Iron Smelting in Ancient Odisha

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The article briefly presents the history of iron and steel, its discovery and production since the ancient times in Bharatvarsha and specifically in Odisha, how it fulfilled the two most basic needs of human beings, i.e., food and security, and most importantly acted as a catalyst for rapid development of civilisation. With certain examples it explains the high standard of engineering and technology in the field of metallurgy practiced by the ancient craftsmen of Bharatvarsha and its Odisha region that at the time was far superior in comparison to the contemporary developed countries in the West. It goes on to explore the people, the process and the technology involved in its production. The huge demand for Indian iron in domestic and export markets kept the activity bubbling at its peak for ages. However, the activity level of traditional iron smelting started to fall gradually, in spite of existing demand, after the British East India Company took over the Country and the State of Odisha in late 18th century and early 19th century respectively. Subsequently, it came to a complete stop after the British Administration quashed Paika Revolution and Sepoy Mutiny. Being revengeful and to safeguard their security in future the British rulers destroyed all the traditional iron foundries, brought the source of raw materials under their control and confiscated all the weapons owned by the natives. Finally the last nail in its coffin was driven in early 20th century after large scale commercial manufacturing of iron using modern blast furnaces was started in India.

With time advancing, the civilisation from its dawn passed through different periods like the Stone Age, the Bronze Age[1] and the Iron Age, all defined by discovery and predominant use of the respective materials in their respective periods. "C. J. Thomson first pointed out in 1836 that the march of human civilization is closely identified with the dominant use of a particular material at the given historical period. He suggested that the division into the three ages - stone, bronze and iron - captures this progress over ten millennia."[2] Discovery of metals ended the most primitive Stone Age of human civilisation and with the subsequent discovery of each metal it was driven one-step up the scale of its progress. Finally, the discovery of iron worked like a catalyst to the process, and the evolution of human civilisation picked up speed progressing in an exponential manner. Iron facilitated manufacturing of stronger and better implements, tools and weapons for

production of more varieties and quantities of agricultural produce and made hunting of wild animals easier. For an individual the weapons made of iron worked like an extension and a multiplier of human physical strength to bring many more powerful animals, birds and lizards and even other human beings under its control. It secured the most basic need of mankind, i.e., food. The weapons made of iron provided them with more power and better security from wild animals and aggressive enemies. In other words iron helped the mankind to fulfil its two major basic needs like food and security in a better manner with less effort and time involved. After fulfilling their basic needs for survival, being curious, the human beings utilised their leisure time in exploring and studying the nature around them and developed interest in finding ways to harness it for their benefit. Consequently their culture was advanced further and the process accelerated continuously utilising the database acquired by the human beings during their related increase in leisure time. Hence, iron played a very important role in rapid advancement of the ancient civilisation. In fact, in the early days of civilisation iron proved itself to be of more value to mankind than that of gold. The fact is corroborated by the act of Porus presenting a block of iron as a prime gift to Alexander on his departure from Bharatvarsha.

As time rolled further, along with some other places in the ancient world, many civilisations, cultures, traditions, philosophies, religions, literature, epics, astronomy, astrology, mathematics, medicines, surgery, crafts, architecture and sculpture, trade and commerce, scientific and economic principles, originated and evolved in the east, particularly in Bharatvarsha. When a material available in nature is transformed to another form or state to fulfil a need of the mankind the act is a subject of culture, the process applied is technology and the principle that explains its transformation is the science behind it. Albert Einstein had once said that India laid the foundation for scientific discoveries made by human cultures of the world since the very ancient days.

DISCOVERY OF IRON:

It is not known precisely when iron was introduced to human civilisation and when mankind first reproduced it from the materials available in nature. Some scholars say that iron was discovered in around 3,500 BC. The name 'Iron' was derived from the Anglo-Saxon word 'Iren' meaning the holy metal. Later its chemical symbol 'Fe' was derived from the Latin word 'Ferrum' representing iron.

