Introduction to Ancient Indian Technology.
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Lecture-40.

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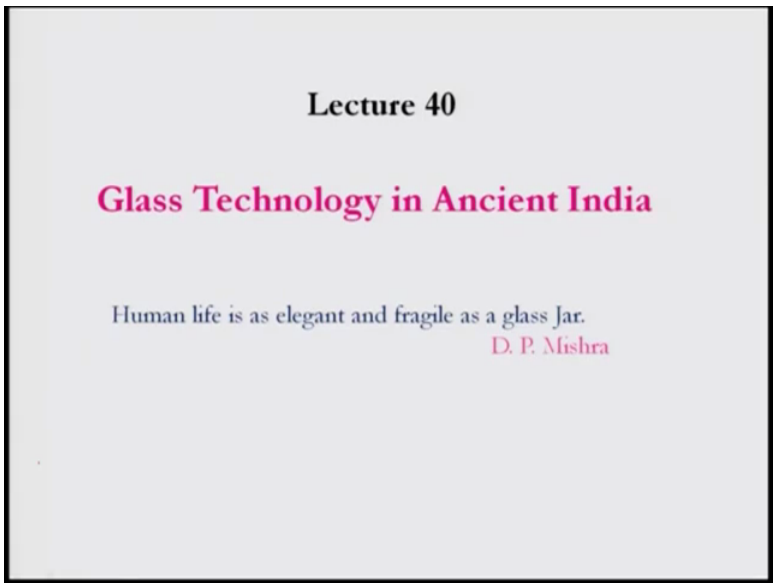

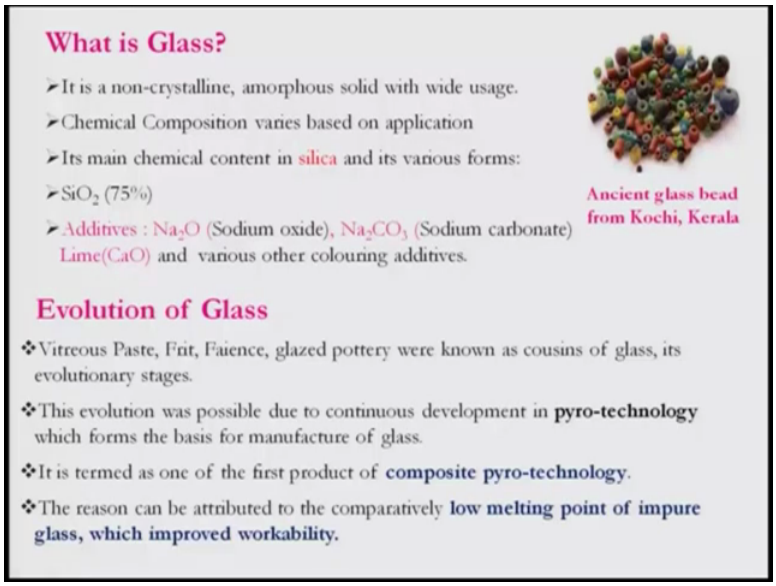

Let us start this lecture with a thought process, human life is as elegant and fragile as a glass jar. And today we will be discussing about glass technology in ancient India. A question might be coming to your mind, what is glass. A glass is basically a non-crystalline amorphous solid with wide usage. And chemical composition of glass, varies, you know from place to place and also it depends on applications.

The main constituent of glass is basically silica and of course it is having various forms. The glass generally contains around 75 percent silica and then rest of the additives like sodium

oxide, sodium carbonate, lime and various other colouring you know additives are being used for making glass. And these I have shown some of the ancient glass beads from Kochi in Kerala and we will be talking about little bit historical aspects later on.

Let us see that how this glass was evolved, the vitreous paste, the frit, faience, glazed pottery were known as the cousin of glass and its evolutionary stages. And of course it was being you know evolved due to the continuous development in pyro technology which form the basis for the manufacturing of glass. And later on of course composite pyro technology was used.

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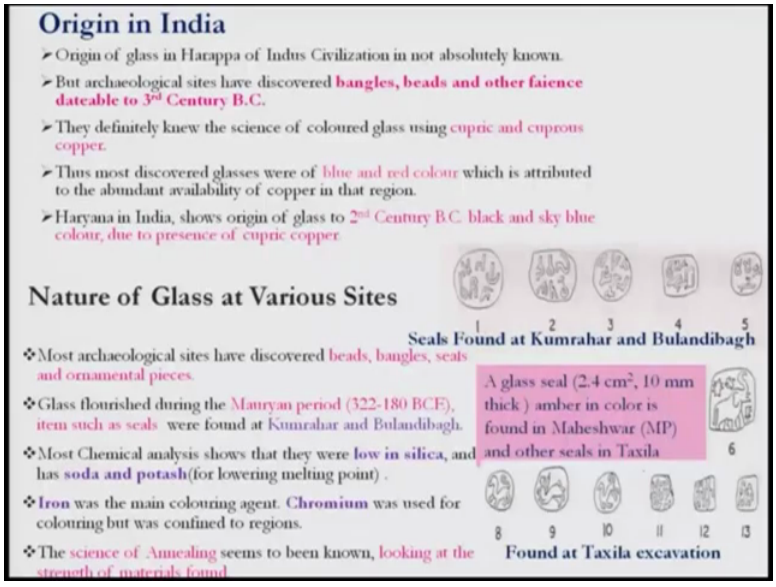

This pyro technology can handle the low melting point in pure glass. U As a result the workability of the glass can be improved. Let us look at how and when glass was originated in India. in Harappan side you will not real find any glass objects as being claimed by researchers. However later on around 300 BC, in some archaeological sites people have found bangles, beads and other faience items. From this evidence one can conclude that the science of coloured glass using cupric and cuprous oxide were known to Indians, at least around 300 BC.

