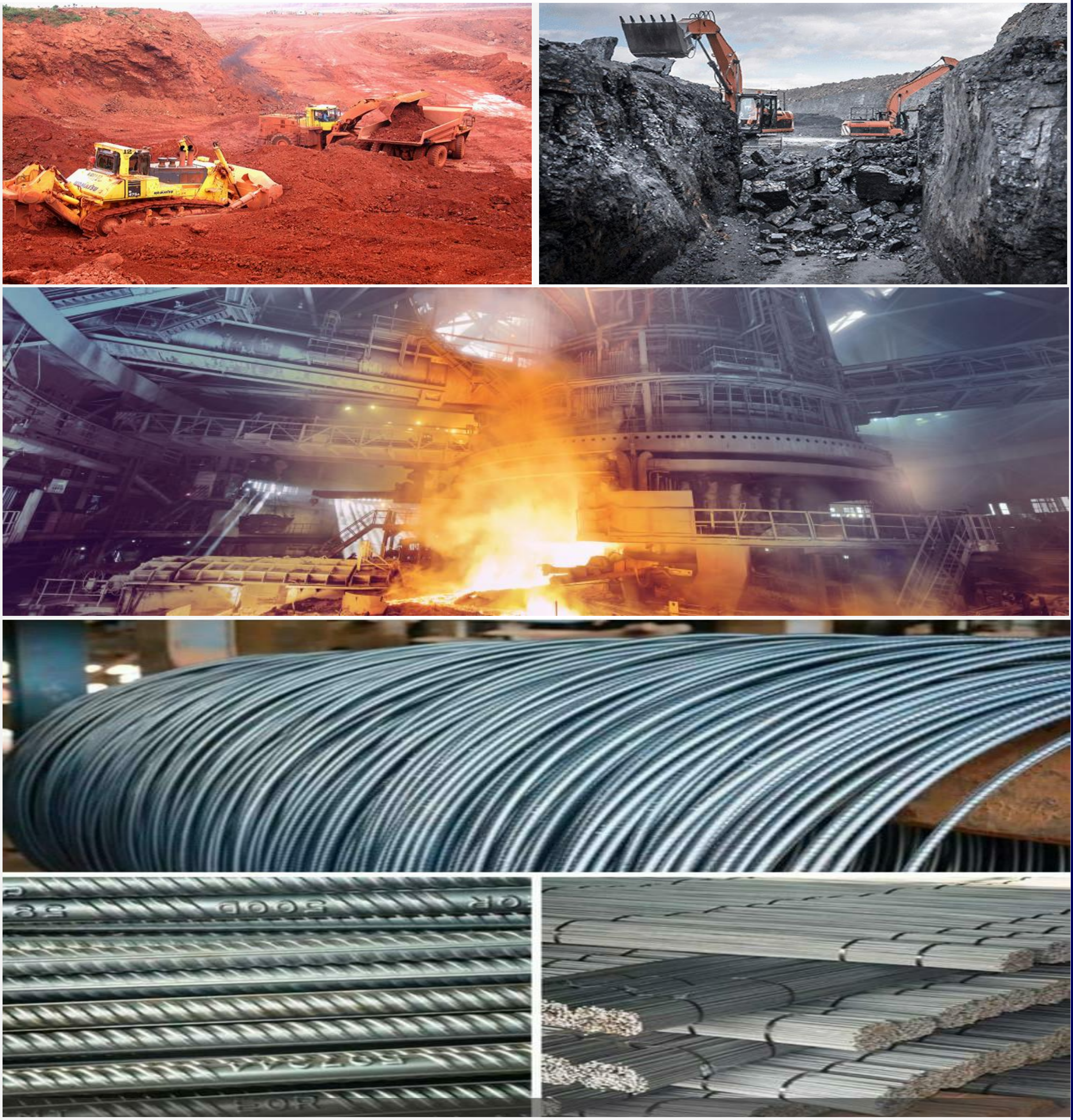
DRI UPDATE

SIMA
Sponge Iron Manufacturers Association
Indian voice for the ore based metallic & steel industry



NOVEMBER | 2020

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Editorial

Dear Readers,

We are once again presenting the new edition of our in house magazine **"DRI UPDATE"**. In our previous edition of September, 2020, I have given a rough sketch of iron ore scenario and expressed my worries about the shortage of iron ore and its impact on DRI and steel industry. If we look into the April-September, 2020 production scenario from these mines , there was hardly 4 million tonnes production compared to about 36 million tonnes corresponding to the previous period of last year. Therefore, there was a gap of 32 million tonnes from these mines. In spite of this gap, shortage of iron ore was not felt too much because of various reasons like lack of steel demand, existing inventory with DRI and steel producers, additional production of non auctioned mines and auction of iron ore fines by SAIL etc. However, with the improvement of steel demand and inventory dry up, producers are now facing acute shortage of iron ore. SIMA has been drawing the attention of the state and central authorities about this situation and its likely adverse impact on DRI and steel production in the country. If this situation continues to persists, I am afraid we will lose the tag of world's largest DRI producer and Iran will take a lead over India.

Energy scenario in India is changing very fast. There is a serious discussion of exploring the possibility of increased use of natural gas, syn gas, hydrogen gas for production of DRI and steel basically to reduce carbon footprints. Steel producers all over the world are under pressure to be carbon neutral. We have to start thinking in this direction. It may be mentioned here that The Energy and Resources Institute (TERI) is of the opinion that coal based DRI plants may not have any future after 25 years. Recently, Hon'ble Union Minister of Coal has stated that India's window for using coal resources may last 20-30 years.

In this edition we have mentioned the DRI and steel scenario from April – September, 2020 which indicate that India's crude steel and DRI production have shown negative growth of about 21% each and steel consumption by 30%. However, the current festival season has brought the smile on the faces of DRI and steel producers. We hope that this scenario will continue to the rest of this financial year.

I wish all the readers a very Happy and Prosperous Deepawali.

Deependra Kashiva

Executive Director

Coal Gasification: To Fast Track India's Economic Prosperity

Damodar Mittal, Jindal Steel & Power Ltd. Angul

Coal is an important natural fuel resource available in India in abundance, with accumulative total reserve of approximately 307 Billion tonnes, estimated up to the maximum depth of 1200m. India has the world's 3rd largest coal reserve.

India is presently dependent upon imports to meet its requirements of metallurgical Coal, petroleum and natural gas. However, the abundant reserve of thermal coal in India has the potential to meet all of its energy requirements.

In India, historically coal has been used for its Thermal Energy properties only. However, coal can be and should be used for its Chemical properties also to produce more **value-added downstream organic and inorganic products.**

At present, the majority of the available Indian coal is consumed by the power producing units. While a small proportion is being used by the steel & cement industry, thus producing a large amount of CO2 and other gases, potentially damaging the environment.

