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MODERN STATE OF IRON ORE MINING

Abstract. This article discusses the current state of iron and steel industry from the global perspective. The modern problems of iron ore mining are shown. The positive and negative impact of different factors on the iron ore and steel market is viewed. The tendencies in iron ore mining of the world's leading producer countries are shown. The current state of domestic iron ore mining is analyzed. The ecological concerns arousing from the usage of large amount of fossil fuels resulting in significant emissions of carbon dioxide in the steel industry are discussed. The solutions some countries are using to handle ecological problems of iron ore mining and transition to greener technologies in steel industry are viewed.

Keywords: mining, iron ore, steel industry, green technologies, ecological problem

Introduction. The iron ore mining industry is a typical key resource industry providing basic raw materials for the steel industry. It has long suffered from the pressure of market fluctuations and high production and distribution costs, mainly due to the lack of coordination and flexibility in decision making. To face the challenge, it is essential to make economic coordinated production and distribution planning decisions in the environment of supply chain [1].

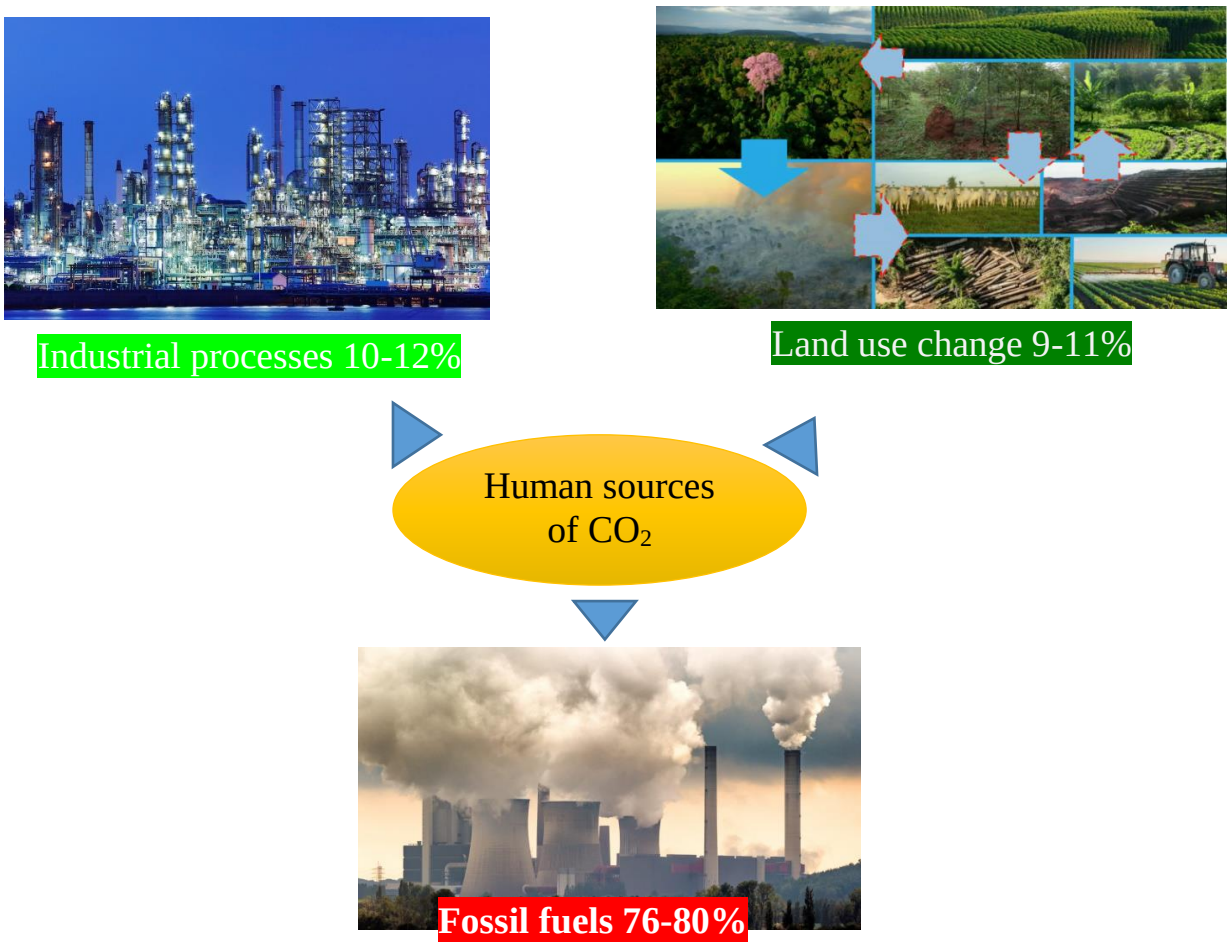

Figure 1. Human sources of carbon dioxide

There is also a concern about the negative environmental impact of the steel industry. It remains one of the main carbon dioxide sources and accounts for approximately 7% of global emissions of CO_2 [2], because the whole industry highly relies on fossil fuels [3]. Thus, the development and transition to green technologies is a crucial task for the whole iron and steel industry. Human sources of global carbon dioxide emissions are shown in Figure 1.

China remains the number one steel producer in the world. The country produced approximately 1050 million tons of steel in 2020. India and Japan are the next leaders with approximately 100 and 80 million tons production each in 2020 [4]. Other steel producing leader countries are shown in Table 1.

Table 1. **World leaders in steel production in 2020**

Country	Production (million tons)
China	1050
India	100
Japan	83
Russia	73
United states	72
South Korea	67
Turkey	36

Methods. Steel production can occur at integrated facilities from iron ore, or at secondary facilities, which produce steel mainly from recycled steel scrap. Integrated facilities typically include blast furnaces, and basic oxygen steel making furnaces (BOFs), or in some cases open hearth furnaces (OHFs). Raw steel is produced using a basic oxygen furnace from pig iron produced by the blast furnace and then processed into finished steel products. Pig iron may also be processed directly into iron products. Secondary steel making most often occurs in electric arc furnaces (EAFs). In 2003, BOFs accounted for approximately 63 % of world steel production and EAFs approximately accounted for 33 %; OHF production accounted for the remaining 4 % but is today declining [5].

