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TECHNOLOGY IN INDIA IN THE EIGHTEENTH-NINETEENTH CENTURY

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"The study of technology is an essential key to the understanding of people's culture", writes Harskovits, in his famous work, *Man and His Culture*[1]. Some studies have, however, been made on Indian arts to appreciate their artistic, socio-religious and aesthetic significance, but no systematic study has been made on technology of different crafts known in different periods of history. Here an attempt has been made to study some important traditional crafts and their technological innovations in the 18-19th century.

INTRODUCTION

The technology in India in the period was highly decentralized on class basis. Some of the manufacturing castes can still be recognised from the titles like *tānti* (weaver), *karmakār* or *lohārs* (ironsmith), *kulāla* or *kumārs* (potter), *suvarṇakār* (goldsmith), *sūtradhār* (carpenter), *kāserā* (copper-smiths or braziers) etc. The enumeration of these classes which constituted various communities or castes is difficult, but there is no doubt that those classes acquired considerable proficiency and earned their livelihood through complex specialisation.[2] Stavorinus in his account of the *East Indies* between 1768-71 reports that the artificers confined themselves to one sort of work. According to him[3], "A goldsmith would not work in silver, nor a silversmith in gold. In the looms, a weaver would weave only one single sort of stuff during the whole life, unless he be compelled to take another in hand." In India the knowledge of technology was mainly traditional. Learning and training of an artisan was limited to his family.

TEXTILE

The process of manufacturing and production of textile was already a known technique in the eighteenth century. This was perhaps known traditionally from the time of Harappa and had attained a sizeable progress in the sixteenth-seventeenth century. Jean Baptist Travernier[4], in an account of 1676 reports that transparent Indian muslins were exported to Persia, Turkey, Muscovie, Poland, Arabia, Grand Cairo and many other places. The Dutch[5] also made investment to this profitable business and did not allow members of their company to engage in private trade. They exported the materials to Philippines, Borneo, Java, Sumatra and other neighbouring countries. Some of the textile crafts also reached its zenith. These crafts were either effected on the surface, or done separately or knitted side by side with the progress of the weaving. Most important of them being brocades, muslins, embroidered fabrics, tie-dyed and printed calico-cloths and the carpets.

In the eighteenth-nineteenth century also, this industry provided employment to hundred and thousands of inhabitants and countless widows, and the textile craft reached further progress. This was considered as a premier industry and captured extensive market even outside India. Hill[6] in his report on Bengal (1756-57) writes that every district in Bengal could boast of special brand and produce cloth of all kinds. Dacca in Bengal enjoyed undisputed superiority in cotton and silk cloth. Its muslin was so fine that a piece of twenty-yards in length could be enclosed in a common tobacco box (size 8″×4″×1″)[7]. The Bihar province was known for cloths of good texture, and northern India, Gujarat, Mysore, Ahmedabad and some parts of Madras (Masulipatnam and Vizagapatnam) for durable cotton goods. The silk and woollen products in India could not be so popular as the cotton ones, but these were also produced in sufficient quantities. Calcutta and Surat were great emporiums for foreign commerce. Cotton, silk and textile stuff were brought to these places for export to European markets.

As to the technique of manufacturing textile-fabrics in the period, details are not available but from survey reports on textile preserved in the museums like Victoria Hall Museum, Udaipur, and the tribal techniques still prevalent in some parts of Bengal, Nagaland, Manipur, Madhya Pradesh, it would appear that there were various phases of operations[8]. Some of the technical operations in cotton were, *wetting* of yarn (i.e. keeping the yarn under water for 1-3 days for removing foreign substances and making it suitable for absorption of sizing materials), *sizing* (starching with flour or *til* oil for stiffness and glaze), *bleaching* (boiling in soap water or solution of impure carbonate of soda and slaked lime for making it sufficiently soft), *dyeing* (colouring with required dye), *spinning* and *winding* (transferring of yarn from the hanks to bobbins for the warp), *warping* (putting a number of threads up and down equal to the length/width of the cloth to be woven), *denting* (drawing warp-ends through the dents of the reed), *beaming* (winding of warp threads on warper's beam) and so on. For silk, cocoons were raised by cultivators by growing mulberry plants and rearing silkworms feeding on mulberry leaves. Cocoons were then sent to silk weavers for reeling.

