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RESEARCH ARTICLE

METALLURGY DURING THE SULTANATE PERIOD

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Article History

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INTRODUCTION

The metals such as iron, copper, gold and silver were extensively used in India during the Sultanate period for multi-purposes. The artisans were very efficient had acquired expertise in the use of the metals and making of their alloys. The mines were treated as spoils and therefore one-fifth goes to the state as its share and four-fifth was given to the finder.¹

Iron

It was used most popular metal for the making of weapons, agricultural tools and implements and household articles. Iron ore of an exceptionally high grade was mined in India and it was used to produce damascened steel which had worldwide reputation²

Iron was mined in the scattered hilly region beginning with Gwalior and extending to the tip of southern India. It was extracted from its ores by methods which were fairly effective. Furnaces were made for this purpose and product was admirable. Coal was not mined but heat was produced by wood and charcoal. Description of the procedures extractions of iron from the ores by the artisans of Kasya hills (North Eastern State). There were large huts at least 25 feet high, the thatch of which reaches down to the ground on all sides. The interior, of an oval form, 15 by 30 feet, in the two diameters, was divided into three apartments, the central one being the smelting room. Two large double bellows, with the nozzles pointed downwards, were set upon one side of the apartment on the upper part of which a man stands with one foot on each, his back supported by two planks. He holds a stick in his left hand, which was suspended from the roof, and has two strings attached to it below, connected with the two bellows; these were worked quickly by a wriggling motion of the loins, and the strength of the leg. The nozzle of the bellows united in a tube which leads underground, from a sort of wind chest, to the hearth about four feet in front of them. Over the hearth was a chimney of pipe-clay braced with iron hoops, two feet in diameter at the bottom, and about 6 feet high.

The mouth at the bottom was on the side away from the bellows, and the chimney inclined from them to direct the heated air from the smelter towards an opening in roof. At the right side of the bellows and even with the top of the chimney, was a trough containing damp charcoal and iron-sand. At every motion of his body, the operator with a long spoon tumbles a piece of this charcoal, with the iron sand adhering to it, down the funnel of the

furnace, and when a mass of melted or rather softened iron was formed on the hearth, it was taken out with tongs, and beaten with a heavy wooden mallet on a large stone by way of anvil. The iron in this state was sent down to the plains for sale or barter.³

Iron and its Alloys

Indian artisans acquired knowledge of iron-carbon alloys and its different phases as depicted in the 13th century A.D text i.e. *Rasa Ratna Samuccaya*⁴ contains a section on the different varieties of iron. For instance, *kantaloha*, soft wrought iron with its five sub-varieties. The second major variety was *mundaloha*, originated from *mundia*, one of the metal smith tribes in dist. Bastar. It had three sub-varieties: (a) *mrdu* (b) *kuntha* (c) *kadara*. *Mrdu* was best of the three. *Tikshnaloha* and or carbon steel had six sub-varieties. These appreciably hard materials were carburized iron which could be hypo-eutectoid (less than 0.83% carbon). *Pogaras* (hair – like lines), *khara* (varities of tikshnaloha), *sara*, *hrnvala*, *vajira*, *taravatta*, *kalayasa*.⁵

Copper

It was used on large scale after iron. According to *Ain-i-Akbari*, not only pure copper but also its alloys with other metals were made.⁶ For instance, in the category of alloys of copper, first come *safidru*, which was known by Indian. *Kasi* (mixture of 4 *sers* of copper to 1 *ser* of tin, melted together). Second was *ruhi*, 4 *sers* of copper to 1-1/2 *sers* of lead, also called *bhangar*. Third was and brass or *pital*, this was made in 3 ways: First, 2 ½ *sers* copper to 1 *ser* of *Ruhi* – *tutiya* which was malleable when cold; secondly, 2 *sers* of copper to 1 *ser* of *Ruhi* – *tutiya* which was malleable when heated, thirdly, 2 *sers* of copper, 1 *ser* of *ruhi* – *tutiya* not worked with the hammer, but by casting. Fourth was *simi* – *sukhta*, this was made of lead, silver and bronze, it had a black luster and used in painting⁷. Fifth was *haft* – *josh*, (*sapta* – *loha*), was a seven metal alloy consisting of gold, silver, copper, tin, iron, lead and zinc⁸. Sixth was *ashdhat*, it was a compound of eight metals, made of *haft* – *josh* and mercury (used as amalgam with gold). No account is available of the working of these mines and the processing of the ore.

