

CHAPTER III

LOST WAX BRONZE CASTING TECHNIQUE IN THAILAND

Technology of manufacturing bronze objects in South East Asia and Asian sub continent is fundamentally similar and in some cases the material and process differs according to the context, geographic region, workmanship or technology and use of the materials. Traditional bronze casting technique is considered the asset and cornerstone of bronze workmanship. With the modernization and change of society the technology tend to change according to the contexts and demand of newness by the pioneers of art. The chapter discusses with the establishment of the Department of fine Arts, keeping the aesthetic technology of traditional bronze casting technology as a valuable asset, the contemporary bronze casting technique is acquired to make more scientific, realistic bronze statues. The difference between the traditional and contemporary method is discussed with the peculiarity of technology practiced in other places of Asia.

3.1 History of the Department of Fine Arts

Religion and art is the vital component of culture. Art whether tangible or intangible, is a source of knowledge and a heritage which is handed down by generation to generation. It is obligatory that it needs to be observed, ready to be passed on to posterity. There is also a need for the promotion of creative contemporary art which can be added to the wealth of wisdom for the current generation. Art as a component of culture; it was given very important attention by the royals of Thailand. During the time of King Rama V, all kinds of artisans in the ministry were collected into one place which was called Wang Thanon Na Phra Wang. In royal initiative, for the convenience of controlling and cooperation of the art and performance, a group of various artists was created which was named as Krom Chang Sib Mhu(the ten groups of artisans). In the reign of King Rama VI, Krom Chang Sib Mhu was incorporated into the Department of fine Arts, which was created on March 27, 1911 attached to the former Royal Household.

According to the information obtained via website of the Fine Art Department, before 1911, Thai cultural heritage in the fields of archaeology, history, literature, drama, music, artistic works, archives, and museums were under the care of various government agencies. The wide range of responsibilities tended to be scattered and left unattended. Until 1911, in the reign of King Rama VI who regarded art and culture as the root of the Thai people and their Kingdom. The Fine Art Department was founded by the Royal Command on March 27, 1911. In this period European art was popular in the country, so Royal Siam Government requested a proficient sculptor from Italy. From this request Professor Corrado Feroci, an Italian sculptor from Florence was selected from 200 applications to work in the Department of Fine Arts. Professor Feroci's contribution on Art in Thailand gave a new dimension in Thai art.

In 1926 during the reign of King Rama VII, the fine Arts Department was dissolved as the Government was unable to allocate sufficient budget for cultural affairs owing to the world economic crisis. All divisions in the department, except the artisans group, transferred to incorporate with the library division, and created to be the Royal Academy called the Royal Academy of Fine Arts. The artisans group was created to be the outer Royal Household Division attached to the former Royal Household. After the political change of the country, the Royal Household was abolished and a group of artisans were transferred to under the Department of Fine Arts which was reinstated in 1933 and until present, the department has under gone continuing changes so as to keep up with the changing circumstances. In 1934, Luong Vichitrawatakron was appointed as the first Director General of the Department. During this period, the art works products from the Department had been well known because all kinds of artisans were collected into the department in the new created division, named the Fine Arts Division. Since this period the status of the department has been secured and continued to prosper until present. Now a day the Department of Fine Arts has duty and responsibility for conservation, promotion and supports in many kinds of National Arts and culture,

particularly the National Heritage. At present Fine art Department is under the jurisdiction of the Ministry of Culture.¹

The history behind the establishment of the Ministry of Culture goes back to the period of Rama VII. It was during the Field Marshal Plaek Pibulsonggram's government, culture was viewed as key dimension in the process of nation building and decided to assume a more active role in cultural development. In 1940 AD and 1943AD two acts on the development of national culture were promulgated. These two acts were later suppressed by the National Culture act 1942 AD and the amendment act – the National Act 1943 AD. As required by the National Culture Acts, the National Culture Institute was founded. Subsequently the Ministry of Culture was established on March 12. 1952. The first minister of the Culture became the Field Marshal Plaek Pibulsonggram as an acting minister. During the late 50s because of political condition the Ministry of Culture was dissolved and their personnel transferred to the Culture Division attached to the Ministry of Education. In October 2, 2002, the Ministry of Culture was reestablished according to the new structure of the Thai government under the 2002 restructuring of the Government Agencies Act. With the jurisdiction over the different departments: 1. Office of the Minister, 2. Office of the Permanent Secretary, 3. Department of fine Arts, 4. Office of the National Culture Commission, 5. Office of the Contemporary Art and Culture, 6. The religious Affairs Department, 7. The Bundit Palansilpa Institute and the public organization like The Princes Maha Chakri Siridhorn Anthropology Centre, the main mandate of the Ministry of culture is to protect , sustain, art and cultural affairs on the nation, and thus contribute to maintaining ultimate symbol of Thai social Values i.e. nation, religion and monarchy.

¹ Nildum, Nilwan, *The architecture heritage management for wang Tha Phra and Wang Thaton Na Phra Lan: from the palaces of builders and craftmaen to the art and culture centre* (Silpakorn University, 2003). P. 20

As a part of Ministry of Culture², mission and function of the Department of Fine Art have specialized in arts, archaeology, literature, museum, architecture, national archives, performing arts, education in the areas of dance, music, composition, craftsmanship etc.³

Within the structure⁴ of the Fine Art Department's one of the major area of work is the visual arts. The institute of fine arts is responsible for a wide range of arts in visual arts ranging from arts education, studies, preservation, design and supervision of the construction of government agencies and Buddhist temples in the traditional style. Likewise, the erection of national monuments and the reproduction of Buddha images come under the supervision of the Institute. In education, the scope of work covers the administration of the College of Fine Arts. The Institute of fine Arts has one of the duties of strengthen traditional craftsmanship known as "Chang sip mu" and ensures its continuity.⁵

Some of the major division of Fine arts Department is the Division of Handicrafts and the School of Fine Arts. After the outer Royal Household was abolished, the groups of artisans were transferred to a new created division named "Kong Praneet Silpa" (The Division of Fine Arts) under the Department of Fine Arts. At that time art works produced from this division was really remarkable, especially sculptures which were produced under the supervision of Professor Feroci. To create lots of national arts the Department of Fine Arts needed lots of craft people. For the purpose to train young apprentices of sculpture, painting, architecture, drafting, and design and for the works in the department, the school of Fine Arts was found under the direction of Professor Feroci. Feroci's studio was made in a western style building near the office building. In 1938, the division of Fine Arts changed its name to "Kong Hattha Silpa"(Division of Handicraft), and adapted Thong Phra Rong Wang Klong to use as an office of the division. The first chief of the division was Phra Phromha Pichitr, a master of Thai traditional arts and

² Appendix 1

³ Appendix 2

⁴ Appendix 3

⁵ Appendix 4

architects, and the other experts were Professor Feroci, a specialist in sculpture and Mr. S. Miki, a Japanese specialist in lacquering. A temporary workshop was built in the area behind the department office building in 1941, but the foundry was made outdoor. Later the working area was moved to the warehouse near Wong Tha Phra. According to Nildum the important statues made at that time was of King Naresaun, King Taksin etc. the following year the Section of Handicraft was taken under the Division of Architecture and the same year with the Government fund a standard foundry with current equipments was built to replace the old warehouse and important statues like of king Ram Khamhang and U – Thong etc. was made in this foundry.

