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WATER SCARCITY ASSESSMENT OF STEEL PRODUCTION IN NATIONAL INTEGRATED STEELMAKING ROUTE

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The main goal of the study was the assessment of the water scarcity in steel production in integrated steelmaking route in Poland. The main goal of Water footprint (WF) is quantifying and mapping of direct and indirect water use in life cycle of product or technology. In the paper Water Scarcity Indicators (WSI) for steel production and unit processes in integrated steelmaking route was performed.

Key words: steel plant, water scarcity, water footprint, raw materials, Poland

INTRODUCTION

Water resources management is important for the iron and steel industry, but still in literature is an insufficient amount of study devoted to the environmental impact assessment. Up to now environmental life cycle assessment (LCA) of national integrated steel plant was performed [1] and laboratory tests of raw materials were focused on the preparation of raw materials for sintering [2].The effect of harmful additives in blast furnace was investigated [3]. Prediction of eco-efficiency (the environment and the economic effects) of many various technologies, including steel technology was presented in [4]. Water footprint (WF) is a new concept which allows quantification of freshwater appropriation The water footprint methodology was introduced by Hoekstra [5,6] as an indicator of freshwater appropriation, with the aim to quantify and map indirect water use and show the relevance of involving consumers and producers along supply chains in water resources management. Paper [7] showed importance of water footprint in steel supply chain. In Poland steel is produced by two process routes, the basic oxygen furnace (BOF) route and the electric arc furnace (EAF) route. According to World Steel Association [8] water management is one of the most important part of the steel industry's sustainability roadmap. The consumption of water for the steel production in integrated steelmaking route is 28,6 m^3 per tonne of steel produced and discharge of water is 25,3 m^3. The steel industry uses saltwater, brackish water and freshwater.

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APPLICATION OF WATER FOOTPRINT IN STEEL INDUSTRY

There are few studies containing the water footprint assessment in steel industry. The first comprehensive water footprint assessment was performed by Tata Steel [9]. It was analyzed the following kind of WF: the direct and indirect blue water footprints, direct grey water footprint, direct green water footprint. Other example of WF assessment for steel production was presented in paper [10]. It takes into consideration quantification a whole water footprint in steel production in United States. It was calculated three scopes for water use in steel production [11]. Each of the three scopes can be split into two categories: use and withdrawal. The process that was responsible for the largest portion of water use was the production of coke. The other study of water footprint for steel industry in Taiwan was performed by CSC appointed the Utility Department and Rolling Mill Department [12]. It was established the water consumption data for the steel coil process. Horie et al. [13] calculated the water footprint for basic oxygen furnace (BOF) and electric arc furnaces (EAF) crude steel and amount of water withdrawal for upstream life cycle until producing crude steel in Japan and China. It was determining the WF as the quantity directly water used (direct withdrawal), and the quantity indirectly water used (indirect withdrawal).

MATERIALS AND METHODS

In this study Water Scarcity Indicators (WSI) for each unit processes in integrated steelmaking route in Poland was calculated. The system boundary included the following unit processes in the steel plant under analysis: the iron ore sinter plant, blast furnace, lime production plant, basic oxygen furnace, continuous casting plant and hot rolling plant. A data inventory was obtained from existing steel plants in Poland. Data (input and output) were converted to functional unit (FU) cast steel. FU of this study was one ton of cast steel produced in the integrated steel plants. WSI included all external data used in the steel production process and wastewater. The wastewater from each process unit is submitted to a sewage treatment plant. In this paper the amount of water used to produce a steel with including direct and indirect water usage. Direct use is water that physically is used during a process, while indirect use is water needed to create something used in the process.

WF assessment methodology consists of four phases [6,14]: setting the goal and scope of the assessment, water footprints accounting, water footprint sustainability accounting and strategic water footprint response formulation. WF accounting stage includes the quantification and mapping of freshwater use with three types of water use [14]:

- blue water footprint - refers to consumption of surface and groundwater through evaporation, incorporation into the product or return flow to a different water body than from where it was drawn.
- green water footprint - refers to evapotranspiration by plants of rainwater stored in the soil as soil moisture.
- grey water footprint - refers to pollution and is defined as the volume of freshwater required to assimilate the load of pollutants to meet local ambient water quality standards.