Iron production can occur onsite at integrated facilities or at separate offsite facilities as discussed above under ‘Primary and secondary steel making’. In addition to iron production using a blast furnace, iron can be produced through a direct reduction process. Direct reduction involves the reduction of iron ore to metallic iron in the solid state at process temperatures less than 1000 °C [5].

The iron and steel industry broadly consists of:

- primary facilities that produce both iron and steel;
- secondary steel making facilities;
- iron production facilities;
- offsite production of metallurgical coke [5].

Results. Kazakhstan produced 15,1 million tons of iron ore in a period of January to April of 2020, in 2019 the production rate was 12,8 million tons for the same period of time. It accounts for 18% increase. Steel production in the same period of 2019 was 1515,2 thousand tons, and in 2020 it was 1206,6 thousand tons; thus, the production rate suffered decrease of 20% [6].

The continuous increase in steel production and consumption will bring about an increase in the industry’s energy use [7]. In 2017, the total energy demand of iron and steel sector grew to 33.44 EJ, which accounted for 21.4% of final energy consumption of the world industry [8]. The proportions by using fuels in world iron and steel sectors are presented in Fig. 4. It is indicated that coal serves as the primary fuel to generate coke and power, which accounts for the largest part (around 75%) [8,9], 9% of the final energy is consumed by natural gas which can effectively power

the process especially in the direct reduced iron (DRI) production, the rest of energy consumption comes from secondary energy i.e. electricity (12%), heat (3%), and other fuel gas and oil products.

In 2007, UK industry produced 15 Mt of steel and UK consumers purchased 20 Mt of steel goods, 13 Mt of which were imported. These intense trade flows reflect business options across different stages of the supply chain. In the UK, the automotive industry exemplifies the discrepancy between trade and domestic end-use consumption: around 80% of the vehicles assembled in the UK are exported, most of them manufactured with imported steel [10]. Such trade flows justify the need to look at both UK and the rest of the world steel activity, since the performance of both influences the overall impact of demand for steel goods [11].

The Swedish steel industry has long been among the most carbon emission efficient in the world [12] and thus the higher than average share of national CO2 emissions represents a comparatively large industry. CO2 emissions per ton of steel have dropped by approximately 10% in Sweden and globally since 2000 [13], but there is a fundamental limitation to further reductions from the blast furnace process arising from the fact that coke (made from imported fossil coal) does not only fuel the process but also acts as the reduction agent for reducing iron ore to iron and hereby causes so called "process emissions" [14]. Studies on the steel sector in Sweden have identified and highlighted direct reduction with hydrogen as one possible promising transition pathway to reduce the carbon intensity of the industry [15,16].

