DRI UPDATE

SIMA

Sponge Iron Manufacturers Association

Indian voice for the ore based metallic & steel industry

MARCH-2022

Editorial

Dear Readers,

Domestic steel scenario in the first three quarters of the current financial year have been very encouraging in terms of production, export and steel consumption. It was thought that country has been gradually coming out from the adverse impact of COVID-19. However, the event in the fourth quarter is threatening the gains of earlier quarters. The developments in the Russia - Ukraine crisis are threatening the entire global supply chain. It is too early to assess its impact in the Indian and global steel industry. We should closely watch developing situation and continue to focus internally as there is a vast indigenous raw materials and demand potential.

The present issue brings out three different articles. The first article focuses on the importance of digital technologies to increase productivity, energy efficiency and predictable operating scenario. Second article is about the Hot Briquetted Iron-C-Flex Project taken up by International Iron Metallics Association (IIMA) regarding the maritime transportation of Hot Briquetted Iron (HBI) and the challenges likely to be faced and talk about the changes of characteristics required to be reflected in maritime regulations. The third article discusses the importance of the skill development and the provisions/schemes available to upgrade the skill.

Today there is a lot of discussion about the need to reduce carbon footprints in our industry. Government of India has announced a very ambitious National Hydrogen Mission. Various Union Ministries are working together to explore the possibilities of reducing the carbon footprints. It may be recall that **National Steel Policy 2017** stipulates the need of reducing the CO2 emissions from the level of 3.1 tonne per tonne of steel to 2.4 tonne CO2 per tonne of steel by 2030. However, there is a thinking that it should be further brought down to the level of 1.72 tonne CO2 per tonne by 2030. The industry feels that it is too ambitious until unless some favorable techno economic distractive technologies are established. As we all know that gas based DRI is highly eco-friendly. However, we have to seriously explore the possibility of substituting coal by other means to reduce CO2 emissions. I am sure in a time to comes we will find out the viable solutions.

Wish you all the best,

Deependra Kashiva
Executive Director

Tenova's *Intelligent* EAF Technologies Aligned To Industry 4.0 Standards

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Summary

The recent development of smart technology and high-speed computer analysis, is rapidly reshaping the traditional EAF process into one that is closely controlled, more predictable and optimized in real-time. Concrete steel plant examples of the deployment of an array of innovative technologies that have enabled dynamic process optimization and dramatically reduced total energy consumption, increased yield and decreased power-on-time will be discussed. Also, innovative sensors coupled with computerized data analysis that is providing breakthrough solutions to chronic problems such as water leak detection and dynamic process control for each stage of the melting and refining process

Introduction

The aim of Industry 4.0 is the creation of smart factory that utilizes a highly digitalized link between production equipment, sensors, Level 1 & 2 control networks, process control models and cloud computing both within specific process steps and across the entire production facility. The net result allows for more effective control & optimization of each process step in a way that is dynamically aligned with changing day-to-day factory constraints thereby minimizing total production costs & inefficiencies.

Herein is described, Tenova's vision for Industry 4.0 as it applies to the creation of an "Intelligent" EAF (***i* EAF®**) steelmaking process. The intent of the *i* EAF® technologies is to continuously monitor and dynamically control to sustain optimal performance day in and day out. In addition, *i* EAF® technology fits within Tenova's ***i* MeltShop®** . Industry 4.0 system to ensure that EAF production is harmonized to meet the plant's daily production constraints thereby achieving the optimum result for the entire steel shop. [1]

The objective is to implement an Industry 4.0 EAF solution that provides continuously improved EAF savings & performance based on:

- Replacing assumptions & related inaccuracies with real-time process measurements in critical areas obtained from robust, reliable sensors;
- Replacing statistical process models which are prone to excessive drift with a new generation of more fundamental thermodynamic & kinetic based process control models that incorporate real-time mass & energy balances;
- Creating a digitalized interface that links process equipment, sensors, Level 1 & 2 networks, and process control models;
- Using cloud computing services to store and analyze large amounts of process data from multiple EAF's & plants where appropriate;
- Employing a team of highly trained data scientists together with machine learning techniques to develop improved & optimized 2nd & 3rd generation process control models;

- Continuously monitoring model performance; and,
- Providing automatic dynamic retuning of the models when necessary to ensure sustained maximum performance over the long-term.

Intelligent EAF – STEP 1 Critical Sensors

Implementation of robust sensors is an important first step in establishing a workable, EAF, Industry 4.0 solution. The sensors provide actual measurements in critical process areas and thereby avoid control errors and inaccuracies that can result when using estimates & assumptions. Off-gas composition, flow, temperature & pressure provide valuable real-time information necessary for closing a real time EAF mass & energy balance, for optimized control of the quantity & timing of both chemical energy & electrical inputs and for optimized furnace draft control. While reliable off-gas sensors have largely been lacking in the past, as explained below Tenova Goodfellow has now developed a full suite of commercially robust sensors that provide these critical process measurements.

A. Full Spectrum Off-Gas Analysis:

Virtually 100% of EAF off-gas consists of 6 species; CO, CO_2, O_2, H_2, H_2O vapor & N_2. Knowledge of this full spectrum off-gas analysis is important for controlling the EAF's oxygen potential, for dynamic control of fume system suction, to enable efficient O_2 lancing & carbon injection, to close a real-time Mass & Energy Balance and for real-time Water Detection which all together dramatically improve EAF energy efficiency, reduce operating costs, improve yield & productivity and improve safety [2].

Traditionally there have been two classes of off-gas analysis technology utilized in EAF steelmaking:

i. Extractive, and,
ii. Insitu Tunable Diode Lasers (TDL)

Both technologies were commercialized about 20 years ago but neither has provided a complete off-gas analysis solution for steelmaking process conditions [3, 11].

In 2015, Tenova Goodfellow developed and patented the 1st commercial "next generation" hybrid extractive/ laser off-gas analysis system designed especially for harsh industrial processes such as exist in EAF & BOF steelmaking [3, 11]. **NextGen®** technology combines the excellent reliability of traditional extractive technology with the faster response time and the lower hardware installation costs of tunable diode lasers. Unlike Insitu systems, NextGen® hybrid technology utilizes off-gas extraction through a redesigned probe positioned directly in the cone of off-gas exiting the EAF at the 4th hole.

Positive extraction remains the best way to ensure high system reliability and avoid lost analytical signals. Compact Extractive Sampling Station(s) are mounted directly on the melt shop floor without the need for an environmentally protective room. A short heated line connects the Sampling Station to the gas sampling probe. Since the Station is compact in size, it can be located in close proximity to the probe thereby shortening the physical distance and time delay associated with transporting the off-gas sample to the analytical cells. The Extractive Sampling Unit has a high speed pump to rapidly & continuously extract the off-gas sample through the probe located in the cone of pure EAF off-gas flowing in the duct. The unit then filters the gas sample to remove particulate matter prior to analysis. The clean gas is then introduced into various types of laser & analytical cells to reliably analyze the off-gas for CO, CO_2, O_2, H_2 & H_2O vapor. Using clean filtered off- gas minimizes analytical cell maintenance. Also filtered gas ensures that there are no analytical signal interruptions as is the case with Insitu lasers.

