ISSN 0543-5846
METABK 50(3) 205-208 (2011)
UDC – UDK 502.72:669.12:669:18=111

SIGNIFICANCE OF ENVIRONMENTAL LIFE CYCLE ASSESSMENT (LCA) METHOD IN THE IRON AND STEEL INDUSTRY

Received – Prispjelo: 2010-06-21
Accepted – Prihvaćeno: 2010-10-25
Review Paper – Pregledni rad

The following paper contains importance of LCA in the iron and steel industry. The metallurgy sector is highly energy intensive and the production of crude steel is associated with significant CO_2 emissions. ULCOS (Ultra Low CO_2 Steelmaking) is the world's initiative to reduce carbon dioxide emissions by 50 % by 2 050 compared with today's best routes from steel production by developing new breakthrough technologies. A new environmental Life Cycle Assessment (LCA) method has been undertaken in ULCOS as the most holistic approach of assessing environmental impact and selecting new technologies. Usage of LCA enables to compare alternative metallurgical technologies.

Key words: Life Cycle Assessment, ULCOS, iron and steel industry

Značaj ekološke metode procjene životnog ciklusa (PŽC) pri proizvodnji željeza i čelika. Ovaj rad prikazuje važnost metode procjene životnog ciklusa (PŽS) u proizvodnji željeza i čelika. Metalurgija zahtijeva velike količine energije i proizvodnja čelika je povezana sa značajnom emisijom CO_2. Vrlo niska emisija CO_2 u proizvodnji čelika (VNECO$_2$PČ) je svjetska inicijativa da se razvijanjem novih tehnologija do 2 050 smanji sadržaj CO_2 na 50 % u odnosu na današnje najpogodnije postupke. Nova ekološka metoda procjene životnog ciklusa je sastavni dio projekta vrlo niske emisije CO_2 u proizvodnji čelika omogućuje holistički pristup procjene utjecaja na okoliš i odabira novih tehnologija. Korištenje procjene životnog ciklusa omogućuje usporedbu alternativnih metalurških tehnologija.

Ključne riječi: Procjene životnog ciklusa (PŽC), vrlo niska emisija CO2 u proizvodnji čelika (VNECO$_2$PČ), željezna i čelična industrija

INTRODUCTION

From a few years steel plants introduce cleaner technologies, BAT (Best Available Techniques) and environmental methods: LCA (Life Cycle Assessment), Cleaner Production and Ecodesign.

LCA is an environmental assessment method for evaluation of impacts that a product, process or technology has on the environment over the entire period of its life – from the extraction of the raw material through the manufacturing, packaging and marketing processes, the use, re-use and maintenance of the product or technology, to its eventual recycling or disposal as waste at the end of its useful life. LCA can assist steel plants in the environmental management [1,2]. LCA is a method of the evaluation of environmental aspects and potential impacts associated with all stages of the life of product, process and technology. The LCA method consists of four phases [3]:

1. Goal and scope definition
2. Inventory analysis LCI (Life Cycle Inventory)
3. Impact assessment LCIA (Life Cycle Impact Assessment)
4. Interpretation

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World Steel Association leads perform of LCA analyses in the metallurgical sector [1]. Life Cycle Assessment (LCA) is undertaken as the most holistic approach for evaluation environmental impact and selecting new technologies to reduce emissions for iron and steel industry.

APPLICATION LCA IN STEEL INDUSTRY

The researches in the world steel industry underline importance of LCA for environmental assessment. Life cycle of steel is presented in Figure 1.

Iosif et al. [2] proposed methodological framework based on the interconnection between the environmental LCA and the process simulation software Aspen PlusTM (Advanced System for Process Engineering). Aspen PlusTM is a process engineering software package that is used to simulate processes based on the thermodynamic models, properties of materials and several ready-made unit operation models. This research could be used for modelling new steelmaking breakthrough technologies for environmentally friendly production of steel. Summary of the European integrated steel plant LCI calculated by the Iosif's model [2] is presented in Table 1. Functional Unit (FU) is quantified performance of a product system for use as a reference unit [3].

