Introduction to Ancient Indian Technology.
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Lecture-39

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We can start this lecture with a thought process “you can create your own life, as an artist sculpts a deity by metal casting”. And today we will be basically discussing about metal castings in ancient India.

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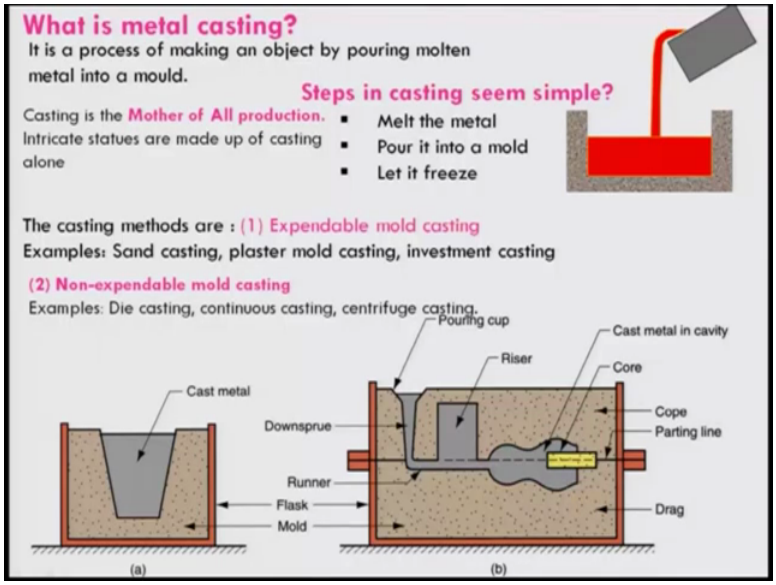

A question might be coming into your mind, what do you mean by metal casting? Metal casting is basically a manufacturing process by which an object is made by pouring molten

metal into a mould. And of course the casting is considered to be the mother of all production. And we know that intricate statutes which are being used as an as idols for our worship, for worshipping purposes are made of casting alone. And if you look at the process involved in metal casting is very simple.

What one has to do is basically metal the metal and then you will have to prepare a mould like that what I have shown here and pour into it. And once you pour it will start solidified due to the cooling effects. But it must be done properly. And then of course you will get a product. So in a simple way one can say that casting having 3 processes. Basically melt the metal and pour it into a mould and let it freeze. Of course it looks to be a very simple but it is no that.

If you are not careful about making the proper mould, pouring it properly and the solidification also should take proper manner, otherwise lot of faults will be there in the casting. And the casting methods are broadly divided into two categories. One is expendable mould casting and another is nonexpandable mould casting. And some of the example of expendable mould casting are sand casting, plaster mould casting, investment casting and others. In case of plaster mould casting, the plaster of paris being used. But sand casting is quite old and it was being used in ancient time. And we will be more discussing about the investment casting which was being used in ancient India profusely for making the statue.

The non-expendable mould castings in which the mould will be used you know used continuously, some of the examples of die casting, continuous casting and centrifuge castings. And this casting is not related to only the metal. It can be used for making glass, even we use the concrete buildings you know concrete slab and other things we do use casting. And keep in mind some of these techniques also will be discussing during the glass making process.

And let me just talk about little bit about the terminology, what is being, what are being used for metal casting. And I have shown here and here a mould and this is having a what you call this are the fan mould will be given. And this is having what you call a flask for a body of that in which you will be preparing a mould it is having two halves, like there is a parting line here. This is the lower part is known as the drag and the upper part is known as the cope. Of course the side view of this entire mould system is being shown here. And which is having cast a metal.

And this portion is the pouring cup through which the metal will be poured. It is having a conical shape. And then of course slowly what you call pipe decreases and this known as downsprue. And after that the metal will be flowing through the runners and there is a riser also in which the molten metal will be kept stored such that it will be going slowly into the cavity, in which the metal will be casted. And there can be a core inside this thing being placed so that you know some hollow things can be made out of this casting.

So this if you look at terminology will be using therefore I thought that I will introduce. Of course there are more terminologies. Now when you will be learning more about casting, metal casting you will be learning about it.

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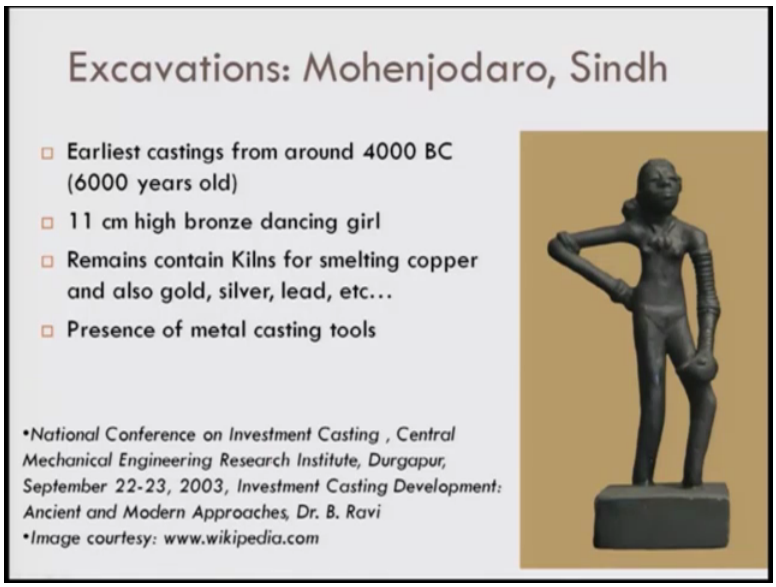

So let us look at now that about the ancient way of making these statue, what I have shown here. You may have seen this statue. This is a dancing girl which of which was obtained during the excavations in Mohenjo-Daro in Sindh. Question arises how it was fabricated? It is having a lot of features. If you look at these are bangles and these are jewelleries. Right. And its having lot of complicated structures like nose, eyes and other things. How one can make this is a very important aspect one might be coming to your mind.

So and this is basically being made by casting and which was considered to be manufactured around 4000 BC. That means around 6000 yrs you know years back. And this of course the size looks to be too small if you look at the today's world. That is around 11cm high bronze dancing girl, like this is made of bronze. And besides this artefact there are several Kilns were being identified in that excavation site in the Indus valley civilization-Mohenjo-daro, Mehengargh and other places. And also other parts of the country. later on of course.

For these kilns are considered to be used for melting copper, silver, gold, lead and others during that era. And besides this metal casting tools were also obtained in this site. And some of this what you call I have taken from this paper and this you can see this image is from which area.