Each extractive sampling station is connected by fiber/coax cable(s) to a compact multipoint central control cabinet that is most often located in the EAF control room. This central unit physically houses the laser beam generators. It sends continuous laser signals via fiber optic cable to each Extractive Sampling Station's analytical cells and receives the return signals by coax cable to continuously analyzes full-spectrum off-gas chemistry for CO, CO_2, O_2, H_2, H_2O vapor & N_2 (by difference from 100%).

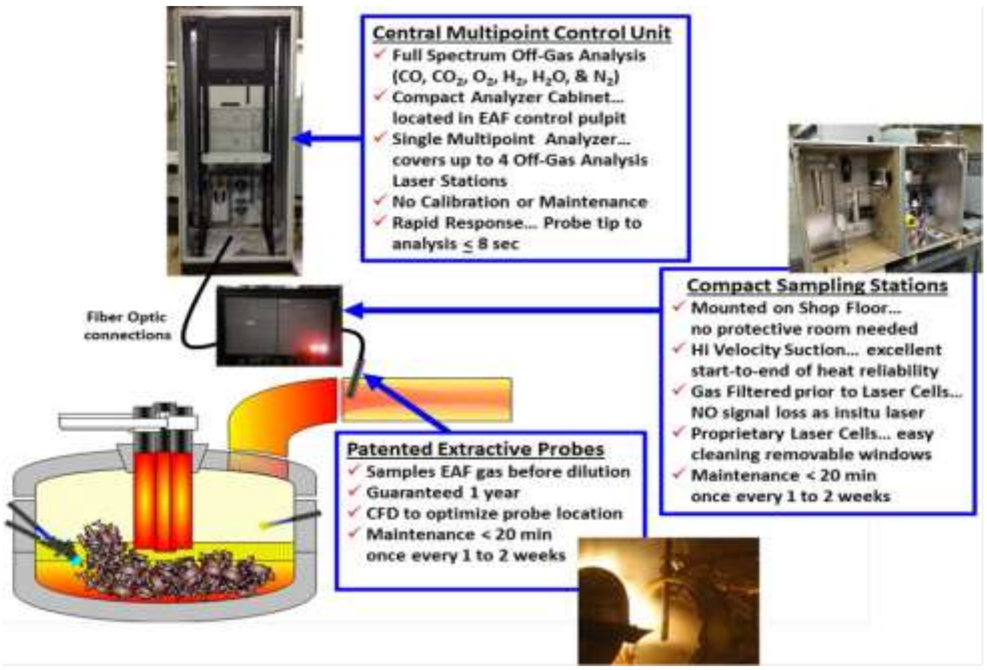

Figure 1: NextGen® Multipoint Hybrid Extractive/Laser Technology

Importantly, NextGen® technology has excellent multipoint capabilities and can be connected to up to as many as 6 independent Extractive Sampling Stations. NextGen® uses a beam splitter to divide the main high powered laser signal into multiple continuous lower powered beams. Because Insitu laser systems require a full powered beam to minimize signal interruptions, they need to use an optical switch to sequentially index the full powered main beam from one sample location to the next. As such, Insitu laser systems provide a series of discrete analyses (8 seconds between individual readings for 2 sample locations, 12 seconds for 3 sample locations & so on). By comparison, beam strength is not a concern with NextGen® because there are no beam interruptions when using filtered gas. Hence, NextGen® seamlessly provides "continuous & simultaneous"off-gas analysis from multiple sampling locations. NextGen® technology is ideally suited for multiple sampling applications – NextGen® installations since 2015 include:

- 4 Systems in top charge EAF shells equipped with upstream & downstream off-gas analysis [5]
- 3 Systems in shops equipped with BOF & AOD furnaces
- 8 Systems in Consteel®, Twin Shell & Shaft Furnace shops [6,7]

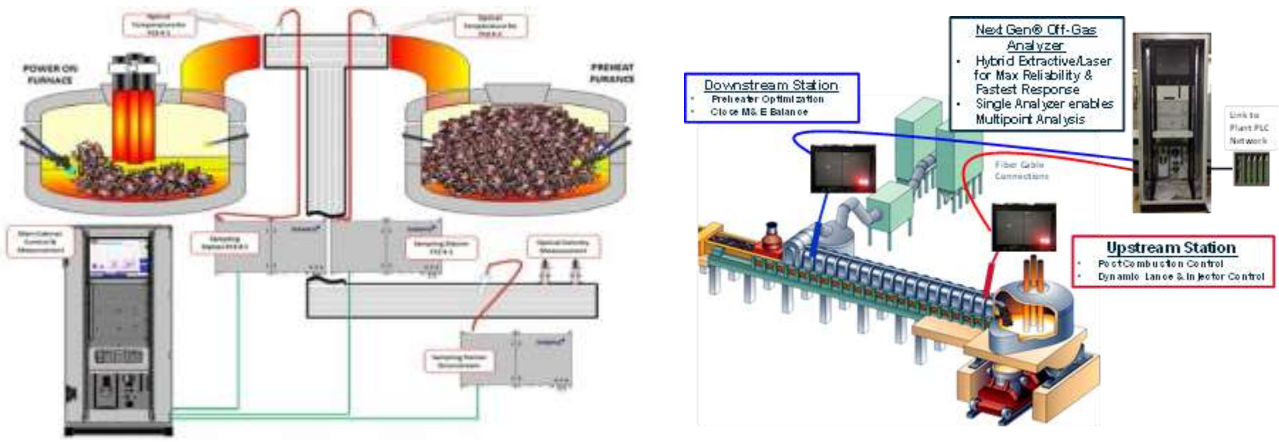

Figure 2: NextGen® Technology in Multipoint Applications

The NextGen® system also offers significantly improved operator safety since there is no off-gas physically at the Central Cabinet thereby removing any concerns from a CO leak in a confined space such as a control room

B. Off-Gas Flow & Temperature Measurement:

Real-time EAF mass & energy balance calculations are powerful process control tools but they require knowledge of not only off-gas % composition but also of off-gas flow and temperature. Contact sensors embedded in the off-gas stream have traditionally been used to monitor off-gas flow and temperature. These contact sensors can suffer from abrasion & thermal degradation that often leads to excessive wear, maintenance & sensor failure.

Because of this, these types of high maintenance contact sensors are often left unrepaired which in turn leads to process control errors & inaccuracies when assumed values are used to replace actual measurements.

To address this problem, Tenova Goodfellow recently developed and commercialized a series of proprietary optical, noncontact sensors to measure both off-gas flow (“**OVM**“) and temperature.(“**OTM**“).

The OVM consists of two small optical sensors attached to optical view ports in the fume duct. These sensors continuously track radiation patterns in the fume stream to measure off-gas velocity. Because there are no components in direct contact with the off- gas stream, the OVM is particularly valuable for measuring high temperature gas flow.

The OTM is an optical sensor that uses a wavelength ratio method to measure off-gas temperature. This design requires minimal maintenance and avoids temperature inaccuracy problems often associated with excessive dust collecting on the optical lens.

The OTM is available in two configurations, either as a remote sensor or as view port sensor (Figure 3).