In 1952, ten years later, section of Handicraft was upgraded to Division of Handicraft and consisted with unit of ten groups of artisans, unit of painters, unit of sculptors, and unit of founders. In 1987, the office of the Division of Handicraft was moved to Salaya district in Nakhon Pathom and new and more modern foundry was built for more capacity. In the same year this unit was developed to be a section of sculpture under the Arts Institute. In 1988 the old foundry was adopted as a museum under the project of “Museum of models and prototype of the National Statues”. It was the first museum of prototype. In 1998 the Director General of Fine Arts, Nikorn Musikamara resurrected the project and a committee was assigned as ‘the Project of the prototype of Thai Arts Gallery’. The project improved the gallery and rearranged the artifacts on display and the foundry was named as “Hall of Sculptures”.

Here it is relevant to find some information on the establishment of the School of fine Arts, which is the important factor of revitalization of Arts in Thailand. With the modernization of Thailand the taste of modern realistic arts particularly in sculpture was greeted with broad enthusiasm by the people. With the increased demand the number of artist, experts became inadequate. With this in mind Professor Feroci was assigned to train a small group of artisans in the Department to be the apprentices for sculptures. Later in 1933, the school of Fine Arts was found in the department by the effort of Professor Feroci in the support of the chief of the division of Architecture, Phra Saroch Rattanimman. The School of Fine Arts was officially found in 1934 and the name was

changed from Rang- Rean(School) Oraneet Silpa to Rang- Rean Silpakorn. Both of them have the same meaning as ‘The School of Fine Arts’. There were three sections in this School, fine arts, creative arts, and musical arts.⁶ The aim of the school was to produce qualified artisans who would work for the government in both modern and traditional art. After the establishment, systematic study of western modern arts had started in Thailand. Professor Feroci is responsible for teaching European style fine arts and other Thai Artisans are responsible to teach traditional art and helped to recognize tradition and awareness in heritage value.

With the initiative of Professor Silpa Bhirasri (Professor Feroci’s Thai name after he became Thai Citizen) first arts exhibition was held in 1942 in the constitutional day and since then the art exhibition is held every year. The school gained good reputation and in October 12, 1943 the school was promoted to the Silpakorn University from the support of the Field Marshal Po Phibolsongkrom. The faculty of painting and sculpture is the original faculty, later other faculty like, archaeology, decorative art, architecture, etc. was added in this university. With the yearly art exhibition, modern arts and artists had gained good opportunity to reveal themselves to public. And the university had become a promising centre of knowledge of art education.

Handicraft Division Salaya, Nakhon Pathom

In 1952, section of Handicraft was upgraded to Division of Handicraft and consisted with unit of ten groups of artisans, unit of painters, unit of sculptors, and unit of founders. In 1987, the office of the Division of Handicraft was moved to Salaya district in Nakhon Pathom and new and more modern foundry was built for more capacity. In the same year this unit was developed to be a section of sculpture under the Arts Institute.

The sculptors consist of altogether 50 expert persons in which ten persons work as sculptor who make the model of the image to be cast. In this group there is one head

⁶ Nildum, Nilwan, “ The architecture heritage management for wang Tha Phra and Wang Thaton Na Phra Lan: from the palaces of builders and craftmaen to the art and culture centre(Silpakorn University, 2003). P. 23

sculptor who is the head of this division. In mould section ten persons work as mould makers and in casting section 30 person works for casting and finishing of the sculpture. In casting and mould maker group too consist a head that instruct and take initiative for the works allocated.(FIG 20)

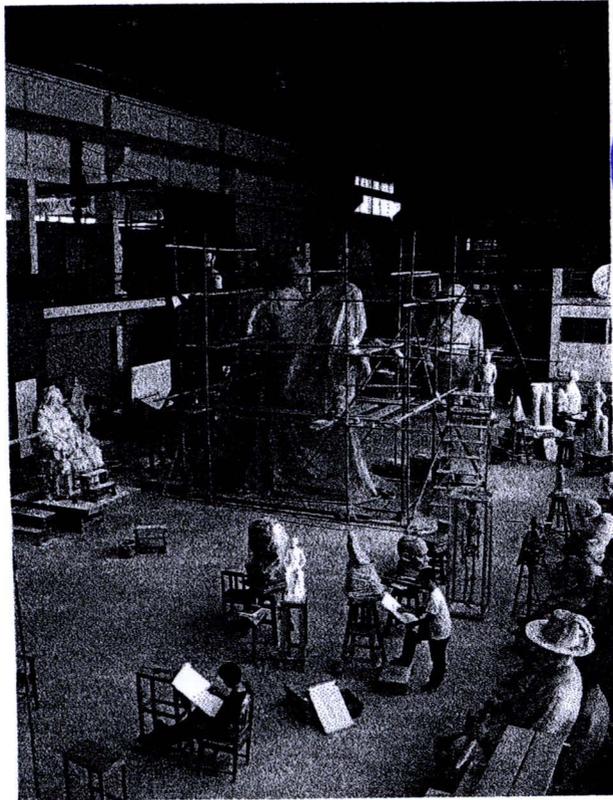


Figure 20 Foundry of sculpture in Salaya.

3.2 Lost Wax “cire perdue” Bronze Casting Technique

Bronze

‘Bronze, according to Concise Oxford Dictionary, means as 1. a yellowish brown alloy of copper with up to one –third tin. 2. A yellowish brown color. 3. A work of sculpture or other object made of bronze.’⁷ Likewise Encarta Dictionary gives some definition of bronze as follows- Copper and tin alloy, a hard yellowish brown alloy of copper and tin, sometimes containing small amounts of other metals. Bronze is harder than copper, is often cast to make statues and work of arts. It is metal with typically hard, shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity. Some other similar metals are, iron, silver and copper.