After *winding*, came the art of weaving. It was usually governed by three primary motions in a loom. The first motion was effected by the depression of the treadle by one foot thus making an opening. Then by the second motion, the shuttle was pushed by giving an oblong pull to the handle resulting a push to another shuttle of the shuttle box which ran across the opening to the other side, and by the third motion, the wept thread was beaten by drawing the sley made of bamboo or wooden rod forward. Mainly two important types of looms, viz. *throw shuttle* and *fly shuttle* were usually used. In the throw shuttle techniques, shuttle was thrown across the shed by one hand from one side and caught by the other in the opposite side of the cloth. The *fly shuttle*[9] technique was first patented by John Kaye of Bury in 1733 and perhaps introduced by the Company. In the fly shuttle technique, shuttle was pushed from one end to the other across the sley which was fitted with shuttle box by packers exerting pull by the right hand. The repeated oscillating motion was effected by hand.

Three changes in the textile technique in the period are noticeable, viz. (*i*) numerous filature system in reeling, (*ii*) drum warping, and (*iii*) flyshuttle technique. East India Company was interested in large scale production of textile goods and established several factories with numerous filatures for reeling. In 1769 it brought even a number of Italian reelers to teach the Italian system[10] to factory hands. In warping, the street-warping and drum-warping techniques were used. The latter was an advanced technique, for specific length could easily be obtained by marking on the drums. In the loom also, fly shuttle technique increased considerably the output of the weavers. The time and labour were very cheap in India. But this large scale production brought a great change in textile industry. In 1815, the company established a textile mill at Broach. A few others were established at Calcutta in 1818. By 1833, Company's interest in the silk industry of Bengal declined perhaps due to silk-worm plague. Bad reeling and hard competition with Japan, China and Mediterranean countries were also considered other factors for such decline. But the cotton mills went on making considerable progress because of quicker adaptations of the large scale manufacturing techniques and superior arts and crafts. England viewed Indian textiles with alarm and indignation. Only vigorous state action in banning the use of Indian textiles strengthened English industry to stand on its own food.[11] A few cotton mills were established by the effort of the Indian themselves, one at Bombay in 1854 by Cowasji Patel and the other at Ahmedabad in 1861 by Ranchotlal. Between 1880 to 1895, a number of textile mills increased from 58 to 154, and the number of employees from 40 thousand to one and half lakhs. By the turn of the century, the textile industry made spectacular progress, and over 80 per cent of the production was still exported to China, Japan and few other places.

METALLIC AND ALLIED WORKS

From the time of Indus valley, bronze and copper were known metals in Indian tradition. According to Ray[12], *casting* (operation of pouring molten metal into moulds in which they solidify) and *forging* (shaping of hot metal by means of hammering) techniques were known to the peoples of Indus valley. According to some scholars bronze statuette of the dancing girl and a crucible with slag sticking to the edges are pointers to this direction and conform to this suggestion. Since copper melts at 1084°C, it appears that people of Mohenjodaro could produce and control a temperature of 1084°C. The metals like silver (960°C), lead (327°C), gold (1065°C) and tin (232°C) were also known to them perhaps because of their availability and low melting point than that of copper. Iron technology (melting point of iron 1533°C) came much later perhaps because of ignorance of producing a temperature as high as 1533°C. The *cire-perdue* (lost-wax) technique was widely known in Gupta, Chola, Pallava and in the Medieval period. The *Samarāṅgana Sūtradhāra* and *Mānasollāsa* give elaborate description of this technique. The process of extracting iron was undoubtedly crude and entailed plenty of labour, but regarding know-how, details are not available.

