Development of Industry 4.0 Technology Domains for a Steel Melting Shop Gyati Chatung Scholar Department of Mechanical Engineering, NERIST, Nirjuli, Arunachal Pradesh E-mail: chatung1234@gmail.com Muralidhar Manapuram Professor Department of Mechanical Engineering, NERIST, Nirjuli, Arunachal Pradesh E-mail: mm@nerist.ac.in

Abstract:

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. Various sub-systems of industry 4.0 considered include Industrial Internet of Things (IIoT), Cyber Physical Systems (CPS), Cloud Manufacturing (CM), Artificial Intelligence (AI). Steel is an alloy of Iron and Carbon where the Carbon percentage is less than 2%. In addition to Carbon, Silicon, Manganese, Phosphorus and Sulphur will also be there. Steel is melted and manufactured in Steel Melting Shop. Thermo Mechanically Treated (TMT) wires are manufactured from concast made steel billets. TMT bars are used for construction of various multi storied buildings, bridges etc. in seismic zones/earthquake prone areas. In the present work, an attempt has been made to develop industry 4.0 technology 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 technology domains for raw materials section, electric induction melting furnace and molten metal handling system was considered. The layout of steel melting section and cyber physical systems developed are presented in figures for SINEL. Some useful conclusions are arrived at.

Key words: Industry 4.0, IIoT, Cyber Physical System, Steel Melting Shop, layout

Introduction:

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. MSMEs are 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. North Eastern states consists of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim amd Tripura covers an area of 2,63,179 sq.km which is 8 % of total india's area. It is considered as category A in industrial backwardness. The total number of MSMEs [1] includes 18.91 lacs employing 29.17 lacs. In North eastern region.

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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 [2-4]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).

1. Building blocks of Industry4.0:

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 [5-7]. Building blocks of Industry 4.0 are shown in Figure 1.



Figure 1: Building blocks of Industry4.0

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Table 1: Definitions of Industry 4.0 technologies

Sl. No.	Industry 4.0 technologies	Definition
1.	T1: Cyber-Physical System (CPS)	Cyber-Physical Systems (CPSs) are smart systems that depend onthe synergy of the cyber and physical components. Physical components suchas sensors and actuators link with the cybe rinformation processing systems.
2.	T2: Industrial Internet of Things (IIoT)	The Industrial Internet of Things (IIoT) is [9] the use of smart sensors and actuators to improve manufacturing and industrial processes. IIoTis animportantpartofIndustry4.0whichprovidestheopportunityt outilize the power of smart machines and real-time analysis to take advantage of the data generated by the machines.
3.	T3: Cloud Manufacturing (CM)	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.
4.	T4: Artificial Intelligence (AI)	Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. It is the ability of a computer program or a machine to think and learn.

1. Steel melting shop and its sub-sections of SINEL:

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 m² and the built area is approximately 57,765 m² 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. Figure 2 shows the layout steel melting shop of SINEL [8].

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Figure 2: Layout of the SINEL Steel Melting Shop

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Figure 3: Industry 4.0 technologies domains and sub-sections of Steel Melting Shopfor SINEL

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Figure 4: Cyber Physical Systems for a steel melting shop of SINEL

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Figure 5: Industry 4.0 technology sub-systems for a steel melting shop of SINEL

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Manufacturing sections	Manufacturing sub-sections	Industrial InternetoOf Things (IIOT) T1	Cloud Manufacturing T2	Artificial Intelligence T3	Cyber Physical System T4
	S1: Warehouse/Automatic Storage& Retrieval (ASR)	Ý		Ý	~
	S2: Load/unload time	~			\checkmark
Raw materials section	S3: Raw material preparation for metal charging				~
	S4: Inventory and EOQ	~	~	V	
	S5: Raw material quality		✓	√	~
	S6:Furnace controller	✓	✓		~
	S7: Furnace cooling system		✓		~
	S8: Furnace lining system		✓		~
	S9: Metal charging system		✓	√	~
Steel melting section	10: SMetal charge preheating system		v		~
	S11: Ladle refractory monitoring system				~
	S12: Molten metal pouring ssytem		Ý		✓
	S13: 15T ladle with molten metal	v	Ý		√
	S14: Tundish		✓		~
	S15: Chemical laboratory	~	~	✓	~

 Table 2: Identified Industry 4.0 technology domains for a steel melting shop

Out of the six sections, steel melting section was considered for detailed analysis for Industry 4.0 application domains. Table 2 presents the identified Industry 4.0 technology 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. Technology domains for Industry 4.0 sub-systems (CPS, CM, IIoT and AI) are also presented. Figure 3 shows Industry 4.0 technologies domains and sub-sections of Steel Melting Shopfor SINEL Figure 4 shows Cyber Physical Systems for a steel melting shop of SINEL. Cyber Physical Systems for each of the systems like metal charging system,

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induction furnace melting, slag removal and tapping system, ladle lining and preheating and molten metal transportation to Concast are considered. Figure 5 represents Industry 4.0 technology sub-systems for a steel melting shop of SINEL.

1. Conclusions:

A steel melting shop 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 technology domains for Steel Melting Shop sub-sections was developed and presented in a tabulated form. The layout of SINEL was redrawn suitable for cyber physical systems for raw material system, induction furnace sub-systems and ladle section. 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.

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