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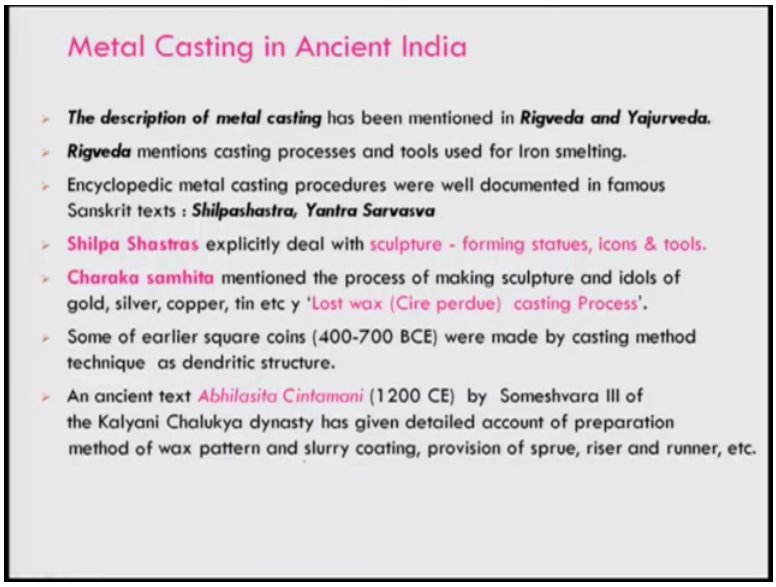

So let us look at now the metal casting in ancient India. I will be just giving bird's eye view of the a What you call evidence. But it is not just what you want. if you look at the Rig Veda and Yajur Veda has provided a brief discussion, description about the metal casting. And Rig Veda mentioned the casting process and tools used for iron smelting. Beside this there are several text are there. Let me quote 2 Sanskrit text. One is Shilp Shastra and Anthsarvasva, which you people might be aware by this time. And it has really documented the metal casting procedures in a very intricate manner, in a very exhaustive manner.

And shilp shastra you go if the as the name indicates it basically deals with the sculpture making. And when you talk about sculpture making is a statue, idols and then tools and other things. And charak sanhita which we have discussed several times, mentioned that not discussed really. And in that the process of making sculpture and idols if gold, silver copper, tin are being mentioned. And then they have talked about a process known as lost waxs casting process.

And in modern times it is also known as the investment casting. And besides this evidence there are some of the earlier coins which dates back to 400-700BC were manufactured by casting methods techniques as a dendrite structures. Dendrites basically tree like structures. And there are several also other text are there but let me mention another very important text

which is known Abhilashita chintamani written by Saumya Sharad III of Kalyani Chalukya dynasty around 1200 CE. Which has given a detailed account of preparation method of wax pattern, slurry coating and provision of sprue, riser, runner like whatever we have discussed in the terminology of the casting, modern casting. Those were have been mentioned in that book.

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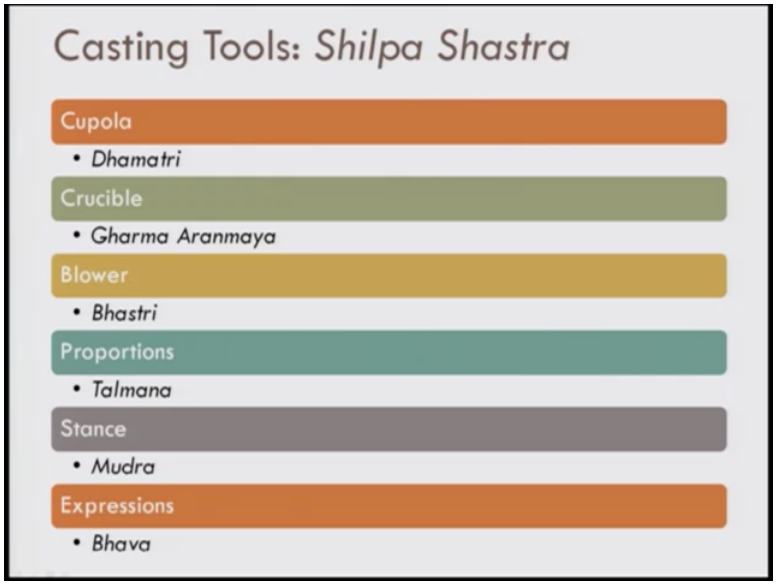

if you look at the Shilp shastra these are the tools which are being used. The Cupala which is in Hindi or in may be Sanskrit dhamatri. That is basically a furnace which is being used to heat the metal and also for like foundry work. And Crucible where you know on the part which will be used for melting the metal and this is known as the Crucible is also known as a Dharma Namaya. And blow air is of course is known as Bhastri. This air blower we have seen in iron during like when we are discussing about iron making. And these are of course the tools of course beside this there are several other kinds of tools like a tong, and other kinds of tolls are were being used.

But what is important for statute making is basically the proportions or taalamana. Right? And stance what we call mudra, these are an expression or the bhava. These are very important which is a part of an art. And you should have a feeling for that to you know sculpt in such a way that you will get a good statue. So therefore it is a combination of the technology and the art which is you know, which was being used for making this making the statues. So that is a very important point you should keep in mind which is not that you segregate it, separate the knowledge rather combine it and make a product of it.

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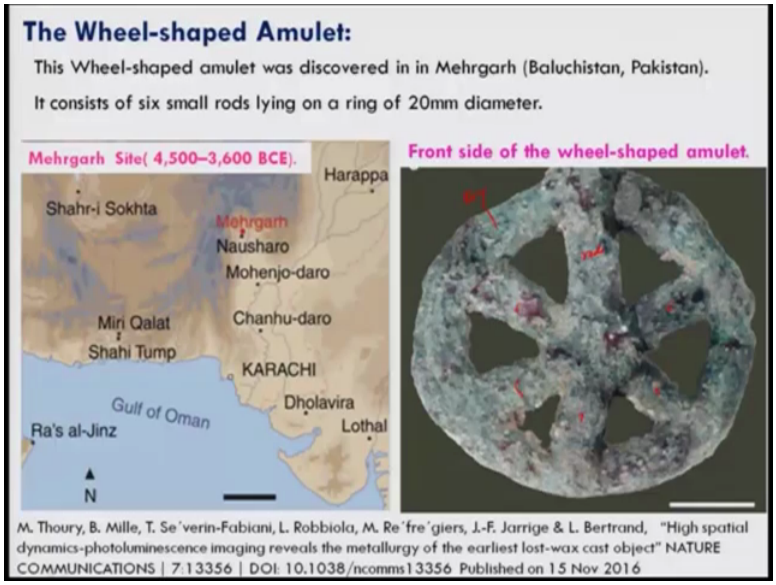

now we will be discussing about a wheel shaped amulet which was exavacated in the Mehergarh which is located in the Baluchistan under Pakistan. This is the place. We have talked about Mehergarh several times. Right? And these are all Indus Valley civilization or now we are calling it as a Saraswati Sindh civilization. And which is around 4500-3600BC. And this wheel-shaped amulet you know is shown here, it is basically the front side. And if you look at it is now rusted, because it is made of copper. And question arises how it was made? It was made basically 6000 yrs back.