In this study bronze generally taken as an art object or the sculptures made of bronze from the prehistoric period in which the amount of other alloys mixed in the metal varies such as to make bronze copper, tin, zinc and lead and other noble metals as silver and gold are mixed in different combination in different case.

Casting

According to Concise Oxford Dictionary, ‘cast’ means an object made by casting metal or other material. In plaster cast, a mould is used to make such an object.⁸ According to the Encarta Dictionary, 1. Casting means making of objects using moulds which is the making of a solid object by pouring molten metal, glass, or plastic into a mold and allowing it to cool and 2. Manufacturing arts objects using a mold.

Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more components together; examples are

⁷ Judy Marshall, *Concise Oxford Dictionary* (Oxford University Press, New York, 1999).

⁸ *Ibid*, p. 219

epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods.⁹

Lost Wax 'cire-perdue' casting method

Lost wax or 'cire – perdue' in French, is a method of casting bronze using a clay core and a wax coating placed in a mould; the wax is melted in the mould and bronze poured into the space left, producing a hollow bronze figure when the cast is discarded. The wax is the exact impression of the bronze figure to be made. Clay core is not required for the solid cast method, only the outer surface is covered with layers of mould.

3.3 Contemporary Bronze Casting Technique in the Foundry of Fine Arts Department in Salaya

Thailand has a very old history of bronze casting. The traditional bronze casting technology is more or less similar to the ancient technology mentioned in old Indian literary sources, only the casting materials varies according to the geographic region, traditional bronze casting technology is a slow and time consuming process. The case study of the traditional bronze casting process is discussed from the beginning in second part of this chapter. For the first part process of the contemporary bronze casting technology with 'lost wax' or 'Cire Perdue' is discussed.

The foundry of The Fine Arts Department in Salaya specializes mainly on contemporary bronze casting technique. The sculptures made in this foundry are monumental and religious. Monumental sculptures are made of the big Thai monarchs and hero personnel as well as elite persons. Item of art mainly sculptures in this research was made for religious purposes or for the royal and national purposes which required highly innovative process requiring great skill, experience and patience which will be

⁹ <http://en.wikipedia.org/wiki/casting>, 27 Dec. 2009

outlined in the process description. During the period of the study the foundry was undergoing big projects of making huge and very time consuming sculptures which due to time constraints I was unable to follow and document from the beginning to the end of the procedures. However any statues which were made in the foundry took more than a year depending on the size. For the purpose of my study I followed different sculptures and photographs provided by foundry officials that are described on sequence but the photographed objects may vary with the availability of the objects being cast or molded.

Preparation for the construction of bronze sculpture

Bronze Sculptures are made in the initiative of the Fine Arts Department or on the order basis from any organization, provincial government offices or from the donor companies. The proposals for the making of the statue, a project are formed with consultation of the sculptor of the foundry. The project then does numerous researches on the person whose sculpture is to be made and start to collect photographic and portraiture documents with short history on the person. Then the place is allocated where the statue will be consecrated and layout design is prepared by a consultant agent. The design represents the sense of the place after the establishment of the statue as a national monument. For example, Phetchaburi Province Government had a project of Phra Nakhon Khiri Historical Park to build King Mongkut Memorial Park. Principle reason of the project was to honor Rama IV who initiated the modernization of Siam. And another reason to choose the land was that, the King Rama IV bought 714 rai of land at Phetchburi by his own money in 1858 and built the palace at Phra Nakhon Khiri. This is Thailand's first palace located on the hill. Currently there are 24 rai of land left which is available for the construction of the statue.(Fig. 21) (**Annex 8 for plan**)

The employee of Kasikorn Bank Public Company Limited, Mr. Wuttichot, had joined hands with the authorities of Phetchaburi as a coordinator to consult the Fine Arts Department about the construction of this statue. After that, they asked the construction permission from the Prime Minister's Office and the Bureau of the Royal Household. After they are permitted to build the statue, they have asked the Fine Arts Department to

build the statue. The royal representative had participated in the ceremony to lay the Foundation Stone and the establishing ceremony of the statue. Besides, many monks and Brahmans performed the sacred and holy ceremony.

Constructing the Inner Moulds

Casting image is a delicate process which is always executed by specialized artists who belong to a professional of family business or the individuals. Due to the fact that entire manufacturing process is divided into several separate stages, the artisans specialize in particular skills according to their individual ability and qualification. There is always a chief artisan who supervises and coordinates the complete process, and is also responsible for contacting patrons and suppliers of the requisite materials.

After the proposal is approved by the Fine Arts Department, the appointed sculptor prepares himself for the performance to make an idol which in future will become a national monument representing the historic value. The size and type of the image determines whether or not solid or hollow casting is admirable. Small and big statues can be cast hollow in order to save metal. If the image to be cast has to be solid and heavy, the wax model of it must be prepared out of a solid piece of wax.

The finalized pictorial document is taken as an authentic visual aid to make a sculpture. When photograph was not in practice a picture was drawn with free hand and in proportion if a god's sculpture was to be made. When a human sculpture was to be made the person whose sculpture have to be made, he have to be a model for the sculpture. In the foundry of Fine Arts Department the sculptors mostly take evidence of the pictorial document to make the sculptures of the Kings and the Hero personals.

At the beginning a prototype image is prepared with the detail to be made at the final image. This image is usually not taller than two feet or even smaller than one foot is sculpted by clay or wax. To start sculpting the sculpture the sculptor must have knowledge of the anatomy of human body. He makes first the body without cloths on which is only the naked body. When he makes the naked body he takes utmost care to

show the curvature of the muscle, bone structure, position of the statue or posture. He has to take reference from the live human form from a human model or have to take help from the anatomy book.(Fig 22,23) After the small model is prepared, a sketch with the required proportion and scale to the height is drawn on a big drawing board attached to the wall. The sketch will determine where the strengthening rods and wooden clutches are to be placed. (Fig 24,25)

Miniature model of the sculpture is inspected by the head official and the experts for its perfectness. After the donor or the ordering party is satisfied with the model, the appointed sculptor makes preparation to mould the real size sculpture. At first a revolving wooden base is set up, upon which a frame for the chair which is just like a table is set up. On the chair an iron rod bent according to the requirement of the posture of the body from head to the leg portion is securely attached. The wooden clutches tied on the iron rods are attached on several places to help hold the clay in place as shown on the figure. (Fig 25)