Campbell[13] in his survey of Madras in 1833 gave a description of a furnace being used in large numbers by the ironsmiths of South India for the production of bar iron. The furnace was of a conical shape having a height of 4 ft. 6 inches. The diameter varied from 13 inches at the bottom to 7 inches at the top. It had two openings at the bottom, for letting in the blast given with the help of bellow and the other for taking out the slag. Common magnetite iron ore (Fe_3O_4) and requisite amount of charcoal were introduced from the top. Two men were required to work on it, one at the bellows and the other to put fuel in ore, and letting out the slag. The furnace was first filled with charcoal. When it was well heated, ore was let down through a hole at the top. Some 25 to 30 basketful of ores (one basketful weighs roughly 5 to 7 seers) were consumed by a furnace in one day. The furnace was similar to the modern *blast furnace* being used for the manufacture of pig (or cast iron). This gave bar iron of high quality containing a considerable portion of steel. The price of these bar irons was cheaper than the cheapest English bar iron then sold in India and these were in demand in England for producing steel of good quality. In Madhya Pradesh, Bihar, Bengal and Maharashtra, the medieval method of smelting iron ore and forging of iron bars are even practised now by the tribals like *Lohār*, *Tāmtā*, *Āgārias*, *Khuntiā*, *Chokhs*, *Mariās* and *Muriās*, *Birs*, *Asurs* etc. According to Buchanan[14], the manufacture of steel from iron ores was a common industry in Mysore district in the first decade of the 18th century. The steel wires[15] manufactured at Seringapatam for musical instrument attained very good standard and were sent to different parts of the country. Twining[16] reports that industrious inhabitants at Munger in Bihar and Birbhum in Bengal could manufacture iron utensils of almost every descriptions. They could also manufacture chairs, tables, sofas, cots, bedsteads, drawers which were extremely neat and scarcely inferior to European furniture.

Attempts had been made from time to time to work on ores on a large scale by modern method by the British Government. In 1874, Bengal Iron Company was established at Barakar. In 1891 the establishment was able to employ 821 people and produced 12 thousand tons of pig iron. But by the end of the century the indigenous iron had been crushed out of existence by the imported iron. By 1891-92, the quantity of imported iron was little below 2 lakh tons. The figure shows that the indigenous method of smelting pig iron gave only a precarious and supplementary means of subsistence to a small class of people in India.

Zinc was perhaps first discovered in India in the medieval period; reference to which are available from different *Rasaśāstras*. Zinc as an amalgam with mercury gave rise to *rasaka*. The large heaps of zinc and lead bearing residues, slags, clay retorts and fragments of furnaces found in *Zawar Area*[17] (in the state of Mewar, Udaipur) bear evidence that mining and smelting of zinc was traditionally known from the time of Lakh Singh, who mounted the throne at Chitore in 1383 A.D. Chemical analysis of slag has shown that metallic zinc and zinc oxide were recovered from zinc sulphide ores by a process that resulted in the waste product of glassy slag.

Captain Brooke who visited Zawar mines in 1844 and again in 1848 had outlined the general process of smelting of zinc ore. The retorts were first filled with ore and charcoal or other carbon bearing materials as a reducing agent. It was then capped with clay-cover and tube and then placed in an inverted position over perforated hearths. The retorts were then kept at high temperature by putting fire to the sorrounding coal with the help of blast of air set through the bottom of perforated hearth, through which the clay tubes were protruded downwards. The incoming air kept the tubes cool and the zinc metal and zinc oxide were deposited in the tube, since the temperature of the retort became high enough to distil zinc. When the process of distillation was completed, the condensing tubes were broken off, and zinc and zinc oxide were recovered. The smelting process was therefore basically similar to the pyrometallurgical zinc smelting technique used in England as late as 1854. In the present day technique, zinc sulphide ores are roasted before they are placed in retorts, but it is not known whether this was actually done at Zawar.

The manufacturing of gold and silver ornaments by *soldering process* (joining together with alloys of tin and lead in varying proportions of copper and zinc) or *repousée process* (decorating of a metal sheet of gold or silver by carving designs in the reverse side and then turning the metal) were well known. These processes appear to have been practised in India from very early times. The manufacture of the glass of different colours was also current, since use of ear-rings among the Indian women were much in use.

The coal mining might have been known traditionally from ancient times. Large scale production started in 1854 when Dwarakanath Tagore took initiative to establish the Carr-Tagore Co., which was later named as Bengal Coal Company. The importance of coal began to be felt with the spread of western civilisation with its railways, mills and workshops. The number of mines rose to 87 in 1891, and the people employed were as many as 34 thousands including men, women and children. But the coal production was not in a position to meet the demands of the railways and other industries. The Company took measure to import coal from England. By 1894, the number of coal mines in India increased to 123 and the number of employed persons were as many as 43 thousands.

Some Miscellaneous Technology

The processes of the manufacture of paper, ink, soap, oil, etc. have been analysed.