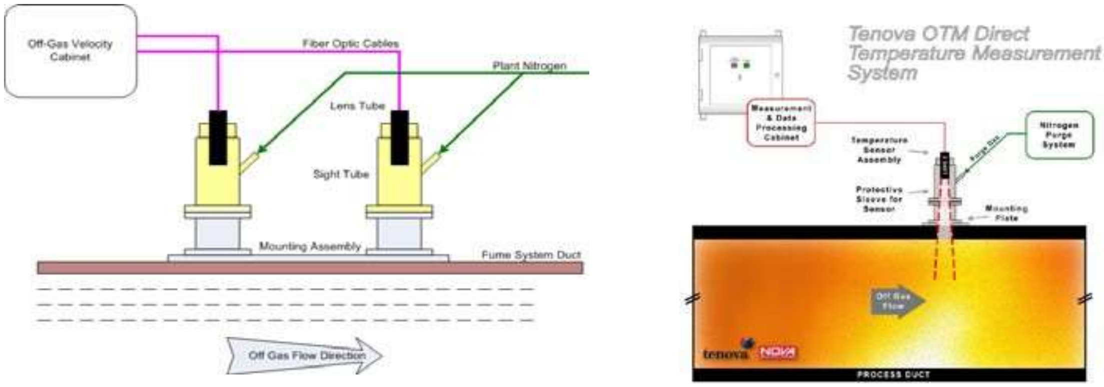

Figure 3: Tenova's OVM & OTM Optical Sensors

C. EAF Static Pressure Measurement:

EAF static pressure is an important measurement for fume system draft control. Tenova Goodfellow's proprietary static pressure probe is mounted on the furnace elbow and is similar in design to the NextGen® off-gas analysis probe. Tenova's pressure probe design has proven to be much more reliable and require less maintenance than more commonly found pressure ports located in the furnace roof. [4]

Intelligent EAF – STEP 2 Fundamental M&E Balance Process Control Models

Typical EAF control is based on 'kWh/ton'. With this conventional method, each heat's sequencing & energy delivery is essentially the same and is made without consideration for chemical energy inputs, and energy losses & inefficiencies - 'Kwh' is fixed by the transformer and 'ton' is fixed by the charge weight.

A better approach is to control the EAF with real-time mass & energy balances – in this case, the timing & quantity of chemical energy ('kWh equivalent') and electrical energy ('kWh') is made dynamically on a heat specific basis allowing for the "actual total net energy" received by the charge after energy losses & process inefficiencies [4,5,8].

Tenova's *i* EAF ® technology utilizes the critical sensors described above together with a link to the plant's Level 1 & 2 network to obtain the measurements needed to close real-time EAF mass & energy balances. As shown in Figure 4, the typical installation arrangement includes:

- A single NextGen® Control Cabinate Connected to Upstream & Down stream Sampling Stations
- OTM optical off-gas temperature sensor
- OVM optical off-gas velocity sensor
- An EAF static pressure probe

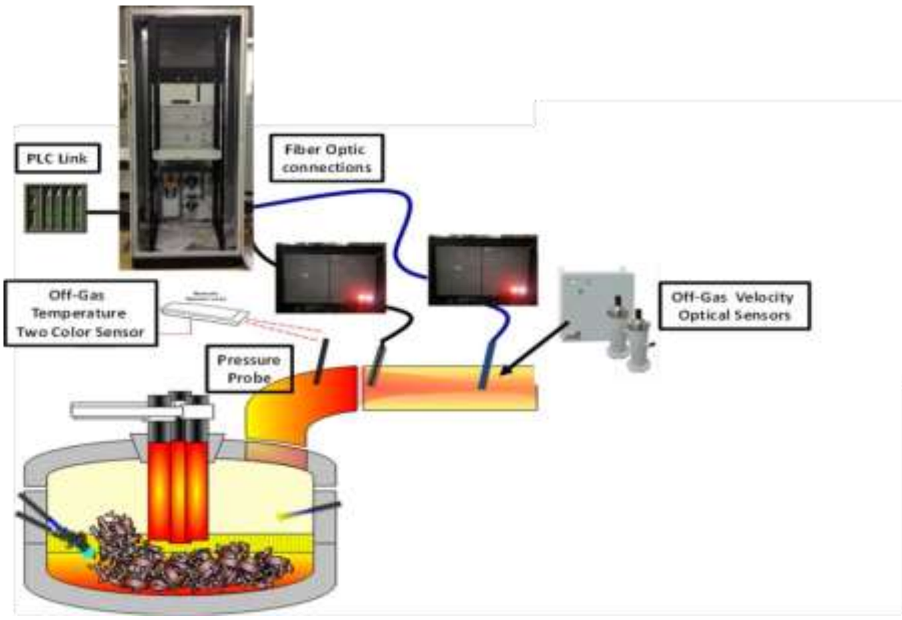

Figure 4: *i* EAF® Typical Hardware Arrangement

The *i* EAF® uses fundamental process control models incorporating thermodynamic & kinetic algorithms and mass & energy balance calculations. When using actual sensor measurements, experience shows that fundamental models offer a higher degree of precision than statistical models which are prone to performance drift as operating conditions change.

The *i* EAF® is programmed with several independent process control models that work independently to evaluate different aspects of the EAF process. [4] Each model contributes to the calculation of the total chemical & electrical "**Net Energy**" delivered to the charge/bath after losses & inefficiencies:

Total Net Energy =

Σ Electrical In + Σ Chemical In

Σ Off-gas Losses – Σ Other Losses

Total Net Energy is calculated second-by-second from start-to end of the heat and is used to dynamically control all energy inputs. The *i* EAF® also uses Total Net Energy to calculate the melting progress of the charge ("%MP") from 0% MP at the start of melting to 100% MP at the flat bath fully melted condition.

The *i* EAF® incorporates three control Modules:

- **Module 1:** controls the quantity of chemical energy input during melting based on the NextGen® full spectrum off-gas analysis;

- **Module 2:** controls the timing for indexing chemical & electrical energy set points during melting based the Total Net Energy delivered to the EAF after losses
- **Module 3:** controls O_2 delivery once flat bath conditions exist to hit the aim endpoint %C, ppm O & temperature.

The *i* EAF® includes a web based HMI that can be viewed by authorized users on any PC, tablet or phone connected to the internet. The software has been configured with an exceptionally open architecture allowing an unparalleled level of user customization. The *i* EAF® comes with built in process control algorithms for all standard EAF equipment including burners, lances, injectors, powder feeders, electrical control, etc. The software allows authorized users at the plant to enter additional code in any programming language that can be compiled as a library. As such each plant can customize the basic *i* EAF® software including:

- Modifying existing *i* EAF® process control model algorithms to meet specific user requirements
- Adding new user developed process control models
- Adding control programs for any new or nonstandard EAF equipment including 7 in North America and 6 in Europe & the Middle East.
- Modifying existing HMI screens, adding new HMI screens, generating reports, etc. to meet specific user requirements

While individual plant results can vary, the Average performance benefits with Tenova's *i* EAF® technology across all installations is summarized in the table below:

BENEFITS	STEEL PLANT SIGN-OFF at Project Completion	LATEST COMPLETED INSTALLATIONS	
OPERATING COST	✓ US $ per tls Cost Savings from electricity, carbon, fuels & oxygen	Average Saving Minimum Saving	from $1.47 to $4.25 per tls $1.00 per tls
		Module 1 (Average Saving)	Module 1+2+3 (Average Saving)
ENERGY	✓ Electricity	8.0 kWh per tls	15.0 kWh per tls
	✓ Gas & Fuel	38.8 sft^3 per tls	38.8 sft^3 per tls
	✓ Injected Carbon	2.2 lbs per tls	2.2 lbs per tls
	✓ Charge Carbon	3.1 lbs per tls	3.1 lbs per tls
	✓ Total In-EAF Energy (kWh equivalent)	24.0 kWh per tls	30.0 kWh per tls
WATER DETECTION	✓ Water Leaks Detected in Real-Time	40L/m	
PRODUCTIVITY	✓ Power On Time – POT	Average Saving	2.0 min per heat
	✓ Productivity - tls per POT	Average Increase	4.6%
	✓ % Yield	Average Increase	0.4%
ENVIRONMENTAL	✓ CO_2 Reduction	Average Reduction	17.9%

Intelligent EAF – STEP 3 Digitalization

Tenova's latest step in developing an Intelligent EAF is an "**EAF Digitalization Program**" implemented by a team of data scientists & process experts using cloud data storage technology and machine learning to monitor & analyze EAF process performance, develop improved process control models and dynamically retune process models.

STEPS 1 & 2 described above created a digitalized interface within the EAF shop that links operating equipment, critical sensors, Level 1 & 2 networks, and *i* EAF® process control models to achieve dynamic mass & energy based control of the EAF process.

The **3rd STEP** completes the **Digitalization** by leveraging on advanced analytics, machine learning methods and Digital Cloud services.

In May 2017, Tenova entered into a partnership with Microsoft® including strategic consulting and Azure cloud computing services. Azure offers superior data security and as well as the most comprehensive compliance portfolio of any cloud provider.

Tenova's Digitalization Program is designed to:

- use the Azure cloud computing services to store and analyze large amounts of process and/or water detection data from multiple EAF's & EAF plants where appropriate;
- employ a team of highly trained data scientists applying machine learning techniques to develop improved & optimized 2nd & 3rd generation process models, i.e. "Digital Twins";
- continuously monitor hardware & process model performance;
- provide automatic dynamic retuning of process models when necessary to ensure sustained maximum performance is maintained over the long-term.

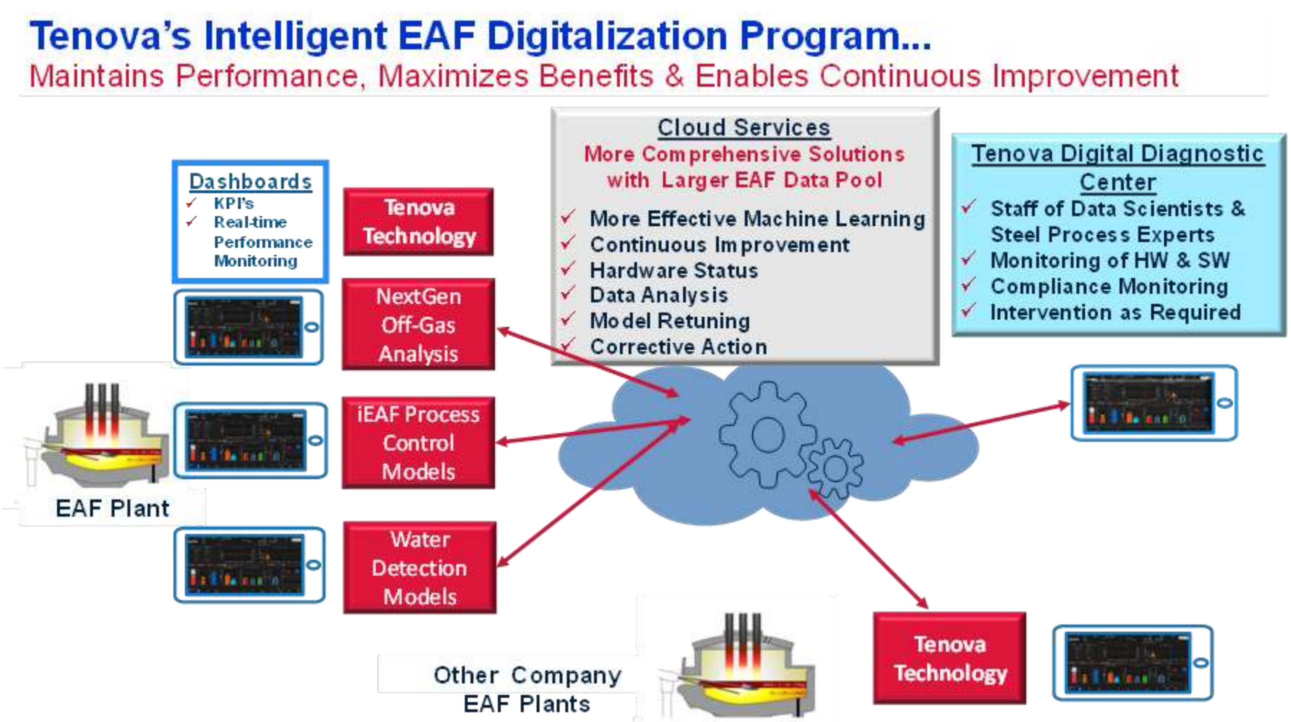

Figure 7: Tenova's Digitalization Program - designed

Tenova's **Intelligent EAF Digitalization Program** is focused on four main areas:

I Continuous monitoring of **NextGen®** system hardware to quickly identify & alert the plant when the equipment requires service & maintenance (see Figure 6)

ii Continuous monitoring & improvement of ***i*** **EAF®** process models to sustain & maximize operating performance benefits over the long term (see Figure 7)

iii Continuous improvement of the **NextGen® Water Detection** models to minimize missed leaks and false alarms over the long term [9,10]

iv Provide automatic dynamic retuning of the ***i*** **EAF®** process models and/or **Water Detection** models when necessary to ensure sustained maximum savings, water detection performance and minimum false alarms over the long-term.

Conclusions

This paper describes Tenova's vision for Industry 4.0 as it applies to creation of an "Intelligent EAF" steelmaking process. This program is designed to provide continuous improvement and better technology/performance alignment between individual plants in companies with multiple production sites.

Tenova's Industry 4.0 Intelligent EAF solution incorporates several steps:

- Development & installation of a suite of robust, & reliable sensors that provide process data measurements in EAF critical areas including off-gas full spectrum analysis, off-gas flow, off- gas temperature & EAF static pressure

- Replacing statistical process models which are prone to excessive drift with a new generation of more fundamental thermodynamic & kinetic based process control models that incorporate real-time mass & energy balances

- Creating a digitalized interface that links process equipment, sensors, Level 1 & 2 networks, and process control models

- Using cloud computing services to store and analyze large amounts of process data from multiple EAF's & production sites

- Employing a team of highly trained process experts & data scientists applying machine learning techniques to develop improved & optimized 2^{nd} & 3^{rd} generation process control models

- Continuously monitoring model performance

- Providing automatic dynamic retuning of the models when necessary to ensure sustained maximum performance over the long-term

Figure 8: Tenova's Digitalization Program Continuously Monitors System Hardware Health, Example of a NextGen® Dashboard

Figure 9: Tenova's Digitalization Program Continuously Monitors System Software, Example Water Detection Dashboard

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HOT BRIQUETTED IRON-C-FLEX PROJECT: Addressing a Challenge to the HBI Value Chain

Chris Barrington Chief Advisor – International Iron Metallics Association (IIMA)

INTRODUCTION

Hot Briquetted Iron (HBI) continues to grow in importance as a merchant feedstock for the global steel industry, with a significant volume of trade involving maritime transport. The pace of growth can be expected to accelerate as the steel industry progresses along the pathway towards decarbonization of production.