And it consists of 6 small rods. These are the rods you know if you look at the rods here, lying in a ring. This is the ring 1. And the diameter is of course too small 20mm, still then how they might have manufactured. And this thing what you call researched well by something around 7 scientists from western countries. And they have published this work in Nature communication on 15th November 2016. And they have used very sophisticated instruments like highly spatial dynamics auto-lumination illumination imaging techniques to reveal lot of metallurgy about earliest lost wax casting object this amulet. And I would urge you people to study and look at it, I will be just you know mentioning about it.

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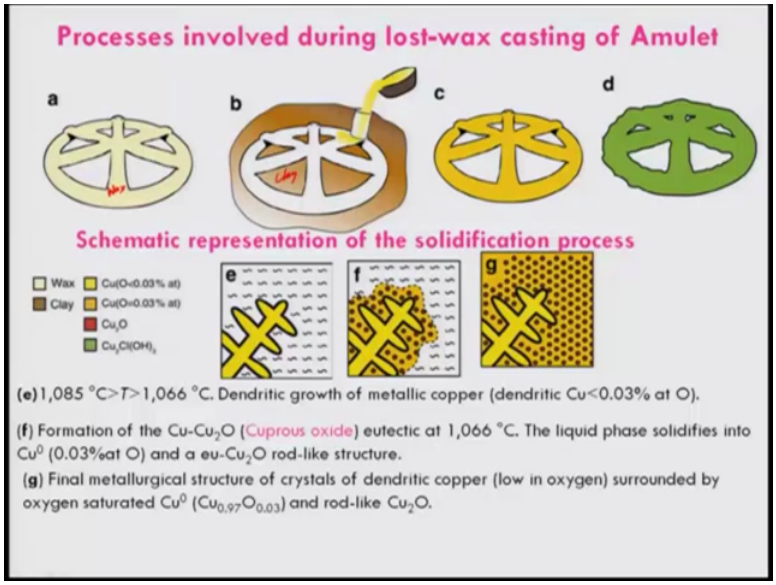

Let us see that how they have fabricated this amulet, which is which was one of the oldest, rather the oldest among all the lost wax casting products made in ancient time across the globe. So they have also not only you know taken studied extensively, they have also made a model of this same thing, this amulet. And they have used something wax this model and rod of circular diameters. And then they have made it into 6 things and then joined with a ring. And this what you call model is created first.

And after that they used some kind of clay and put it this thing and model, mould is prepared out of this model. And of course like as I told that this model is made of wax which can be melted easily at a very low temperature as compared to the metal. So these can be heated such that you know this this model can be meted out and then the shape will be formed. And after that you can pour this molten metal through this sprue. And then the metal will be going through all the places and then solidification will be occurring.

And this is the piece what they got. Of course after that you will have to break this mould you know after it it solidifies completely. And then you can get this metal casted amulet. And this is the thing what they got you know which is rusted one, what we had seen, this one. Now they have also looked at this casting from this process and like take a smaller portion and then investigated using these modern techniques of imaging. And as I told earlier this is basically wax and this is your clay, clay kind of thing throughout.

And they looked at a small portion and to find out what is happening during solidification process. They have found that you know there is a dendrites structures when the temperature is between the 1085 to 1066 degree Celsius. There is a dendrite growth of metallic coppers

and of course oxygen will be around maybe 0.3 percent. And this will be starting there and then subsequently what happened around something 1066 degree C cuprous oxide and copper, right eutectics are formed. As a result the liquid phase solidify into this cuprous, the saturated copper.

And also a copper and cuprous oxide rod-like structures, if you look at these are the rod-like structures which have shown here. And this phase subsequently what happens like this low final metal structure crystallo-dendrite copper is all being made being made throughout this domain. And suddenly oxygen saturated copper. Right? If you look at these are basically the red one - this one is a cuprous oxide and this yellow one is basically the saturated copper.

As a result they get a rod-like structures also, cuprous oxide. But in the finally that is what is being now you know one can what is actually artefact for what is being what is 6000 years old. The people are finding something copper oxi-chloride phase within the dendrites. While the saturated copper fully oxidized to the cuprous oxide within the eutectics. And this as a result this eutectic cuprous oxide is preserved. And that they have found out of this and they have also mentioned that this is the oldest you know artefact or the product of which was made by the lost casting across the globe. And that means it was made in India basically.

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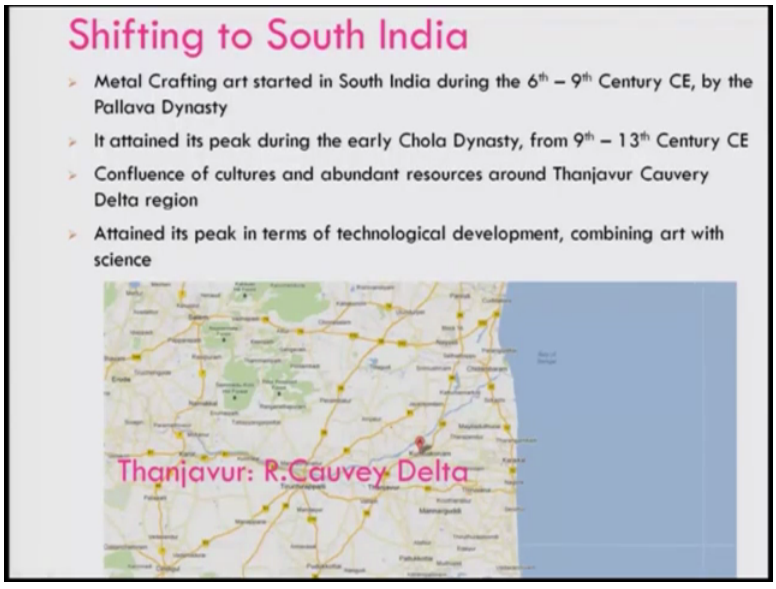

And of course there is a lot of gap between that techniques and which is how it is propagated from the Sindh from this Indus valley civilization towards the south and other parts of the country. But what literary evidence suggest that you know that again there is a arousal of this technology. It might have migrated from that towards the south. But there is metal casting art got started in south-India around something 600 to 900 CE by Pallava dynasty. And this of

course attains peak during early Chola dynasty like 900-1300 CE. And of course this think was being being propagated and also supported by the king at that time.

