INNOVATION POTENTIAL IN THE REDUCTION OF ENERGETIC COST IN THE STEEL PRODUCTION

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Abstract
The metallurgical industry is the branch with the largest energy consumption in the world. Currently, energy represents around 20% of the total cost of producing steel and the number is still rising.

Over the last few decades, the steel production achieved several significant improvements regarding the lowering of energy intensity. For all technological changes the following ones can be mentioned: continuous casting and thin sheet metal production. The research capacities of the sector have been obviously intensive and successful and at the same time the research activities have been supported by both the private and the public sector, so a further development and improvements may be expected.

According to the report of American Iron and Steel Institute, there are three ways how to achieve savings in energy consumption. The first one is the implementation and continual improvement of currently known technologies, the second one results from stronger and systematic research and development (R&D) activities focused on the radical improvement of current technologies and the third one stands on the research and development of quite new technologies, production processes or energy sources. In the innovation terminology the three ways represent incremental, radical and systematic innovations.

The paper focuses on analysing of all three ways with the aim to bring a comprehensive and actual review of the R&D activities as a kind of opportunities not only for Czech companies.

Keywords: energetic sources, metallurgy, innovation potential

1. ENERGY USE IN STEEL INDUSTRY

Energy conservation in steelmaking is crucial, to ensure the competitiveness of the industry and to minimise environmental impacts, such as greenhouse gas emissions. Steel is also essential for energy production and transmission and saves energy over product life cycles through its light-weight potential, durability and 100% recyclability. Recycling meets the idea of permanently sustainable development, not only from ecological, but also from economic point of view [1]. In 2007, 1.3 billion tonnes of steel were produced. Production levels are expected to double by 2050 to meet the growing demand for steel around the world [2].

The strengthening competition from India and China, the demand decrease of fundamental steel consumers as the recession result, the rising prices of energy inputs as well as the fluctuation of their supplies and last but not least the strengthening environmental pressures, these all factors force steel producers to seek more intensively for savings in their energy consumption. The following facts represent information inputs for future possible innovations in energy savings:

1. Energy constitutes a significant portion of the cost of steel production, from 20% to 40% in some countries. Thus, improvements in energy efficiency result in reduced production costs and thereby improved competitiveness.
2. The energy efficiency of steelmaking facilities vary depending on production route, type of iron ore and coal used, the steel product mix, operation control technology, and material efficiency.

3. Energy is also consumed indirectly for the mining, preparation and transportation of raw materials, including: coal, iron ore, recycled steel and limestone (about 8% of the total life cycle energy required to produce the steel).

4. About 95% of an integrated facility’s energy input comes from solid fuel (mainly coal), 3-4% from gaseous fuels and 1-2% from liquid fuels [2].

![Diagram showing energy savings](image)

So what are the ways to lower the energy consumption? For example in 2005 USA set a program with the goal to develop new steelmaking technologies which will take steel production from approx. 330 liters to 138 liters of oil/t of crude steel in 2025. Such significant savings required transforming the steelmaking process (see Fig. 1). Fig. 1 also shows, that only a small portion of this reduction process could be achieved by the implementation of already known practices [white area]. The rest of the column (energy savings) may be achieved only by innovation and research into todays processes (yellow and green area) and more even in completely new processes (red area) [3].

2. KNOWN AND IMPLEMENTED TECHNOLOGIES FOR ENERGY SAVINGS

Improvements in energy efficiency have led to reductions of about 50% in energy required to produce a tonne of crude steel since 1975 to 2005 in most of the top steel producing countries as a result of for example:

- Intense sharing of best practices throughout each region
- Improved recycling of steel-containing products and quality of recycled steel
- Improved use of by-products from steelmaking and yield increases [2]
From more concrete technologies that somehow in the end save energy in metallurgical processes and have been already successfully implemented the following ones can be mentioned [6, 7]:

- powdered black coal injections to blast furnaces as well as intensification by oil, plastic or natural gas by their blasting through the tuyères,
- O₂ blasting into the EAF furnaces,
- melting by electric heating,
- refining technologies outside of melting unit,
- utilization of partly sewage sludge, silage, sawmill wastes or another waste could as a fuel at the fluidised bed boilers in the energetics in the metallurgical plants. This heating technology has been already verified in the TŠ nec Iron and Steel Works and can serve as example for next innovative cases),
- flexibility of the ratio scrap/pig iron in the steelmaking charge.