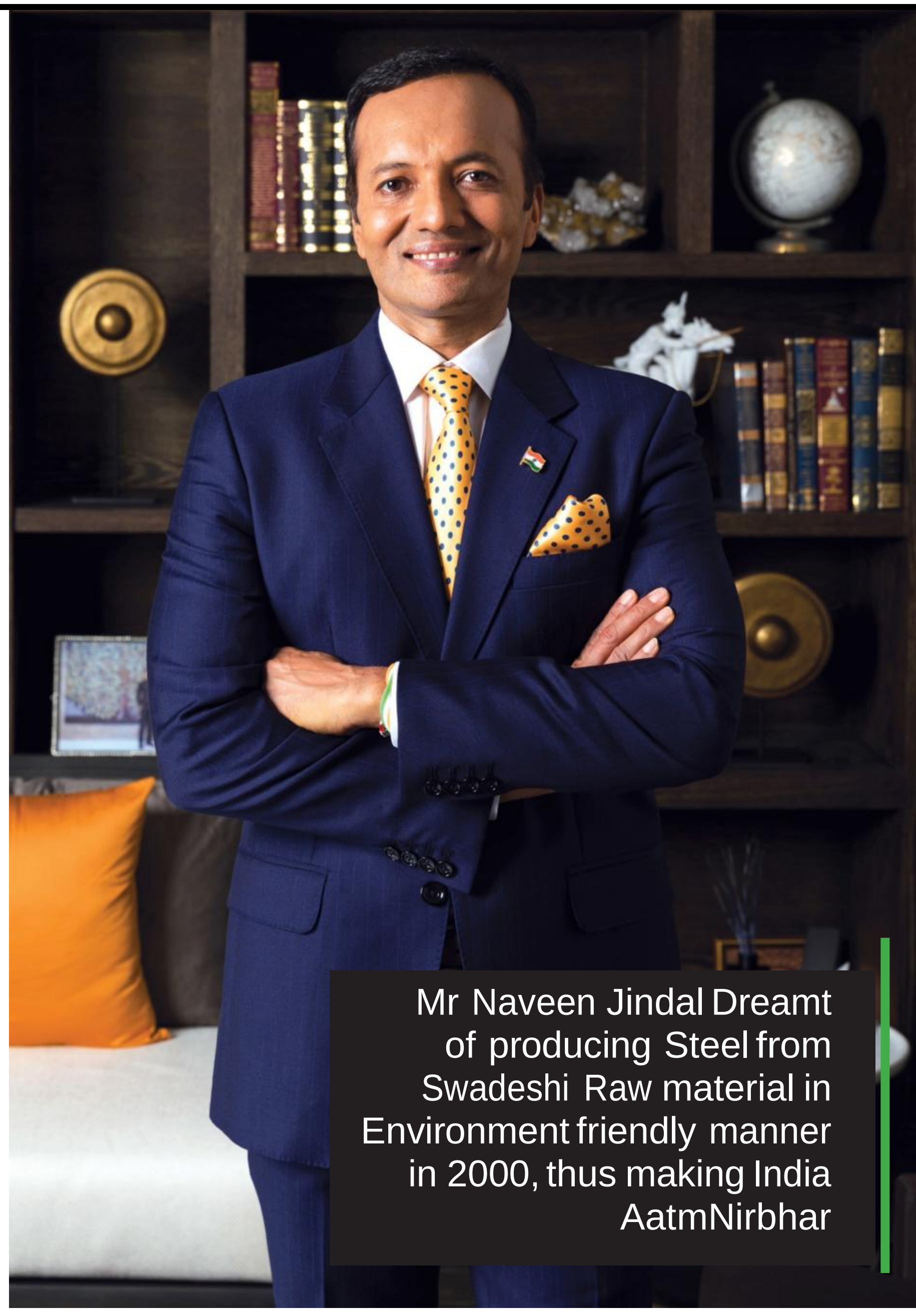
Hon'ble Prime Minister Shri Narendra Modi during his visit to the USA in Sept 2019 told the Bloomberg Global Business Forum that the Government is looking at ways to use technology in coal gasification to ensure that the natural resource is used by the country in a clean and environment-friendly manner to meet its energy requirements.

He had further said "The solution is coal gasification. By doing coal gasification we can get clean energy. We are inviting other countries to come with their technology for use in coal gasification,"

Why Coal Gasification for India:

- Clean Energy Technology to Harness Huge High Ash Coal Reserve.
- To make India "AatmNirbhar" by Import Substitution Provide Energy Security.
- Minimise Current Account Deficit (CAD)
- Convert Low Value Feed of Thermal Coal to High Value Products
- Bring Prosperity & Development at remotely located coal mines by way of Job creation and economic development.

Given the potential of converting indigenous coal to energy and useful chemicals, NITI Aayog has setup a Technical Committee to discuss and suggest a roadmap with suitable technology for development of Surface Coal Gasification (SCG) in Indian conditions. The committee will also look at a suitable business model for the development of SCG in the country. The Union Government has already set a target to gasify 100 MT of coal under four major projects with an overall investment of Rs 20,000 crore by 2030.
Jindal Steel & Power Ltd (JSPL) installed state-of- the-art and the **World's First DRI Plant** (1.80 Million Tonne per Annum capacity) based on

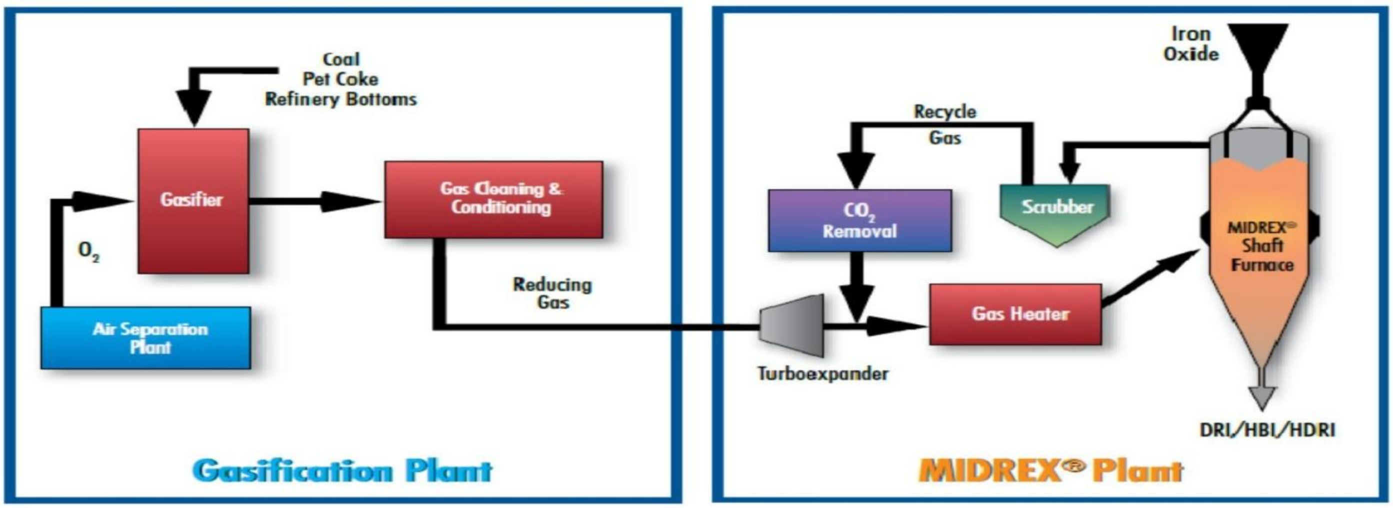


"Coal Gasification technology" located at Angul-Odisha which being operated using SWADESHI high ash non-coking coal available in abundance in the State of Odisha.

The SynGas Project at JSPL Angul started in 2007 and was commissioned in 2014 making India AtmaNirbhar by way of Import substitution of Metallurgical Coal, thus saving precious foreign exchange. Coal gasification is a potential long-term solution to India's energy requirements, in an environment-friendly manner. Adoption of this technology will immensely help India to achieve the targets set during COP21 to reduce Greenhouse emissions by 30%. The National Steel Policy envisages production of 300 Million tonnes of crude steel by 2030 and the success of Coal Gasification technology will create a new segment of capacity addition in India which will be based on domestic coal, thereby minimizing the need of imported coking coal. This will also save our precious foreign exchange.

JSPL has installed Coal Gasification Plant (CGP) with technological support from M/s Lurgi – Germany. In CGP, synthesis gas ("Syn-gas") is produced by using high ash coal as a fuel and the Syn-Gas is used as a reducing agent in **gas based vertical shaft kiln** for making DRI.

JSPL Angul CGP - DRI Configuration: The process is named as MAXCOL Process.



Advantage of Gas Based Vs Coal Based DRI Production:

GAS BASED	COAL BASED
1. Clean Technology.	**1.** Prone to Pollution
2. Energy Requirement is 20% less than that of rotary kiln based plant.	**2.** High Energy Requirement.
3. Product suits best steel making qualities.	**3.** For making High quality steel additional refining set up investment and cost to be incurred.
4. DRI fines (-5mm) generated is 5%. Thus, Loss in SMS are less due to low % of fines.	**4.** DRI fines (-3mm) generated is 30-40%. Thus, Loss in SMS are more due to high percentage of fines.
5. - Sulphur content in DRI is in range of 0.003-0.01% which is very low.	**5.** Sulphur in coal is partly absorbed by DRI and partly goes to atmosphere as SO_2 contributing to air pollution.
6. Average Metallization is 92-94%	**6.** Average Metallization is 86-90%

Today, the world's first CGP-DRI plant at JSPL Angul has become a "Technology Demonstrator" being frequently quoted by industry participants, studied across the world by various institutes of repute including Harvard, and is frequently visited by national and international dignitaries.

