Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 6, Issue 9; October-December, 2019, pp. 544-548
© Krishi Sanskriti Publications
http://www.krishisanskriti.org/Publication.html

Industry 4.0 and its Application Domains for a Steel Melting Shop of an SME

Gyati Chatung[1] and Muralidhar Manapuram[2]

[1]M.Tech, 2nd Year (CIM), Department of Mechanical Engineering,
NERIST, Nirjuli, Arunachal Pradesh-791109, India
[2]Professor, Department of Mechanical Engineering,
NERIST, Nirjuli, Arunachal Pradesh-791109, India
E-mail: [1]chatung1234@gmail.com; [2]mm@nerist.ac.in

Abstract—*Industry 4.0 originated from a project in the high-tech strategy of the German government in 2011.Various sub-systems of industry 4.0 considered include Industrial Internet of Things (IIoT), Cyber Physical Systems (CPS), Cloud Manufacturing (CM), Artificial Intelligence (AI)for control of steel melting system using sensors, actuators, PLCs and PCs with high speed internet.*

In the present work, an attempt has been made to identify and develop manufacturing application domains for Steel Melting Shop of an SME of Arunachal Pradesh. M/S Satyam Ispat North-East Limited (SINEL), Banderdewa in Arunachal Pradesh. Industry 4.0 application domains matrix for raw materials section, electric induction melting furnace and molten metal handling system was considered. Cyber Physical Systems developed are presented in figures for SINEL.

Keywords: *Industry 4.0, Thermo Mechanically Treated bar, IIoT, Cyber Physical System, Steel Melting Shop.*

1. INTRODUCTION:

The backbone to an industrialized nation is manufacturing. The word manufacturing is derived from a Latin word "manufactus" which means "made by hand". Manufacturing industry is a secondary sector for the improvement of economy of a nation improving per capita income and generating employment. Micro, Small and Medium Enterprises (MSMEs), are the roots of growth of industrialization in a country. MSMEsare the pillars of economic growth in many developed and developing countries. Manufacturing comes under secondary sector, generating huge employment opportunities and improving per capita income of a nation. MSMEs have employed about 120 million people contributing to the GDP-MSME sector with 8% of GDP.[1] MSMEs are highly vibrant and dynamic sectors forming the backbone of the Indian economy and play an important role in the economy in terms of manufacturing output, employment generation and exports.

In terms of industrial outputs in the world, Indian economy stands sixth in terms of Industrial output in 2016 with 672 billion US $. According to the source of World Steel Association, India stands 2nd out of 38 other nations in the year 2018 in terms of the production of crude steel with a capacity of 106.5 million metric tons whilst the production of the same being 6.3 million metric tons and ranked 34th among 46 other countries of the world in the year 1967. [2]

Industry 4.0 *refers to the visualization of the entire production lines, command and control of the production systems and making decisions on its own by the production systems using sensors, actuators, and computers with wireless connectivity.* In essence, Industry 4.0 describes the trend towards automation and data exchange in manufacturing technologies and processes which include the use of autonomous robots, simulation, horizontal and vertical System integration, Cyber-Physical Systems (CPS), Industrial Internet of Things (IIoT), Cloud Manufacturing (CM) and Artificial Intelligence (AI).

2. BUILDING BLOCKS OF INDUSTRY 4.0:

Advancements in technology trends form the building blocks of Industry 4.0. I4.0 will transform the production of goods leading to greater efficiencies and change the traditional production relationships among producers, suppliers and customers - as well as between human and machines. The building blocks of Industry 4.0 are shown in Figure 1 [3, 4]:

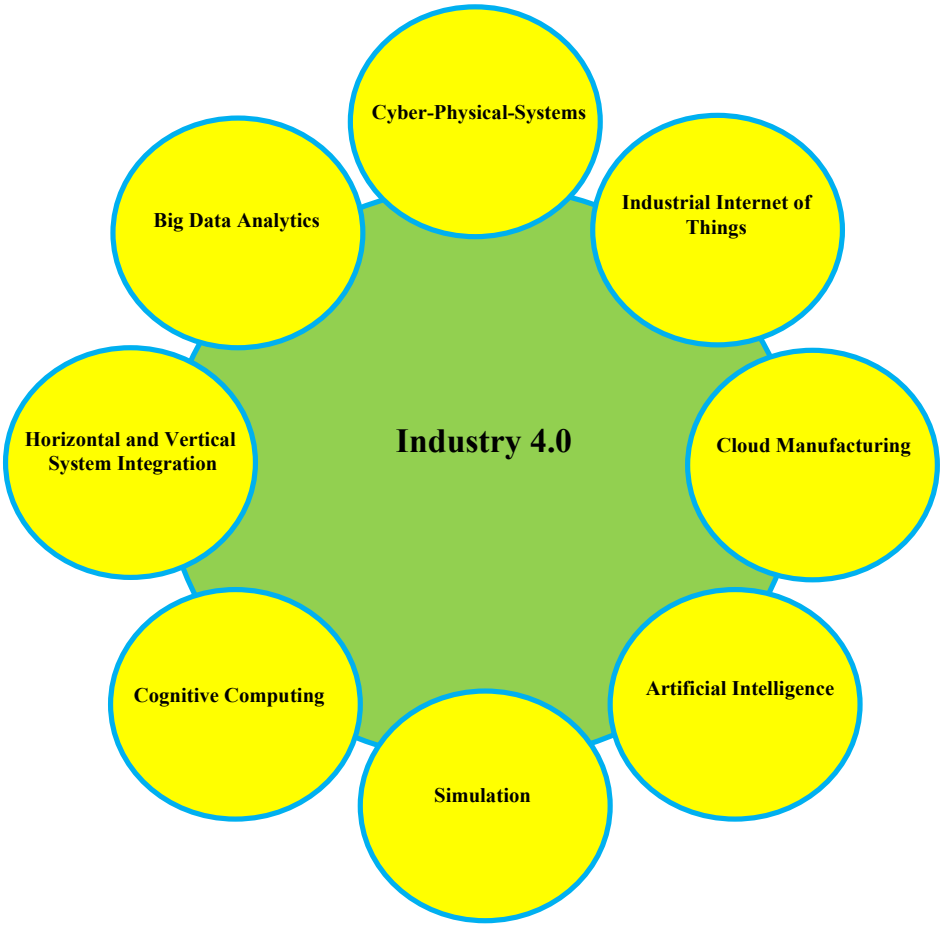

Figure 1: Building blocks of Industry4.0

2.1 Cyber-Physical System (CPS):

Cyber-Physical Systems (CPSs) are smart systems that depend on the synergy of the cyber and physical components. Physical components such as sensors and actuators link with the cyber information processing systems. [5] It is an integrations of computation, networking and physical process.

2.2 Industrial Internet of Things (IIoT):

The Industrial Internet of Things (IIoT) is the use of smart sensors and actuators to improve manufacturing and industrial processes. [6] IIoT is an important part of Industry 4.0 which provides the opportunity to utilize the power of smart machines and real-time analysis to take advantage of the data generated by the machines.

2.3 Cloud Manufacturing:

Cloud manufacturing refers to the use of cloud technologies that gives the users a solution to enable request service from all stages of product lifecycle ranging from design, manufacturing, management etc. [7] Cloud manufacturing is the process of utilizing well established manufacturing resources, such as Enterprise Resource Planning (ERP), through the cloud.

2.4 Artificial Intelligence:

Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. [8] It is the ability of a computer program or a machine to think and learn.