Its alloys

Sultan Mohammad Bin Tughlug experimented i.e. issuing of token coins (bronze coins) on large scale⁹, so that metal workers again got opportunities to produced coins of alloys of copper i.e. Bronze. The metal workers of Sultanate period

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produced high quality of coins as evidenced by their skills in coinage¹⁰. So that copper was used for making of coins.¹¹

Tin

This metal was used in India from ancient times. This was used for making of alloys. Demand for Tin increased when the tradition of tin-coating came, this came along the Turks¹², it was introduced around about 1300 A.D.¹³ It is known that coins belonging to Bahmani kingdoms are found through excavation (1347-1500) found and along it a copper container was also found which had tin coating both internal and external of the container at the excavation site i.e. Brahmapuri. The word *Kalhai* or *Callai* was Arabic, and it might have been derived from Sanskrit *Kastira* or Greek *Cassiteros*.¹⁴ Major Uses of tin were making of bronze, bell - metal and tinning vessels of copper and copper alloys. The tin-coating became profession because of its demand in the royal household and by commons, they were known as *Kalhaigars*. They moved about from house to house for tin-coating along with their all materials and instruments which were required for this purpose but they also had regular shops in the cities.¹⁵

Gold

This metal was precious and very important during this period. The gold smiths were experts in the production of gold jewellery and other products, besides this large number of artisans were employed in the process of mining of gold, extraction from its ores etc.

The process was very simple, the apparatus employed by the artisans consists of a plank four feet in length, two and a half wide at the upper end and tapering towards the lower one, which was one and half, it was hollowed out so as to leave an edge of half – an – inch round the sides and upper end, the under-end being left open for the water to run off, the lower half of the plank was cut into a succession of grooves half an inch deep and the same in width. The plank was placed slightly sloping towards the lower end and the sand washed through a coarse sieve which frees it from the pebbles and gravel; the fine sand which remains in the grooves of the plank was then placed in wooden trenches, polished on the inside with Keoo (The black varnish of the Keoo tree) and in shape and size resembling a shield, with a very small receptacle in the centre. This was immersed so as to leave its outer edge on a level with the surface of the water, and by a rotary motion the fine sand was washed off and the gold remains in the small receptacle¹⁶. Large numbers of professional gold washers were employed in the deposits of Brahmaputra, Sunarnarckha and Sona River.¹⁷

Ain-i-Akbari, while mentioning the details of the working of the mint describes methods for testing the purity of the precious metals, separating the two precious metals from each other and from other ingredients. The *sarafis* (goldsmith) were expert in handling these metals and made use of all the known physical and chemical process involved in their working. Different kinds of workers were employed in the mining industry shown in the *Ain-i-Akbari*.¹⁸

Refining Of Gold

The gold plates which were made by plate makers which was of 6 or 7 *mashas* each and 6 or 7 fingers in length and breadth. These were called adulterated gold plates. They were refined by the following method given in the *Ain - i - Akbari*.

“When the above mentioned plates have been stamped, the owner of the gold, for the weight of every 100 *Jalali* gold *muhrs*, must furnish four *sers* of saltpeter, and four *sers* of brick dust of raw bricks. The plates, after having been washed in clean water, are stratified with the above mixture (of the saltpeter and brick dust), and put one above the other, the whole being of the wild cow. Then they set fire to it, and let it gently burn, till the dung is reduced to ashes, when they leave it to cool, then, these ashes being removed from the sides, are preserved. They are called in Persian *Khak-i-Khalis*, and in Hindi *Saloni*. By a process, to be mentioned hereafter, they recover silver from it. The plates, and the ashes below them, are left as they are. This process of setting fire to the dung, and removing the ashes at the sides, is twice repeated. When three fires have been applied, they call the plates *Sitai*. They are then again washed in clean water, and stratified three times with above mixture, the ashes of the sides being removed. This operation must be repeated till six mixtures and eighteen fires have been applied, when the plates are again washed. Then the assay master breaks one of them, and if there comes out of soft and mild round, it is sign of its being sufficiently pure; but if the round is harsh, the plates must undergo three more fires. Then from each of the plates one *masha* is taken away, of which aggregate a plate is made. This is tried on the touchstone; if it is not sufficiently fine, the gold has again to pass through one or two fires. In most cases, however, the desired effect is obtained by three of four fires”.¹⁹

“After plate makers, the other workers *were* melter of the refined metal, the *zarrab*, (he cuts off the gold, silver and copper into round pieces of the size of coined money), the engraver (he engraves the dies of the coins on steel, and such like metals, coins were then stamped with their dies), the *sikkachi* (he placed the round pieces of metal between two dies; and by the strength of the hammerer both sides were stamped)”.²⁰

Silver

This metal was also precious after gold, and used in ornaments, vessels etc. The artisan who was specialist in this work

Method of Refining Silver

The *Ain-i-Akbari* gives in detail the method of refining of silver which is given below:-