Various global companies have also visited the facility and they have shown interest, installing similar gasification based facility to produce DRI/HBI, Chemicals and other downstream industries for domestic and international markets.

Potential Forex Saving for the Country through Steel Making:

a) Forex Saving through reduced coking coal imports at Current level of Steel Production:

- **India's current Steel Production: 110 MTPA**
- **30% via CGP-DRI Route**
- **Potential Forex Saving on coking coal: $3.5 Billion**

b) By 2030: 300 MT of Steel Production

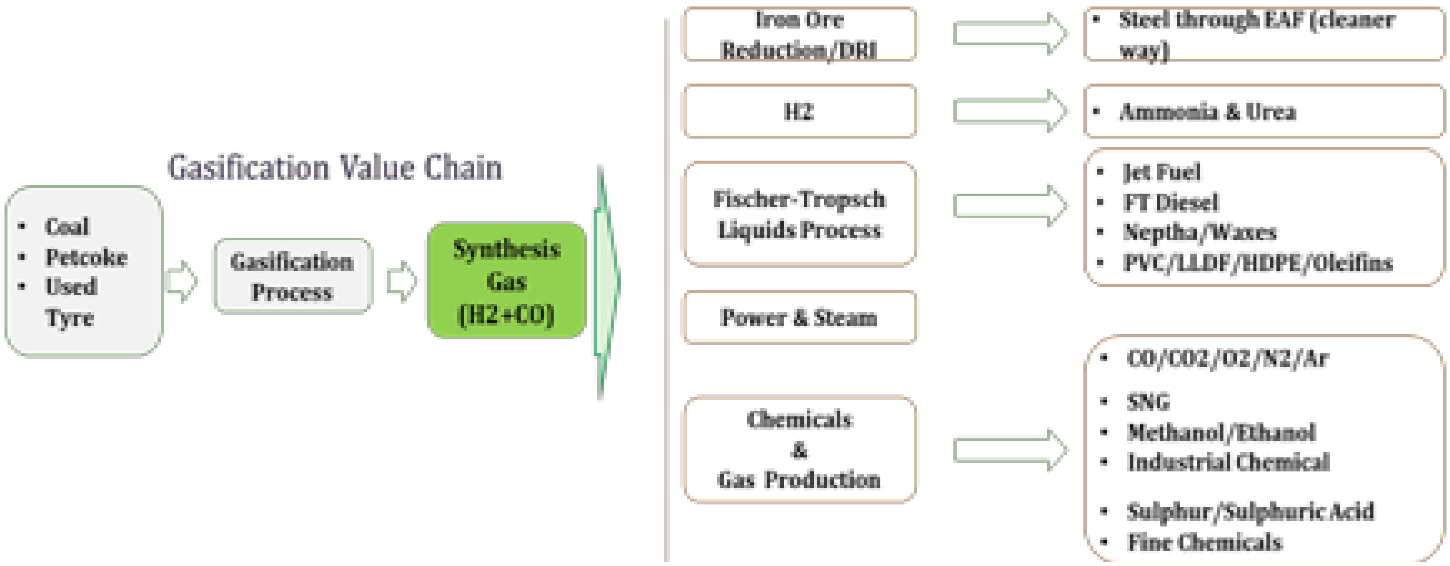
- **30% via CGP-DRI Route**
- **Potential Forex Saving: $9.4 Billion**

We also expect substantial FDI in the sector as many multinational companies would like to install a gasification facility to produce DRI/HBI in India for domestic and international markets. However, it is a proven fact that the success of coal gasification technology depends strictly on coal quality and consistent supply from a single source. The performance of gasifier is highly sensitive to the feed coal quality & certain other parameters and it has been seen that best utilisation of this technology can be ensured by providing dedicated linkage of coal from a single source.

Coal Gasification Plant and use of by-products:

At Angul, the Syngas produced contains methane, carbon monoxide and hydrogen. Compared to the coal combustion process – the CO_2 emitted in the gasification process is entirely absorbed back in to the process and the Hydrogen Sulphide emitted is entirely converted into Sulphur production.

Hence, it ensures energy efficiency and is environment friendly. Besides, all the by–products of the Syngas plant are being recycled through internal use or by sale to external parties. This ensures health and safety of employees as well as local communities and also ensures environmental protection.



- Coal can be used for its **Chemical Energy** and used to produce more **value added products** rather using its thermal energy just for power generation

- 'A National Policy on Coal Gasification' should be formulated and promulgated for faster and smooth implementation of the Coal Gasification technology.

- Coal to be made available **20% lower than** Price for **"Regulated Sector"** (Power)

- Like GoI has offered 20% discount on revenue share for the Coal Gasification and Liquefaction in the soon to be conducted commercial mining.

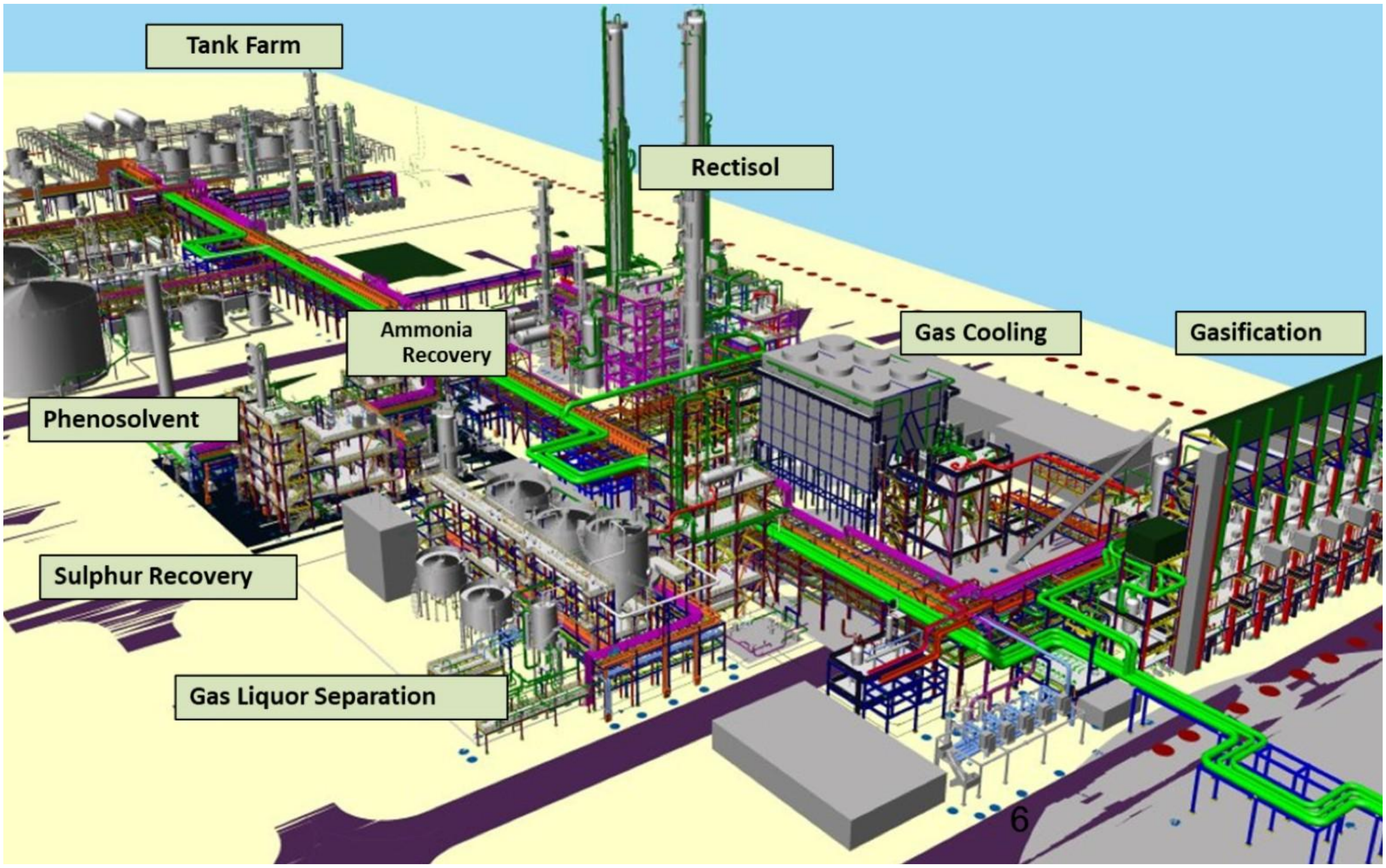
- Coal be made available from a Single Source :

- GoI should hold special auction of Coal Mines for Coal Gasification unit.