Maritime transport of HBI is governed by the regulations of the International Maritime Organisation (IMO), which include specific provisions for all forms of Direct Reduced Iron (DRI). Therefore, it is essential that changes in the characteristics of HBI are properly reflected in maritime regulations.

Several emerging trends have the potential to challenge the status quo with respect to safe shipment of HBI, notably decarbonization of steelmaking and the expected medium-to-long term shift to hydrogen-based HBI, and in the shorter term, the trend towards flexible and higher carbon content of HBI. IIMA has started a project called HBI-C-Flex to evaluate the impact of these trends on reactivity of HBI and safe shipment.

THE GENESIS OF HOT BRIQUETTED IRON-C-FLEX

This story has its beginnings in the 1970s, when HBI started its journey to becoming an established part of the global steelmaking raw materials supply chain – indeed this author travelled to Venezuela in 1975 to procure a trial cargo of FIOR briquettes for the EAF steelmaking industry in the UK. As is well-known, HBI was developed as a densified form of DRI in order to overcome the risk of self-heating inherent with shipping DRI. Over the years, the Venezuelan HBI producers, working together with IIMA's predecessor organization the Hot Briquetted Iron Association (HBIA), developed a generic specification for HBI that was aimed at safe maritime transport. A key element of this specification was density >5,000 kg/ m^3, accepted after much debate by IMO in 2008 for inclusion in the International Maritime Solid Bulk Cargoes Code (IMSBC Code) that came into legal effect in 2011.

HBI has the bulk cargo shipping name "DIRECT REDUCED IRON (A) briquettes, hot moulded" in the IMSBC Code with the following description:

Direct reduced iron (DRI) (A) is a metallic grey material, moulded in a briquette form, emanating from a densification process whereby the DRI feed material is moulded at a temperature greater than 650°C and has a density greater than 5,000 kg/m^3. Fines and small particles (under 6.35 mm) shall not exceed 5% by weight.

Fast-forwarding several years, IIMA's Technical Committee noted the developing interest in DRI/HBI with variable carbon content, ranging from the traditional level of 0.5-1.6% up to as much as 4.5%. A consequence of HBI with higher carbon content is lower density, which in turn raises the question of safe maritime transport and the IMSBC Code; i.e., at what density does the reactivity of HBI increase to the point that it behaves more like DRI with its attendant risk of self-heating thus requiring more comprehensive safety precautions, notably the need for ships' holds carrying DRI to be inerted with a blanket of nitrogen?

Information and scientific data behind the selection of a density of >5,000 kg/m3 for safe shipment have proven difficult to find. Much of the research on this topic was conducted in the pre-digital era and it appears that many of the relevant files have been lost or destroyed for one reason or another. Therefore, we decided to conduct a literature search as the first step. The Austrian metallurgical research organisation K-1 MET, together with the Ferrous Metallurgy Department of Leoben University, was commissioned to carry out the project, which was designated HBI-C-Flex.

BROADENING THE SCOPE

Fast-forwarding again to the present, one of the over-arching preoccupations of the global steel industry is the goal of an 80- 95% reduction of CO_2 emissions in steel production relative to 1990 by the middle of the 21st century. A key component of this vision of carbon-neutral steelmaking is a progressive, but not necessarily total shift from the integrated Blast Furnace/ Basic Oxygen Furnace (BF/BOF) to the Direct Reduction/Electric Arc Furnace (DR/EAF) steelmaking route, with hydrogen- based DRI and natural gas-based DRI with CCUS (carbon capture, utilization, and storage) progressively replacing conventional DRI.

Figures 1 and 2 are based on data for the Sustainable Development Scenario from the steel chapter of the International Energy Agency's "Energy Technology Perspectives 2020 report [1]. The total DRI production of 411 Mt predicted for 2050, when compared with the 108 mt produced in 2019, represents an increase of 280%. This article will not debate the likelihood that such a scenario will eventuate, but two aspects are relevant from the perspective of HBI-C-Flex. Firstly, the question of where will all this DRI be produced: integrated with steel plants, integrated with iron ore operations, or somewhere in between? The answer is probably all of the above. But whatever the case, it seems highly likely that a significant proportion of DRI will be produced in the form of HBI and transported internationally by sea. Furthermore, an increasing proportion of this HBI will be hydrogen-based and contain little or no carbon. What are the implications of this for safe shipping?

Secondly, this greatly increased DRI production will have profound implications for iron ore supply. The market for DR-grade pellets (and pellet feed) is currently very tight and IIMA's analysis suggests that the current and planned supply of DR-grade pellets will be fully utilized by around 2030. This means additional supply will be needed and/or the direct reduction industry will have to utilize a proportion of lower grade feedstock. In the latter case, the issue of HBI density and safety of shipping again arises.

Thus the scope of the HBI-C-Flex Project has become multi-tracked:

- HBI with little or no carbon (H_2– based)