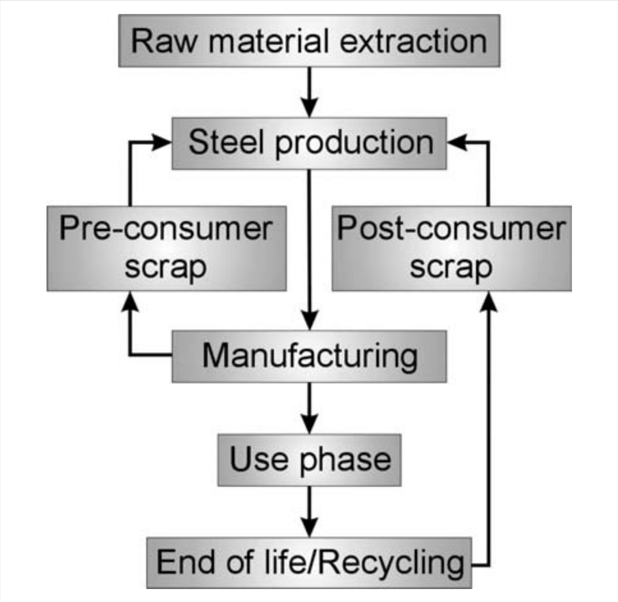

Figure 1 Life cycle of steel [4]

LCA in analysis of metallurgical processes is acting as part of International World Steel Association (Worldsteel). The World Steel Association has released its 2 010 global steel Life Cycle Inventory (LCI). The datasets provide the most accurate and comprehensive data on the environmental profile of 16 key products, representative of the spectrum of steel production. The LCI datasets are used for material selection and product design. The data enables a full life cycle approach to be utilised when determining the environmental impact of steel-containing products, including their carbon footprints. It is used in LCA studies that guide the development of environmental standards and regulations, and helps manufacturers in compliance and voluntary improvement initiatives [4]. LCA can be used for environmental assessing of processes, to compare products carrying out the same function and to provide information for their choice between different products.

Zhang et al. [5] compared LCA on steel and concrete-construction office building and it was found that the life-cycle energy consumption of building materials per area in the steel-framed building was 24,9 % as that in the concrete-framed building, whereas, on use phase, the energy consumption and emissions of steel-framed building are both larger than those of concrete-framed building. As a result, lower energy consumption and environmental emissions were achieved by the concrete-framed building compared with the steel-framed building on the whole life-cycle of building.

LCA IN ULCOS

The European Steel Industry has created a consortium of industries and of research organizations that has taken up the mission of developing the breakthrough technologies – the ULCOS (Ultra-Low CO_2 Steelmaking). The consortium develops a breakthrough steelmaking process that has the potential of meeting the target of reducing GHG (Greenhouse Gas) emissions. The ULCOS project is today the largest endeavour within the steel industry worldwide, proactively looking for solutions to the threat of global warming [6]. LCA analyses are performed in the frame of ULCOS project in the purpose of assessing of the influence of metallurgical processes on the environment and choice of new technologies [7,8,9]. According to ULCOS interconnection between LCA and Aspen Plus is a powerful tool in the selection of new technologies for environmental friendly steel production [2].

Table 1 **Summary of the integrated steel plant Life Cycle Inventory (LCI) calculated by the model [2].**

Materials inputs		
Identification	Unit	Quantity
Iron ore	kg / FU	1 321
Coal for coke-making	kg / FU	430
BF injection coal	kg / FU	154
Scraps	kg / FU	127
Pellets	kg / FU	139
Lime	kg / FU	40
Internal electricity	MJe / FU	884
Intermediates products		
Sinter	kg / FU	1 403
Coke	kg / FU	336
Hot metal	kg / FU	1 020
Liquid steel	kg / FU	1 077
Slabs/blooms	kg / FU	1 027
Coke oven gas	Nm^3 / FU	1 32
Blast furnace gas	Nm^3 / FU	1 478
Converter gas	Nm^3 / FU	82
Material outputs (by-products)		
Slag	kg / FU	423
Tar	kg / FU	10
Ammonium sulphate	kg / FU	4
Hot-rolled coil	kg / FU	1 000
CO_2	kg / FU	1 587
Sintering dust	kg / FU	1

FU: one ton of hot rolled coil

LCA OF STEEL IN AUTOMOTIVE INDUSTRY

Life Cycle Assessment (LCA) has been adopted by the steel industry as a means to comprehensively evaluate material choices, and their effect on life cycle GHG emissions. Major automakers use LCA as a tool for design and material selection decisions.