- GST Compensation Cess of Rs 400/MT to be waived to further promote the adoption of Gasification.

- A Senior Officer in Ministry of Coal with the charge of Coal Gasification **will help the industry and thus the national mission.**

Angul : Coal Gasification Complex at a Glance



JSPL Angul Coal Gasification Complex: Night View

Gasification Unit

Gasification Unit

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Experience and Developments of the ENERGIRON DR Technology for H_2 Use

Pablo Duarte, Tenova HYL., Mexico.

Abstract

The trend of the steelmaking industry is in the direction of decarbonisation to comply not only with environmental regulations but with a sustainable approach for steel production. Current actions of steelmaking industry, as part of the decarbonisation of global and specifically Europe's economy, is towards intensive steel scrap recycling as part of the circular economy, and to hydrogen-based iron reduction as a long-term substitute for carbon-based processes.

The ENERGIRON technology scheme (the innovative DRI Technology jointly developed by Tenova and Danieli) has been characterized by the inspiration of innovation. Starting by installing the first gas based direct reduction in the 1950's at industrial scale in Hylsa steelmaking facilities in Monterrey, using H_2 rich gas (in a ratio of H_2/CO ~5) as reducing gas, incorporating selective CO_2 removal for increasing process scheme efficiency while reducing energy consumption and providing practical solution for CO_2 capture and commercialization (CCU), developing the ZR (reformerless) scheme for further process efficiency while producing high-Carbon DRI (>3%C) since more than 20 years ago, using the breakthrough reliable Hytemp® System for hot DRI transport and EAF feeding by environmental friendly, totally enclosed pneumatic transport, and developing schemes for intensive H_2 use. This paper is focused on the benefits and advantages on H_2 use through the ENERGIRON process for Carbon Direct Avoidance (CDA) as compared to other proposals.

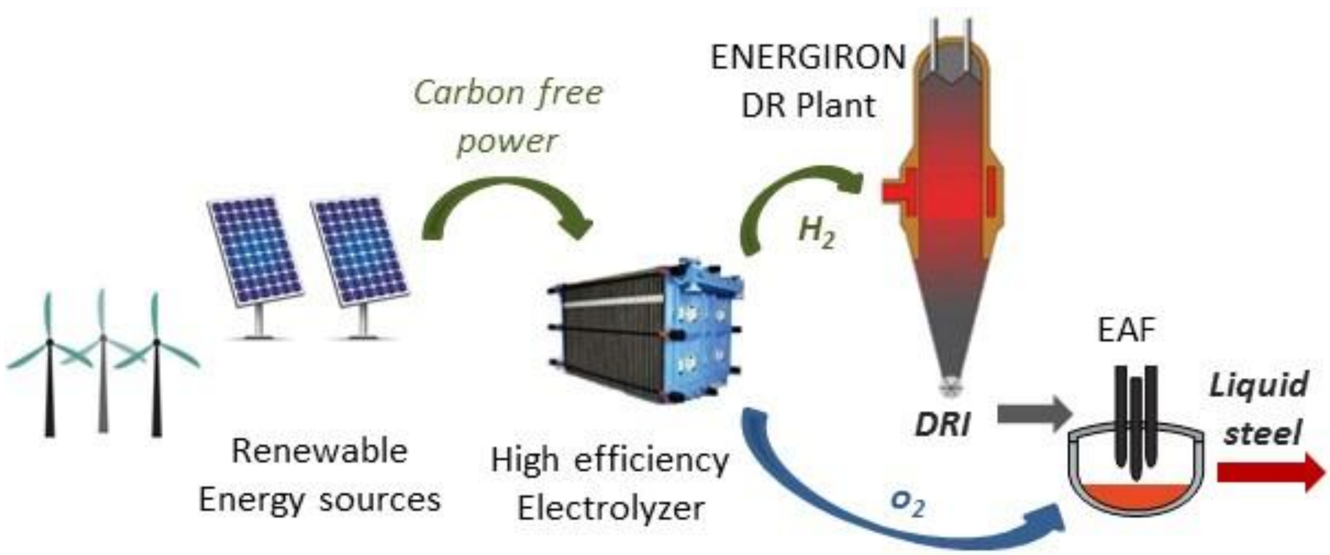
Introduction

As compared to the coal-based BF-BOF route, any energy source providing hydrogen (H_2) and carbon monoxide (CO) can be used as reducing agent for iron oxides reduction in the DR process. This makes DRI-EAF (or DRI-OSBF) the best available technological solution for decarbonisation of the steelmaking industry. The simplified process configuration when using H_2, makes the DR process very efficient in terms of energy consumption and scheme simplicity. The expected energy consumption for the ENERGIRON DR process is reduced from 10,2 GJ/t DRI with natural gas (NG) to as low as 6,6 GJ/tDRI with H_2 for process plus additional 1,6 GJ/tDRI as fuel and about 25 kWh/tDRI for the core plant. This exceptionally low electricity consumption is not only because of the H_2 use but also due to the high operation pressure of the ENERGIRON system (≥6 barA @ top gas).

On the other hand, in the EAF meltshop, to overcome the negative effect of the gangue in DRI, by feeding high-metallised, hot DRI to the EAF, the power consumption is significantly reduced to figures very close to the case of 100% scrap melting, overcoming the negative effect of the gangue content in the DRI. Typical power consumption for a charge of 80% hot DRI and 20% scrap is about 400 kWh/tLS. Feeding high percentages of DRI is required for production of high-end quality steels.

Sustainable H_2 generation is based on the application of electrolyzers, using power from renewable sources (i.e. eolic, solar PV) and eliminating carbon footprint (CDA) for ironmaking and steelmaking (Figure 1). For this industrial application, H_2 shall be generated by high efficiency electrolyzers, There are different available electrolysers technologies, such as: Atmospheric Alkaline Electrolysers (AAE), Proton Exchange Membranes (PEM) and High Temperature Electrolysers (HTE), being the first a mature technology in the MW range for industrial use.