It is presumed that, while examining the meteors falling down on earth from space, mankind was introduced to iron as a hard black material having better properties than that of the metals or alloys available then, like copper or bronze. The meteoric iron, having a rich content of nickel, is hard and black in colour. Such a large piece of meteor is preserved in the Great Pyramid of Egypt since about 2900 BC.[3] It might have also been possible that iron was discovered accidentally by the primitive human beings after a great forest fire that reduced the iron ore lying on the topsoil to metallic iron. According to A.K. Vaish, P.K. Biswas, and others, "The reduction of iron ore to the metal might have taken place in closed furnaces used for glazing pottery which reached the temperature of over 1000°C."[4] It also might have been possible that iron was accidentally discovered in Vedic fire altars (Havan Kunda) along with other metals while performing rituals.[5] In India and China, the metal is believed to have

been in use since at least 2000 BC. Some authorities ascribe the discovery of the original process of smelting iron to the people of India to a much earlier date.[6] From the remote ancient time to the Neolithic period no metals appear to have been in use. The early hymns of Rig-Veda, created in about 2000 BC, reveal the knowledge of extracting metals from ores. AYAS (metal-iron) was the third Rig-Vedic metal after gold and silver. Yajur Veda also mentions about iron. Hymns in Rig Veda have reference to metallic coats of mail and helmets put on by the soldiers. In the areas like present West Bengal and most likely in Odisha[7] the Aryans were using iron implements, tools and weapons in agriculture and warfare since 1st millennium BC.[8] Descriptions of weapons like swords, spears, arrowheads, various implements of iron, and surgical instruments devised by saint Sushruta are described in many ancient Indian scriptures. Archaeological evidences prove that these weapons and implements belonged to 4th century BC and the surgical instruments to 3rd century BC. The sculptural images at Udayagiri in Bhubaneswar and the later age Sun Temple at Konarak and many other temples at different places in Odisha display the use of weapons like, battle-axes, daggers, spears, javelins and swords of many varieties including double-bladed and conical types.[9] In the past, Bharatvarsha in general and Odisha in particular were much ahead of the western countries in the field of iron smelting technology. Sharada Srinivasan and Srinivasa Ranganathan say, "It is generally acknowledged that from the beginning of civilisation up to 1800, the knowledge of materials and the mastery over their composition was more advanced in the Far Eastern cultures, such as Indian and Chinese, than in Western cultures."[10] The Greek historian "Herodotus wrote the first western account of the use of iron in India. xxxxx The Indian mythological texts, the Upanishads, have mentions of weaving, pottery and metallurgy as well. The Romans had high regard for the excellence of steel from India in the time of the Gupta Empire."[11] As per A.K. Vaish and others, "The travel records of Voysey, Buchnant, Hadfield, and Varier clearly show the supremacy of Indian iron and steel technology over their western counterparts even in 18th century." Only thereafter, in 18th century during the Industrial Revolution, the western countries gained superiority in the subject of materials development and utilization.[12]

Many wonderful articles of iron manufactured in the ancient foundries of Bharatvarsha are still seen at different places revealing the extraordinary skill of the ancestors. A block of steel gifted by Porus to Alexander in 326 BC,[13] the clamps at Asoka's Bodh Gaya monument of 3rd century BC, the excavated iron implements of 250 BC at Adichanallur in Tamil Nadu, the 22 feet high rust-free iron pillar with a circumference of 16 inches and weighing approximately 6.5 Tons created by Chandragupta II (Vikramaditya) in around 400 AD and now installed in the premises of Qutub Minar in Delhi,[14] the 44 feet long iron pillar of 12th century AD at Dhar weighing about 8 tonnes, the12th century AD iron trident at Tanginath temple, the trident of 14th century AD on Mount Abu, the iron pillar on Kordachari hill, the cannon lying at Tanjore having a length of 750 cm (24½ Feet approximately), the iron cannon Landa Kesab weighing about 50 tonnes lying at Bijapur, the 18th century AD rockets of Tipu Sultan made of cylindrical iron pipes are some of the examples in this regard.[15] In this field Odisha was also not running behind. The huge rectangular rust-free iron beams belonging to 13th century AD now lying at