And most discovered glasses were of blue and red colour which might be due to abundant availability of copper in this region. In Haryana around 200 BC, some of the glasses made of black and sky blue colour were being obtained in the excavation sites which may be due to the presence of cupric copper and nature of glass at various sites. When you look at, most of the archaeological sites have discovered beads, bangles, seals and ornamental pieces. Of course nowadays the glass is very cheap and we use for various other applications, optics you

know like, your laser glass, and then several places. But at that time it was considered to be very previous and they were used as ornaments, and glass flourished during the Mauryan period because the people have found out several seals from Kumrahar and Bulandibagh areas.

And these are the seals which were obtained you know from these two sites, and these are all Bhrami 'lipis' are being mentioned they were using it as a seal. And most chemical analysis show that they are low in silica and has soda and potash maybe for lowering the melting point of the glass. And iron was being used for, as a colouring agent, because iron was there, eastern part of the country and even other parts of the country also and chromium was used for colouring but it was confined to certain regions. If you look at here I am showing you a glass seal of 24 cm square and 10 mm thick which was obtained in Maheswar MP and other seals in MP, this one, and which is having a colour of amber.

And there is several seals were obtained in Taxila during excavation, there are several seals of different you know motifs are there and from this one can conclude that the science of annealing was known to the ancient glass making people, because the strength of this glass was quite good which cannot be possible without annealing it.

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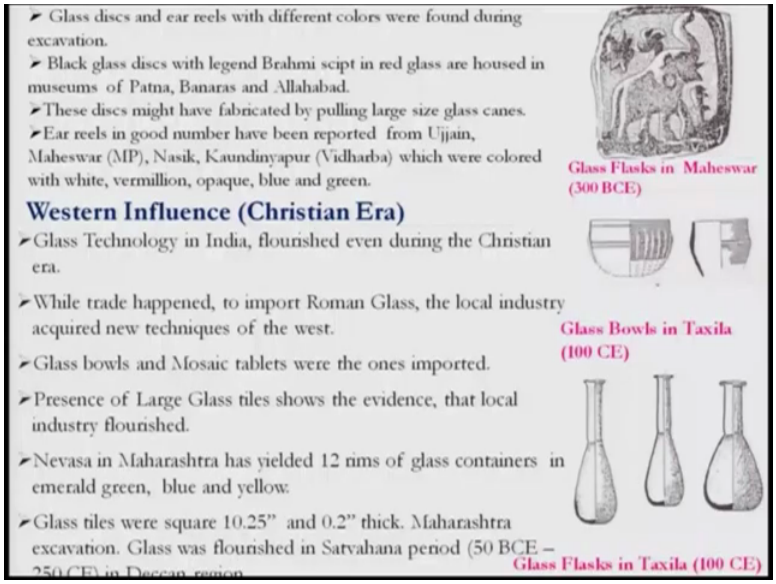

That is a seal, glass seal which was obtained in Maheswar in 300 BC. The glass disks and ear reel with different colour were found during the excavation and black glass disk with legend Bhrami script in red glass were housed in the museums of Patna Banaras and Allahabad region. One can get it. I must tell you that lot of this, excavated items are being preserved in

various museums across the country, one can visits and find it out and also do research on that. And this disk might be fabricated by pulling large size glass scales what people have anticipated.

The ear reels in good numbers are being reported from Ujjain, Maheswar in MP, Nasik, Kaundinyapur in Vidarbha region which are coloured with white, Vermilion, opaque, and blue and green colour. That means they were using a lot of colouring agent for that or maybe some impurities are there. And of course this is still the Common Era, what was earlier known Christian era.

And people are claiming that western, particularly western people, particularly from Rome, they influenced the glass technology in India because of, there was a trade between the Rome and India at that time. And the local industry might have acquired some new technology of glass making from the west, particularly the glass bowls and mosaic tablets were imported as claimed by some of the researchers. But more research has to be done to, you know prove it, because reason given by the researchers is not that sound. And presence of glass tiles was evident that local industry was flourish at that time.

And particularly let me just show you the glass bowl in Taxila, which has been shown here and these were made in Taxila by the foreign technology as claimed by some researchers but I feel that more research should be done to prove that. And Nevasa in Maharashtra yielded 12 rim glass contained in emerald green and blue and yellow colours and the glass tiles of square, you know 10.25 inch and 0.2 thickness was obtained in Maharastrian excavation.

And glass was also flourished in Satvahana period around something 50 BC to 250 C in Deccan region. It is not that only the Taxila and other Indus valley area, civilisation area, Harappan site, but also the other parts like southern part also having evidence of glass items. So this glass flask was obtained from Taxila which dates back to around 100 C.

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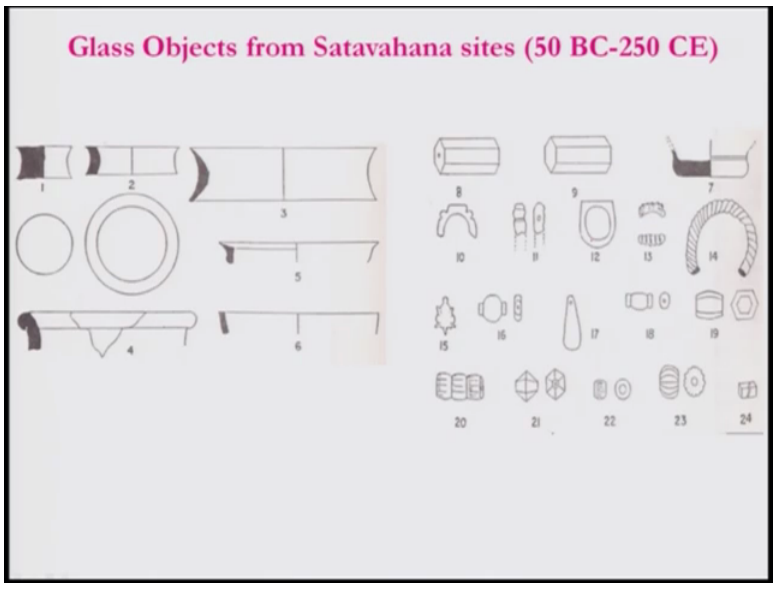

So there are several as you call glass objects were obtained from the Satvahana sites. These are the objects basically top view is shown here and here, these are the utensils and these are various items which are shown starting from the bead to the various intricate complicated shapes you know, sizes being obtained.