After the base and strengtheners are set the sculptor places the small model at side and pray to take permission from the soul of the person whose statue is going to be made and offer a flower garland (in Thai, *malai*) and burn incense stick. (Fig 26)

Special sticky clay brought from outside Bangkok is sorted out for its impurities and stone particles. Clay is grounded into more fine dust and soaked in water to make clay lumps which enable the sculptor to apply on the sculpture. The sculptor starts to paste wet water based clay¹⁰ on the frame previously made by iron and wood. He uses various tools to shape, scrap and mould as his very intimate tools. Tools are very important for the molding sculptures in required shape. (Fig 27)

¹⁰ Water based clay is used for larger sculptures for which it is desired to capture a gestural quality- one that transmits the motion of the sculpture in addition to that of the subject. Water based clay must be protected from drying. Water must sprayed from time to time and covered properly by cloth and plastic.

The wet water based clay is shaped according to the small model. (Fig 28)The sculpture is made naked with taking keen interest to reveal the anatomy of the body. A human model is used to take reference and model spends the day with very tiresome posture to give his best of attitude towards the sculptor. (Fig 29)Since making the anatomy is the most important part of constructing a sculpture, the time limit is unlimited. It may take more than six months or so depends on the size of the sculpture and for the finished sculpture takes more than a year for the monumental statues.





Figure 21. Plan of the King Mongkut Memorial Park, Phetchburi. Photo by Mr. Wuttichot

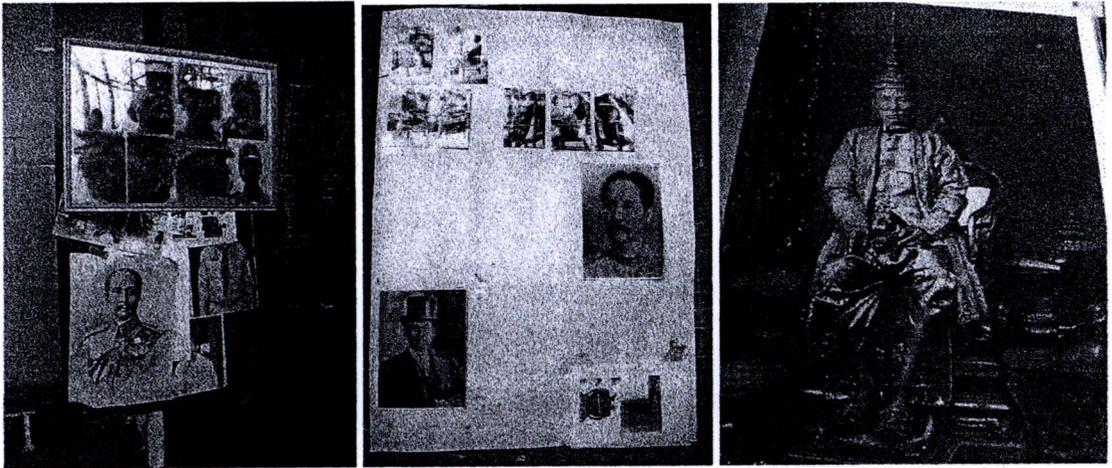


Figure 22. Photographic References.

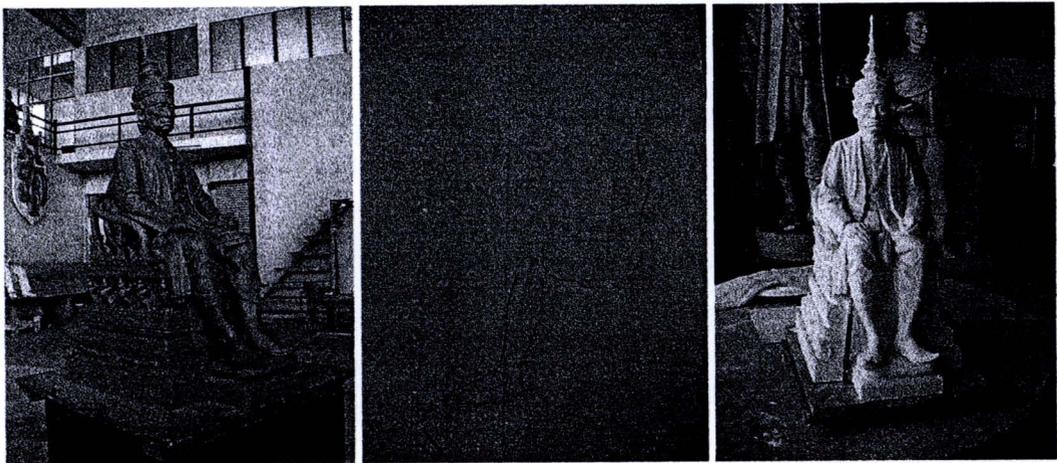


Figure 23 Model of King Mongkut and the scale drawing of the sculpture.

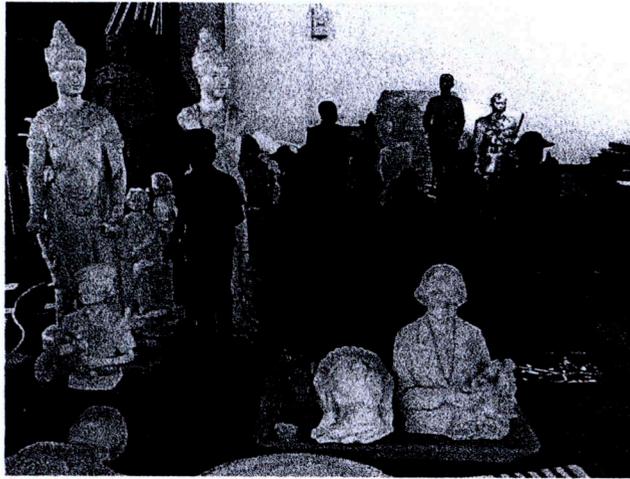


Figure 24 Small models of the statues previously made by the Fine Arts Department