- HBI produced from lower grade iron ore

- HBI with high carbon content

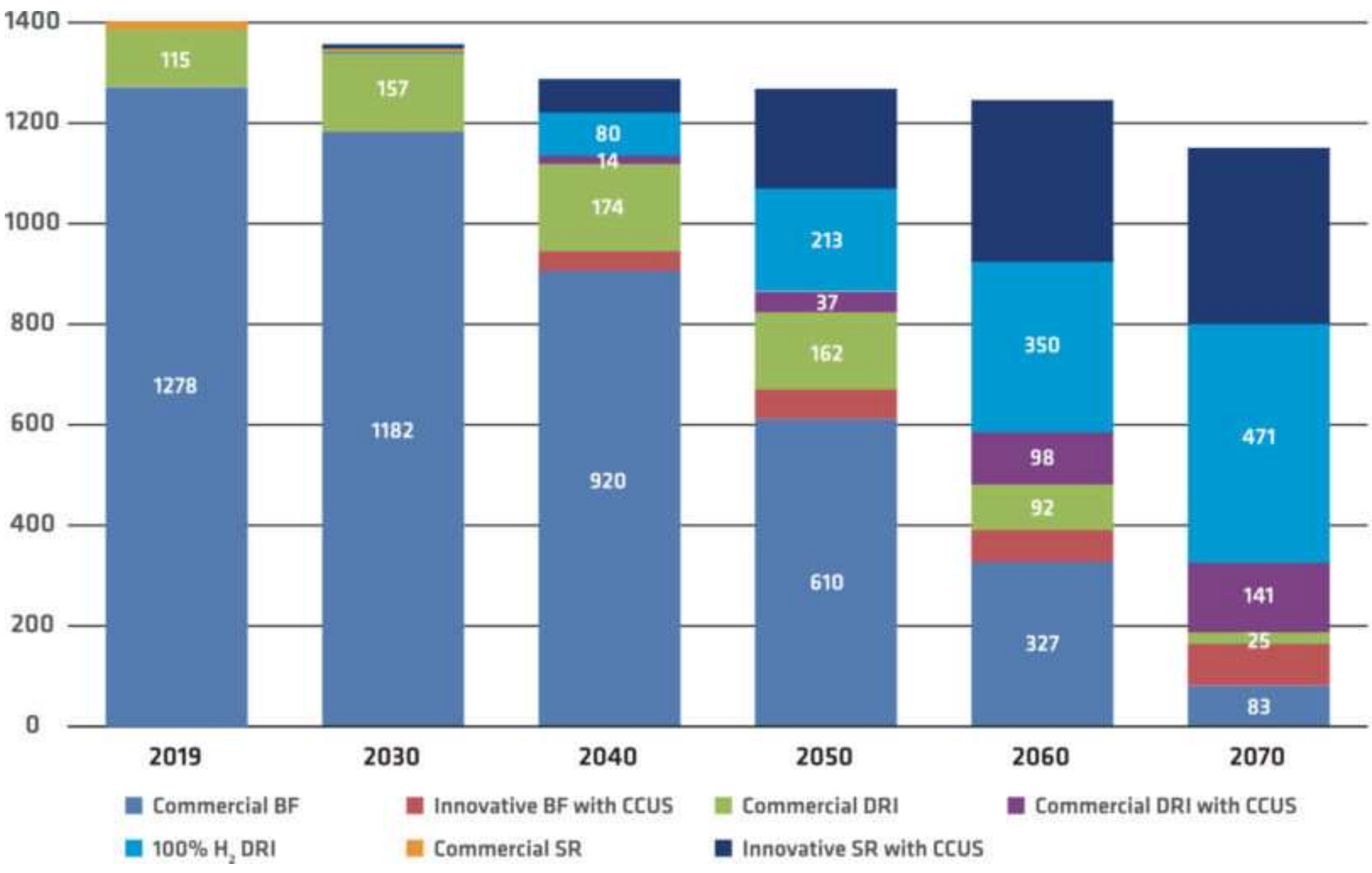

FIGURE 1.

Iron Production by Technology in the Sustainable Development Scenario (mt) [2]

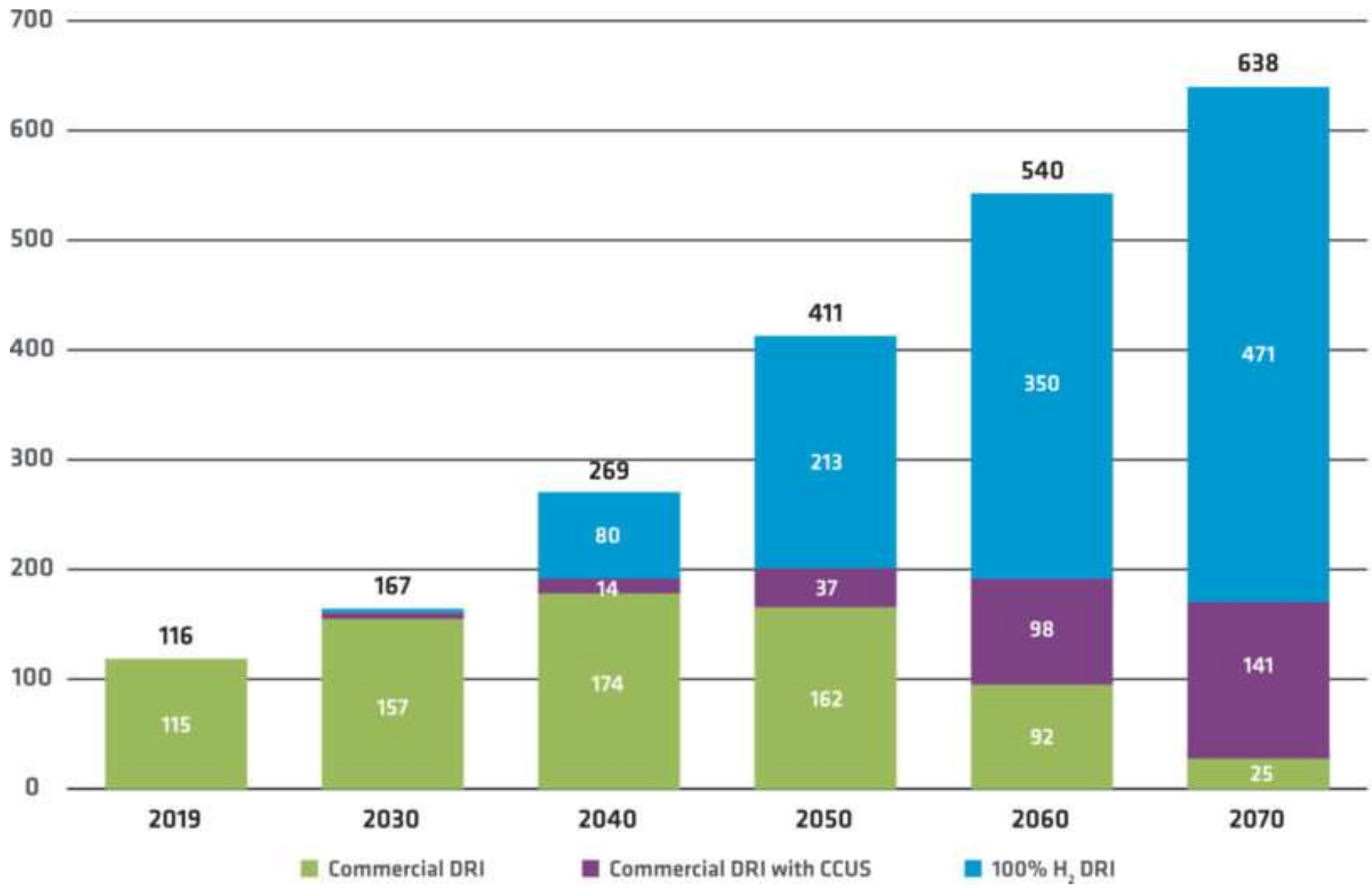

FIGURE 2.

DRI Production by Technology in the Sustainable Development Scenario (mt)

RESULTS OF THE LITERATURE SEARCH

Whilst the search revealed a reasonable number of scientific papers and articles, none of them provided the basis for the >5,000 kg/m3 density threshold. The impact of the chemical composition and mineralogy of the source iron ore, as well as the reduction conditions were barely investigated and discussed. Nor was there a clear interpretation of the effects of the carbon content. Importantly, considering the interaction between the various parameters influencing DRI reactivity, assessing each of them in isolation is not practicable. A reasonable interpretation might be that the choice of >5,000 kg/m^3 was a case of "applied science" with a practical outcome.

Therefore, we concluded that a systematic study is required to investigate the various parameters considered as being the principal drivers of reactivity and thus the self-heating hazard. The study should seek to establish a correlation between these parameters and DRI/HBI reactivity and thereby fill the knowledge gap in the literature. A laboratory-scale concept has been developed to study DRI/ HBI reoxidation behaviour, taking into consideration the principal HBI production process steps from direct reduction of the iron ore to hot briquetting of the final product.

