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THE BREAKTHROUGH TECHNOLOGIES TO REDUCE CARBON DIOXIDE EMISSIONS FROM STEEL PRODUCTION

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ABSTRACT:
The paper presents new ULCOS (Ultra Low CO_2 Steelmaking) breakthrough technologies in combating climate change. ULCOS is today the largest endeavour within the steel industry worldwide proactively looking for solutions to the threat of global warming. ULCOS is the world's most ambitious research and development initiative to reduce carbon dioxide emissions by 50% by 2050 compared with today's best routes from steel production by developing new breakthrough technologies: the Blast Furnace with Top Gas Recycling, ISARNA, Advanced Direct Reduction and Electrolysis.
KEYWORDS:
ULCOS (Ultra Low CO_2 Steelmaking), The European Steel Technology Platform – ESTEP, New Blast Furnace

1. INTRODUCTION

The climate change challenge will induce changes in the production, distribution and consumption patterns of steel and other materials. Insights from industrial economics and evolutionary theory on innovation for sustainable development are needed to assess the rationale behind the adoption and diffusion of new breakthrough technologies named Ultra Low CO_2 Steelmaking (ULCOS) [1]. Birat JP. [2,3] identified that technological rupture in the steel industry is the conjunction of the following factors: saturation of the prevailing technology and modification of the economic context, in terms of raw materials and markets, the coming to maturity of alternative technologies and the development of more radical ULCOS technologies which are described in this paper.

2. THE ULCOS PROGRAM

European Steel Technology Platform ESTEP is committed to the CO_2 challenge [4]. In paper [5] was presented the most important problems with the reduction of CO_2 in Poland. That paper has presented the proposal related to the allocation of emission allowances and its consequences for the functioning of steel plants. The European Steel Industry has created a consortium of industries and of research organisations that has taken up the mission of developing the breakthrough processes – the ULCOS (Ultra Low CO_2 Steelmaking) consortium. The consortium develops a breakthrough steelmaking process that has the potential of meeting the target of markedly reducing GHG (Greenhouse Gas) emissions [6]. The European steel industry is strongly committed to making its contribution to the fight against climate change and the reduction of greenhouse gas emissions. They each need to be further evaluated in detail with regard to their technological, process, economical and environmental performance. The European Steel Technology Platform will work closely with the European Zero Emissions Technology Platform, which is also focusing on research into CO_2 capture, transport and storage [7].

ULCOS scope includes the selection main routes for steelmaking that would demonstrate the technical and economical feasibility of the chosen concepts. The initiative was taken by Europe's three largest steelmakers; Corus, ArcelorMittal and ThyssenKrupp. It is a consortium of 48 European companies and organisations from European countries that have launched a cooperative research and development initiative to enable reduction in Carbon dioxide (CO_2)

emissions from steel production. The consortium consists of all major EU steel companies, of energy and engineering partners, research institutes and universities and is supported by the European commission. The aim of the ULCOS program is to develop breakthrough technology that will reduce the Carbon dioxide (CO_2) emissions of today's best routes by at least 50 %. [8].

ULCOS is a major program, which plans to find innovative and breakthrough solutions to decrease the CO_2 emissions of the steel industry. Within 5 years, the project will deliver a concept process route, based on iron ore, with a verification of its feasibility in terms of technology, economic projections and social acceptability. The project hence starts by examining a panel of technologies, which have passed a first prescreening but need to be investigated more closely. ULCOS program is divided on four phases [9]. In step 1 of ULCOS (2004-2010) program are identified four new breakthrough technologies. In step 2 (2010-2015) will be developed large scale demonstration plants. The first technology identified to be taken to the next stage: Top Gas Recycling in the Blast Furnace with CO_2 Capture and Storage (CCS) and work will continue on three other technologies: ISARNA, Advanced Direct Reduction and Electrolysis. Phase 3 (2015-2020) and 4 (2020 onwards) will contain development of the first commercial-scale plants and deployment of the technologies in Europe and throughout the world. Implementation and deployment can take place from 2015-2050 [9].