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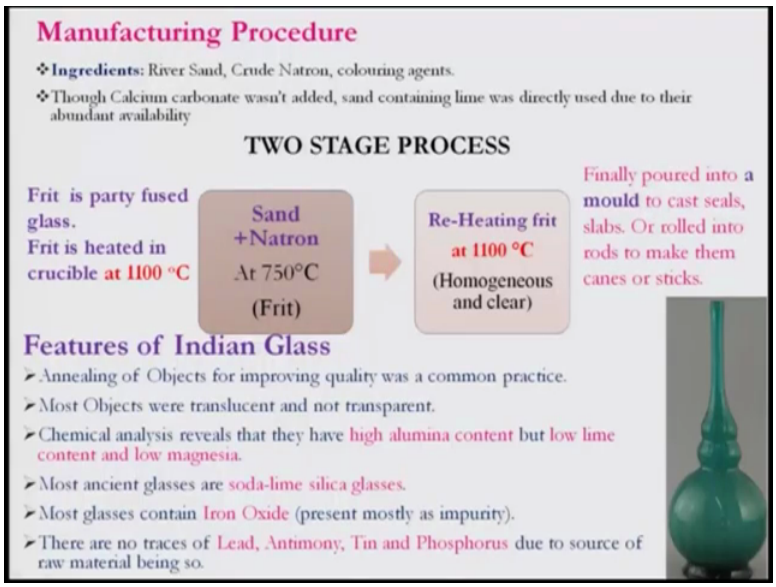

So let us look at how glass was manufactured, of course the ingredients were generally used the river sands, or crude Natrons and colouring agents. These are the three ingredients which are important. Though the calcium carbonate was added but sand containing lime was directly used due to their abundant availability. Let us look at the two stage process which is

being talked about. First of course is the sand and natron were being heated to the temperature of 750 degree Celsius which you called the frit.

Frit is partly fused glass and then subsequently it is heated in a crucible around 1100 degree Celsius so that you know it will be homogenous and become clear. Finally poured into a mould to the cast seals or slabs or any other things what you can think of, or it can be rolled into rods to make them canes or sticks. And if you look at the same casting process is being used, what you know, we have discussed during the metal casting process. The features of Indian glass if you look at, the annealing of the glass objects were carried out to improve the quality and most of the objects were translucent not transparent.

Of course later on the transparent glass was made in country. But in earlier days, it was not, and chemical analysis reveal that it was they have high aluminium content but low lime content and low magnesium. And most ancient glasses are soda lime silica glasses, as I told that melting point will be very low and even today also people are using these glass for making beads and other things in the UP and some other places also. And most glasses contain iron oxide because it was profusely being across the country and it is as a part of impurity people might be adding to colour the glass. There are no traces of lead, antimony, tin and prosperous due to the source of raw material being you know.

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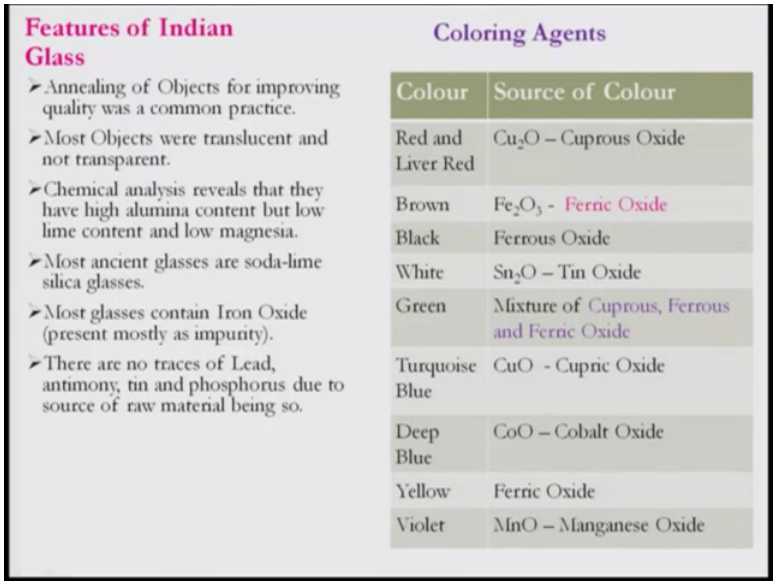

Let us look at some of the colouring agents like cupreous oxide is used for the red and liver red, and ferric oxide is brown and ferrous oxide being from black and tin oxide for white colour and of course for green, mixture of cupreous, Ferrous and ferric oxide being used and

for turquoise blue is cupric oxide being used and cobalt oxide is used for deep blue and ferric oxide for yellow, magnesium oxide for violet. So these are the colouring agents what you know, ancient, what, were being used in ancient time for making glass.