Ultimately, we hope to develop (1) a standardized approach to measuring DRI reactivity, (2) a predictive model relating the self-heating tendency with cargo properties, and (3) a process and guidance for risk assessment and control to underpin the paramount goal of safe handling and transport of HBI at sea and on land.

At IMO, the various types of DRI have a higher-than-average profile due to incidents in the past, meaning that to arrive at a basis for either a new schedule for lower density HBI or an amendment to the existing DRI (A) schedule, a well argued, scientifically based, and peer reviewed case will have to be presented.

It should be noted that the IMO process for addition of hazardous cargoes to the IMSBC Code can be very lengthy, thus necessitating careful and thorough preparation with safe shipment being at the top of the agenda.

THE NEXT STEP

HBI-C-Flex is a project that has important implications for industry participants along the HBI value chain in its broadest sense. The study as outlined above would be a multi-year project and given the accelerating pace of movement along the pathway to carbon-neutral steelmaking, IIMA intends to engage with potential project sponsors over the coming weeks to secure support to commence this vital research.

For further information or to discuss participating in the HBI-C-Flex Project, please contact Chris Barrington, Chief Advisor, International Iron Metallics Association (IIMA), at: cbarrington@metallics.org.

Reference Notes:

1. Data kindly provided by IEA

2. The Sustainable Development Scenario (SDS) sets out the major changes that would be required to reach the main energy-related goals of the United Nations Sustainable Development Agenda, including an early peak and subsequent rapid reduction in emissions, in line with the Paris Agreement, universal access to modern energy by 2030 and a dramatic reduction in energy-related air pollution. The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global "net-zero" CO_2 emissions for the energy system as a whole by around 2070.

(**Source: Direct From Midrex, September 2021**)

Skill Development in Iron and Steel Sector to help SME Sector

Team: Indian Iron and Steel Sector Skill Council (IISSSC)

1. Iron & Steel Industry in India is poised to grow at a significantly robust rate in order to cater to the growing demand for steel from the critical sectors of the economy like infrastructure, construction, engineering & fabrication, automobile, transport, household appliances, etc. The industry has set out a roadmap to achieve 300 million ton of cruse steel capacity by 2030-31 from the current capacity of 138 million ton. A massive modernization and expansion programme by the major steel producers along with upgradation of facilities and high capacity utilization by the small and medium enterprises are under way. The actualization of these gigantic efforts requires knowledgeable and skilled workforce to efficiently set up and run the new plants as well as to cope with the challenges of manning the upgraded steel plants.

2. The Indian Iron & Steel Sector Skill Council (II&SSSC), is an industry (Iron & Steel, Rerolling, Sponge Iron units, Ferro Alloys, Steel Construction and Welding) driven non-profit company limited by Guarantee, registered under the Indian Companies Act, 1956. The company is promoted by Institute for Steel Development & Growth (INSDAG) and Bengal Chambers of Commerce & Industry (BCC&I) and mandated under National Skill Development Corporation (NSDC). The Governing Committee of the Council includes major Iron & Steel companies, Iron & Steel and related Associations, Foundry Association& Indian Institute of Welding etc.

3. IISSSC has so far received approval for**42**Qualifications Packages (QP) and corresponding National Occupational Standards from NSDC / NSQC. These job roles were prepared by IISSSC based on the job role, feedback from the Industry and requirements of training needs in different areas like mechanical, electrical, furnace operator, material handling and also in related industries like Ferro Alloys. The training is being conducted by reputed Training Partners affiliated with NSDC / IISSSC and Assessments are being done by independent Assessment Bodies affiliated with IISSSC. Based on the assessments, the certificates (govt. recognized) are issued by IISSSC to the successful candidates. Govt. has launched several schemes for skill development activities in the country. The one of the main flagship program of the govt. is Prime Minister Kaushal Vikas Yojana (PMKVY).

4. IISSSC in addition to skilling of existing employees for the major steel plants like SAIL, RINL, Tata Steel, JSW, JSPL has also conducted RPL (Recognition for Prior Learning) program for the SME Sector.

As we all know that India being a densely populated country with young population, govt. wants to make India as a Human Resource Power in the world. For fulfilling the same motive several schemes are launched by our Govt. for skill development in our Country. Some of them are very useful and beneficial for SME Sector. Out of them two are mentioned below.

SCHEME 1

RPL(Recognition of Prior Learning) : The programme recognizes the value of learning acquired outside a formal setting and provides a government certificate for an individual's skills.

MSDE in 12 February 2021, requested various Ministries including Ministry of Steel for ensuring

- Engaging skill certified workers for Government contract works.
- Introducing phase-wise certification of their workers.
- At least 10% of the skilled workers to be certified by 2021-22.
- Target 100% workers to be skilled certified by 2026-27 in skill eco-system.

Accordingly Steel Producers may draw out a Plan for certifying their workers in association with IISSSC, so that gradually, 100% of their workers can be brought under skill eco-system by 2026-27.

This step is taken by the Ministry to benefit the industry in long run. Currently Contractual employees are engaged in various important aspects of production involving productivity, safety and health hazards, application of new techniques/work practices and knowledge. Industry is having huge facility to train their own employees and they keep updating the skills and knowledge of their own employees but contractual employees are generally left behind from undertaking training of short duration and skill development. In case for working, training is provided to the contractual labours then industries have to incur additional expenses for training of those contractual labours.

On the other hand the benefits by Industries for engaging trained & certified contractual labours are as follows:

- Will reduce cost of providing in-house training since the labours are already trained & certified.
- Availability of abundant skill certified labours ensuring uniformity of output and getting optimum value for wages paid.

- Higher productivity at workplace
- Reduce incidence of accidents and providing improved Safety standards.
- Skill training in specific job roles would help the industry as well as the contractors to identify right persons for individual functional area.

5. The performance of the Council in PMKVY (Prime Minister Kaushal Vikas Yojana) 1.0& 2.0is under:

The performance of the Council in PMKVY 1.0 (2015-16)

Total Enrolled	Trained	Assessed	Certified
28301	28301	27873	22732

The performance of the Council in PMKVY 2.0 (2017-18 till date) is under:

Total Enrolled	Trained	Assessed	Certified	Placed
24877	23702	23228	22029	10481

RPL Training Program under PMKVY for FY 2017-21

Sl No	**Scheme**	**Trained**	**Placed**
1	PMKVY-RPL(Recognition for prior Learning)2017-18	3000	Existing Employees Being Re-Skilled
2	PMKVY-RPL(Recognition for prior Learning)2018-19	1424	Existing Employees Being Re-Skilled
3	PMKVY-RPL(Recognition for prior Learning)2019-20	6016	Existing Employees Being Re-Skilled
4	PMKVY 3.0 CSCM RPL	380	Existing Employees Being Re-Skilled
	Total	**10820**	

Industry wise PMKVY RPL Training Program

CentreName	Sum of Enrolled	Sum of Oriented	Sum of Assessed	Sum of Passed	Sum of Certified
JSW-Vijayanagar	5998	5243	5164	5123	5123
Primero Odisha Centre	3000	3000	2817	2768	2768
JSPL-Raigarh	711	711	662	662	634
JSPL-Dolvi	649	649	573	568	568
Tata Steel - JNTVTI	506	506	361	360	360
JSPL-Angul JSPL-Angul	471	471	395	395	395
Shyam Steel Durgapur	371	371	251	249	249
JSPL-Patratu	56	56	55	55	55
RINL-VIZAG	107	56	56	56	56
TOTAL	**11869**	**11063**	**10334**	**10236**	**10208**

SCHEME 2

NAPS (National Apprenticeship Promotional Scheme):

NAPS was launched in August 2016 by Government of India to promote the Apprenticeship in the country by providing financial incentives, technology and advocacy support.

