Education and Culture DG

Lifelong Learning Programme

ESTEP

GT VET
Greening Technical VET – Sustainable Training Module for the European Steel Industry

Industry Driven Job Requirements Roadmaps and strategies documents for the European steel industry

Project Meeting Gliwice
7th and 8th of July 2011

sfs tu technische universität dortmund

Education and Culture DG
Lifelong Learning Programme

ESTEP

Introduction

- The goal of this analysis is to research what is the future for steel sector at all and especially for European one
- Development of steel sector is inseparable linked to sustainable development what for GT VET project means that it will tend to minimize the nuisance to the environment
- Metallurgical production is responsible for emission of greenhouse gases directly (from production processes) and indirectly (using e.g. a lot of the electricity by manufacturing of which massive greenhouse gases emission occurs)
- Processing emission of CO_2 in European steel industry is almost at the lowest level coming from stoichiometry
- The small reserve in direct (processing) emission and indirect by decreasing energy consumption and simultaneously increasing energy consumption efficiency is not sufficient
- The significant progress in minimizing the nuisance to the environment is linked with implementation of breakthrough technologies - **in the range of environmental sustainability breakthrough technologies are responsible for future shape of the sector**

sfs
technische universität dortmund

Education and Culture DG

Lifelong Learning Programme

Introduction (continued)

- Unfortunately steel sector does not have a document about its development prepared with foresight methods. The lack of this kind of the technological forecast is only partly replaced by other documents
- Documents selected to be analyzed:
  1. European Steel Technology Platform - Vision 2030, Report of the Group of Personalities, March 2004
  2. Technology Roadmap Research Program for the Steel Industry, American Iron and Steel Institute, Final report, December 2010
  3. 2008 Sustainability Report of the world steel industry, worldsteel Association
  4. Steel's contribution to a low carbon future - worldsteel position paper, worldsteel Association
  5. 21st Century Steel, 2008-2009 Update, worldsteel Association
  6. A European Recovery Plan, Communication from the Commission to the European Council, Brussels, 26.11.2008, COM(2008) 800 final
  7. Manifesto of the European Steel Industry for the European Commission 2010-2014, EUROFER, *European Commission, European industry in a changing world, SEC (2009) 1111, pages 181-188*
  8. Manifesto of the European Steel Industry for Members of the European Parliament 2009 – 2014, Eurofer,
  9. The European Steel Industry's Contribution to an Integrated Product Policy, Final Report, EUROFER
  10. Combating Climate Change, a Global Approach to Foster Growth, Competitivity, and Innovation for European Steel, EUROFER
  11. Jeroen de Beer, Ernst Worrell, Kornelis Blok, FUTURE TECHNOLOGIES FOR ENERGY-EFFICIENT IRON AND STEEL MAKING, Annu. Rev. Energy Environ. 1998 . 23:123–205

Introduction (continued)

12. Dr. Gunnar Still, Corporate Coordinator Environment and Climate, Dr. Hans-Jörn Weddige, Head of Corporate Climate Policies, The Future of Steel - Basic Principles and General Lessons, ThyssenKrupp Steel Europe, presentation for OECD Meeting, 10.12.2009
13. Clean steel a blast from the future (Steel, Cement & Paper - Identifying the breakthrough technologies that will lead to dramatic greenhouse gas reductions by 2050) – Report, http://www.steelguru.com/ 08/03/2011
14. Gudenau H.W., Senk D., Banich A., G. Bottcher G., Frohling C., Kweon O. S., Wang S., Wieting T., Sustainable Development in Iron- and Steel Research, CO_2 and Wastes, ISIJ International, Vol. 44 (2004), No. 9., pp. 1469-1479
15. Birat J.-P., Alternative ways of making steel: retrospective and prospective, Revue de Metalurgie, No. 11, 2004, pp. 937-955
16. Birat J.-P., Innovation paradigms for the steel industry of the 21st Century. Future directions for steel industry and continuous casting, Revue de Metalurgie, No. 11, 2002, pp. 958-979
17. Birat J.-P., Lorrain J.-P., de Lassat Y., The CO_2 tool: CO_2 emission & energy consumption of existing and breakthrough steelmaking routes, Revue de Metalurgie, No. 9, 2009, pp. 325-336
18. Birat J.-P., Lorrain J.-P., The cost tool: operating and capital costsof existing and breakthrough routes in the future studies framework, Revue de Metalurgie, No. 9, 2009, pp. 337-349
19. Issues behind Competitiveness and Carbon Leakage - Focus on Heavy Industry, IEA Information paper, Julia Reinaud, International Energy Agency, © OECD/IEA, October 2008
20. Breaking through the technology barriers and Overview of the CO2 Breakthrough Program and Linkage to worldsteel, worldsteel Association, Fact sheet; Sharif Jahanshahi, CSIRO – Minerals Down Under National Research Flagship; John Mathieson, BlueScope Steel Research; CSRP’08 Conference, 18-19 November 2008, Brisbane