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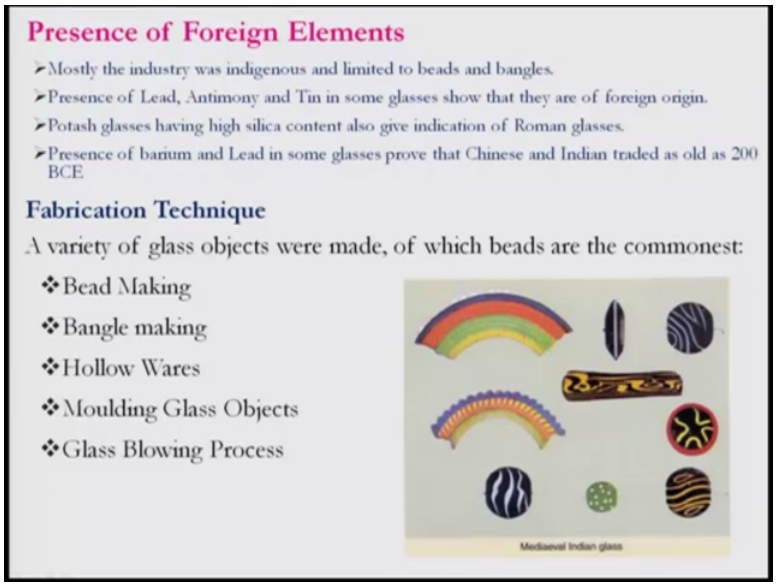

Actually the foreign technology has come some of the people are talking about it, but mostly the industry as indigenous limited to beads and bangles. That is indigenous technology of glass making was limited to the beads and bangles, as claimed by some researchers and if they find that lead antimony and tin in some of the glasses they always say that this is of foreign origin.

But I do not, I really could not say why, because lead was here in this country, tin was also there, so why they will say that it is of foreign origin is a questionable thing. And potash glasses having high silica content also give an indication of Roman glass and potash is being used in our iron, the rustless iron pillar I had discussed. So why these people are saying that one has to also do research and find out. Because of these two reasons, they are saying these glasses are from the western countries.

And of course you can find presence of barium and lead in some glasses prove that Chinese Indian traded as old as 200 BC. Again if you look at that way, I do not know what they are interpreting. This is the logic which is given by researcher, which I do not think is right, maybe right I do not know, but more research is required to you know remove these doubts from the minds of the people.

So variety of glass objects were made in ancient times and some of these objects are you know being mentioned here, like bead making, and even till we are making the not only the beads but bangles and hollow wares, and moulding glass objects and glass blowing process. So some of the things, medieval indian glasses shown here, it is of various, very colourful and lot of items you know, how they are making this art, it is basically an art. It is very, looking you know very complicated and also gorgeous and colourful.

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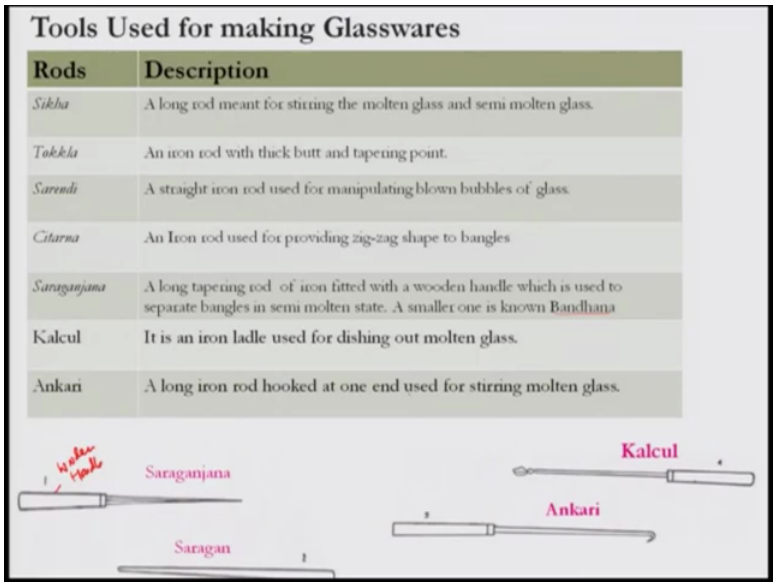

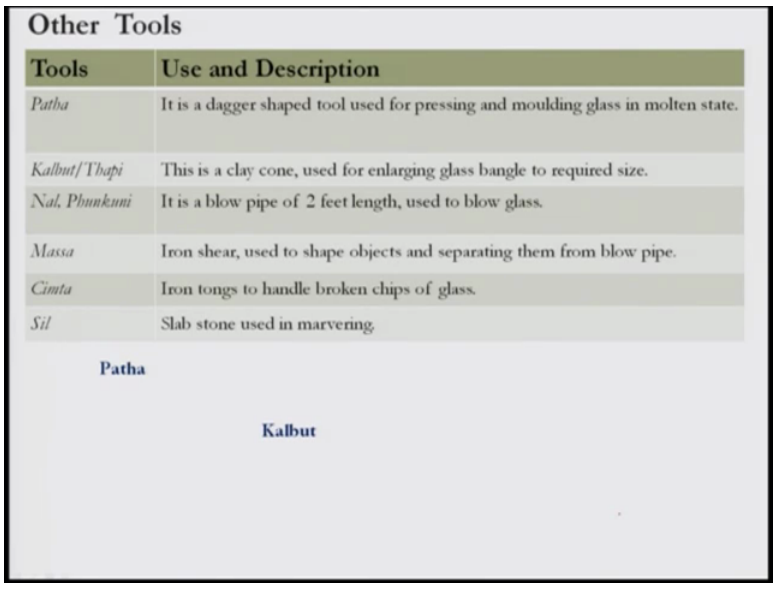

So various tools were being used for making glass wares in ancient India, some of them I am just you know discussing here. One is Sihka, sikha is basically long rod meant for stirring the molten glass and semi molten glass. And tokkla, tokkla is iron rod with a thick butt and tapered point and if you look at the Sarrendi, a straight iron rode used for manipulating blown

bubbles of glass. And Citarna, an iron rod used for providing zig zag shape to the bangles because for making bangles you have to give that shape.

And Sarangajana, which have shown a figure here, a long tapering rod of iron fitted with wooden handle, this is your wooden handle which is used to separate bangles in semi molten state and of course the smaller one is known as bandhana. The Kalcul, it is an iron ladle used for dishing out molten glass. This is the Kalcul. Ankari is a long iron rod hooked at one end used for stirring the molten glass. And let us look at the patha, it is a dagger shaped used for pressing and moulding glass in the molten state and this similar thing is also being used for concrete work.