As a result there is a confluence of culture and abundant resources around Tanjaver-Kaveri delta region. And attained its peaks in terms of technological development combined art with the science what I was mentioning earlier. This is a very much what you call amalgamation of both art and science together. And this is the region, the Tanjaver region where you know it was being developed in earlier time.

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And if you look at I have taken 3 figures here, Lord Natraj, Lord Natraj's statue is quite intricate in nature. I will be discussing little more about it in the next slide. And this is the Lord Vishnu statue which is quite intricate in metal, is a marvel of metal casting, so also the goddess statue. And I must tell you that there is a lot of research is going on about the dancing of the lord Shiva. Right? And which is very famous. And then one aspect want to bring to your attention that lot of like astrophysics Nirupama Raghavan ex-director of Nehru Planetarium had done research and connected these star positions of orient constellations to the image of Lord Natraj due to paucity of time I will not be discussing. But you can explore that thing.

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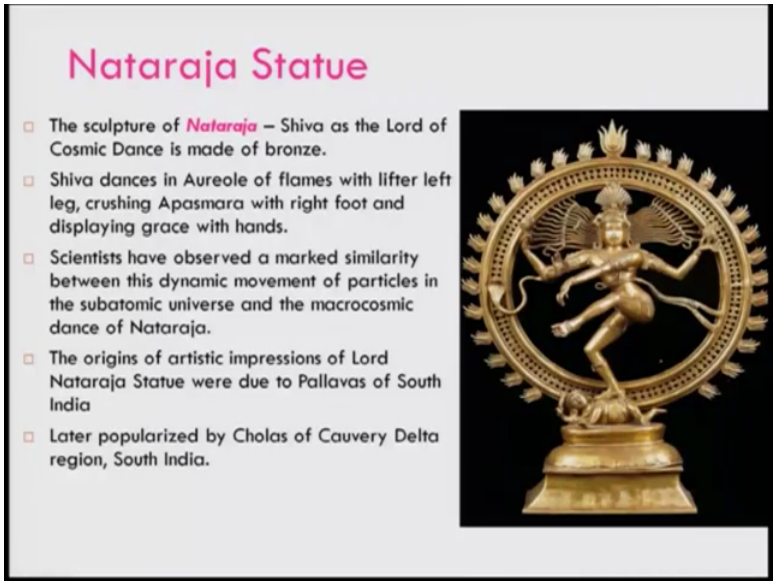

And beside this there is a book known as Tower of Physics by Freed Di' Capra. Who has mentioned about this dance in the from the scientific point of view, you can look at that. And if you look at this Natraj sculpture which was you know like being there and being worshipped in various temples. But the Chidambaram is the very important you know temple where in the city of Chidambaram and in Tamil Nadu. Which you can see it is quite intricate. And this figure shows that dance of Lord Shiva.

And this dance is not ordinary dance, it is considered to be the cosmic dance of Lord Shiva. And this statue is made of bronze and you can see that there is a aura parallel of the flames which are here. These are the flames with between the left leg and pressing the upper samara with the right foot and displaying the grace with hands. And this statue is really very intricate from the point of view manufacturing.

But lot of mythological things and also lot of science will also be involved in that. For example some of the scientists have observed a marked similarity between this dynamic moment of particles in the sub-atomic universe and the macro-cosmic dance of Natraj. I think some of us should look at this aspect and combine with the manufacturing and you know how it was a confluence of the art and science and also spirituality in it.

The origin of artist impression of Lord Natraj is due to the Pallavas of South-India as I have mentioned earlier. Of course later on it was being carried forwarded by the Cholas of Kaveri-delta region in South-India, also later on other Southern kings also took it ahead.

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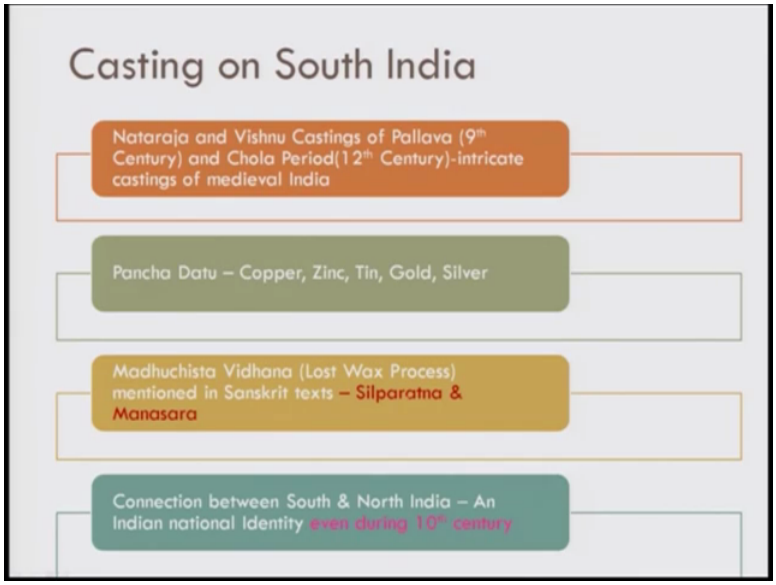

So let us look at like this casting in the South-India which is still going on in a very pockets of the South-India as a family business or as a family enterprise. But it is dwindling out. But the Natraj and Vishnu casting of Pallava and the Cholas intricate casting you know was very much popular in medieval India. And this casting was basically also made out of Panch-Dhatu, it is a alloy of copper, zinc, tin, gold and silver. We call of course in English lost wax process but in Sanskrit it is the Madhi-chista Vidhan, Vidhan means method or process.

And as mentioned in Shilpratna and Manasara and later on of course this kind of things propagated to other parts of the country. It looks to me it has taken a cycle. That means from the Indus valley civilization it might have come to the south side. After that it has gone also from the south to the north. So it might be you know these things. It clearly indicates that this method of casting that is the lost wax casting is an Indian nationality identity particularly during 10th century.