Figure 1. Carbon-free steelmaking route based on ENERGIRON ZR Process



Reduction of iron ores with H_2

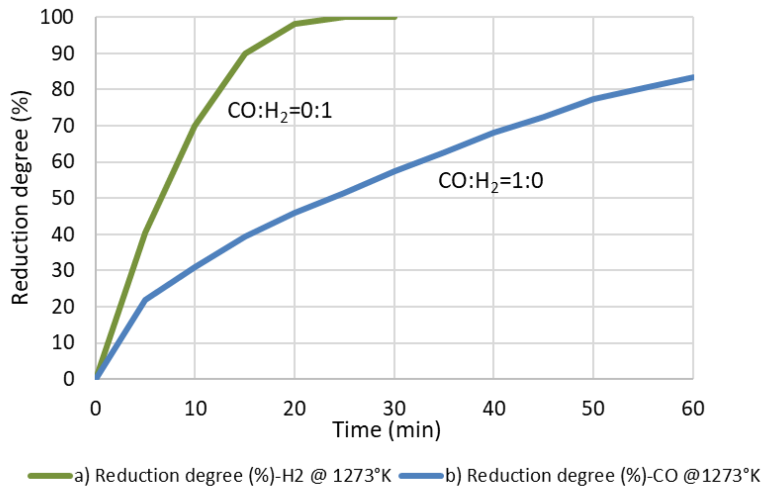
The gas reducing agents are CO, H_2 and mixtures of both. Thermodynamics of iron oxides, dealing primarily with equilibrium between iron oxides, CO and H_2, provides the potential for a reduction reaction to occur. This is indicated by the Gibbs Free Energy ($\Delta G°$):

$Fe_2O_3 + 3H_2 \Rightarrow 2Fe° + 3H_2O$ ΔG° @900°C: -11.103,3 kJ/kg mol H_2; ΔH_{rxn} @900°C: +21.881,0 kJ/kg mol H_2

$3Fe_2O_3 + 2CO \Rightarrow 2Fe° + 3CO_2$ ΔG° @900°C: -8.149,4 kJ/kg mol CO; ΔH_{rxn} @ 900°C: -11.401,1 kJ/kg mol CO

As observed, thermodynamically H_2 reduces iron oxide easily than CO, as per change of Gibbs free energy [2]. On the other hand, the exothermic or endothermic behavior is indicated by the enthalpy change (ΔH_{rxn}) of the corresponding reactions.

Figure 2. Change of reduction degrees with time for CO:H_2: 0:1; CO:H_2: 1:0



Kinetically, the effect of temperature on the extent of iron ore reduction has been investigated using gases with different H_2/CO ratios [3]. The changes of reduction degree at 1000°C for CO/H_2 ratios of 1:0 and 0:1, are indicated in Figure 2. In general, the higher the temperature the faster the extent of the reduction process, whether the reducing agent is H_2 or CO. However, the reduction of iron ore with H_2 is more than 4 times faster as compared to CO; i.e. 98% reduction in ~20 min vs. 83% reduction in 60 min at 1000°C. Reasons are:

1) the equilibrium of H_2 decreases with increasing temperature because it is an endothermal reaction, leading to a higher reducing potential at high temperature, and as a result, the driving force of the reduction reaction is enhanced;

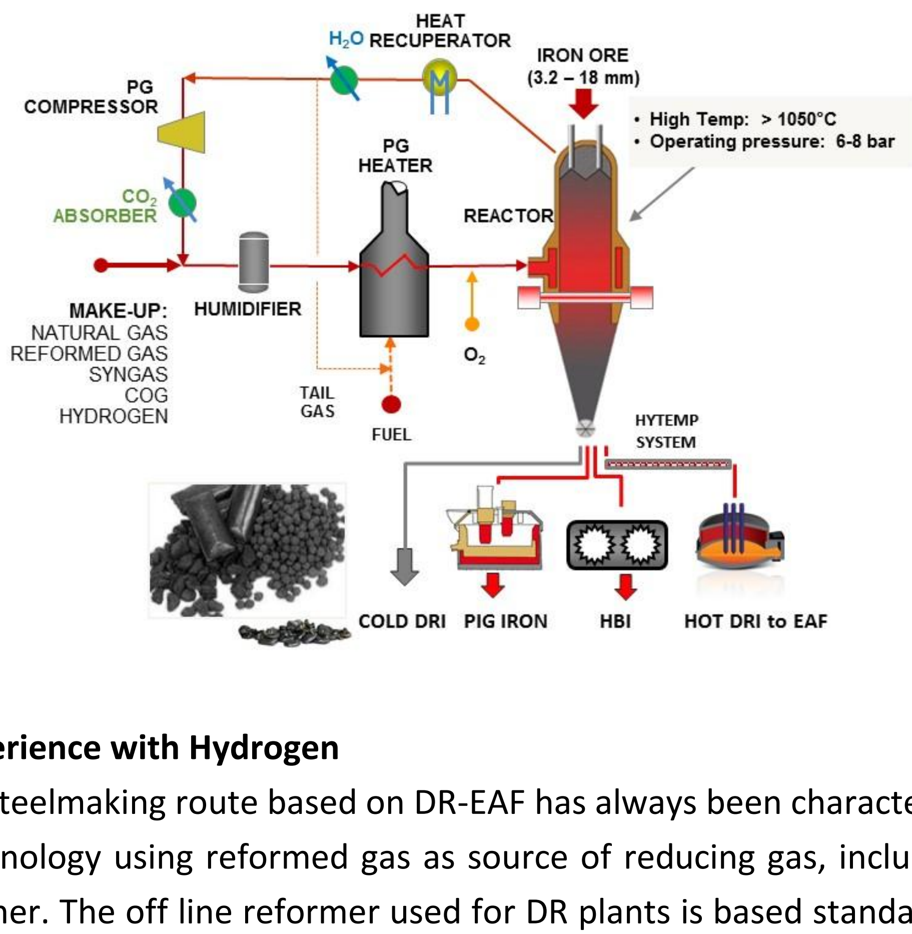
2) the high temperature contributes to a high mass transfer coefficient.

On the other hand, iron ore reduction with CO requires lower reducing gas temperature because of the exothermal reaction behavior, and kinetically is much slower than the reduction with H_2.

The ENERGIRON ZR Process

The ENERGIRON ZR process, as shown in Figure 2, is a major step in reducing the size and improving the efficiency of direct reduction plants [1]. The same ZR process scheme configuration can be used for any application, regardless of whether using NG, H_2, reformed gas from external steam/NG reformer, syngas from coal gasifiers, or COG, depending on availability. As indicated in Figure 2, the ENERGIRON ZR scheme can produce cold DRI (CDRI), hot DRI (HDRI) which can be directly fed to: 1) Hytemp® System for transport and direct feeding to an adjacent EAF, 2) to briquetting presses for production of HBI and 3) to a proprietary Tenova OSBF melter for production of hot metal/pig iron. The latter is a breakthrough approach for production of hot metal using NG as reducing agent, decreasing to <50% the carbon footprint as compared to the conventional coal-based BF while keeping BOF downstream steelmaking unchanged.

Figure 2. ENERGIRON ZR Process scheme



Long lasting experience with Hydrogen

Historically, the steelmaking route based on DR-EAF has always been characterized using H_2. The ENERGIRON technology using reformed gas as source of reducing gas, includes a conventional steam/NG reformer. The off line reformer used for DR plants is based standard technology with hundreds of references in DR and hydrogen plants; there are more than 40 HYL/ENERGIRON plants having used this type of NG reformers. For any reformer, H_2 is produced in different concentration, depending on the oxidants ratio being used; i.e.

$$CH_4 + H_2O = 3H_2 + CO$$

$$CH_4 + CO_2 = 2H_2 + 2CO$$

Typical operation characteristics for the ENERGIRON plants and for the DR competing technology (Midrex) are shown in Table 1.

These industrial operating data reflect the long-lasting industrial experience of ENERGIRON plants with intensive use of H_2 for DRI production.

Table 1. Characteristics of reformed gas in DR technologies

Parameter related to H_2	ENERGIRON	Other DR technology
H_2O/C ratio in NG Reformer	2.0 – 2.5	1.5
H_2/CO ratio in reducing gas	4 – 5	1.7
%H_2 to reactor (% vol.)	~70%	~55%

In addition to the vast industrial experience using H_2, in the 1990's, Tenova HYL carried out extensive tests at pilot plant (Figure 3) with ≥ 90% (vol.) H_2; producing H_2 from reformed gas from the industrial DR plant by water shifting and CO_2 removal. The demonstration/pilot plant at Hylsa Monterrey had a production rate of 36-tonne DRI/day with all flexibilities to produce: CDRI, HDRI for HBI production and HDRI for direct pneumatic transport to an adjacent pilot plant EAF.

This plant also included all capabilities for synthesis of all type of reducing gases; from 100% H_2 to 100% CO, including reformed gas, typical COG and gases from coal gasification. In fact, the ZR scheme was developed and demonstrated in this facility during the 1980's. The experimental campaign included 15 different process conditions, depending on the DRI type and quality to be achieved.