And the Kalbut or Thapi, is a clay cone used for enlarging the glass bangles to require size, it will be rotated, I will be showing some of these things to you in a video. Nal of course what we call Phunkuni is basically a pipe through which you will be blowing the glass and Massa, iron seer used to shape the objects and separating from the blow, like this is a Massa it is basically a tong in English you can call. And Cimta some people call it Simta, it is an iron tong to handle broken chips of glass and Sil the slab stone used for marvering it.

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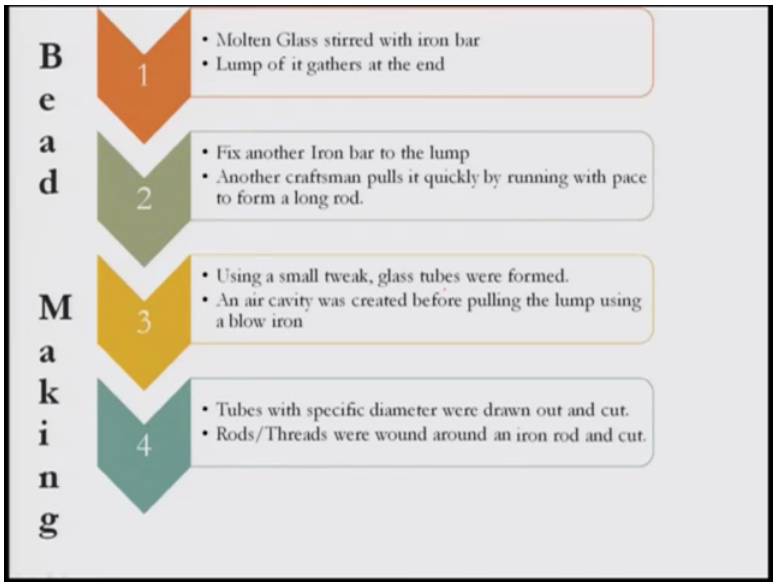

So let us look at bead making, what is being done during the bead making is that, first the molten glass will have to be stirred with an iron bar as I told. Lump of this glass gathers at one end and once is done, then fix another iron bar on the lump and maybe another craftsman will be pulling this quickly and running with a pace. That means he will be travelling towards that with pace to from a long rod, see rod is being made like that, right. Suppose if you are

having some glass and then you move it, right and at a little speed so that glass can be made and using a small twig, glass tubes are formed and air cavity was created before pulling the lump using a blown iron that means you can make a tube.

Of course this is for making a, what you call hollow type, the glass tube we want to make by this. This may be used for bead making or may not be. But one can make by blowing the air through that. And tubes were specific diameter drawn out and cut and rods and threads were wound around an iron rod and cut. These are the process what is being done like basically to make this beads and then.

I will be showing you a video that how this bead can be made and it is again it has to be rotated. If you take this thing and you will make it rotate with an iron rod sticking to this glass right and one can rotate that thing so that it will be moving through and then one bead can be made.

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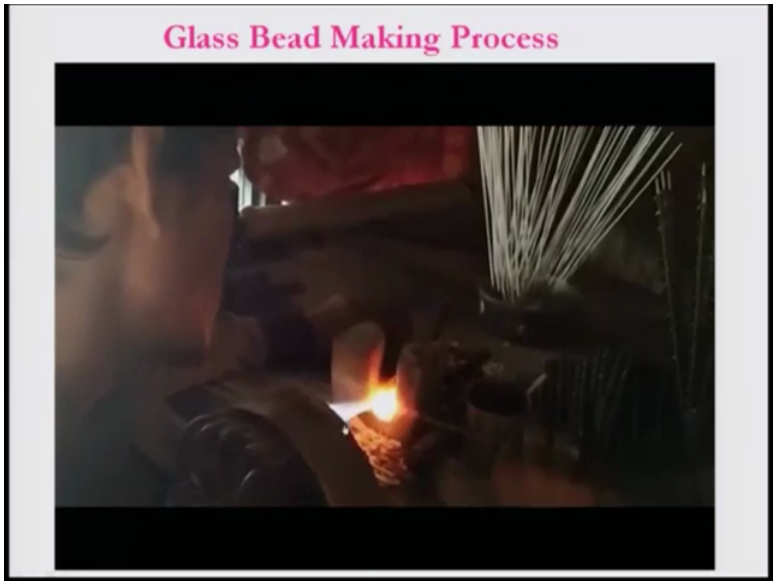