the Sun Temple in Konark are considered a wonder even at the present time. The largest of these beams is about 35 feet and 9 inches long having a width of 8 inches and 8 to 10 inches thick being thicker at the centre. Apart from the Sun Temple at Konark many such beams are also used in construction of the 10th -11th century Lingaraja Temple in Bhubaneswar and the 12th century temple of Jagannatha in Puri. To cast the beam the required number of rectangular bars of length 1½ to 2 feet, width and thickness of 2 to 3 inches were arranged in the shape and size of the beam inside a long rectangular pit and then molten iron flowing down from a large smelter was made to cover all around and penetrate the assembly. In cases, to pre-heat the contraption it was given a molten lead bath and then melted iron was poured over and around it fusing all the plates together to finish it as one solid rectangular iron beam with the load bearing capacity of almost equal to that of the ones now being manufactured in modern steel plants.[15] As many different articles were being exported in huge quantities from Kalinga-Utkala (ancient Odisha) to various distant lands many other articles of iron must have also been manufactured to meet the requirement of the flourishing maritime activity of the time. Apart from it, considering the high level of maritime activity in the Kingdom Pandit Krupasindhu Mishra writes, "There must have been many articles of iron manufactured for construction of the huge numbers of seafaring ships and boats."[17] As the Chinese traveller Hiuen Tsang states, some of these ships were so huge that they carried around 300 passengers along with luggage, food and other essentials for the long journeys. Some huge ships known as Hati Boita (elephant carrying boats) in local language, apart from passengers and crew, were even carrying elephants to distant lands along with merchandise for trading.

IRON SMELTING IN ODISHA:

Continuing with the tradition of keeping no written records since the Vedic era, no documents either of the history or the process of production of iron in Bharatvarsha was maintained. However, archaeological evidences show that iron was being smelted all over India. The activity was more at the vicinity of regions having substantial iron ore deposits. Its process was a closely guarded secret amongst a few communities, the skill being continuously refined and transferred from one generation to the next within the specific families of their respective communities just by verbal and practical instructions and through direct participation in the process of its production. The tribal people of Odisha producing iron from locally available raw materials using primitive processing methods dates back at least to 1300 BC to 1200 BC which continued well into the 19th century AD. The communities in Odisha like Kondhs, Agarias, Kamars or Lohars in general were producing iron in small clay furnaces built over the ground though in the undivided District of Koraput some used underground furnaces. The products of these primitive furnaces were meant primarily to meet the local demand of metals for manufacturing of agricultural implements, tools, household and decorative articles and also weapons. Later it was used for manufacturing different articles of iron for export. Up to 19th century AD iron was produced abundantly nearby most villages of Odisha located in present districts like Koraput, Malkangiri, Nabarangpur, Kalahandi, Bolangir, Bargarh, Sambalpur, Deogarh, Angul, Dhenkanal, Sundargarh and Keonjhar as the main required raw-material, i.e., iron ore, was available at these places in plenty, even in the topsoil or at a very shallow depth in the ground. Usually the male members of the

respective communities scout for the location of iron ore. They were experts in identifying the content and the suitability of the ore from its physical properties like weight, colour and texture. On the other hand, the women in the family collect dry twigs from nearby forests and convert it to charcoal by controlled burning. Charcoal is the second important raw material required for the process. Apart from iron, articles of other metals and alloys like bronze, brass and copper were also being manufactured and exported from Odisha. All the major raw materials for these articles were available within the State excepting some like copper and tin which were being imported from Japan and the Straight Settlement (Part of Malaysia now) respectively.[18]