- For CDRI conditions, some minimum required amount of NG was injected to the conical/cooling zone of the reactor. The following results were achieved: Metallization of 94%-96%, %C content of ~1,0%. H_2 has been controlled in a range of ~90% vol.
- For the HDRI, HBI was produced to prevent fast re-oxidation due to low %C. Metallization of 94%-96% and %C obtained between 0,2% – 0,8% being the latter for the condition of some NG injection to the reduction circuit. H_2 was also controlled in ~90% vol.

These tests provided all necessary information to define:

- Process and design parameters mainly related to optimized flow-temperature correlation.
- DRI quality in terms of metallization and carbon content.
- Optimization of operating pressure, reactor L/D ratio, solids residence time (τ), to consistently achieve the DRI quality, determination of fluidization factor (*f*) to ensuring proper gas velocities and distribution through the solids bed, among others for the proper gas distribution and design of the scheme for H_2 utilization.

These campaigns at demonstration/pilot plant tests with highest H_2 volumes providing the fact that the ENERGIRON process is already fit for the use of 100% H_2, when needed. All required data for design and operation under this condition is available and can be directly applicable to any existing and/or new DR plant installation.

Figure 3. HYL Pilot Plant tests campaigns with ≥90% (vol.) H_2

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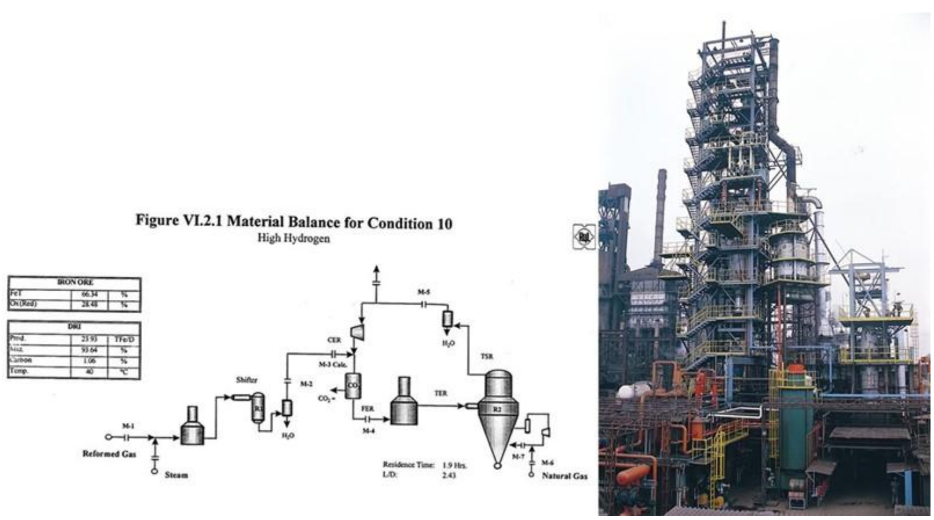
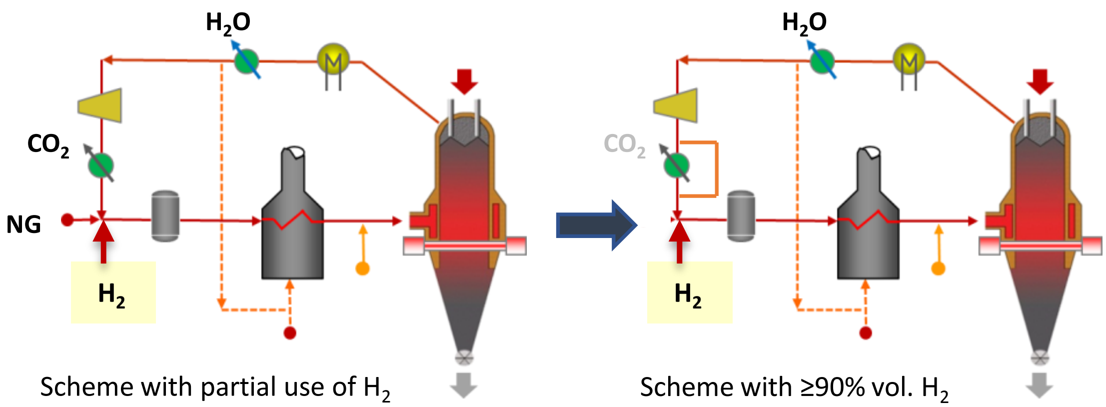


Scheme with high H_2 use and energy consumption figures

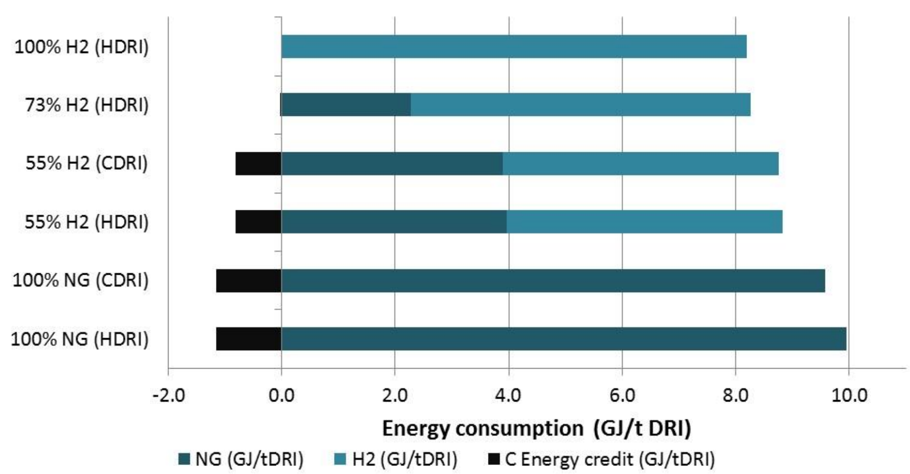
For the case of H_2, the same ZR scheme applies. The only difference is that, for H_2 utilization higher than ~73% (energy) or ~90% vol. at reactor inlet, the scheme is simplified by-passing the selective CO_2 removal system. For higher H_2 concentrations, any carbon input to the system, via NG, along with other components like N_2, are eliminated through the tail gas purge from the system, which is used as fuel in the gas heater (Figure 4).

Figure 4. ENERGIRON ZR Scheme with H_2 use



In terms of energy consumption, the impact of H_2 (figures as % of total energy input), as compared to NG is indicated in Figure 7, showing the potential energy credit of the %C in the DRI, when being melted in a EAF.

Figure 7. Energy consumption figures as function of NG/H_2 ratios (% energy input)



Unique advantage for the use of H_2 with high operating pressure

Unique benefits of the ENERGIRON ZR technology for the direct use of H_2 is related to the high operating pressure (6-8 bar a), which is reflected in:

- <u>Gas sealing</u>

  Tight sealing is required to prevent any leak of the most diffusible gas in nature. In the ENERGIRON DR plants, the high operating pressure is managed using mechanical sealing for pressurization/depressurization from atmosphere. Mechanical sealing allows higher pressure drop (ΔP) due to friable ores and/or additional fines and is preventing any gas leak/air intake. By this, any additional ΔP is simply handled by the compressor instead of lower gas flow and/or decreasing production rate.

- <u>Fluidization and gas distribution</u>

  Regarding the reduction reactor design, there are two fundamental parameters which define the size and geometry of the shaft: 1) the fluidization factor (*f*) and the solids residence time (τ). The gas velocity of the gas inside any moving bed reduction shaft has the following functionality:

  (1) $V_G = V_{mf} * \boldsymbol{f} = k * [F_{G(act)} * F_S * (M * T)^{1/2}] / [D_i^2 * P^{1/2}]$

where:

V_G is the actual gas velocity inside the shaft

f *is the fluidization factor (<1)*

V_{mf} is the velocity of minimum fluidization; i.e., the gas velocity at which the solids flow is suspended

k is a function of solids and gas properties, the bed's void fraction and particle size distribution

$F_{G(act)}$ = Specific reducing gas flowrate (actual cond.)