3. STEEL MELTING SHOP ANDITS SUB-SYSTEMS:

Steel is an alloy of iron and carbon where the carbon composition is less than 2%. *In addition to Carbon, Silicon, Manganese, Phosphorus and Sulphur will also be there.* Steel is melted in a Steel Melting Shop (SMS). They are used for construction of bridges, rails, roads, buildings etc. North-East India is prone to earthquakes and hence, Thermo Mechanically Treated (TMT) rods are used in construction purposes. TMT bars are manufactured in SINEL, Banderdewa, Arunachal Pradesh. It got its certificate of commercialization and BIS certificate in the year 2006. ISO certificate was obtained in the year 2009. The area approximates 61,650 m^2 and the built area is approximately 57,765 m^2 producing 2400 metric tons of TMT rods of varied size ranging from 8mm to 32 mm diameter rods. With manpower of one manager and a production engineer along with 90 technical staff and 260 non-technical employees, TMT rods are rolled from billets and are produced by continuous casting of molten steel. Mild steel scrap, sponge iron, pig iron and cast iron are used as raw materials.

The SINEL factory is sub-divided into six units as follows:

1) Raw material storage unit.
2) Steel melting unit.
3) Continuous casting unit.
4) Billet reheats unit.
5) TMT bar roller unit.
6) Thermax control unit.

Out of the six sections, steel melting section was considered for detailed analysis for Industry 4.0 application domains. Table 1 presents the identified I4.0 application domains for SINEL for various sections and sub-sections of a steel melting shop. Around 15 sub-sections for metal charging, induction furnace melting and tapping, slag removal and tapping into ladles are considered. Application domains for Industry 4.0 sub-systems (CPS, CM, IIoT and AI) are also presented. Figure 2 shows Induction furnace and Cyber Physical Systems for steel melting shop of SINEL. Cyber Physical Systems for each of the systems like metal charging system, induction furnace melting, slag removal and tapping system, ladle lining and preheating and molten metal transportation to Concast are considered. Figure 3 represents Induction Furnace and Industry 4.0 sub-systems using sensors, actuators and high speed Internet for a steel melting shop of SINEL.

4. DISCUSSION AND CONCLUSIONS:

An SME producing steel for TMT bars in Arunachal Pradesh was considered for practical data collection for development of Industry 4.0 and sub-systems for SMS. Industry 4.0 application domains for Steel Melting Shop was developed and presented in a tabulated form. Cyber Physical Systems were developed for raw material system, induction furnace sub-systems and ladle section. It is shown in a schematic diagram form. Induction furnace steel melting and Industry 4.0 considering Industrial Internet of Things, Cloud Manufacturing, Artificial Intelligence and Cyber Physical Systems by using sensors, actuators and high speed internet was considered and presented in a diagram form. The Industry 4.0 systems for steel melting section are expected to enhance operational parameters and productivity and quality for SINEL.

5. ACKNOWLEDGEMENTS:

The authors gratefully acknowledge the necessary help rendered by North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh and M/s Satyam Ispat North East Limited (SINEL), Banderdewa, Arunachal Pradesh.

REFERENCES:

[1] https://www.indiamsme.org/about-msme-sector-india

[2]https://en.wikipedia.org/wiki/List_of_countries_by_steel_production

[3]Samnur Islam, “Studies on Industry 4.0 application domains and development of a framework for an SME”, May, 2019, Department of Mechanical Engineering, NERIST,

[4] RupshreeOzah, ManapuramMuralidhar and SubrataKushari, “Application of Intelligent systems for Manufacturing Industries: A study”, Vol 5, Issue 3 (VII): July-September 2017, International Journal of Research in Management & Social Science

[5] Matthew N. O. Sadiku, Yonghui Wang, Suxia Cui, Sarhan M. Musa, “Cyber Physical Systems: ALiterature Review”, Vol 13, No 36 (2017), European Scientific Journal

[6]https://optiware.com/blog/what-is-industrial-internet-of-things-iiot-and-why-is-it-important-in-manufacturing/

[7]https://www.researchgate.net/publication/229131933_From_cloud_computing_to_cloud_manufacturing, XunXu, “From cloud computing to cloud manufacturing”