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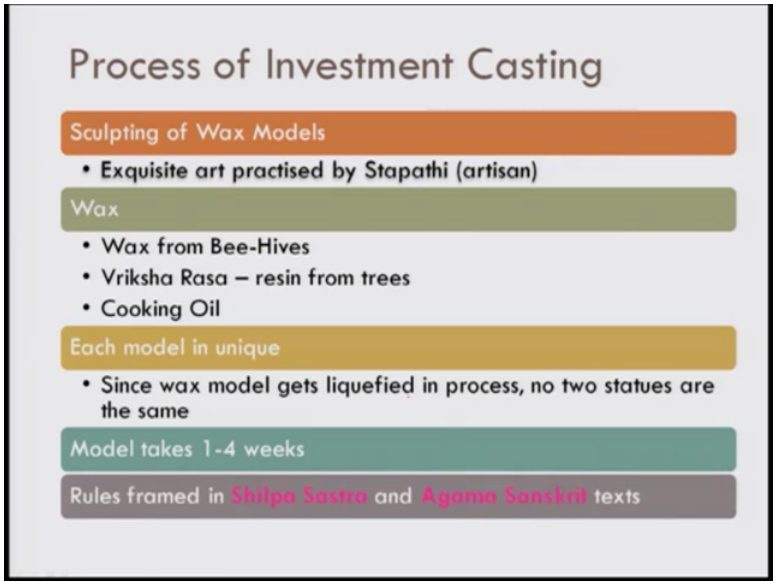

Let us look at the processes involved in the investment casting. Of course the is one has to make use this wax model. Right? And it has to be sculpted. Sculpted means very intricate part has to be done and it can be done by an artist or what is being known Tapati. They should have a go hand, good mind to do that intricate phase in the model itself which is a very you know easy to manage, easy to place the shapes.

And then this waxes are being generally used form the beehives or Vriksha-Rasa, a resin from the tree or the cooking oil also people do use or a combination of all three. And that it clearly indicate it is organic in nature. And each model is unique because it will be done by artist and not by a machine. Therefore each statue will be different and it will be having different also the expression. And wax model gets liquified in the process as I old no two state are the same.

And this is a very very pain-staking job and it takes lot of time. This model takes around 1 to 4weeks. And once make this model and then you will have to make this moulds and then you will have to pour the metal and allow it to cool. And it takes times. And rules framed in Shilpashastra and Agamashastra texts are being followed very strictly for manufacturing this.

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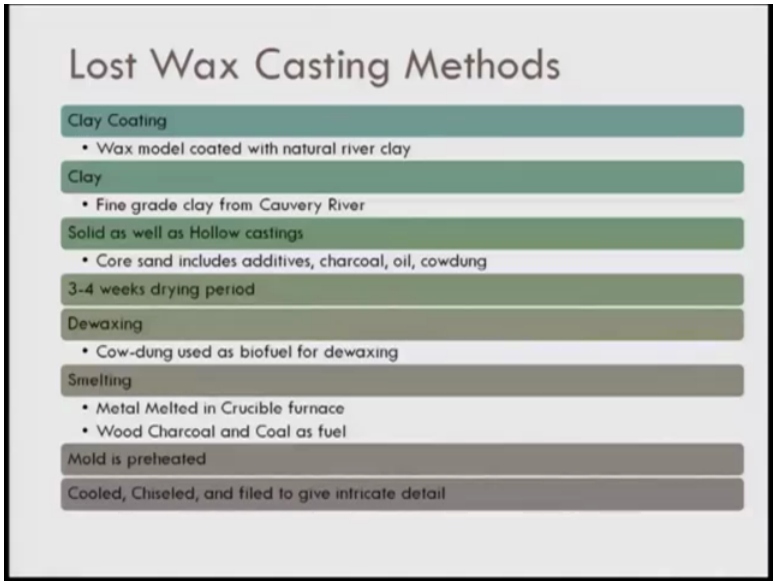

Let me let you little elaborately like as I told that that model is being made. But after that this wax model is to be coated with natural river clay or maybe some kind of what you call layer has to be placed so that the metal will not come in contact with that. And then fine grades clay from the Kaveri River is being used in Southern India but in other parts other materials can be used. And coarse sand includes additives, charcoal, oil and cow dungs, like some of the things you can mix and do that. It takes again 3 to 4 weeks for drying period so that it will be to know ensure that everything is fine.

And then de-waxing is done for that cow-dung is being used as a fuel for de-waxing. And once the de-waxing is done then you will have to melt the metal in a crucible furnace suing the wood charcoal or the sometimes coal as a fuel. Nowadays of course people are using gaseous fuel energy. And this mould has to be pre-heated before you pour this melted metal. And then subsequently it will be cooled and after that solidification is occurring in a natural way. And once you get that you will have to break this mould and then chisel it, file it and also polish it to get the intricacy. But one has to be careful that intricate shape should not be you know spoiled in the process of filing and then also the, also the polishing.

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Processes involved in Lost Wax Casting

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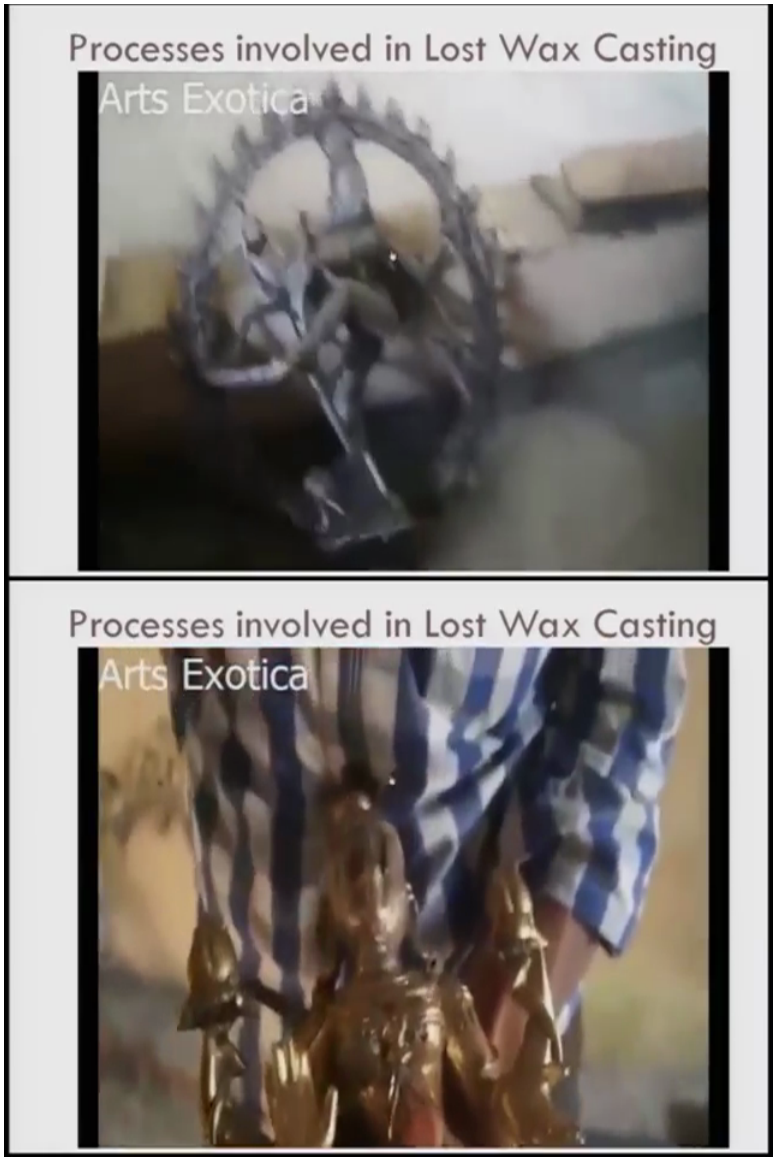