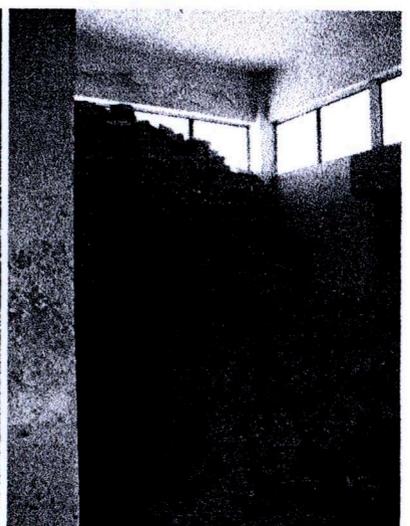
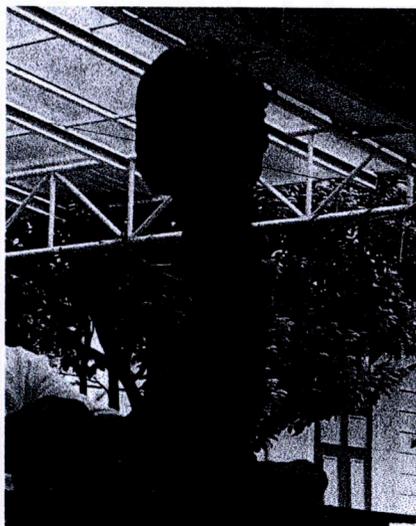
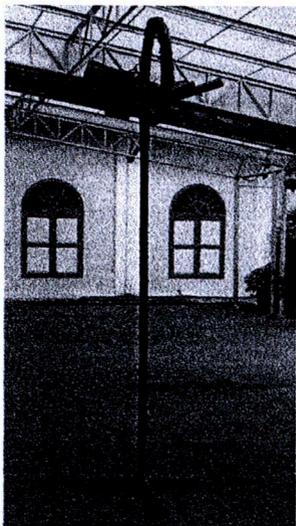
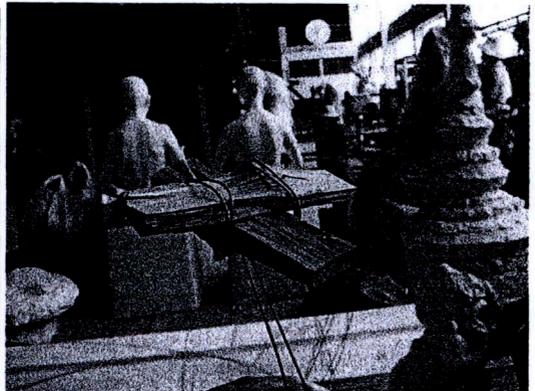
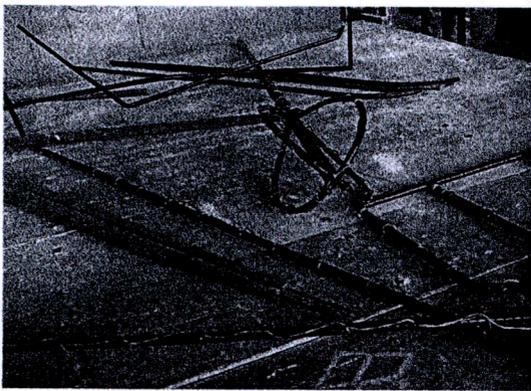


Figure 25 Iron and Wooden Strengtheners and clay.

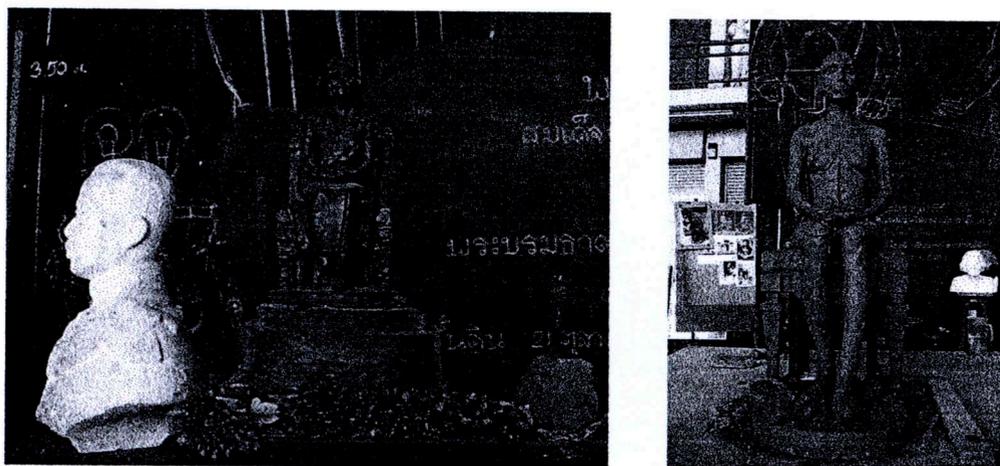


Figure 26 Offering flower to the model sculpture before starting the statue

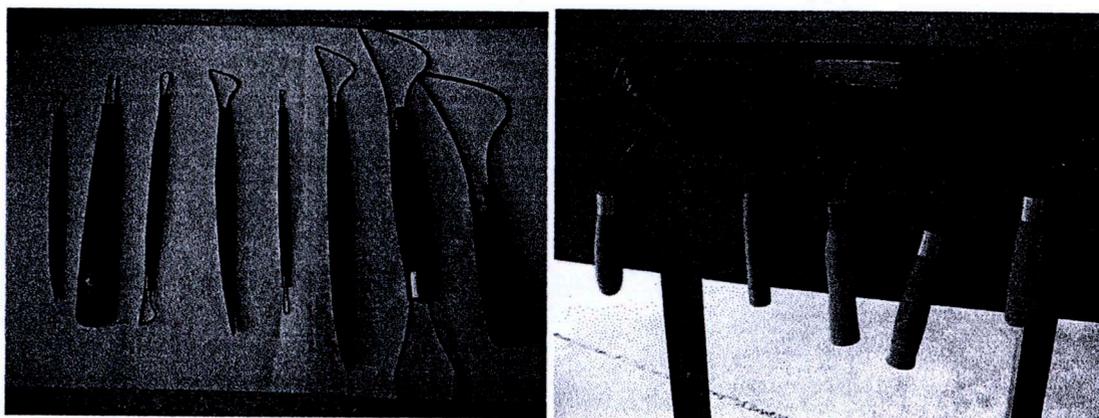


Figure 27 Tools of different sizes and shapes.



Figure 28 Small model of King Mongkut and the clay sculpture being made.