In its energy concept 2010/2011, German government set out the goal of reducing greenhouse gas emissions in Germany by 80–95% by 2050 against 1990 levels, with a simultaneous reduction of electrical power demand by 25% and primary energy demand by 50% by 2050 against 2008 levels [17]. The primary means foreseen for achieving this is the expansion of renewable energies, which are intended to provide 60% of final energy consumption and 80% of power production by 2050 [18]. Therefore, the German landscape has seen a continuous expansion of wind turbines during 2003 to 2015 from 14 to 45 GW and photovoltaic installations in the same time from 0.5 to 39 GW for power production [19].

China produced 49.2% of the world's total steel production in 2017. From 1990 to 2017, the world's total steel production increased by 850 Mt, of which 87% came from China. After 30 years of rapid expansion, China's steel industry is not expected to increase its production in the medium and long term. In fact, the industry is currently in the stage of industrial restructuring, and great changes will arise in production structure and technical level to solve pressing issues, such as overcapacity, high energy intensity (EI), and carbon emission. These changes will directly affect the global energy consumption and carbon emissions [20].

Hydrogen direct reduction of iron ore (HDRI) coupled with electric arc furnace (EAF) could reduce specific emissions from steel production in the EU by more than 35%, at present grid emission levels (295 kg CO_2/MWh). The energy consumption for 1 ton of liquid steel (tls) production through the HDRI-EAF route was found to be 3.72 MWh, which is slightly more than the 3.48 MWh required for steel production through the blast furnace (BF) basic oxygen furnace route (BOF) [21].

Discussion and conclusion. Modern humanity heavily relies on the iron and steel industry. However, the technological processes associated with them create challenges. The biggest one is the environmental impact. The energy consumption and the emissions of greenhouse gases of the steel industry are very high. The leading steel producing countries are still using coal as a primary source of energy. Also, the pandemic could reduce the demand for steel and iron. The transition to a cleaner technologies, like direct reduction with hydrogen could be an environmentally friendly option of steel production. The well-coordinated solutions of the main players in the global steel market could improve the situation with the demand.

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ТЕМІР ӨНДІРУДІҢ ҚАЗІРГІ КҮЙІ

Аңдатпа. Бұл мақалада темір және болат өнеркәсібінің қазіргі жағдайы ғаламдық тұрғыдан қарастырылады. Темір кенін өндірудің заманауи мәселелері көрсетілген. Темір кені мен болат нарығына әртүрлі факторлардың оң және теріс әсері қарастырылады. Әлемнің жетекші өндіруші елдерінде темір кенін өндіру үрдістері көрсетілген. Отандық темір кенін өндірудің қазіргі жағдайы талданды. Қазба отынның көп мөлшерін пайдалану нәтижесінде пайда болатын экологиялық проблемалар талқыланады, бұл болат өнеркәсібінде көмірқышқыл газының айтарлықтай шығарылуына әкеледі. Кейбір елдерде темір кенін өндірудің экологиялық мәселелерін шешу және болат өнеркәсібінде жасыл технологияларға көшу үшін қолданатын шешімдер қарастырылуда.

Негізгі сөздер: тау-кен ісі, темір кені, болат өндірісі, жасыл технологиялар, экологиялық проблема

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СОВРЕМЕННОЕ СОСТОЯНИЕ ДОБЫЧИ ЖЕЛЕЗА

Аннотация. В данной статье рассматривается современное состояние железной и сталелитейной промышленности с глобальной точки зрения. Показаны современные проблемы добычи железной руды. Рассмотрено положительное и отрицательное влияние различных факторов на рынок железной руды и стали. Показаны тенденции в добыче железной руды в ведущих странах-производителях мира. Проанализировано современное состояние отечественной добычи железной руды. Обсуждаются экологические проблемы, возникающие в результате использования большого количества ископаемого топлива, что приводит к значительным выбросам углекислого газа в сталелитейной промышленности. Рассматриваются решения, которые некоторые страны используют для решения экологических проблем добычи железной руды и перехода к зеленым технологиям в сталелитейной промышленности.

Ключевые слова: горное дело, железная руда, сталелитейная промышленность, зеленые технологии, экологическая проблема