With the availability of technology, raw materials and skilled manpower in plenty, and demand for the product being high, the industry of iron smelting flourished in almost every part of Odisha. Each village in Kalinga-Utkal (Odisha) was self-sufficient with its needs. The various wings of administration like, revenue, education, health, security and law and order systems were completely decentralised, each village having its own system functioning independently in harmony with the central policies of the Kingdom. Whatever the villagers required for living their day-to-day life like, household articles, agricultural implements, ornaments, weapons and other articles of iron, wood, stone, gold and silver were being crafted in the respective shops of the blacksmith, the carpenter, and the goldsmith, established in every village. The iron producing families were also available nearby. This socio-economic-political structure minimised the dependence of a village on other localities. Hence, during an outside invasion and on-going battle at a particular area, the entire Kingdom was not affected; excepting that locality only, the people of other parts of the Kingdom lived their lives as usual and practiced their respective crafts without any hindrance.

THE PROCESS:

The ancient process of manufacturing iron was more complicated than that of copper and bronze as it had to go through the processes of repeated heating and cooling to make it useful for different categories of articles like, agricultural implements, household and decorative articles, tools and weapons. Its production and process were dependent on the availability of required raw materials, proper smelting systems, the technology, technically skilled human resource and of course, the demand for the end product. All these above-described elements favouring production of iron were abundantly available in Odisha.

The process of smelting iron consisted of various steps like (1) collection of raw materials such as suitable iron ore and dry twigs, (2) setting up of the smelting furnace, (3) production of charcoal from twigs, (4) loading and firing the furnace to start the smelting process, (5) collecting the crude iron mass, and finally (6) subjecting it to further processing for slag removal, quenching and tempering for making it suitable for each of the various types of products.

1. Collection of Raw Materials: The families of iron smelters usually put up their dwelling houses close to a water body in or around the forest areas near the source of iron ore. The male members of the family go searching for the required quality and quantity of iron ore which they could identify from its physical properties like weight, colour and texture. Mostly they collect

the ore lying on the ground or at a shallow depth below its surface. For charcoal dry twigs of trees like Sal, Teak, Jamun or even Bamboo are collected from the nearby forest. The women in the family gather the twigs and prepare charcoal from it. The children in the family helped their parents by carrying out minor jobs. In the process the entire family is involved and the children get themselves trained to carry forward their legacy as the next generation of iron producers.

2. Setting Up of the Smelting Furnace: The shape of the primitive smelting furnace, called Bhati in local language, is to some extent similar to that of the modern day blast furnaces.[19] These are usually made of clay or mud, wider at the bottom and gradually tapering towards the top, rising to a height of 3 to 4½ feet above the ground. The top is kept open. A bellows, that is Vati in native language, made of leather and wood or bamboo is fitted to the furnace at the bottom to force air through the pile of iron ore and charcoal mix providing more oxygen for better burning to develop high temperature inside the furnace. An outlet pipe is provided or simply a channel is dug out at one side of the furnace at the bottom to let the molten material flow out. At times, without the outlet pipe or channel, the molten material simply flow down to the bottom of the furnace and accumulate there to be collected at the end of the process on breaking down the mud furnace.

3. Producing Charcoal from Twigs: The charcoal pit is setup near a water source. The dry twigs are placed in it and set on fire. The fire is quenched at proper time and then covered with green leaves and sand to avoid further access of air (oxygen) to prevent it from turning to ashes. Sometimes the twigs are placed just on surface of the ground and burned.[20]

4. Loading and Firing the Furnace: The collected iron ore is broken into small pieces, washed and dried in the sun. After adding the processed ore to the required quantity of charcoal the mix is loaded into the furnace from top. The furnace or the Bhati is lit at the bottom and once it catches fire the air bellows (Vati) is operated, usually by foot, to aid the fire to spread from the bottom to the top and throughout its breadth developing a high temperature inside the furnace. Under high temperature carbon monoxide produced by burning charcoal reduces iron oxide present in the ore to metallic iron. The process takes six to eight hours to convert the ore to a spongy metallic mass of crude iron that collects at bottom of the furnace. Modern blast furnaces of steel plants use coke, i.e. calcined coal, in place of charcoal for smelting iron with high carbon content.