So let me just show you a video which is I have taken from the internet. Look at this is the wax which is then mixed with the material and then you will have to make this kind of a shape and then intricate wax being formed. And if you look at this is the statue of Lord Lord Vishnu which he can prepare and he can make a model like that which is being shown here with all intricate shapes and lot of things has to be done. And he is rolling his wax into some form and look at that how he is using the hand and also the little small tool to make the hand.

Means the fingers of the hands so nicely you know, with a mudra, postures. Then you will join with that and then of course lot of work has to be done on this. And this is the artistic work one has to. Then he has toe the mould being prepared out of this. And it has being dried. And being placed properly. And some layer will be given. And it is placed on this portion. And then of course that is another this is a Natraj statue what is coming up. And it has being fired that this wax being drained out of this because of pre-heating and then the space been

created for the melted metal to go in and you got the statue which is a Lord Shiva and Natraj which is quite complicated.

You know out of just one casting he could manage to do, of course you can come off course this is another statue which he is showing. You can see that process. It looks to be very simple but it is very intricate, complex and time-consuming, requires lot of patience.

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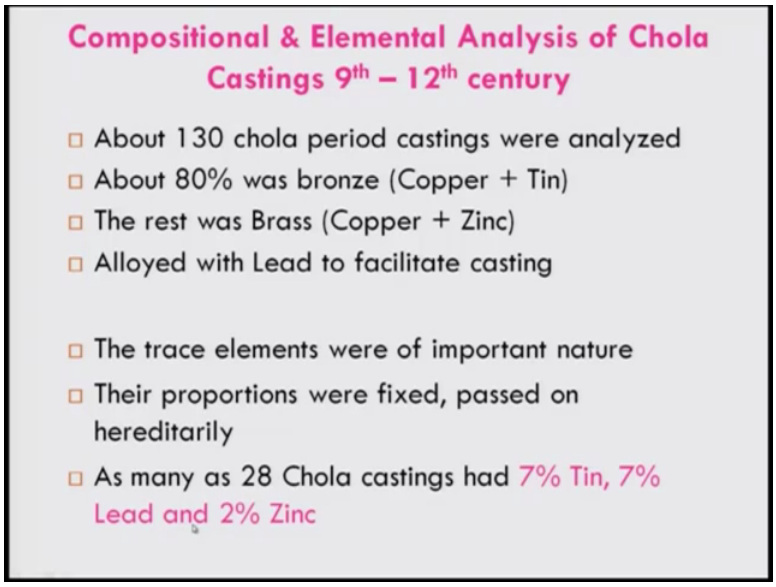

So lot of research work has been done, but I will show you some of them. That is compositional element analysis of Chola casting. And about 130 Chola casting were analysed. And out of which 80percent are bronze that is made of copper and tin, rest are brass, copper and zinc. And of course they are alloyed with lead to facilitate casting. People have used. And their proportions are fixed, passed from one generation to another generation. And this is kept as a secret. This technology is kept as a secret so also the you know the material composition. And as many as 28 Chola castings had 7 percent tin, 7 percent lead and 2 percent zinc of course rest will be carbon.

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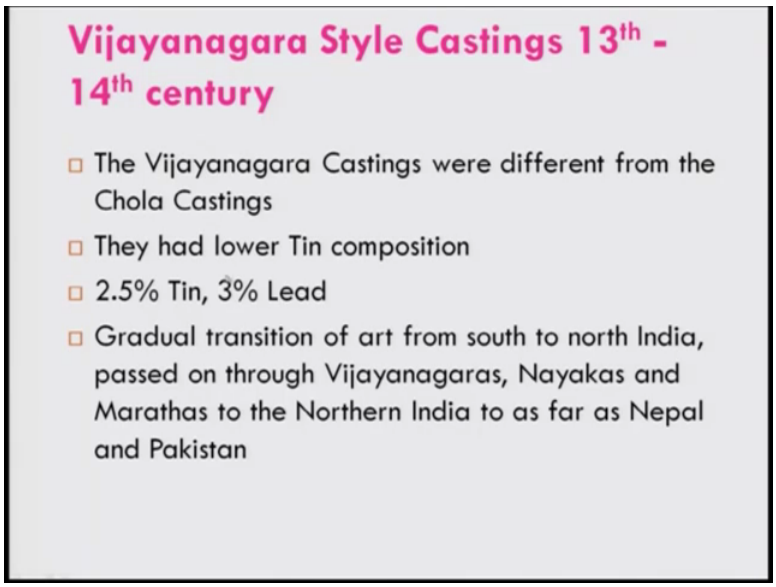

And this technology was also being flourished during the Vijaynagar dynasty 13 to 14th century. And they had lower tin composition 2.5 percent tin and 3 percent lead. And this gradually transition of this method of producing statue took place from South, North India passing through the Vijaynagr, Nayakas, Marathas to Northern India to as far as Nepal and Pakistan. So I told earlier it has taken a one circle according to the present interpretation.

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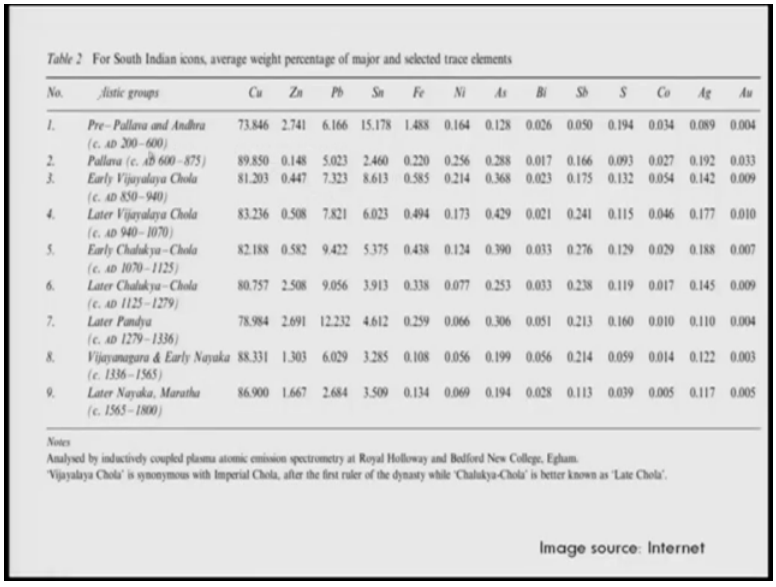