Paper

According to some scholars, Arabs first learned the technique of manufacturing paper from the Chinese captives at Samarqand, and it is through them the *Kurasani paper* was first introduced into India in the 8th century A.D. According to others, Chinese paper came to India through Nepal between 7th and 9th century A. D. Ghori and Rahman[18], in their survey on paper technology in India has shown that the craft was more or less known in Medieval India. As to the technique of manufacturing paper, Captain Moor[19] (1790), who had intimate knowledge of the Maratha life, gives a description of paper making at Hurry Hal, situated on the eastern bank of Toongabhadra river. In a shallow well of 8 ft. diameter, a block of hard wood was fixed at the centre. The materials from which the papers had to be prepared were moistened with water for several days and then beaten to a pulp on the central wood by a heavy hammer or wooden beater. Old cloths, old tents, rotten gunny-bags, rags and such things were usually used, but when these things were not available, the bark of particular shrubs or *khaḍ* (hey) was mixed in proportion after these were washed well and soaked in water for several days. The pulp, after being sufficiently beaten, was mixed with little quantity of water in chunamed (limewater) reservoirs. A quantity of gum (from *bābul* tree) was also dissolved in the water. The moulds made of bamboo strips were then dipped into this mixture and the materials adhering to it when lifted out gave a sheet of paper after it was dried.

Buchanan in his *Patna Gaya Report*[20] gives a description of paper manufacture as prevalent in Bihar in the beginning of 19th century. He says that wood instrument called *dhenki* was used for beating the pulp. The pulp was then bleached with soda water and washed, and the process was repeated six times. The bleached pulp was then put into a cistern with large quantity of water and diligently stirred with a stick. After an hour it was wrought off into sheets as usual.

The beating engine (Hollander) was first discovered by the Dutch between 1690 and 1720. This was perhaps a substitute of stamping or hammering technique known in different cultural areas. This is definitely the product of the industrial revolution in Europe which activated the large-scale operations. Moreover, Europe made some qualitative improvement of bleaching action by chlorine gas (discovered by Berthelot in 1785), or soda ash (by Leblanc in 1791) and paper making materials by the use of wood and special type of grass as pulp[21]. Buchanan, however, gives a list of 110 families of paper makers in Bihar who were engaged in this industry. Hodgson, British resident in Kathmandu in 1837 recommended Nepal paper for office use in place of paper of Hindustan for its quality. In 1841, British Government opened a factory at Darjeeling but closed it for it was found to be uneconomical. The paper industry by modern method sprang up only in 1862 when Girgaum paper mill was started at Bombay. By 1891, the number rose to eight, of which three were established in Bombay Presidency, three in Bengal, one at Gwalior and one at Lucknow.

Ink

The manuscripts of the 18th and the 19th century used golden, silver, black and red inks for writing of manuscripts. The first two types of inks had been mostly used for royal personages and rich persons. The red ink is not suitable for eye and was used mainly for drawing boarder lines, geometrical designs, and beginning and end portion of the manuscripts. The most popular ink was of course black. Various methods of manufacturing ink both in solid and liquid form were known from ancient times.[22] Traditionally, black colour was obtained from *kajjala* (soot), yellow or pigment from *haritāla*, white colour from *śaṅkha* (conch) powder, reddish brown from *darada* (red led), blood-red from *alaktaka* (red sap), dark red from *gairika* (red chalk). The techniques for manufacturing of black inks which were still prevalent in the period may be summarized as follows:

i) Roasted rice+lamp black+little sugar+(sometimes) juice of a plant called *Kesurte* (*Verbesina scandens*). (Mitra—*Notices of Sanskrit Manuscripts*, Vol. 3, p. 6). The labour of making this ink was great, for it required several days' continued trituration in a mortar before the lamp-black would be thoroughly mixed with the rice infusion. Otherwise, the lamp-black would settle down at the bottom in a paste leaving the infusion on top making it unfit for writing. Sometimes Acacia gum was also used to give a gloss to the ink, the ink was usually used for writing on the paper.

ii) Kesurte juice+decoction of *āttā*. The ink was used for palm-leaf manuscripts, absorbed into the leaf and could not be washed off. The ink is lasting and the gloss do not fade for centuries (Mitra—*Notices of Sanskrit Manuscripts* Vol. 3, p. 6).

iii) Soot (prepared by burning *kacalis*, coconut-halves or of *almonds*)+oil. This was used on the palm-leaf writing. First, manuscripts were scratched with an iron stylus having a pointed end, then the scratched surface was besmeared with the mixture, and lastly, it was cleaned by means of a cloth (*Jaina Citra Kalpadruma* by Muni Punya Vijayaji).