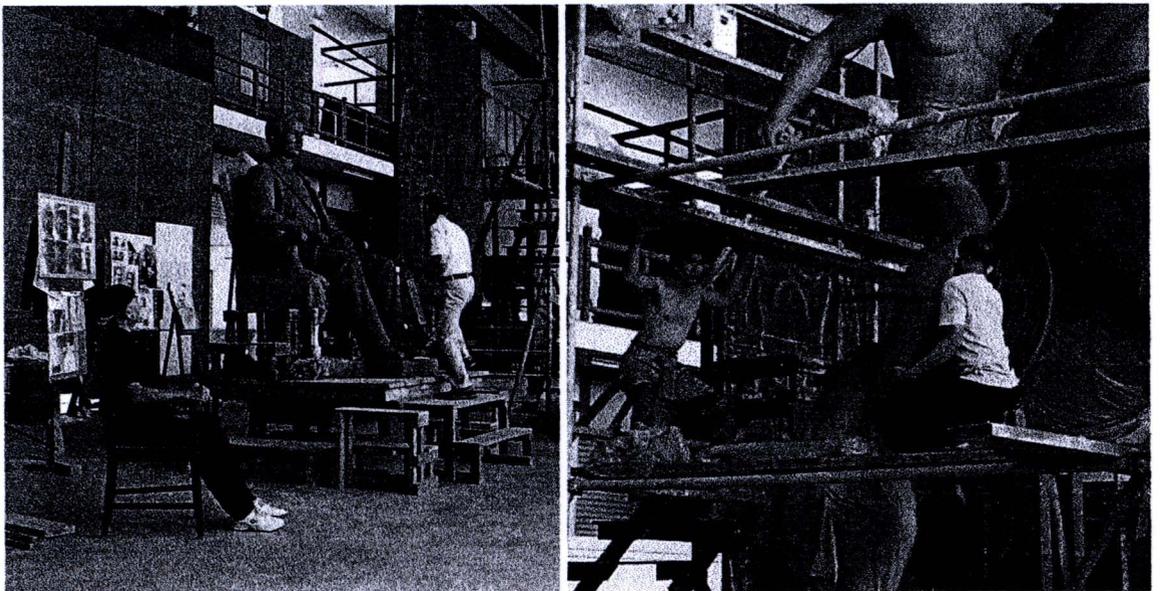
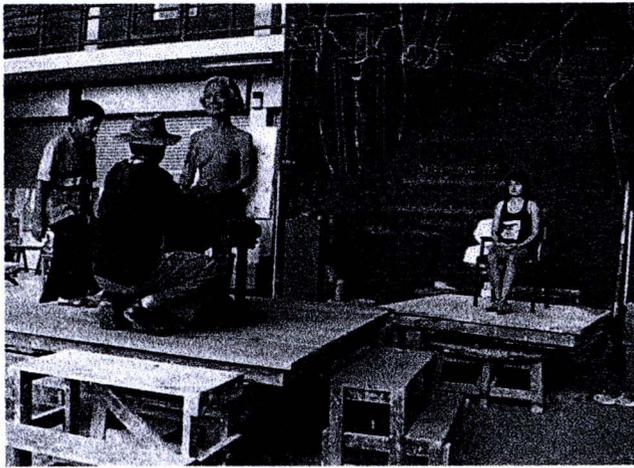
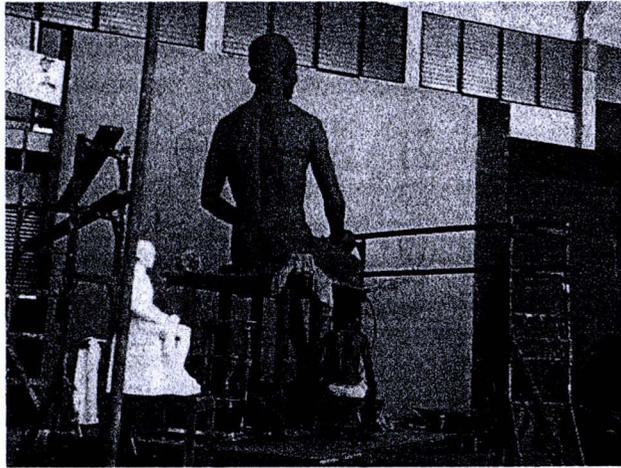


Figure 29 Human model posing for the anatomical reference.

When the sculptor is satisfied with the anatomy, he prepares to make cloths on the necked body. The way he makes the clothes is really amazing that the cloths upon the body reveal the contour of the body as well. (Fig 30) The clothes' folds and designs on the clothes are carved with care and intricacy. The clothes, facial expression and the whole sculpture ultimately seem very realistic. To give the finishing touch to the sculpture is the most tiring job. The sculptor is never satisfied with his work that every time he see his work, he see something lacking and defect on the sculpture as the head of the sculptor says. The clay sculpture is the most important work to cast a bronze sculpture because the accuracy of the clay sculpture gives the bronze statue the perfectness and the purpose that the makers want from them. In another word the clay sculpture testifies the resemblance to the final bronze statue.

The clay statue finishes with long effort of the sculptor. Other parts of the statue for example the chair or the throne and other associated parts are carved and if to be attached, they are attached to the sculpture. In some cases the accessories can be carved separately and joined afterwards the bronze cast. While the statue of King Rama V was made, the chair was attached and the leg of the chair was the prototype they already have in the foundry. The prototype leg can be detached easily so that it can be cast or mould separately. With the completion of the sculptor's task, the task of the mold section begins henceforth.

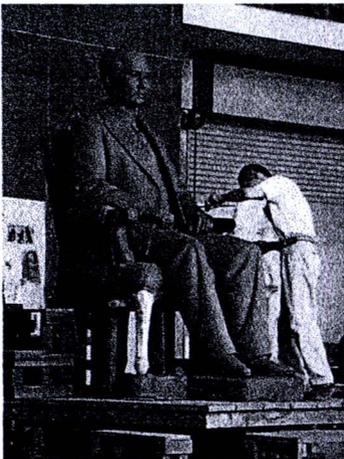
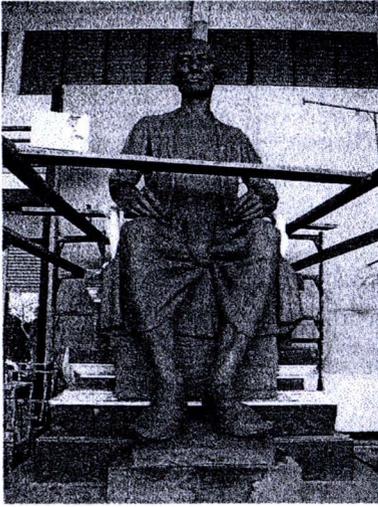
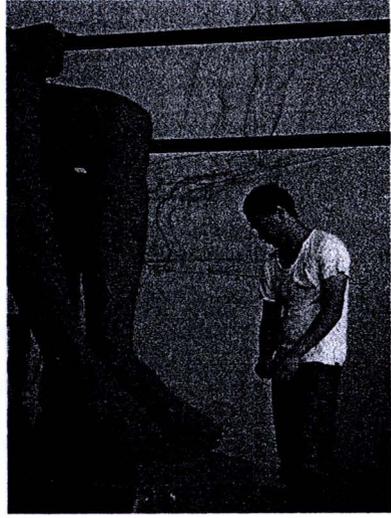


Figure 30 Fashioning Clothes over the body.