Table 2 For South Indian icons, average weight percentage of major and selected trace elements

No.	Alistic groups	Cu	Zn	Pb	Sn	Fe	Ni	As	Bi	Sb	S	Co	Ag	Au
1.	*Pre–Pallava and Andhra (c. AD 200–600)*	73.846	2.741	6.166	15.178	1.488	0.164	0.128	0.026	0.050	0.194	0.034	0.089	0.004
2.	*Pallava (c. AD 600–875)*	89.850	0.148	5.023	2.460	0.220	0.256	0.288	0.017	0.166	0.093	0.027	0.192	0.033
3.	*Early Vijayalaya Chola (c. AD 850–940)*	81.203	0.447	7.323	8.613	0.585	0.214	0.368	0.023	0.175	0.132	0.054	0.142	0.009
4.	*Later Vijayalaya Chola (c. AD 940–1070)*	83.236	0.508	7.821	6.023	0.494	0.173	0.429	0.021	0.241	0.115	0.046	0.177	0.010
5.	*Early Chalukya–Chola (c. AD 1070–1125)*	82.188	0.582	9.422	5.375	0.438	0.124	0.390	0.033	0.276	0.129	0.029	0.188	0.007
6.	*Later Chalukya–Chola (c. AD 1125–1279)*	80.757	2.508	9.056	3.913	0.338	0.077	0.253	0.033	0.238	0.119	0.017	0.145	0.009
7.	*Later Pandya (c. AD 1279–1336)*	78.984	2.691	12.232	4.612	0.259	0.066	0.306	0.051	0.213	0.160	0.010	0.110	0.004
8.	*Vijayanagara & Early Nayaka (c. 1336–1565)*	88.331	1.303	6.029	3.285	0.108	0.056	0.199	0.056	0.214	0.059	0.014	0.122	0.003
9.	*Later Nayaka, Maratha (c. 1565–1800)*	86.900	1.667	2.684	3.509	0.134	0.069	0.194	0.028	0.113	0.039	0.005	0.117	0.005

Notes
Analysed by inductively coupled plasma atomic emission spectrometry at Royal Holloway and Bedford New College, Egham.
'Vijayalaya Chola' is synonymous with Imperial Chola, after the first ruler of the dynasty while 'Chalukya-Chola' is better known as 'Late Chola'.

Image source: Internet

And let me show you the compositions from the pre-Pallava time which is something 200 CE to the 1800. You know till this Mughal till the British people, even till the Maratha periods it was continuing, if you look at copper was the major one. Also the zinc percentage varies from dynasty to dynasty. And of course lead will be there, which is for easing the cast or

facilitating the casting process. Rest of things of course sometimes tin is also there, right, depending on the what they need. And others are constituents which are may be part of the impurities of the metal. What they will be getting or ores they will be getting.

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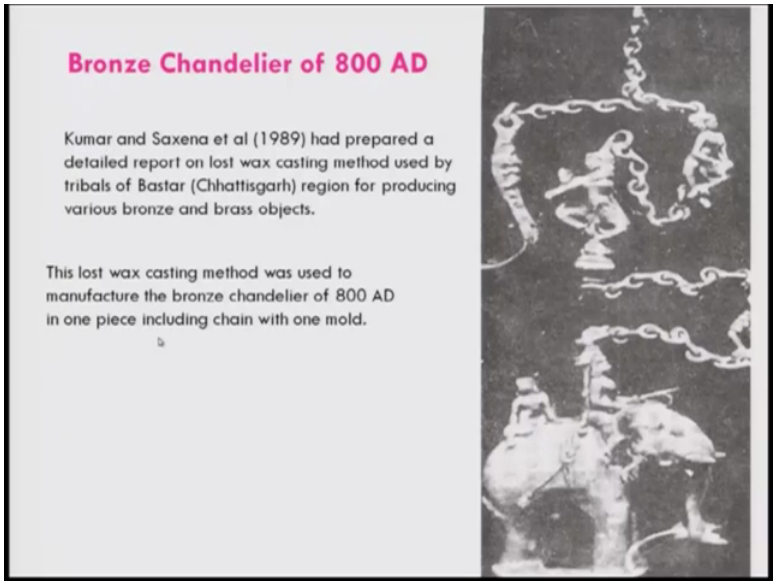

Let me talk about bronze chandelier of 800Ad. If you look at like the Kumar and Saxena et al had prepared a detailed report of lost wax casting method used by trials of Baxter, Chattisgarh region by producing various bronze and brass objects. If you look at like the technology basically were with the people who were being neglected by us. Like low-income group people, tribal people and those technologies are still continuing. And with the modern education I think it is just going out. Nobody is interested to take, keep that technology with us which is indigenous.

Let me show you this bronze chandelier, which is quite complex. There is an elephant, two person are sitting, these chains are there and there is a dancers and then you know if you look at it has been claimed that this this chandelier was made by the lost wax casting around something 800AD in one piece, including the chain with one mould. How it was possible? It is a really mind boggling proposition to say this. Even in today it is not possible to do that.

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And we need to do more research and how it can be? And if it has been done really great thing. So there is a claim by some of the researchers that Indian metallurgy science and investment casting was transferred to Europe through the Portuguese explorer around 1400 CE. But I am having little doubt about these things. But however, you can explore it, do not take it as it is. We need to have more evidence for that. Why they are saying? They are saying that the head of the Papal foundry in Rome around 1400 a CE, his name is Vannocio Biringuccio.

He has been quoted as saying that "the art of casting is closely related to sculpture". Of course he has told lot of other things. "It is highly esteemed, it is a profitable and skilful art and in large part delightful". So this is the ethos were what Indians were having. Maybe one can say that ways, but more conclusive evidence are required to talk about.