Glass Bead Making Process

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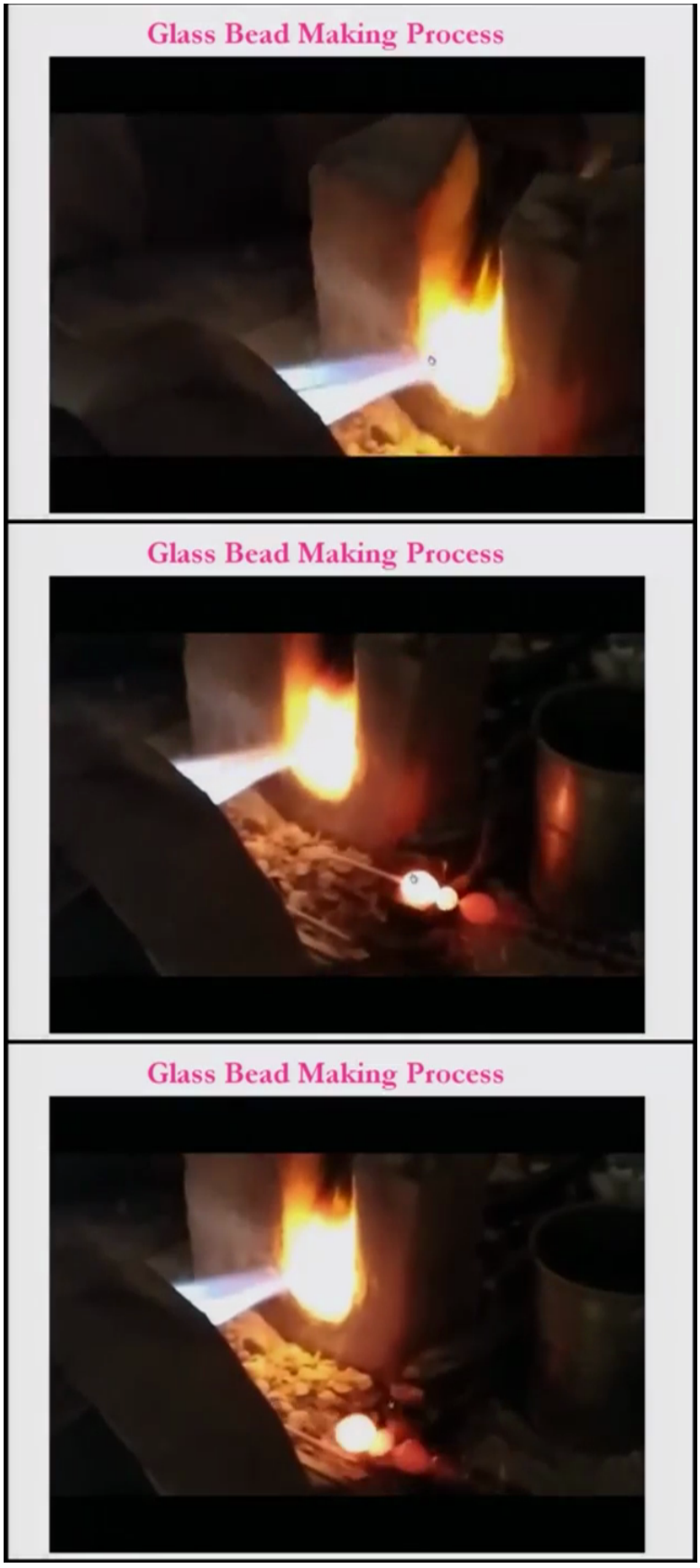

So let us see that how the glass bead is being made. So here it is what you call flame which is coming out of burning of liquid fuel nowadays people are using kerosene but earlier days

people were using the bio oil or vegetable oil and of course there is a way of blowing the air that you can get a blue flame. And blue flame is essential for making good uncontaminated bead. So if you look at what is this artist is doing, he is rotating the glass which is on the what you call in the iron rod.

This is your iron rod and as it is rotating its taking a bead shape and you can say it is basically something centrifuging effect will be there here and after that he will be suing this thing for a die to get some proper shape and size kind of things so this is the way how the glass bead is being made.

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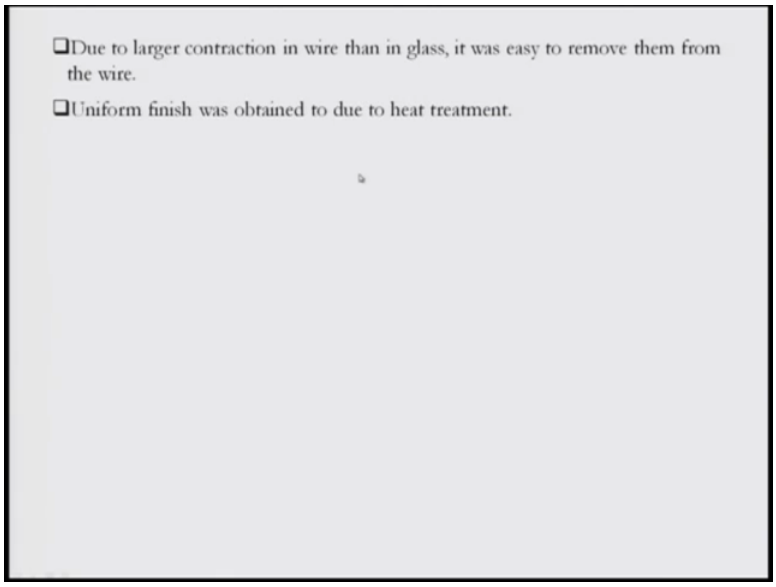

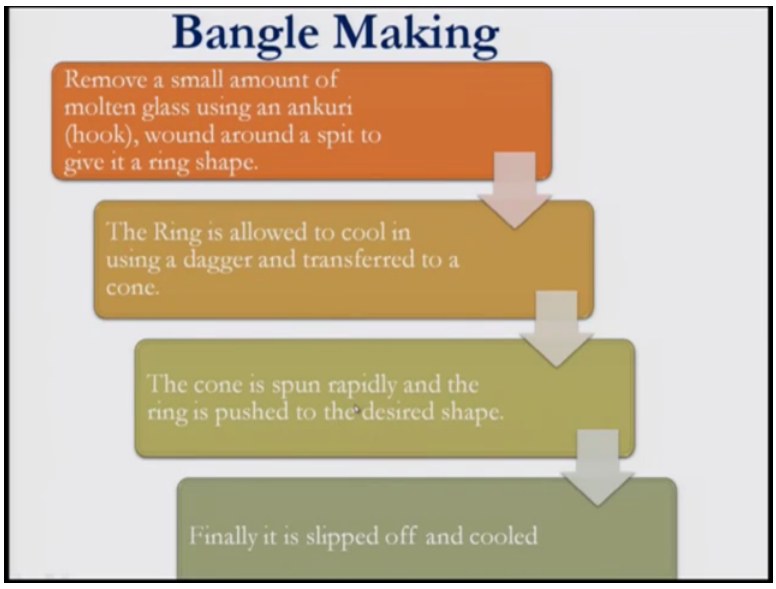

Due to larger contraction in the wire than in the glass it was easy to remove from the wire and uniform finishing can be obtained to due to heat treatment because some annealing can be

done about that. Let us now look at bangle making, what is being done here, one has to you know take out small about of molten glass using an Ankuri or a hook to wound around a spit to give it a ring shape.