The present ULCOS phase will end in 2009. Preparations for the next ULCOS phase are already in progress. The next phase is expected to run from 2010 to 2015. The objective of this phase is to further develop selected technologies. For the most mature technologies, such as top gas recycling, this will mean industrial scale demonstration. For less mature technologies like electrolysis this will mean further laboratory scale testing.

Table 1. Subprojects in present ULCOS program [11].

No	Subprojects (SP)
SP1	New Blast Furnace
SP2	New Smelting Reduction
SP3	New Natural Gas Based Processes Route to Steel
SP4	Hydrogen steel production
SP5	Electrolysis of Iron Ore
SP6	CO_2 Capture and Storage (CCS)
SP7	Biomass steelmaking
SP8	Electricity – intensive steelmaking

Table 2. Scenarios of virgin iron routes [12,13].

Technologies	%
Direct-Reduced Iron	5
H_2 pre-reduction	10
NG pre-reduction	15
Smelting reduction	10
Electrolysis	1
Blat Furnace	59

For Isarna the step to industrial demonstration will depend on the outcome of the pilot plant programme, which will extend into ULCOS II [10]. ULCOS program is organized in sub-projects. Table 1 presents the structure of the present ULCOS program [11].

The virgin iron routes, beyond the BF, have been complemented by Smelting Reduction, and low-carbon intensive routes, i. e. pre-reduction by Natural Gas, Hydrogen pre-reduction, Electrolysis (provided hydrogen and electricity are CO_2 lean), and Direct-Reduced Iron, the BF remains at 59% of the ore routes (Table 2) [12,13]

3. THE ULCOS BREAKTHROUGH TECHNOLOGIES

The concept of the Top Gas Recycling Blast Furnace (first breakthrough ULCOS technology) relies on separation of the off gases so that the useful components can be recycled back into the furnace and used as a reducing agent. From first ULCOS technology it can be obtained benefits: 25 % less carbon usage, 50 % CO_2 reduction if CCS is applied, 35 % coke rate reduction and productivity increase. ISARNA smelter technology (second breakthrough ULCOS technology) is a new technology under development by ULCOS.

From second ULCOS technology it can be obtained benefits: 20 % reduction of CO_2, 80 % reduction with CCS, use of biomass. Advanced Direct Reduction is third breakthrough ULCOS technology. Direct-reduced iron (DRI) is produced from direct reduction of iron ore by a reducing gas produced from natural gas. The reduced iron is in solid state and for melting the iron, electric energy is required. This is carried out in an Electric Arc Furnace (EAF). Presently, this process is more expensive than reducing the ore in a conventional blast furnace and it also demands that better quality iron ore is used in the process. For the Top Gas Recycling Blast Furnace, ISARNA and Advanced Direct Reduction, the aim of a 50% reduction of Carbon dioxide (CO_2) emissions can only be reached if each of these technologies is combined with CCS. Alkaline Electrolysis is

fourth breakthrough ULCOS technology. Electrolysis of iron ore is the least developed process route currently being studied in ULCOS. This process would allow the transformation of iron ore into metal and gaseous Oxygen (O_2) using only electrical energy. Producing iron by electrolysis would mean that coke ovens and the reactors used for reducing the iron ore, such as a blast furnace, would no longer be required [8].

4. THE CONCLUSIONS

The European Steel Technology Platform and the work of the ULCOS program are good examples of an industry working to develop appropriate technologies to maintain its future competitiveness. The EU steel industry recognises it has a responsibility to reduce emissions, and is working hard to develop the breakthrough technologies required. The objective of the ULCOS project is 50% reduction in CO_2 emissions based steel production by 2050. In the ULCOS program innovative ironmaking processes are under development. Each of these technologies has the potential to achieve the ambitious CO_2 reduction targets, but only with the help of supporting technologies like CO_2 Capture and Storage (CCS) and the use of sustainable biomass. Entering the 21st century, the steel production route must have four functions: production of high performance steel products, conversion of energy, treatment of waste and reduction of greenhouse gases.

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