Water scarcity, one of the environmental assessment aspect, is quantified as the ratio of water use to water availability. WSI is based on a consumption-to-availability ratio (CTA) calculated as the fraction between consumed (referred to as blue water footprint) and available water. The latter considers all runoff water, of which 80 % is subtracted to account for environmental water needs. The indicator is applied to the consumed water volume and only assesses consumptive water use [15]. The Water Scarcity Indicators were calculated with SimaPro 8 software and the Ecoinvent database 3.

RESULTS AND DISCUSSION

The studies of water consumption were conducted to explore the environmental aspects of steel production in terms of water footprint. The life cycle inventory of water use and wastewater in national integrated steel plant was presented in Table 1. The results of the water scarcity were presented in Table 2. A comprehensive life cycle inventory (LCI) of national steel production in the integrated steel plant was shown in paper [1]. In Table 1 was shown external flux (tap water and wastewater) and internal flux (circulating cooling water).

Quantification of Water Scarcity was performed according to Hoekstra et al [15]. The raw materials that contribute the most to indirect blue Water Footprint in integrated steel plants in Poland are iron ores, iron pellets, refractory, iron scrap, electricity and lubricant oil.

According to Figure 1 Basic oxygen furnace (BOF) has the largest Water Scarcity Indicator in the national integrated steel production route, while the continuous casting plant and lime production plant have the least WSI. The highest rate of WSI in BOF is associated with the largest use of tap water and refractory.

Table 1 **Direct water use and wastewater in integrated steel plants in Poland / m^3/FU**

Inputs and outputs	Input		Output
	Tap water	Circulating cooling water	Wastewater
Iron ore sinter plant	0	0,43	0,39
Blast furnace	0,35	23,08	0,20
Lime production plant	0	0	0,39
Basic oxygen furnace	90,60	0	1,12
Continuous casting plant	0,54	9,78	0,75
Hot rolling	13,27	1,40	1,42

Table 2 **Comparative analysis of Water Scarcity for steel production in Poland / FU**

Raw materials	Input data	Unit	Water Scarcity / %
Tap water	104,76	m^3	27,21
Iron ores	1 239,44	kg	16,64
Pellets	250	kg	14,08
Refractory	63,33	kg	11,68
Iron scrap	209,32	kg	9,81
Electricity	515,19	kWh	8,26
Lubricating oil	42,03	kg	8,23
Limestone	303,29	kg	2,84
Coke	13 070,8004	MJ	0,56
Dolomite	39,59	kg	0,35
Anthracite	6 46,9704	MJ	0,13
Coke oven gas	3 185,784	MJ	0,13
Coke breeze	1 769,1731	MJ	0,08

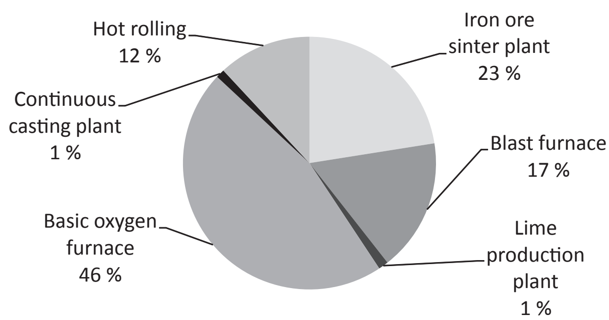

Figure 1 Water Scarcity in unit processes of integrated steel production in Poland.

CONCLUSIONS

In recent years water resources management has become one of the most important part of sustainable steel. This paper discussed the water scarcity of iron and steel technologies. This work was the first to account water scarcity for the entire steel production in integrates steelmaking route in Poland.

Water Scarcity of steel production in a national integrated steel plant was performed based on inventory data obtained from steel production results in Poland. It was found that the Water Scarcity were related direct with the tap water use, while the indirect Water Scarcity were related mainly to iron ores, iron pellets, refractory, iron scrap, electricity and lubricant oil.

The largest water scarcity in the entire steel production system occurred in the basic oxygen furnace system production, and the major source of water scarcity was the consumption of tap water and iron ores.

The results of this study offered a water scarcity of Polish steel production and could be used as the first step in performing a holistic water footprint of steel that includes all the stages of the steel life cycle.

This paper can provided practitioners and decision makers in the steel industry understand their water sources impacts and formulate and developing a comprehensive water management strategy to decrease water footprint.

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