“They dig a hole, and having sprinkled into it a small quantity of wild cow dung, they fill it with the ashes of mughilan wood (*babul*); then they moisten it, and work it up into the shape of a dish; into this they put the adulterated silver, together with a proportionate quantity of lead. First, they put a fourth part of the lead on the top of the silver, and having surrounded the whole with coals, blow the fire with a pair of bellows, till the metals are melted, which operation is generally repeated four times. The proofs of the metal being pure are a lightning-like brightness and its beginning to harden at the sides. As soon as it is hardened in the middle, they sprinkle it with water, when flames resembling in shape the horns of wild goats, issue from it. It then forms itself into a disc, and is perfectly refined. If this disc be melted again, half a *surkh* in every total will burn away i.e. 6 *mashas* and 2 *surkhs* in 100 and *tolas*. The ashes of the disc, which are mixed with

silver and lead, form a kind of litharge, called in Hindi and *kharal*, and in Persian *kuhna*; the use of which will be hereafter explained.”²¹

Separating Impurities

The khak when washed was called in *Hindustani kukrah* and still contained some gold and silver, for the recovery of which the well-known technique of cupellation was applied.

The most accurate assay method particularly for low concentration was cupellation. The process was chemically simple, but it required skilled craftsmanship. In this process, the couples were placed under a muffle in a furnace and annealed for half an hour before adding either the lead button from a scarification or crucible-fusion of ore or a bullet of lead to which a weighed metal sample was added.

Separating Silver from Gold

The *Ain-i-Akbari* gives the process of separating silver from the gold. According to it, “they melt this composition six times; three times with copper and three times with sulphur, called in Hindi *chhachhiya*. For every *tola* of the alloy, they take a *masha* of copper and two *mashes*, two *surkhs* of sulphur. First they melt it with copper and then with sulphur. If the alloy be of 100 and *tolas* weight, the 100 *mashas* of copper are employed as follows

They first melt fifty *mashas* with it, and then twice again twenty-five *mashas*. The sulphur is used in similar proportions. After reducing the mixture of gold and silver to small bits, they mix with it fifty *mashas* of copper and melt it in a crucible. They have near at hand a vessel full of cold water, on the surface of which is laid a broom-like bundle of hay. Upon it they pour the melted metal and prevent it, by stirring it with a stick, from forming into a mass. Thus having again melted these bits, after mixing them with the remaining copper in a crucible, they set it to cool in the shade; and for *tola* of this mixture two *mashas* and two *surkhs* of sulphur are used, i.e. at the rate of one and one-half quarter *ser* ($\frac{3}{8}$ *ser*) per 100 *tolas*. When it has been three times melted in this manner, there appears on the surface a whitish kind of ash, which is silver. This is taken off, and kept separate; and its process shall hereafter be explained. When the mixture of gold and silver has thus been subjected to three fires for the copper, and three for the sulphur, the solid part left is the gold. In the language of the Punjab, this gold is called *kail*, whilst about *dihli*, it is termed *pinjar*. If the mixture contains much gold, it generally turns out to be of 6 ½ *ban*, but it is often only five, and even four. In order to refine this gold, one of the following methods must be used. Either they mix fifty *tolas* of this with 400 *tolas* of purer gold and refine it by the *saloni* process or else they use the *sloni* process. For the latter, they make a mixture of two parts of wild cow dung, and one part of salt-peter.

Having then cast the aforesaid *pinjar* into ingots, they make it into plates, none of which ought to be lighter than 11/2 *tolas*, but a little broader than those which they make in the *saloni* process. Then having besmeared them with sesame-oil, they strew the above mixture over them, giving them for every strewing two gentle fires. This operation they repeat three or four times; and if they want the metal very pure, they repeat the process till it comes up to nine *ban*. The ashes are also collected being a kind of *kharae*.”²²

Zinc

There is little information about this metal. This was also used in Ancient India on small scale, but around the thirteenth century A.D. there was a boost mining and metallurgy of zinc and lead in Zawar region of Rajasthan.²³

Lead

Lead was also mined from ancient period in India.²⁴

Bidri

This is an alloy of zinc, copper, lead, tin and iron. bidriware is sleek and smooth dark coloured metal work with very small and delicate work on its glossy surface.²⁵ This craft is a kind of damascene work. These craftsmen came in India from Syria or Iraq and some were settled at Ajmer in Rajasthan and some moved down to south-ward during the 15th c A.D and settled at Bidar. When the art flourished in that place for centuries, it became known as bidriware craft.²⁶

Process of this craft

First the surface of bidriware made smooth and a solution of copper sulphate applied to it to darken it temporarily for engraving. Then light coloured and delicate design engraved on its surface and this pattern of design can be seen clearly. Then this piece goes to the inlayer, he done inlay work of silver, brass or gold. After this process, the final stage has been burnished, in order to get black surface. This is done by applying a paste of ammonium chloride potassium nitrate, sodium chloride, copper sulphate and mud which darkens the body by producing a characteristic black patina while having no effect on the inlay. Then paste is washed off and finally oil is rubbed into the piece to deepen the blackness of the patina. With this result the lustrous dense black body contrasting with the brilliant lining-white (silver) or yellow (brass or gold).²⁷

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