The scheme has the following two components

1. Sharing of 25% of prescribed stipend subject to a maximum of Rs. 1500/- per month per apprentice with the employers.

2. Sharing of basic training cost up to a maximum of Rs. 7,500 per apprentice.

Features

1. Wider option for the apprentices-integration with other schemes - Courses approved by State Government/Central Government such as PMKVY, DDU-GKY etc. shall be linked with apprenticeship training. These courses will be given status of optional trades & the relevant practical content for on-the-job training shall be added by respective course approving authority.

2. Ease of Administering through technology - A specially designed online portal "www.apprenticeshipindia.org" shall be used for administering the entire implementation of the Apprenticeship Training online. It shall facilitate the requirements of all key stakeholders such as Candidates, Industry, DGT, RDSDEs, NSDC, SAA, SSDMs and BTPs

3. Promoter and Facilitators/Third Party Aggregators (TPA) - Since this scheme involves multiple stakeholders, the role of facilitators or Third Party Aggregators (TPAs) becomes important for mobilizing the apprentices, mapping their preferences with the demand from the establishments for apprenticeship opportunities posted on the portal, and helping the establishment in identifying Basic Training Providers. TPAs are engaged as per the guidelines issued by MSDE for their selection.

NEWS ITEMS

Snam and Tenova together for Decarbonization

The two companies will collaborate over the next three years to design integrated solutions based on the use of green hydrogen to decarbonize the metals industry.

An agreement to foster the decarbonization of the metals sector in Italy and abroad: **Snam**, Europe's largest energy infrastructure operator, and **Tenova** committed to conducting joint strategic studies and market analysis to implement specific infrastructure and metals **production systems by usinggreen hydrogen**.

The aim is to bring **integrated, turnkey commercial solutions tested in industrial plants** to implement a substantial reduction of CO_2 and NOx emissions in the metals production process – from melting to processing of half-processed products.

"*Through this agreement* – **Cosma Panzacchi**, EVP Hydrogen at Snam commented – *we further develop our network of partners and projects to introduce green hydrogen into the relevant productive processes of the metals industry. Hydrogen is essential to cut emissions from the production of steel and other metals, as well as from all hard-to-abate sectors such as cement, ceramic, chemistry and refining. Snam is willing to contribute through its technologies and know-how by enabling, as fast as possible, the hydrogen transition of such crucial commodity chains for the Italian economy".*
Snam will provide its expertise in **hydrogen** technologies as well as transport, whereas Tenova will contribute through its know-how in this sector, more specifically in **combustion systems for reheating and heating treatment**, and in **electric arc furnaces**. The collaboration between the two companies will develop through specific tests in the laboratory under construction at Tenova's headquarters (in Castellanza, Varese), and through installations and production tests on industrial sites.

"Everyone talks about green hydrogen, but the reality is that its supply and use are still limited, and, at the same time, pressures to mitigate climate change are getting stronger. For this reason, we are developing a ready-to-use solution for our customers, directly at their production sites. The expertise of Snam and Tenova is complementary, and together we are ready to face the challenge of decarbonization, on which Tenova has been working for years thanks to solutions that make us the ideal technological partners to improve environmental performances without compromising the economic ones", commented **Roberto Pancaldi**, Tenova CEO.

Tenova's combustion systems, a key part of the agreement with Snam, represent an extremely innovative solution and unique on the market. First, they enable CO_2 emissions reduction in a scalable and flexible fashion: once installed, these systems can work through a blend of natural gas and hydrogen in variable percentages, up to 100% of hydrogen, whereby maintaining emissions well below the most restrictive limits. Furthermore, they can be integrated with advanced 4.0 technologies, offering significant advantages in terms of management and maintenance, thanks to Tenova's digital infrastructure.

Through its know-how on hydrogen technologies and transportation, Snam will be able to secure an optimized integration across the entire value chain, thus meeting this industry's needs.

Pyromet to Upgrade Sibanye-Stillwater's PGM Furnace

Sibanye-Stillwater selects Tenova Pyromet to upgrade their largest Platinum Group Metals smelting furnace.

Tenova Pyromet has been selected by **Sibanye-Stillwater**as their technology partner for the upgrade of their **largest PGM (Platinum Group Metals) smelting furnace**.

Sibanye-Stillwater awarded a **feasibility study** in November 2020 to Tenova Pyromet to develop the upfront engineering and budget estimate for the upgrade of the crucible of their Furnace no. 1 at Marikana, North West Province, South Africa. Subsequently, in July 2021, Tenova Pyromet has been awarded the contract for the **detail design, supply and construction** of the furnace crucible upgrade. The detail engineering and procurement phase is well underway, and the construction phase is due to start during the second quarter of 2022.

Sibanye-Stillwater's main objectives with the furnace upgrade are to further improve **reliability, campaign life and availability in the long run**.

According to **Bennie du Toit**, Sibanye-Stillwater Vice President Smelting, *"We selected Tenova Pyromet for the Furnace no. 1 upgrade based on their innovative technical offering as well as our positive experience with Furnace no. 2, which has been reliable and stable for almost a decade."* Furnace no. 2 was designed, supplied and constructed by Tenova Pyromet and started up in 2012.

Tenova Pyromet's **innovative composite graphite-copper sidewall coolers**will be employed in the upgraded furnace sidewall. The design represents the next iteration of the reliable copper plate cooler design used on Furnace no. 2 combined with Tenova Pyromet's composite graphite-copper MAXICOOL® high intensity coolers, successfully in operation on another PGM smelter. Tenova developed a patent that covers the use of graphite in combination with copper cooling to prevent the sulphide corrosion of the copper cooling elements in a furnace sidewall. The use of graphite helps to protect the copper cooler from the corrosion caused by free sulphur present in the furnace sidewall adjacent to the concentrate feed layer.

"Tenova Pyromet is honoured to be selected by Sibanye-Stillwater and it is a privilege to continue our relationship with their highly competent smelter team. They continually challenge us to improve our technology and products", stated **Hugo Joubert**, Tenova Pyromet Manager for Base Metals and Copper Products.

To date, Tenova Pyromet has designed and supplied 8 circular PGM smelting furnaces in South Africa.

STATISTICS

Item	Performance of Indian Steel Industry		
	April-Jan 2021-22(mt)	April-Jan 2020-21(mt)	% Changes
Crude Steel Production	98.887	83.716	18.1
Hot Metal Production	64.959	56.116	15.8
Pig Iron Production	4.874	3.906	24.8
Sponge Iron Production	32.719	27.955	17.0
Total Finished Steel (alloy/stainless + non-alloy)			
Production	93.271	77.048	21.1
Import	3.907	3.792	3.0
Export	11.142	8.837	26.1
Consumption	86.829	75.580	14.9
Source: JPC; *provisional; mt=million tones			

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