Various other traditional methods were known. Some of them used *picunand* (*nimba*), *bhṛṅgarāja*, *triphalā* (*haritakī*, *vibhītak* and *dhātri lākṣārasa* (lac-dye) *kāsīs* (green-vitriol, green sulphate of iron) etc. The inks both in solid and liquid form were in good demand during Mughal, Maratha, even British period, since their record department consumed large quantities of writing accessories. In Poona and Kolhapur, there exists still some Brahmin with surname *raktavān* which perhaps indicates their profession as ink maker.

Coconut or Mustard Oil

This is one of the most important village techniques by which mustard seeds or dried oily seeds of coconut were pested by a heavy wood or iron pestle. The iron pestle was usually fixed at the middle of a perforated wooden or metallic case. A circular motion of the pestle was created with the help of a fixed rod, one end of which was fixed to the pestle and the other end was attached to the ox effecting circular motion. This important and useful industry was prevalent in many places of West Bengal and Kerala and in some other places by the end of the nineteenth century and has now become obsolete with the introduction of large scale manufacturing technique. *Tilli* and *Tambuli* classes are still in existence in different parts of Bengal for their association with the manufacture of oil.

Soap

The Portugese word for soap (*sābão*) has been introduced into almost every language or dialect of the East. Kane[23] reports that the roots and crushed fruits of various kinds of soap tree had been in use in India for cleaning textile and impure articles. The term *sābuna* was first used by Guru Nanak[24] (1469-1538) who says (*Japaji Sāhib*) 'if the cloth gets dirty with urine, wash them with *sābun* (soap)'. It is not definitely known when the chemical preparation of soap was first introduced into India. Francis Buchanan in his *Patna-Gaya Report*[25] (1811-12 A.D.) first gives a report of manufacturing soap chemically in the company's factory at Bihar. The prescription is as follows:

Tallow (42 seers), linseed oil (15 seers), lime (2 seers) and impure soda (8 seers) were heated together to produce soap (84 seers). Each boiler produced $2 \times 84 = 168$ seers in a month and two families on an average were engaged for each boiler.

Buchanan reports that there were about 21 soap makers in the city of Patna and in the district of Berar. One Marathi MS., *Pes āvaicyā sāvalit*[26] (1773) prescribed *sāvan* and other materials against skin diseases. In the list of English goods being sold in Poona market in 1788, soap was mentioned as soap *vilāyeti*.[27] Soap industry thrived in India during the period and reached somewhat a prosperous stage at a time when foreign soap was being sold in the Poona market. Based on European methods, two factories came up at Merrat (Bihar) towards the end of 19th century. In 1891, these two factories produced 9808 maunds of soap.

CONCLUSION

Apart from textile, metal-working, paper, ink, oil and soap, there were various other technologies, traditional or new, developed in the period. Some of these were printing, rice-cleaning, bone-crushing, rope-making, brewing, manufacturing of sugar, nitre, indigo, brick-making, lime-burning, potting, jute and leather technology etc. The technology associated with the industries of necessity of the villages and luxury industries of the town received little monetary support and faced almost no competition from outside except textile. On the other hand, the large scale manufacturing technique brought by British Raj made an important impact though indirect in the industrial as well as technological system in India. As a result of this impact, some of the manufacturing techniques have totally been vanished while some other have only been preserved with improvements and adaptations accrued from new technology, railways, opening of new roads, use of steam power etc. Several exhibitions[28] of articles manufactured with the aid of the machinery or according to scientific methods followed in Europe were organised in India by the end of the 19th century. One was at Cossipur (near Calcutta) under the auspices of the Indian Industrial Association of Bengal. The list of exhibits included pharmaceutical preparations, maps, looks, scientific apparatus, match, paddy, husking machine, surgical instruments, varnish, lamp, harmoni-flute, ink for polishing shoes, toys, biscuits etc.[28] This shows that India entered into an intermediate phase of technological development by the end of nineteenth century.

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