Analysis

- Environmental issues and the development of new steel solutions for many applications will necessitate the implementation of new production routes. In this respect, breakthrough technologies will be particularly important and, as a consequence, a large effort in R&D and innovation will be required. The issues of security and competence of human resources must also be developed in parallel with these activities [1]
- Breakthrough technologies considered in [1]:
  - meaningful progress in the reduction of CO_2 emissions requires new approach and breakthrough technologies for reduction of iron - this idea has led to the initiative of ULCOS project (Ultra Low CO_2 Mitigation), in which the most promising technologies are studying in detail and testing on a pilot scale
  - thin strip casting
  - breakthrough concepts in annealing and coating operations - much more compact lines for continuous annealing and hot dip galvanising
  - new technologies for heating and cooling steel strip in a fast and controllable way
  - intelligent manufacturing - where conventional technologies are mature and robust enough to guarantee stable performance, intelligent manufacturing technology should contribute to developing more flexible production processes

Analysis (continued)

- The purpose of the programme [2] was to save energy, increase competitiveness and improve the environment
- Breakthrough technologies considered in [2]:
  - increasing the level of pulverized coal injection (PCI) into blast furnace
  - alternative ironmaking processes:
    - suspension reduction of iron ore concentrates using hydrogen
    - molten oxide electrolysis
    - paired straight hearth furnace
  - sustainable steelmaking using biomass and waste oxides
  - sequestration of CO_2 by hydrous carbonate formation with reclaimed slag

Analysis (continued)

- The most promising breakthrough concepts to date include [3]:
  - recycling blast furnace top gas after decarbonising and further CO_2 storage (proposal of the ultra-low carbon dioxide steelmaking (ULCOS) programme),
  - smelting reduction and direct reduction with oxygen use and CO_2 capture and storage,
  - electrolysis of iron ore,
  - use of hydrogen produced from CO_2 - lean sources,
  - use of sustainable biomass
- One of the examples of breakthrough technology is FINEX which is an innovative and eco-friendly iron-making process [3]. As the world's first commercialised smelting reduction technology, FINEX opens a new chapter in steel production. With FINEX, the sintering and coke making steps are eliminated. This removes two steps compared to the conventional blast furnace (BF) method. The shorter process leads to lower costs and fewer pollutants

Analysis (continued)

- EUROFER [10] believes ETS requires a fundamental review because the current arrangements are not working
- Problems with current ETS are as follow:
  - flaws in its conception,
  - it is failing to tackle world emission at their source,
  - ETS leads to export of CO_2 emissions to non-ETS countries,
  - ETS distorts competition in the global steel market,
  - the present ex-ante allocation system is impractical and distorting,
  - no penalties for underperformance and no incentives for innovation
- EUROFER proposes the Baseline and Credits system, which is the weighted average of emissions per ton of production for the sector. This would serve as the basis for the allocation of allowances per plant. The performance of each plant is compared against the baseline. If they perform worse than they must pay for allocations traded from operators performing better than the baseline. The price of these allocations will be set higher than the cost of investments in efficiencies. There is therefore a clear incentive to invest in efficiencies. As efficiencies take hold, the baseline or sector average of emissions will move down, which will drive further investments in improvements. So, the allocation system, which will be ex-post, will be truly performance-based with a clear discipline to improve performance.

Analysis (continued)

- In the paper [11] the potential for the improvement of energy efficiency in the iron and steel industry that can be realized in the long term was analyzed
- On the basis of the results of this analysis, it was concluded that long-term energy-efficiency improvement should be directed toward reducing these losses by:
  - avoiding intermediate heating and cooling steps;
  - reducing the temperature required in various process steps;
  - recovering and applying heat at high temperatures.
- Breakthrough technologies considered in [11]:
  - smelting reduction processes, which avoid coke making and ore agglomeration and on near-net-shape casting techniques, which avoid or reduce the need for reheating before rolling – reducing specific energy consumption (SEC) from the current best-practice (blast furnace – converter) figure by 35%;
  - direct reduction (DRI) has a lower energy requirement than reduction of ore in a smelting reduction (SR) process, mainly because melting is avoided. However, subsequent melting in electric arc furnace (EAF) remains necessary to shape the steel – production of steel in the DRI-EAF route reduces (SEC) from the current best-practice figure by 25%;
  - more efficient melting furnaces, more efficient casting and shaping techniques, and assuming a 60% efficiency of electricity generation may reduce (SEC) from the current best-practice figure by 50%

Analysis (continued)

- Breakthrough technologies identified in [13]:
  - ULCOS
  - Blast Furnace top gas recycling - greenhouse gas emissions are reduced if CO_2 is sequestered and can lead to up to a 50% reduction compared to the current EU average specific emissions; the technology is expected to be ready for market deployment by 2020
  - Fastmelt process - technology that uses a complete redesigned blast furnace in the form of a rotary hearth furnace that is more efficient in reducing iron ore; CO_2 emissions are 55% lower when the process is combined with Carbon Capture and Storage (CCS); Fastmelt process without CCS is on the verge of market deployment
  - electrolysis - would reduce iron-ore by electricity; this theoretically allows for complete carbon neutral steel production (if the applied electricity is produced without generating CO_2 emissions); the technology is still in the early stages of development and might require another 20 years of development before the first commercial scale production facility could become operational
  - Hisarna coke free steelmaking – technology being developed and piloted by the ULCOS project; *w*ith respect to environmental performance, implementation of Hisarna technology is expected to yield a CO_2 reduction of 20% compared to the average blast furnace in Europe; when combined with CCS, reductions of up to 80% of emissions are expected to be achievable