Intensification technologies are important mainly for satisfaction of metallurgical demand, quality or flexibility of production assortment. In the final result they bring profit in the form of primary raw material savings as well as in the production cost decrease [7].

More specific locations of some already known and well verified innovative solutions follow.

Sinter Plant

For the improvement of sinter plants there are actual and some already inaugurated techniques such as the preheating of sinter mix by steam decreases coke consumption and increases permeability. The steam will be produced by heat recovery from the sinter cooler and the energy requirement will be reduced by up to 10%. The Low-Emission Technology is based on the selective recycling of exhaust gas and the recovery of heat and residual fuel value of exhaust gas. It leads to a degradation of pollutants and a conservation of sinter quality.

Cowper Heating

Also conventional Cowper stove was improved in the last years. First of all, the heat recovery with several different systems leads to an increasing efficiency of hot blast production. Recuperative systems, burners or BF gas fired preheaters for combustion air and gas reduce the fuel consumption. New burners enable the use of weak gas, the new design leads to an ideal mixture of gas and air inside the combustion shaft, the homogenous combustion atmosphere avoids CO-emission. In combination with the preheating systems as well as with the exact and fast gas mixture control a high hot blast temperature is reached with a minimum of rich gas.

Steel Plant

Within steelmaking an important control parameter with relevance for energy consumption is the adjustment the target casting temperature of liquid steel. To avoid an unnecessarily high energy input for example in the BOF, which has to be lowered during ladle treatment by cooling scrap addition, a system for through-process prediction of temperature evolution within the complete steelmaking route has been developed. Depending on the thermal status of the tapping ladle, the control system adjusts the target BOF tapping temperature so that further temperature control actions during ladle treatment are minimised. The average BOF tapping temperature was thus decreased by 10 K, leading to energy savings of about 5 kWh / ton of liquid steel.
Reheating Furnaces

The greatest energy savings at reheating furnaces in rolling mills are based on the optimization of heating and heat recovery systems. With thermal regenerators the heat of waste gas is recovered and by preheating the combustion air up to 1.000°C the fuel consumption is reduced about 10-40 %, depending on the kind of furnace and the waste gas temperature [4].

3. TECHNOLOGIES IN RESEARCH AND DEVELOPMENT

Among some more concrete further improvements that are necessary and already under researchers’ attention belong [6, 7]:

- Usage of BF Gas in high temperature plants as reheating furnaces, by preheating gas and air up to nearly 1.000°C,
- Combination of high quality standards for heat treatment with energetic improvement measures, e.g. for the production of high quality surfaces as in galvanising lines,
- Automatic plant inspection and monitoring system, automatic diagnostic system,
- Advanced control system for reheating furnace and rolling mill,
- Thermo-mechanical treatment (in rolling mills),
- Units for direct heat saving and elimination of temperature decrease (coil-box or encopanel in the strip rolling mills),
- Selective local reheating of semi-finished products before finishing rolling,
- DRI as selective use of energy coal and decrease of coke consumption (more on DRI opportunities lower),
- Coupling ironmaking and steelmaking processes to energy generation and thereby making maximum use of the chemical energy and thermal energy by-products of iron and steelmaking; direct connection of continues casting and rolling.