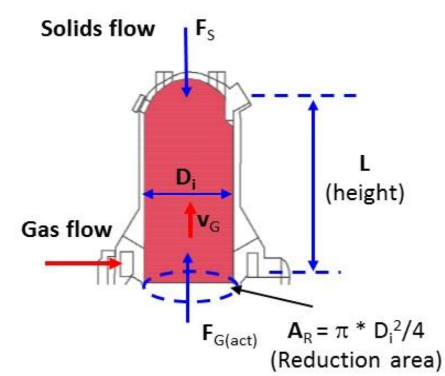
Fs = Production rate

M = Gas molecular weight

T = Reducing gas Temperature

P = Operating pressure

Di = Reactor internal diameter



On the other hand, the residence time is defined as:

(1) $\tau = V_R / [F_S/\rho_S] = L * A_R / [F_S/\rho_S]$

where:

τ *is the residence time*

V_R, A_R *= volume, area of the cylindrical (reduction) area*

L *= the height of the reactor cylindrical (reduction) section*

ρ_S *= solids density*

The fluidization factor (*f*) cannot exceed a maximum value and the residence time (τ) is determined from experimental data, leading to the required volume (V_R). Thus once M (M_{H2} =2), solids properties, required reducing gas (F_G) and H_2 temperature (T) are fixed, the only variables to optimize the reactor design are: diameter (D_i) and height (L).

From above equation (1), It can be easily noted that a high operating pressure allows better flexibility in terms of diameter (D_i), height (L), and residence time (τ) for a better gas distribution.

- Effect of high operating pressure on overall power consumption for H_2 scheme

Regarding the recycle gas compressor for, the power requirements is a function of the compression ratio; i.e.

Compression $\propto (P_2/P_1)^k$

For the same ΔP, higher suction pressure at compressor leads to lower power consumption, as observed in Table 2 below.

Table 2. Effect of high operating pressure for High-H_2 scheme (~96% vol.) on power consumption

Parameter @ PG compressor	ENERGIRON	Other DR technology
Suction pressure (bar a)	5,4	1,1
Discharge pressure (bar a)	7,5	3,2
Gas flow (Nm^3/t DRI)	1440	1440
Power (kWh/t DRI)	20	82

The impact on power consumption for PG compressor with H_2 for lower pressure operation is 4 times higher, reflecting the higher overall energy efficiency of the higher operating pressure of ENERGIRON process.

Remarks

- The ENERGIRON ZR process is a proven DR technology for H_2 use:
- Same process scheme for NG and H_2 in any proportion
- All ENERGIRON DR plants with external reformer are already using ~70% H_2 (%vol.).
- Extensive campaigns were carried out in a demonstration plant in the 1990's with >90% H_2
- ENERGIRON has been the DR technology of choice for projects based on up to 100% *Green* H_2 from renewable energy, like HYBRIT in Sweden and SALCOS in Germany.

References

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[2]Amit Chaterjee; Second edition 2012; *Sponge iron production by direct reduction of iron oxide*.

[3]International Journal of Minerals, Metallurgy and Materials. Volume 22, Number 7, July 2015, Page 1.

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PROCESS INTEGRATION OF COAL BASED SPONGE IRON PLANT

Shabina Khanam, Associate Professor Deptt. of Chemical Engineering, IIT Roorkee

Back Ground

Sponge iron, also known as Direct Reduced Iron (DRI), is widely used in the steel making process. By contributing 25% of the world's DRI production, today, India is the largest producer of sponge iron in the world. Although most of these plants have acquired the desired level of operational efficiency, energy utilization is found to be below the desired limit. Hence, a large scope exists to make the sponge iron industry more competitive by cutting down its internal energy losses using modern technology. The present process consumes around 42 times more energy than that is required theoretically as shown in Fig. 1.

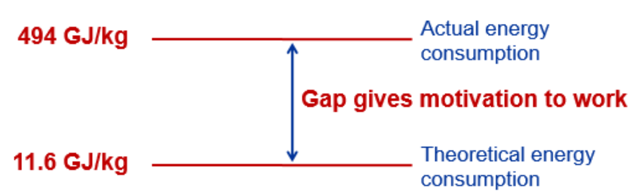

Fig. 1 Theoretical and actual energy consumption in sponge iron process

The energy consumption gap in Fig. 1 can be reduced by the use of Process Integration (PI) techniques up to a maximum of 50% as can be seen from Fig. 2 (https://www.slideshare.net/arvindbjo/pinch-analysis-a-tool-for-efficient-use-of-energy):

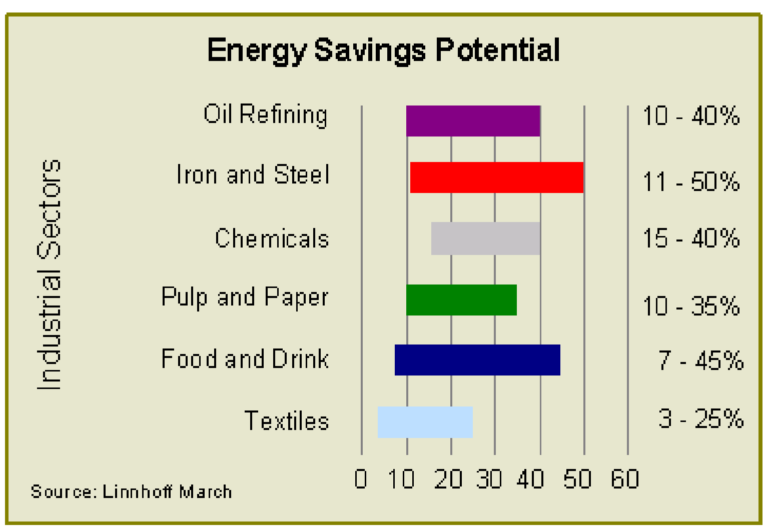

Fig.2 Potential savings in energy that can be achieved using PI techniques in different industries

Further, cost components to produce one tonne of sponge iron is shown in Fig. 3, which shows that coal consumption alone contributes 31.8% to the total cost. For the Sponge Iron industry, the major source of energy is coal. This energy is produced by the combustion of coal in the presence of air. If the energy consumption is reduced through proper heat integration amongst different components of the process then the consumption of coal can also be reduced, which subsequently reduces the production cost and will increase profit margins.

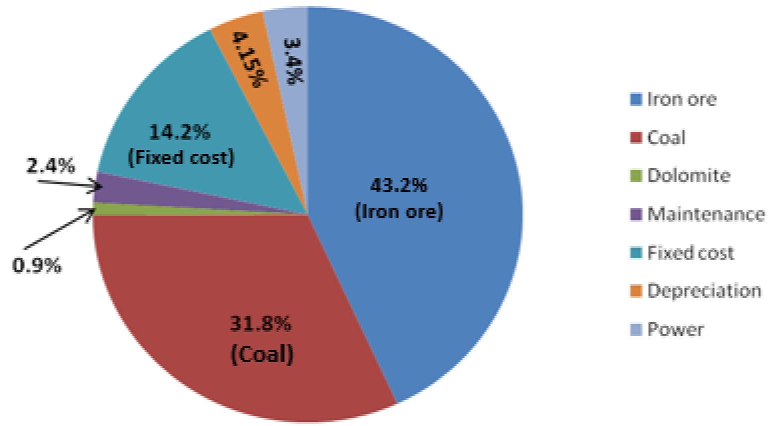

Fig. 3. Cost components (source: our research work)

Heat Recovery Options in Sponge Iron Plant

In India, different coal based sponge iron production processes are used such as SL/RN, Codir, ACCAR, DRC, TDR, SIIL, and Jindal. All these processes use some common equipment such as feed pipe, rotary kiln, transfer chute, rotary cooler, product processing and handling system, dust settling chamber (DSC), after burning chamber (ABC), gas cleaning system and chimney. SL/RN process was developed jointly by the **S**teel Company of Canada, **L**urgi Chemie, **R**epublic Steel Company, and **N**ational Lead Corporation in 1964. This process is the oldest and probably most widely used coal-based sponge iron process in India.