5. Collecting the Crude Mass of Iron: After the furnace cools down the mud wall of the furnace is broken down and the mass of crude iron settled at the bottom is collected for further processing to make it suitable for crafting each of the many different objects like household articles, agricultural implements, tools and weapons, etc.

6. Further Processing for Slag Removal, Quenching and Tempering: The mass of crude iron collected from the furnace is again subjected to heat and then pounded with a hammer repeatedly folding it to remove the slag part or the impurity it contained. The process of heating and beating is repeated several times to make it free from most impurities, compress the spongy mass to make it malleable and ductile enough for production of household articles, agricultural implements, some tools, pots and pans, etc. This category of iron is known as

wrought iron which has less carbon content than steel and hence not as strong as steel.

The articles crafted from slag-free iron is subjected to heat again and then dipped in a liquid to cool it rapidly for adding some strength of steel to it. The liquid could be simply water, water mixed with certain ingredients, oil, etc. "The selection of the liquid depended upon the quality of the steel required to be produced for a specific purpose, and extended over a wide range of objects, namely, from water to organic matters, such as blood, ghee or milk from a mare or a camel or an elephant, a mixture of fish-bile with milk from deer, goat and horse blended with toddy, and many other queer liquid preparations."[21] The quenching process adds the strength of steel to the outer layer of wrought iron making it suitable for crafting tools and implements.

According to M. Ahmed, "There is an interesting account of tempering of swords in Brihat Samhita, the famous Treatise on Astronomy, which shows that the ancient people had the practical knowledge of various processes of making iron and steel and knew how to temper a blade for varying use using different liquids."[22] For making tools of iron the quenched steel goes through the next process of heating it to a bit lower temperature than that of the quenching process and then allowing it to cool down gradually in the surrounding air. This process is known as tempering which renders the iron piece less brittle making it more suitable for tools and implements. Adding more carbon during the purifying process makes the steel harder for production of better quality tools and sharp weapons like swords, spears, etc. A high quality steel known as Wootz was being produced in South India, especially in Hyderabad, which was exported to Rome, China and many other countries in Asia and Europe.

RISE AND FALL OF TRADITIONAL IRON SMELTING IN ODISHA:

It is not known exactly when production of iron by the traditional process first commenced in Kalinga-Utkala (Odisha). However, it is presumed that iron was being produced in the Kingdom in full swing spanning a long period, since 300 BC till late 19th century AD. During the ruling periods of Keshari and Ganga dynasties the craft of iron making was at its peak, continued so for quite a long time to gradually die down during the British Colonial period to be completely vanquished in the last half of 19th century AD. Kalinga-Utkala was a prosperous and basically an agriculture-oriented kingdom, and hence, apart from household articles, there was a huge demand for farming tools and implements. The flourishing art, craft, sculpture, maritime and commercial activities at the time required various tools and other articles of iron for domestic use, export market, and also for building on-land transport vehicles, seafaring ships and boats. The large army of fulltime and part time soldiers maintained especially by the Gangas and the later ruling dynasties required huge quantities of various weapons like swords, spears, battle axes, arrowheads, and subsequently cannons, guns and other battle accessories made of steel and iron. The temple building activity during the Kesharis and the Gangas required iron beams, clamps, nails and tools and articles of other metals in huge quantities. Consequently the iron industry in Odisha was kept bubbling with high demand for its products.