Then this ring shape is allowed to cool using a dagger and transferred to a cone and the cone will be rotating. I will be showing a video to show that. As a result the centrifugal force will acting and then you know it will be enlarged and it will take a proper circular shape. The cone is spun rapidly and the ring is pushed to the desired shape finally it is slipped off and cooled, so this is a very simple technique, even people are using today. And this you can call it as a centrifugal casting or a semi centrifugal casting because RPM is not that much here.

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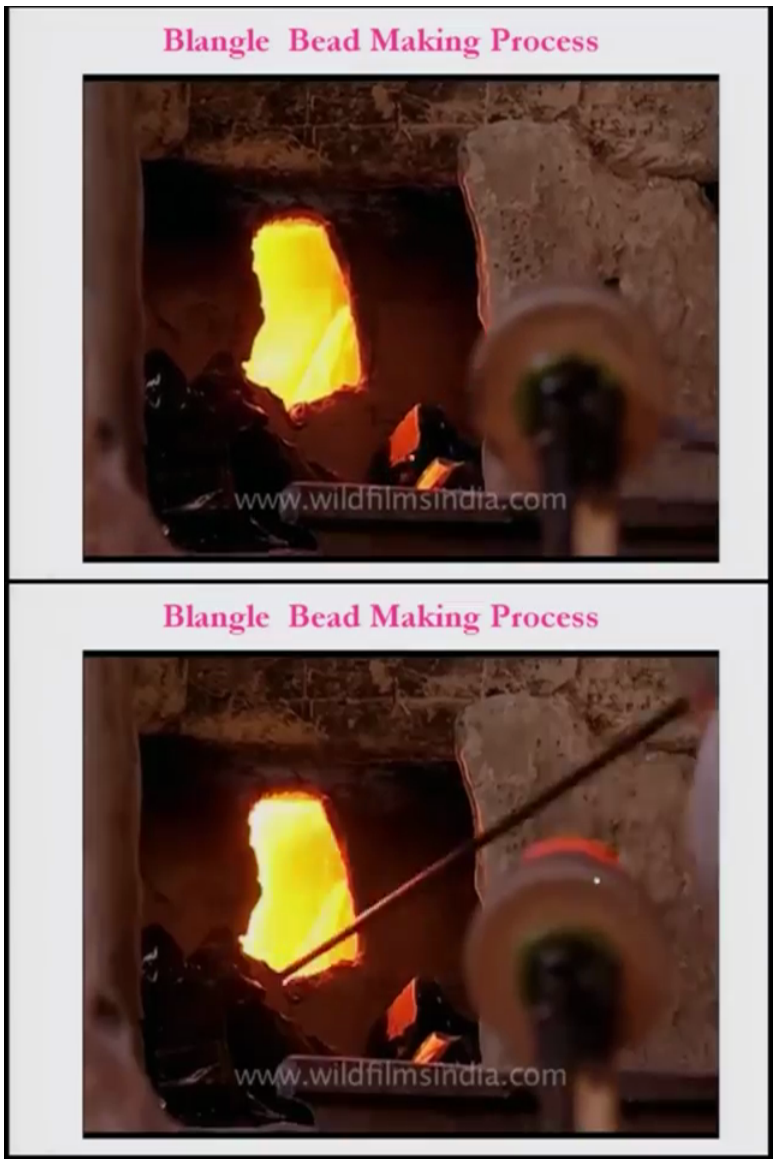

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So let us look at what is being done here. This is use kind of a molten glass is being taken and then it will put into round shape and it is putting into this rotating cone and then which is

enlarging again it is being taken and then to that. So this is the process by which what you call the bangle is being made. So look at this is the cone which is rotating at a certain RPM and depending upon RPM it will get into and it will end here. There is a stopper so that you know size can be managed with this stopper on this bangle which is rotating.

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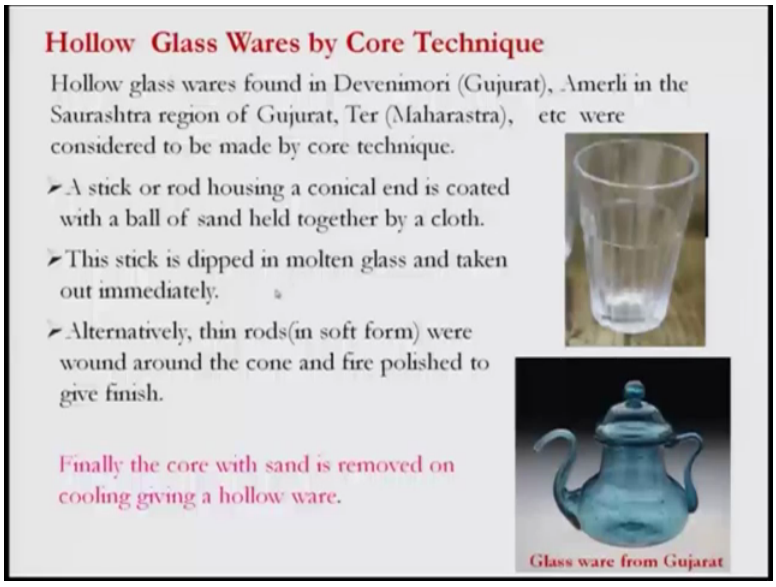

Let us see now that hallow glass wares being made by the core technique. And these are some of the glassware from Gujarat I have shown which is hallow and this is a glass which we use to used earlier days, nowadays we are using plastic tumbler. And hallow glasswares found in Devenimori in Gujarat, Amerli in Sauratsra region of Gujarat, Ter in Maharashtra and other places, which were considered to be you know manufactured by the core technique. What is being done here, a stick or a rod housing a conical end is coated with a ball of sand held together by a cloth. That means basically a cone was there and then what is being done, that some sand being placed with the help of a cloth and then, and this is your mould you can say, one kind of mould.