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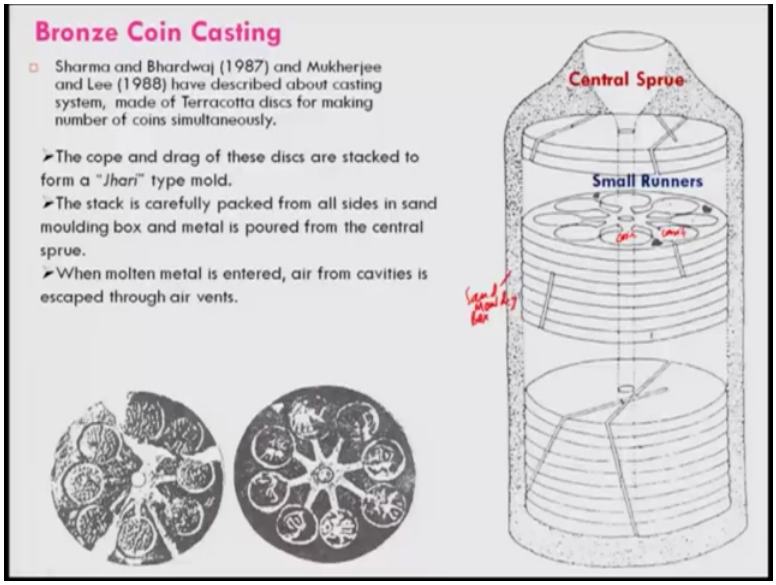

Let me discuss about another very interesting casting methodology which was being evolved in our country particularly for making Bronze coins of several quantity at that time. For that Sharma and Bhardwaj and later on Mukherjee and Lee have described about this casting system made of terracotta discs for making number of coins simultaneously. It is like a mass production of coin.

Let me just show you that this is the you know mould assembly what is having. And if you look at these are the coins mould what is there. It is having both what you call this is having a central sprue here. The metal will be poured in this and it will be coming to that everywhere. And these are the small runners which are there to all these discs will be going. So if you look at this, looks like a 1,2,3, 4, 5, 6, 7, 8, 8 you can get in 1 this thing in 1 plate itself.

This having a cope and drag if you look at two of them, this disc are stacked to form a Jhari type mould, there is a mould, this is one on top and other is on bottom this stack. The stack is carefully packed from all sides. There are several kinds of stack will be there. Right? It is packed form all the sides in a sand moulding bar. This is your sand moulding bars. And the metal is poured as I told earlier through the central sprue. And molten metal is entered into this places through the runners.

When it will be entering it is important that some what you call cavities, you know some air vents will be provided such that air from the cavity, these are the cavities. Right? right cavities, will be going out so that you will get a very good coin without much you know problem in that.

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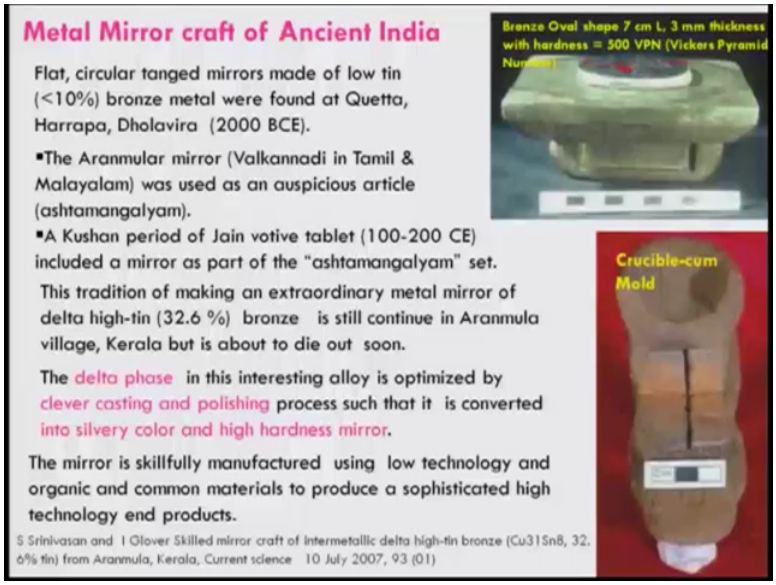

So let me talk about another very interesting thing which I got I mean yesterday only. That is the Metal mirror craft of Ancient India. The evidence says that the flat circular tanked mirror made of low in tin around 10 percent, bronze metal were found in Quetta, Harappan region and Dholavira around 2000 BC. And this work basically what I am saying I have taken from Sharadha Srinivasan and I. Grover, and article which was Current Science. I have given reference here, you can see. It is quite a complex this thing.

And the today it is being what you call being fabricated in Kerala in a village known as Aranmular. And this is very famous known as Aranmullar Mirror. And which is in Tamil and then in Malaya known as Valakanadi. And was used in earlier days as an auspicious article during the Asta Mangalayan, this is known as even the Asta Mangalayan or Asta Mangalam is even used not only in the South even in the eastern side. And this tradition is, was continuing from the around 100 to 200 CE as we have got a something from chain motile tablets which was in the Kushan period. And it included a mirror as part of Astamangalam set.

So this mirror, metal mirror basically was used as a part of our culture. And interestingly the tradition of making this external metal mirror of delta high tin, around something 32.6 bronze, still continue in Aranmular village in Kerala. But it is about to die out soon, because people are not interested in doing that.

And it is so interesting and also so good that one should think of why one should not continue it. And this I have shown you a oval-shape bronze mirror of 7cm long. This is your around 7cm and thickness is 3mm and it is having hardness of 500vpn which is Vicker's pyramid number and which is much higher than the steel. And of course it has been described how

they made it and which I will not be discussing due to the paucity of time. And they have used basically crucible cum mould. The mould will be here and this is the upper portion is crucible. They will be melting it here and pouring it and doing that.

And interestingly what they have done that the cooing is also done by the clay cooling which is a fast cooling they will have to do an inverted this thing after casting it so that that whatever you know maintain temperature will be maintained around something 540 to 350. So that this delta phase of this interesting alloy will be maintained. And during the polishing process the hardness also increases. So the delta phase as I told earlier that in this interesting alloy is optimized by clever casting and polishing process such that it is converted into silvery colour and high hardness mirror.

Of course the temperature, the melting temperature is around something 750 degree C. But however they will have to maintain this temperature and you will be mixed so that you will get hardness. So if you look at the mirror is you know skilfully manufactured using low technology and organic and common materials whichever will be there to produce a sophisticated high technology end products. And that was a tradition which is going on from 2000 BC till today but it is about to die.

Now it is not only with this metal mirror but it is with a lot of products because when I was a kid like you and I had seen in villages lot of small scale industries were going on or we call you know entrepreneurs who were doing this metal casting across the country. But today you will not find them they have gone with the time. And as a result they are coming to becoming labourer in some other places instead of becoming entrepreneur. So let me just tell you that we need to revive this technology and also improve it such that this product can be made and it has to be also can be documented properly and more research is required. Thank you very much for listening to this lecture. And in the next lecture we will be talking about glass making in ancient India. Thank you.