WorldAutoSteel performs LCA to demonstrate that Advanced High-Strength Steels (AHSS) and optimized vehicle design can reduce total life cycle GHG emis-

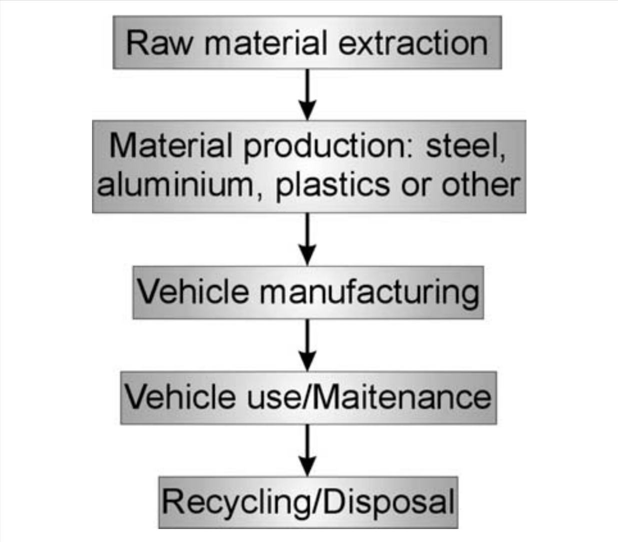

Figure 2 Life cycle of vehicle

sions while maintaining safety and affordability. Life cycle of vehicle is presented on Figure 2.

The steel industry has made significant reductions in its energy use and is committed to take positive action to achieve further reductions in CO_2 emissions. Material choice becomes more significant for vehicles using advanced powertrains and fuel sources.

Material constitutes an important role in a vehicle's total life cycle emissions. Steel produces five to twenty times less GHG emissions in the material production phase than other materials. Though some weight savings may be achieved using alternative materials which could lower use phase tailpipe emissions, the impact to the environment over the vehicle's total life cycle could be compromised. LCA helps auto-makers in evaluation and reducing the total energy consumed end the lifetime GHG emission of their products [4].

DEVELOPMENT OF LCA IN STEEL INDUSTRY

In 1 996 International Iron and Steel Institute (IISI) carried out a "cradle to gate" Life Cycle Inventory (LCI) study [10]. LCI is one of the phases of a Life Cycle Assessment. The Worldsteel launched its innovative worldwide Life Lycle Inventory study for steel products. This was the first time that an international LCI study of a specific material had been carried out. The study was updated in 2000 and the current dataset was released in February 2 010. The American Iron and Steel Institute (AISI) initiated a LCA program in 1 994. The program centers on training and education, conducting studies of steel products, participating in LCA projects which include steel, and promoting the development of LCA [11].

LCA is an internationally accepted methods for measuring the environmental impacts over the life cycle of a defined system. LCA perspective is used to analyze GHG emission in steel making process to take measures to reduce GHG and build sustainable steelmaking [12]. LCA can be used for a range of steelmaking routes, including conventional and emerging technologies [13].

Environmental aspects of future development metallurgy technology can be determine in dynamic LCA [14,15]. Dynamic LCA considers changes of technologies, which take place in future.

LCA FOR NATIONAL STEEL MILL

LCA for Polish steel mill was conducted in Central Mining Institute. Iron ore sintering process is the dominant emission source in steel mill. Burchart-Korol Š16Ć performed Life Cycle Assessment (LCA) in the iron ore sinter process. The calculations were made with the SimaPro 7.1 programme (Ecoindicator 99). Environmental impact assessment was made in the most important categories: „human health", „ecosystem quality" and „resources". Conducted analyses and the LCA application for the technology of sintering process showed that the most influence of this process is damage to "human health" caused by respiratory effects. Inorganic pollutants and dust from iron ore sintering process are related to respiratory effects.

CONCLUSION

Among the methods available to evaluate the environmental, economic and social performance of materials, technologies and products, Life Cycle Assessment (LCA) provides a holistic approach that considers the potential impacts from all stages of manufacture, product use and end-of-life.

LCA is used in iron and steel industry as a means to comprehensively evaluate processes, material choices and their effects on life cycle GHG emissions.

LCA of a steel product looks at resources, energy and emissions, from the steel production stage to its end-of-life stage, including recycling.

It is important to integrated environmental assessment and results of LCA into product design at an early stage to improve the environmental and economic performance of the product/technology.

Environmental Life Cycle Assessment study in iron and steel industry is widely developing in the world. This method can be used for selecting new optimal technologies or products. LCA is important methods using for environmental impacts assessment of current, alternative and future technologies in the iron and steel industry.

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Note: The responsible translator for English language is Niuans Translation Agency, Gliwice, Poland