recover the top pressure from the Luleå blast furnace would reduce CO₂-emissions by 10 kg per tonne of steel.

- **Slagcement.** Granulated blast furnace slag is, to a great extent, used as a raw material for the cement industry in Europe. CO₂-emissions are reduced by one tonne per tonne of granulated slag, according to a German study. In Sweden the structure of the cement market is such that slag cement production is very limited. For an increased production of slag cement, a close cooperation with the cement industry is needed. If all blast furnace slag produced in Luleå would be used for cement production it would result in reduced CO₂-emissions by 165 kg per tonne of hot metal. The reduced emissions will not take place at SSAB, but at the site of the cement producer.

- **Improved hot water balance.** A problem for the energy recovery is a positive hot water balance, e.g., the usage of recovered energy is limited. By connecting the hot water net to the net of another community, near by, the balance can be improved. A potential reduction of CO₂-emissions is estimated to 22 kg CO₂ per tonne.

The potential theoretical reduction of CO₂-emissions from SSAB Luleå Works for different modifications and improvement in the steel production is shown in Fig 7.

---

**Fig 7.** Potential reduction of CO₂-emissions kg/t crude steel for SSAB Luleå Works. Some clarification to Fig 7 are made below:
- for estimating the effect of slag granulation, 165 kg slag per tonne of hot metal and 100 % yield from liquid slag to cement is considered.
- it is estimated that the recirculation of BOF-slag can be increased by 5 kg per tonne of hot metal.
- a prerequisite for balance in the liquid flow is that all hot metal is charged as liquid into the BOF.
- scrap charging into the BOF is increased up to the level where cooling with iron ore is avoided, e.g. to a scrap rate of 26 %.

**Product quality aspects**

The development of steel products is moving towards higher and more narrow strength. This means that steel constructions become lighter, leading to a reduced environmental impact. From an environmental perspective, including CO₂-emissions, it is important to consider all different steps in steel production as well as for the usage of the final steel products. Important steps are:

- production of raw materials and energy generation.
- production of steel.
- transportation of raw materials, products and wastes.
- production, usage and recirculation of final products.
- deposition of wastes.

Birat et al [4] have reported the energy consumption for a car during a ten years life cycle, divided into manufacturing of the car, production of components for the car, production and transportation of gasoline and usage of the car during the life cycle, Fig 8.

Fig 8. Energy consumption during the life of a car. (Source: Birat et al).

The major energy consumption is the gasoline, and its production (90 %). This motivates the great efforts being made in car manufacturing to reduce the weight and produce more efficient engines. SSAB is participating in the ULSAB-project (Ultra Light Steel Auto Body), which has inspired the company strategy towards a higher ratio of high strength steels.

SSAB Tunnplåt is to a great extent utilising the possibilities given by the very pure Swedish iron ore. The strategy to increase the ratio of high strength steels, being energy efficient in its utilisation, is well supported by existing process route. The localisation, close to the ore mines and far from highly populated areas where scrap is generated, are strong arguments to continue with the ore
based steel production. Internal scrap, as well as external local scrap is today re-circulated via addition into the BOF, without any negative influence on product quality, minimising transportation of iron units. The virgin scrap, from the first life cycle of the SSAB products, also gives pure iron units when being recovered in European EAF’s, close to the customers.

**Long term solutions**

Long term solutions to the global CO2-emission problem can hopefully be developed in the joint European ULCOS project. Of special interest for SSAB are:

- Full oxygen blast furnace operation, combined with CO2-washing of the top gas and recirculation of reducing gas. The proposed process has a potential to substantially reduce CO2-emissions from the blast furnace and also opens up for capture and storage of the isolated carbon dioxide.

- Production of pre reduced iron by natural gas, close to the gas field, opens up a great possibility for capture and storage of carbon dioxide within the gas field. The pre reduced iron, almost without any CO2 backpack, can be used in EAF, BOF or BF, leading to substantially reduced CO2-emissions.

**6 DISCUSSION AND CONCLUSIONS**

There are today no new smelting reduction processes, either established or under development, that will lead to a substantial reduction of carbon dioxide emissions from the iron- and steelmaking. New process concepts under development are mainly focusing on usage of cheaper raw materials.

A change towards scrap based production would strongly reduce the emissions of carbon dioxide. On the other hand, EAF-steelmaking in Luleå is not possible, due to the production of high strength steels, as well as a limited availability of scrap.

Among integrated steel plants, SSAB Luleå Works has the lowest CO2-emissions, mainly due to usage of 100 % LKAB-pellets, which have low emissions in their production, due to the chemical energy in magnetite ore, and gives an energy efficient blast furnace operation, with an outstanding low slag volume.

Energy saving investments, like hot stove preheating or top pressure recovery, have only marginal effects on CO2-emissions.

An analysis of potential possibilities to reduce CO2-emission from the steel production in Luleå shows that improvements in process optimisation, improved balance in liquid flow and higher yields, gives the strongest effect. Slag granulation, followed by slag cement production would substantially decrease the emissions. This reduction will take place at the location of the cement producer.

For the long term solution to the problem with huge emissions of carbon dioxide from the steel production, a giant joint European research program is starting up, involving almost the whole European steel industry, in cooperation with suppliers, research institutes and universities.
REFERENCES