Some of the technologies have been already applied in modern metallurgical plants but most of the steel producers still operate without them because it doesn’t pay to implement the new technologies into older plants. Those producers can verify on experiences of the already applied technologies their return and do research with more concrete (verified) data. As for more specific locations of potential innovations, the following should be in the focus of further research:

New Blast Furnace Concept (Oxygen Blast Furnace)

As the blast furnace is the main source of CO₂ it is clear that the main target is the reduction of carbon carriers, especially the coke, in the blast furnace process. A large project in Europe is the so-called ULCOS project (Ultra Low CO₂ Steel making), which evaluates biomass, electrolysis, hydrogen use, natural gas use for steel making but also the massive carbon reduction in the blast furnace.

Use of Coke Oven Gas for the Production of DRI

Another potential efficiency improvement refers to the alternative utilization of coke oven gas. Generally, a coking plant is linked with the interconnecting network of an integrated iron and steel works. Excess coke oven gas is internally used by other steel works consumers for heating of sinter plant ignition furnaces,
pusher type heating furnaces in rolling mills and for electric power generation in power plants. As a result of measures aimed at optimizing the energy consumption of integrated iron and steel works production systems, there partially is coke oven gas in excess which must be internally and externally used for power generation in a power station. The profit depends on the regional electric power prices [4].

4. CHALLENGES FOR FUTURE RESEARCH AND DEVELOPMENT

At the present time there is a serious problem of exhaustion of existing kinds of energy sources, such as oil and gas. It is become actually researching and working out of practical method for reception [4]. Approaches towards less energy intensive steel production (low-carbon ironmaking and steelmaking) could involve:

- Developing new processes having lower energy intensity, or new technologies that enable improved energy performance for existing processes. This includes technologies that can take advantage of the energy currently lost in existing processes. Alternative approaches may include:
  - Avoiding of heating/cooling steps.
  - Further reduce of the required temperatures (semi-hot forming).
  - Application of biotechnological processes in the branch of raw material preparation
  - Recovering and applying heat at high temperatures.
  - Developing processes having lower carbon intensity or that use renewable forms of carbon.

The steel industry can also develop technologies to transform the industry so it generates its own fuels or uses alternative fuels as they are developed by others. Such strategies can greatly reduce the use of natural gas an important national and industry goal. This requires making better use of the hydrocarbon fuels that are already in use, weaning itself away from its dependence on hydrocarbon fuels, and finding ways to sequester the greenhouse gases produced. In all likelihood, there will be no single technology that will accomplish all that is needed, but a combination of technologies [3]

Alternative fuels that could be substituted into the steelmaking process:

1. Hydrogen, as it becomes available could be used to reduce iron ore or as a fuel in furnaces and transportation equipment. The steel industry is a producer of hydrogen in its cokemaking facilities and blast furnaces.
2. Electrolytic winning of iron from iron ore and electro-refining of iron is a possible alternative to the blast furnace and BOF and EAF furnaces.
3. Biometallurgical processes may become feasible.
4. Consumer waste products such as garbage, plastics, waste oils, tires, auto fluff etc.
5. Coal gasification or liquefying technologies which should be explored to manufacture syngas from coal on site at a steel plant [3].

5. CONCLUSION

Tough world competition and open economy force metallurgical companies to provide better products and services for lower prices. Relying on ad hoc improvements are no more effective; it is necessary to be one step ahead, i.e. be actively searching for innovation stimuli.[9] Over last few decades steelmaking processes
have optimised energy use significantly but there are left many opportunities for further savings. Some innovative and efficient technologies have been already implemented and verified in many more developed metallurgical companies and so their application means for many out-dated steel plants worldwide a surest way how to innovate incrementally without a huge R&D investments. Other innovative solutions for energy savings are already in the phase of intensive R&D and were implemented in a few most modern plants. And the third group of innovations waits for more focused exploration and so most risky R&D investments as their possible return is in dispute. But only such breakthrough technologies are expected to lead to major energy savings, with a time frame of ten, twenty years and beyond.

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Acknowledgement
The work was supported by the specific university research of Ministry of Education, Youth and Sports of the Czech Republic No. SP2011/27.