It appears from the literature that in SL/RN process around 30-40% of heat is lost with waste gas. This heat can be recovered using Pinch analysis, which works based on PI principles. The prime objective of Pinch analysis is to achieve financial savings by better process heat integration (maximizing process-to-process heat recovery and reducing the external utility loads i.e. coal). There are five key steps of pinch analysis in the design of heat recovery systems for both new and existing processes:

Step-1: Data Extraction, which involves collecting data for the process and the utility system
Step-2: Targeting, this establishes figures for best performance in various respects
Step-3: Design, where an initial heat exchanger network is established

Step-4: Optimization, where the initial design achieved in Step-3 is simplified and improved economically
Step-5: Try to change the operational strategy of the process to maximize heat integration

Following options can be proposed to recover heat in SL/RN process:

- Preheating of kiln feed, coal and total air using waste gas exiting ESP
- Preheating of kiln feed, coal and total air using waste gas exiting ABC
- Power generation using the heat of waste gas exiting ABC
- Cooling of hot sponge iron through waste gas
- Hot sponge iron is used to preheat kiln air
- Hot sponge iron can be cooled by supplying its heat to water, which is further used to preheat air or can be used for some other purpose.

In a recent research work of ours, we have analysed the above options using 4 steps (Step-1 to Step-4) of pinch analysis. The salient outcomes of heat recovery options are:

1) Sponge iron plant consumes 14.2% - 37.4% less coal in the heat integrated process in comparison to an existing process.

2) This integration amounts to saving of 7.26 Cr/yr – 18.97 Cr/yr (depending on heat recovery option considered)
3) The payback period is found from 6 months – 2.5 years (depending on the heat recovery option selected)

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News Release

Midrex and AMI to offer DRI-based steelmakers complete process optimization solutions

Charlotte, North Carolina, USA and Monterrey, Nuevo León, Mexico, September 10, 2020 – Midrex Technologies, Inc. and AMI Automation have entered into a strategic agreement to provide steelmakers worldwide with a new approach to process optimization for DRI-based integrated EAF steel mills.

The alliance offers steelmakers a comprehensive way to use Midrex's and AMI's latest digital tools and extensive process know-how together to optimize the complete DRI/EAF process. Combining each companies' respective strengths will streamline the entire process remotely – from reduction of iron ore through production of liquid steel in the EAF to achieve the optimum performance for combined DRI/steelmaking plants.

Midrex continues to bring innovation to the direct reduction industry with the introduction of Remote Professional Services (RPS) as part of MidrexConnect®. RPS digitally transforms data into actions. Midrex engineers in Charlotte can evaluate all areas of a MIDREX® Plant anywhere in the world in real-time to optimize product quality and process performance, enhance equipment protection, and increase plant availability.

AMI will provide its comprehensive suite of SmartFurnaceTM products and services to optimize the EAF's. The new approach provides the equipment, the technical know-how, the continuous remote monitoring and support, OPTaaSTM (Optimization-as-a-Service), to ensure the highest efficiency EAF performance using an INDUSTRY 4.0 digital business approach. The AMITech Center (ATC Remote Monitoring Center) is a critical cornerstone of this initiative and provides the latest technologies available to allow AMI´s specialists to continuously monitor and optimize the EAF operation using Analytics, Machine Learning and AI tools. This new approach ensures that customers will be using the best and most modern technology and optimization practices to melt DRI in their EAF's.

Fernando Martinez, Vice President and co-founder of AMI Automation commented, "We are thrilled to have this strategic relationship with Midrex. AMI has a long history of helping our customers use our technology to operate the most efficient EAF's in the world. Working with Midrex will allow, for the first time, the entire steelmaking process to be coordinated.

It also reinforces AMI's commitment to innovation and finding ways to help our customers achieve and maintain new performance levels using digital tools and new digital business models combining the best process know-how in the industry."

“The power of digitalization is allowing us to better focus our process expertise on optimizing the performance of MIDREX Plants,” KC Woody, COO of Midrex Technologies, said. “By teaming up with AMI, we can offer our customers practical and sustainable solutions from the DRI plant through the EAF melt shop.”

Midrex Technologies, Inc.
Midrex is the world leader for direct reduction ironmaking technology and aftermarket solutions for the steel industry. As the technology provider of the MIDREXP® PProcess for 50-plus years, Midrex designs, builds and services Direct Reduced Iron (DRI) plants.

The MIDREX Process fits the need of steelmakers seeking a dependable and clean source of iron. Each year, MIDREX Plants produce more than 60% of the world's DRI in its three forms: cold DRI (CDRI), hot DRI (HDRI), and hot briquetted iron (HBI). The MIDREX Process is unsurpassed in the industry in terms of production and process flexibility.

The company’s headquarters and research and technology development center are located in Charlotte, NC, USA. Midrex Technologies also has offices in the United Kingdom, China, Russia, India, and Dubai.
For more information, please visit www.midrex.com.

About AMI Automation
AMI Automation is a premier international automation and control solutions company. Its Meltshop Solutions division is a recognized innovator and world leader with over 30 years dedicated to EAF Optimization using the latest automation and control technologies to make EAF’s run better and more efficiently. AMI Automation´s team of experienced, specialized engineers is one of the largest technical groups fully dedicated to EAF Optimization.
With this new partnership AMI continues its focus on designing, manufacturing and implementing innovative technology solutions to provide process improvements that help run companies more efficiently.
For more information, please visit www.amiautomation.com

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Statistics

Item	Performance of Indian Steel Industry		
	April-Sept. 2020-21*(mt)	April-Sept. 2019-20(mt)	% Changes*
Crude Steel Production	43.363	55.000	**-21.2**
Hot Metal Production	30.178	36.602	**-17.6**
Pig Iron Production	2.020	2.960	**-31.8**
Sponge Iron Production	**14.537**	**18.351**	**-20.8**
Total Finished Steel (alloy/stainless + non-alloy)			
Production	38.586	51.621	**-25.3**
Import	1.985	4.018	**-50.6**
Export	6.544	3.935	**66.3**
Consumption	35.864	50.989	**-29.7**
Source: JPC; *provisional; mt=million tones			

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RESULTS OF E-AUCTION FOR COAL MINES UNDER 11TH TRANCH

(11TH tranche of auction under the coal mines (Special Provisions) Act, 2015)

S.No.	Coal Mine	Auction Closing Date	Closing Bid Submitted by	Closing Bid %age share of Revenue
1	Takli-Jena-Bellora North and South	02.11.2020	Aurobindo Reality and Infrastructure Pvt. Ltd.	30.75
2	Urtan	02.11.2020	JMS Minng Pvt.Ltd.	10.5

S.No.	Coal Mine	Auction Closing Date	Closing Bid Submitted by	Closing Bid %age share of Revenue
3	MarkiMangali-II	02.11.2020	Yazdani International Pvt Ltd.	30.75
4	Radhikapur West	02.11.2020	Vedanta Limited	21
5	Chakla	02.11.2020	Hindalco Inds.Ltd	14.25
6	Bandha	03.11.2020	EMIL Mines & Mineral Resources Limited	21
7	Brahmadiha	03.11.2020	The Andhra Pradesh Mineral Development Corp. Ltd.	41.75
8	Dhirauli	03.11.2020	Stratatech Mineral Resources Pvt Ltd.	12.5
9	Sahapur West	03.11.2020	Sarda Energy and Minerals Ltd.	26
10-11	Gotitoria (East) & Gotitoria (West)	04.11.2020	Boulder Stone Mart Pvt. Ltd.	54
12	Urtan North	04.11.2020	JMS Mining Pvt. Ltd.	9.5
13	Gare Palma IV 1	04.11.2020	Jindal Power Ltd.	25
14	Rajhara North Central & Eastern	05.11.2020	Fairmine Carbons Pvt. Ltd	23
15	Sahapur East	05.11.2020	Chowgule and Company Pvt. Ltd	41
16	Radhikapur East	06.11.2020	EMIL Mines and Mineral Resources Ltd.	16.75
17	Urma Paharitola	06.11.2020	Aurobindo Reality and Infrastructure Pvt. Ltd	26.5
18	Gondulpara	07.11.2020	Adani Enterprises Ltd.	20.75
19	Gare Palma IV/7	09.11.2020	Sarda Energy and Minerals Ltd.	66.75

Source: Ministry of Coal

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