The native process of iron production in Odisha started to decline after the British occupied it in 1803 and implemented their policies. Soon after quashing the revolution launched by Jayee

Rajguru and his associates in 1804 to reinstate their King, and then especially after supressing the Paika Bidroha (Paika Revolution) headed by Buxi Jagabandhu in 1817, the British Administration confiscated the weapons owned by the native soldiers and destroyed all Bhatis or foundries of iron to prevent its further production for making weapons. The brave and skilled fighters of Odisha, popularly known as Paika, lost their morale, and were converted to mere docile, lifeless peasants and domestic servants under the British Administration. Whatever of their self-respect and confidence remained was destroyed after the British Administration confiscated the weapons and destroyed the iron foundries all over India after suppression of the Sipoy Mutiny of 1857. Subsequently the British Raj restricted the native iron producing communities to procure raw materials from forestland and brought the mining activity under their control. To discourage them further, they imposed heavy taxes on such activities and started to supply imported iron and other materials at a cheaper rate in comparison to the heavily taxed domestic products. Finally, in the beginning of 20th century, after introduction of new technology and modern blast furnaces for commercial production of iron in large scale, this activity of the community for production of iron using the traditional method was completely wiped out.

References:

1. In fact Copper Age came in between Stone and Bronze ages. However, as bronze is an alloy of copper and tin and more suitable for making tools and implements, Copper Age was merged with Bronze Age after running for a brief period of about 1000 years and the new classification of the periods of human civilisation was categorised as Stone Age, Bronze Age and Iron Age.
2. Sharada Srinivasan and Srinivasa Ranganathan – India's Legendary Wootz Steel – Page 3
3. M. Ahmed - Survey of Traditional Crafts - Series No. 1 – A Monograph of Indigenous Smelting of Iron – Census of India, 1961 – Volume XII – Part VII-A (1) – Orissa – Page 1
4. A.K. Vaish, P.K. Biswas, and Others - Historical perspective of iron in ancient India - Journal of Metallurgy and Materials Science, Vol. 42, No.1, January-March, 2000 – Page 65
5. B. Prakash - Ancient Iron Making in India – Page 30
6. M. Ahmed - A Monograph on Indigenous Smelting of Iron – Page 1
7. Odisha, being merged with the Suba or province of Bengal, lost its own identity for a long period. Consequently, when the formal history of Odisha (Kalinga-Utkala) was written by various outside scholars and travellers, quite often it and its activities and events in many documents are referred to as that of Bengal. In certain cases, using the same principle of being considered as a territory of Bengal, the art, crafts and sculptures of ancient Odisha were also wrongly mentioned as created by the artisans of Bengal which in fact were created specifically by the craftsmen of Odisha.
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9. M. Ahmed - A Monograph on Indigenous Smelting of Iron –Page 3
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11. Ferrous Metallurgy - Wikipedia – Page 4
12. A.K. Vaish, P.K. Biswas, and Others - Historical perspective of iron in ancient India - Journal of Metallurgy and Materials Science, Vol. 42, No.1, January-March, 2000 – Page 73

13. A.K. Vaish, P.K. Biswas, and Others - Historical perspective of iron in ancient India - Journal of Metallurgy and Materials Science, Vol. 42, No.1, January-March, 2000 - Page 67

14. Pravin Despande - Computer Simulation Studies on Delhi Iron Pillar: Estimation of Weight - Current Science, January 2008 - Page 123

15. B. Prakash - Ancient Iron Making in India – Page 36

16. Pandit Krupasindhu Mishra – Konarka (Odia) – Page 232

17. Pandit Krupasindhu Mishra – Utkal Itihas (Odia) – Page 84-85

18. Pandit Krupasindhu Mishra – Utkal Itihas (Odia) – Page 263

19. B. Prakash - Ancient Indian Iron and Steel : An Archaeometallurgical Study - Indian Journal of History of Science, 46.3 (2011) - Page 386

20. B. Prakash - Ancient Iron Making in India – Page 41

21. M. Ahmed - Survey of Traditional Crafts - Series No. 1 – A Monograph of Indigenous Smelting of Iron – Census of India, 1961 – Volume XII – Part VII-A (1) – Orissa – Page 3

22. M. Ahmed - Survey of Traditional Crafts - Series No. 1 – A Monograph of Indigenous Smelting of Iron – Census of India, 1961 – Volume XII – Part VII-A (1) – Orissa – Page 2

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