Process of making plaster moulds

As stated before I followed different statues for the casting process. To start the documentation of the mould making process I got chance to record the process from the beginning. For this King Chulalongkorn's statue was ready. The clay sculpture was made by the head of the foundry and head sculptor Mr. Somkuan Oumtrakul. He was working on the sculpture until the last moment that is the moment the mould group takes charge on the statue to make a plaster mould. He said that every time he looks at the statue he may find some error and he want to correct with his all effort. It took nearly a year to finish the clay statue. (Fig 31)

Cut off the unattached part: On 2nd February 2010, the head of the mould group along with his staffs makes preparation to make the plaster mould out of the clay sculpture of the King Chulalongkorn. After inspection of the sculpture with the expert eyes of the molders, the detachable leg of the chair which is the prototype of the chair legs is detached from the clay chair. (Fig 32) ~~Then two hands which were not attached to~~ the body of the sculpture were cut off with help of a cotton thread or a sharp knife. Likewise the tip of the coat which was not attached to the leg was cut off to make separate mould. While cutting off the parts there is a chance of some damage to the sculpted object which is repaired again by the sculptors without any difficulty. (Fig 33)

Insert zinc dividers: The statue is now ready for the further process. A bowl full of zinc dividers is prepared beforehand. The divider plates are soft enough which can be cut with a scissor in required size and angle. The statue is divided in several parts with inserting several zinc dividers. Dividers enable to separate big block of sculpture into several part. The dividers are inserted on row with the contour of the body sometimes cutting into required shape and bend. Likewise the dividers are inserted into the chair handles and the back of the seat as well. The width of the zinc plates determines the thickness of the plaster coat. (Fig 34,35)

Apply soap mixed oil on the surrounding base: A solution of traditional soap is boiled and allowed to cool for a moment. Then coconut oil is mixed with lukewarm soap

solution and boiled again. The oil solution is applied on the wooden surface of the seat around the base of the statue and on the foot rest. The oil is applied with a brush to make sure that the plaster does not stick to the wood when it is taken off. (Fig 36, 37)

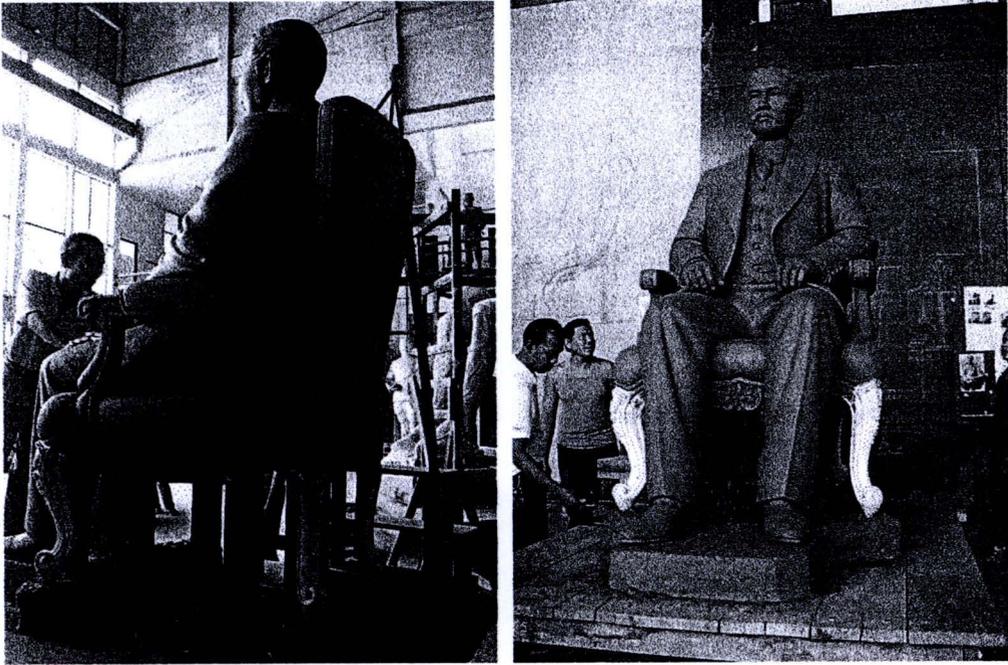


Figure 31 The sculptor giving finishing touch and the mould making group inspecting the statue.

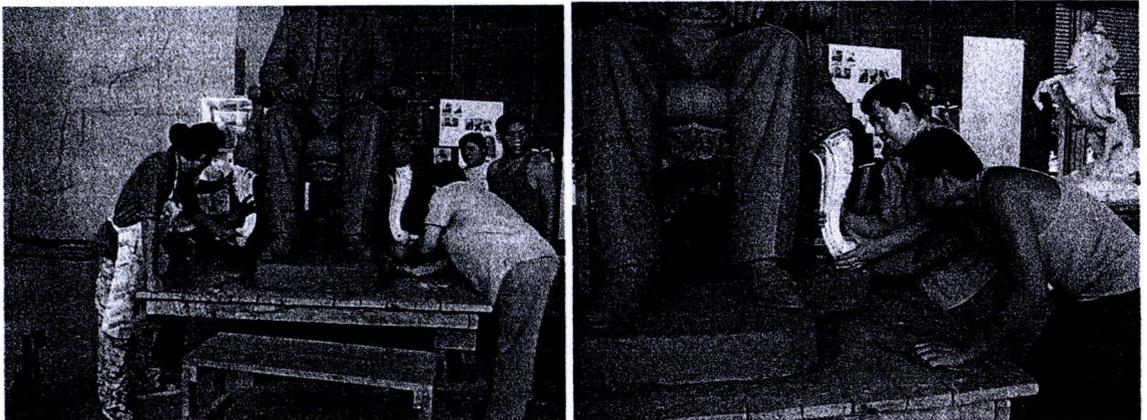


Figure 32 Detaching the Prototype Leg of the Chair.