Analysis (continued)

- In 2003, the World Steel Association (worldsteel) launched the “CO_2 Breakthrough Programme”, an initiative to exchange information on regional activities all over the world [20]. Five possible directions are under examination to develope breakthrough technologies:
  - Coal - would continue to be used as a reducing agent but the ensuing CO_2 would have to be captured and stored
  - Hydrogen - could be used as a reducing agent, as its oxidation produces only water
  - Electrons - could also be used as reducing agents. They can be provided by electricity, for which the corresponding process is the electrolysis of iron ore, or by bacteria. The EU and the US are exploring only the first path, as bacteria that fully reduce ore to metallic iron have not been identified. Electricity in this case would be produced using carbon-lean technologies
  - Biomass - can be used to generate the reducing agent, either from charcoal for example or syngas. Biomass in such a scheme would need to be grown in a sustainable way, but can originate from plantations in tropical countries or from agriculture or forestry residues in more temperate climes. Interest in biomass is strong in Brazil, Australia, Canada and Europe. Biomass can be used in charcoal-based blast furnaces, added to the coke oven charge, burned as fuels in steelmaking reactors or used in direct reduction as syngas, etc.
  - CCS - use of carbon capture and storage technology is a necessary precondition to the continued use of fossil fuel based reducing agents in steel production

Analysis (continued)

- Content of the Major Programs realized within framework of “CO_2 Breakthrough Programme” [20]:
  - ULCOS (Ultra Low CO_2 Steelmaking) (Europe):
    - Nitrogen-free BF with top gas recycling,
    - HISARNA – direct smelting-reduction of iron ore,
    - Electrolysis based steelmaking,
    - H_2 based pre-reduction for EAF;
  - COURSE50 (CO_2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50) (Japan):
    - CO_2 capture systems (CCS),
    - H_2 reduction based ironmaking;
  - POSCO (Korea):
    - Prereduction of, and heat recovery from hot sinter,
    - CO_2 absorption using ammonia solution,
    - CO_2 fixation using marine bio-slag,
    - H_2 production and carbon-lean ironmaking process;
  - AISI (American Iron and Steel Institute) (USA):
    - Flash smelting of iron ore using hydrogen reduction,
    - Steelmaking by molten oxide electrolysis.

Lifelong Learning Programme

Summary

- Steel will continue to be needed and used by mankind long into any foreseeable future. Indeed, no material yet in history has proved as sustainable as iron and steel and there is no sign of any emerging material that can compete with it at a global scale [15]
- The steel industry would need technologies that have the potential of reducing GHG emissions by the "factor 4" that European governments are setting as targets for 2050 and this will make it necessary to re-examine this efficient mainstream steelmaking technologies of today and refocus them on lowering GHG gas emissions while maintaining the same energy efficiency level. There are currently three ways of addressing this question:
    - One consists in staying close to the carbon-based blast furnace technology and to ensure that the ensuing CO_2 is captured and sequestrated; this would lead to deep changes in process in order to make CO_2 capture easier to achieve, such as recycling the BF top gas after decarbonatation and thus operating the furnace under nitrogen-free conditions
    - Another solution would consist in replacing carbon by other reducing agents and fuels, such as natural gas, hydrogen or electricity. This might open the way to using electrolysis for producing steel, a proposal that was never seriously examined in the past because of the high cost of electricity. On the other hand, electricity or hydrogen would have to be produced by dedicated generation plants based on CO_2-free fuels, i.e. renewables, fossil fuels with CO_2 capture and sequestration or nuclear
    - A third solution would be based on the use of biomass, which contains "short-cycle" carbon and would not contribute to GHG emissions because a steady-state production of biomass by agriculture or forestry would be included in the carbon loop

technische universität dortmund

Summary (continued)

- The blast furnace, even at a distance of 50 years in the future, remains at 59% of the ore routes, although all presently existing coke ovens will have been closed by then. This implicitly assumes that conventional integrated mills will still be built in the next 10 to 15 years, before any credible alternative is actually developed [16]
- The forecasted „green" development of iron making technologies means that the work, among others, mechanical and electrical technicians would changed. Blast furnaces might be partially replaced by other more or less similar installations. New skills for operating and maintenance staff would be required.
- Less „green" changes could be expected in steel making technologies. Converters technology seems to be without implementing and breakthrough technologies. In electric steel making process new – more efficient – furnaces could be installed. Some development of skills for operating and maintenance staff would be required.
- At the level of hot rolling process the „green" changes are rather not much expected. Some changes with heat recovery ore avoiding intermediate heating or cooling could be observed. Skills for operating and maintenance staff would be continuously updated.