[8]https://simple.m.wikipedia.org/wiki/Artificial_intelligence

Table 1: Identified Industry 4.0 application domains for a steel melting shop of SINEL

Manufacturing sections	Manufacturing subsections	Industrial Internet Of Things (IIOT)	Cloud Manufacturing	Artificial Intelligence	Cyber Physical System
Raw materials section	Raw materials preparation	✓		✓	✓
	Raw materials preheating	✓	✓	✓	✓
	Raw material charging		✓	✓	✓
Steel melting section	Induction furnace lining and preheating		✓	✓	✓
	Induction furnace melting		✓	✓	✓
	Melt composition control system	✓	✓		✓
	Melt temperature control system		✓	✓	✓
Molten steel transportation section	Slag removal system		✓	✓	✓
	Ladle alignment for molten metal collection			✓	✓
	Ladle refractory monitoring system			✓	✓
	Ladle molten metal temperature control			✓	✓
	Molten metal tapping and pouring	✓		✓	✓
Ladle section	Ladle lining system	✓	✓	✓	✓
	Ladle preheating system		✓	✓	✓
	Ladle transportation to Concast	✓		✓	✓

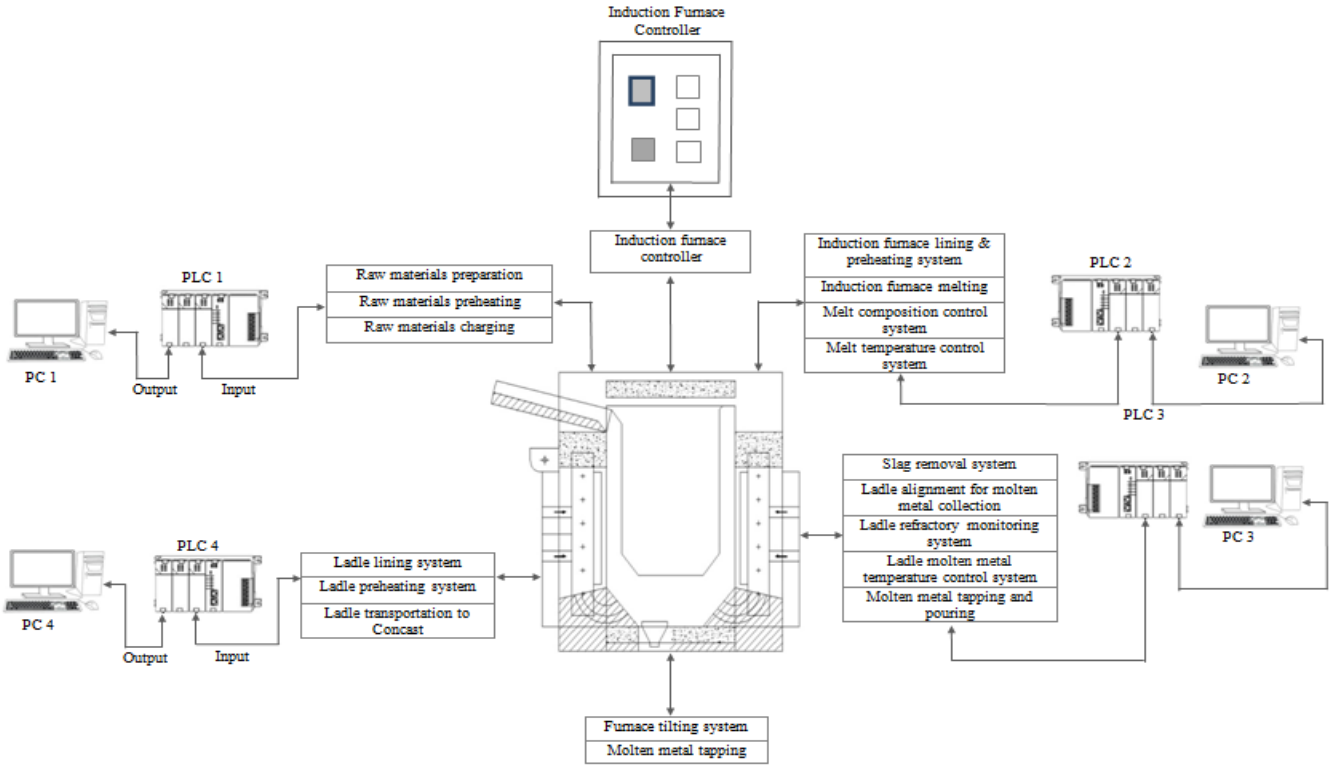

Figure 2: Induction Furnace and Cyber Physical Systems for a steel melting shop of SINEL

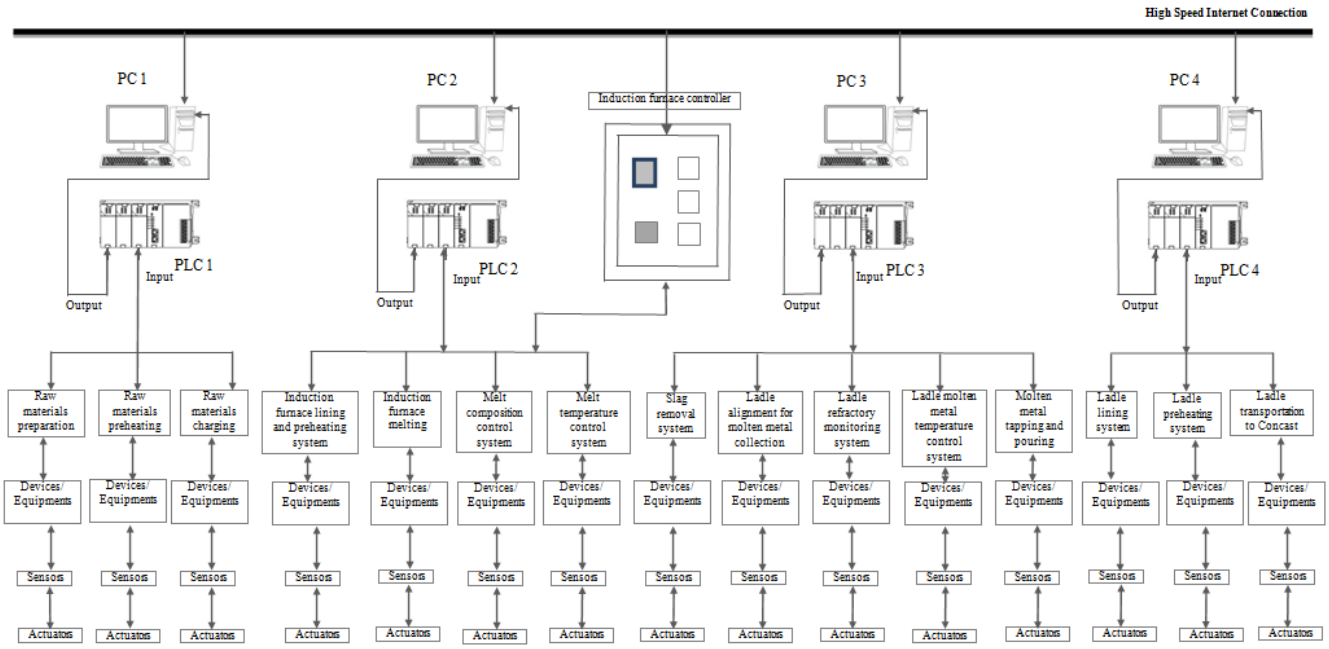

Figure 3: Induction Furnace and Industry 4.0 sub-systems using sensors, actuators and high speed Internet for a steel melting shop of SINEL