The stick is dipped into a molten glass and taken out immediately and then alternately thin rods in the soft forms were wound around this code and fire polished to give a finish. That means, basically you will have to go to you know then go on trying to melt the rest of the material out of the outer side and you will get a hollow glassware. Finally the core with the sand is removed on the cooling or giving to a hollow core because the sand is there, then you can remove the sand portion. Basically sand is used as in insulating material also for that you can have a mould and do that.

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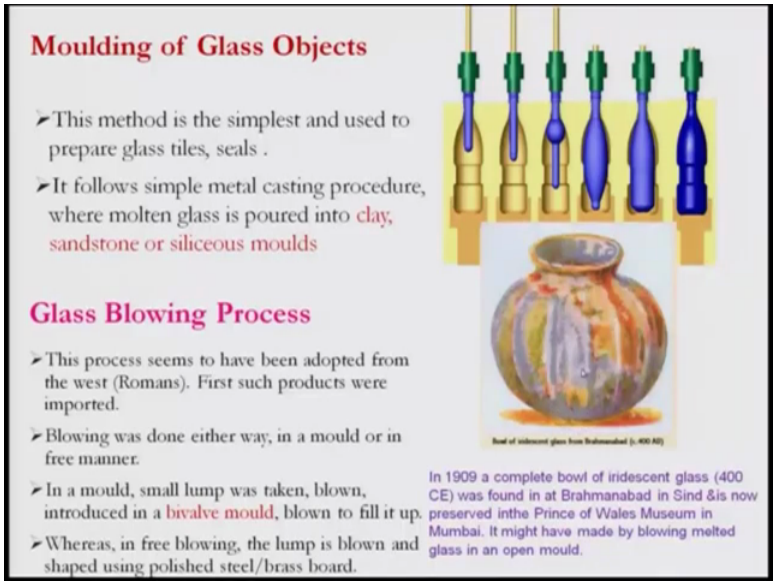

So this is a simple technique what was being devised earlier is being used and let us look at the Moulding of glass objects. This method is one of the simplest and used to prepare glass tiles and seals. And it follows the same metal casting procedure what we have discussed earlier. First of all the glass is to be melted and then it has to be poured into a clay sandstone or a siliceous moulds and then of course this I have shown here which is not of ancient origin but the present one which is there. The mould is here already and you will melt the glass and then pour it and it will slowly enter into this mould and take a shape.

And you allow it to cool so that you will get a glass object out of this. There is another technique that is glass blowing process. And in this process is considered to be imported from western country like particularly Rome and blowing was done either way, either in a mould or in a free manner. You can see even glass blowing section people do use like a glass, by the free manner and that is an art or you can use a pipe to blow that air in proper manner. In the mould a small lump was taken and blown introduced in a bi valve mould that in the two side right, we can separate it, blown to fill it up. Whereas in free blowing lump is blown and the shape using a polished steel or brass board so that you will get a proper shape kind of thing.

So let me show you that a bowl of glass from Bhramanabad which is something around 40 AD, was obtained in the Sindh site and is now preserved in the Prince of Wales museum because this was obtained in 1909 before independence. So and this glass, iridescent glass dates back to the 400 CE, and it has been anticipated that it might be made by the blowing melted method or the blowing process you know, in an open mould better. But how it was made it was really not been talked about it and then one has to find out.

And this is a pitcher which I guess it can be done maybe by what you call rotating the things so that you will get a good shape. So more research you need to be you know, carried out to find out how it was made in earlier times. Let me tell you what I have done in this. I have tried to take the ancient technologies which are related to the life for example agriculture, then water, and also the clothings like textiles we have discussed and we have also discussed about the housings and besides these metallurgical things.

And if you have looked it that, kind of technology which were discussed in this lecture, you can conclude and I have a feel that these technologies are quite simple and quite elegant in nature. And these technologies can be improved on and also can be used today without spoiling the Mother Nature, most of them are organic in nature. And they find they were using the local materials and also indigenously developing this technologies. And these a lot of scope were there for more innovation and as I told man is a creative and curious creature by nature.

So therefore it is essential for a person to be creative and then we can indulge in these kind of arts or the cottage industries, such that we will feel satisfied and happy about it. And also we can earn some money in the process and keep the tradition. So therefore my suggestion to all of you who are taking this course is that this is a very important thing and we need to keep these indigenous technology alive and also as a part of our heritage we will, we will take responsibility for its propagation and do that.

Because we are facing the problem of cultural invasion, what these Britishers and then Muslim rules of the, other things for years together they could not really, you know spoil our culture the way this globalisation and then other modern times spoiling or taking away our culture and heritage. So therefore I would like to ask upon all of you that whatever I have shown you it is a very very you know tip of the iceberg, is a very small portion.

There is lot of things are there what we can do, one way is that we attend we know this thing but very important thing we need to spend you know some of our valuable time whatever we got in this life to keep this heritage and culture intact. For that we need to do research and for that also we need to propagate this knowledge and also we can use this technology to entrepreneurs, because most of the technologies even today are with the poor, downtrodden and the people who are being neglected for years together by the society.

And we should work with them and give them opportunity too propagation and employment. And let me tell you that this if we can revive this indigenous technology which are integrated with the mother nature it will be not only helping us to generate wealth but also it will show the ways and means to modify our modern life, so that it can be integrated with the Mother Nature and it can be made also sustainable development and we can also use this technology and revive it and this can maybe adopted by the western people later on provided we work for it.

And that will be the turning point for, instead of follower than that of a leader. In other words, we will became a world leader provided we keep our tradition and improvise our indigenous technology which are about to die and work for it. And I wish all the best for all of you and if some of you could work for this cause I will be glad and then I will feel that this effort of making this lecture is fruitful and useful. Thank you very much.