Figure 33 Separate two hands with string and repair the damaged parts.

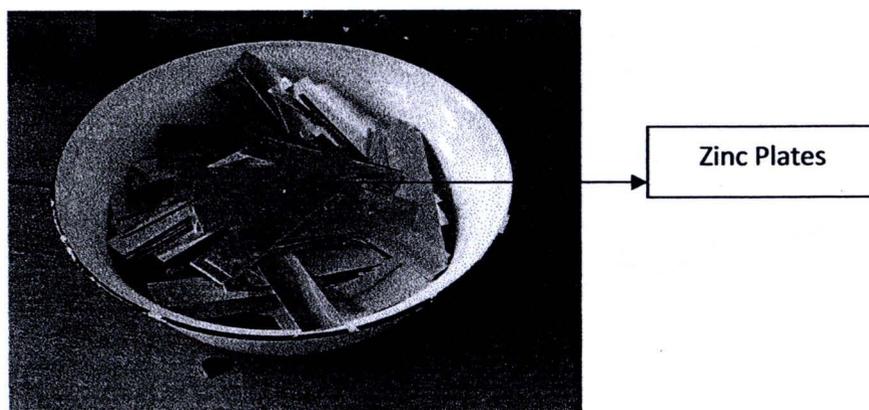


Figure 34 Zinc Plates.

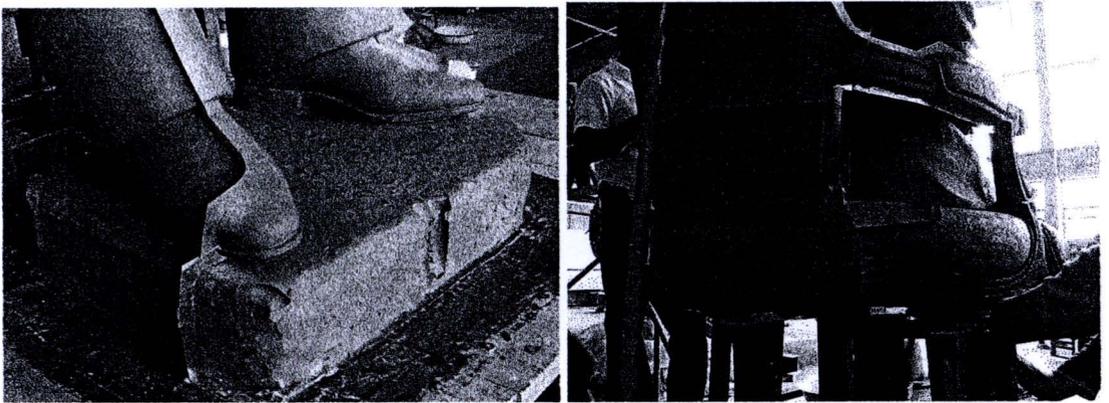
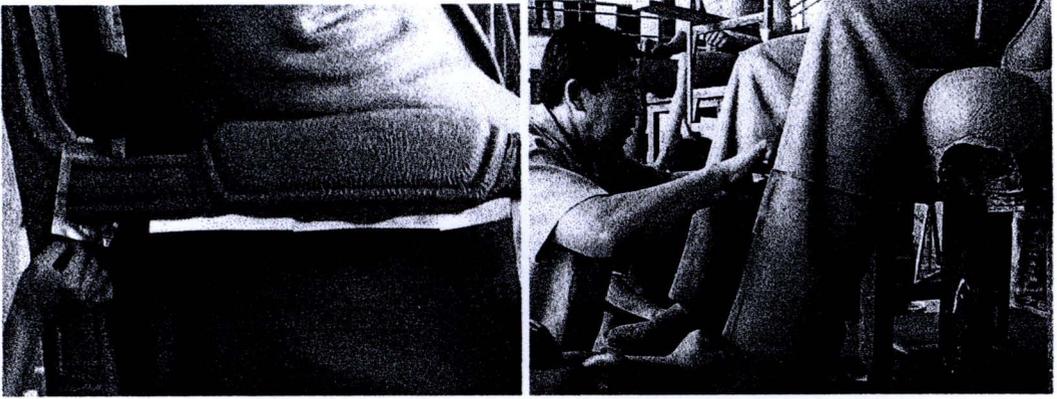


Figure 35 Inserting the Zinc Plated on the clay statue.

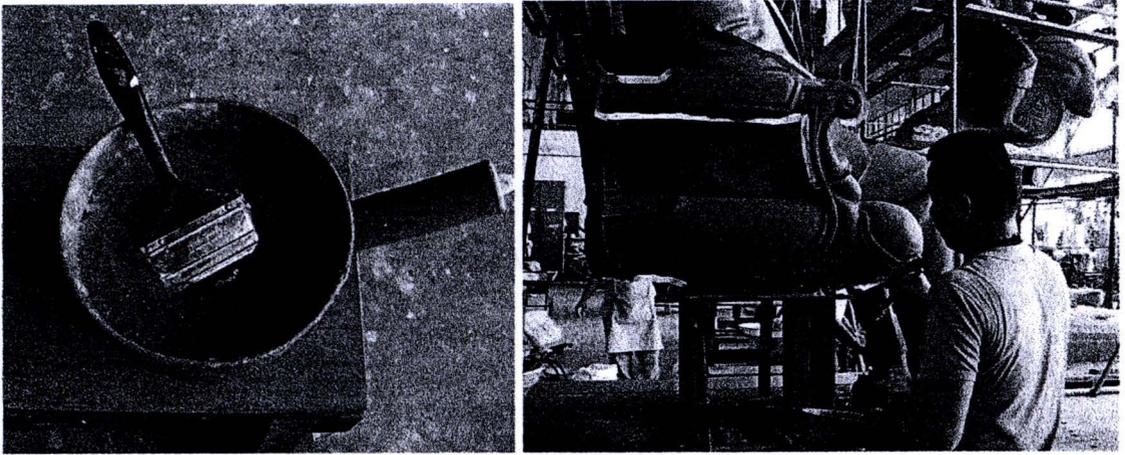


Figure 36 Mixture of Coconut oil and soap solution apply on the surrounding wooden surface.

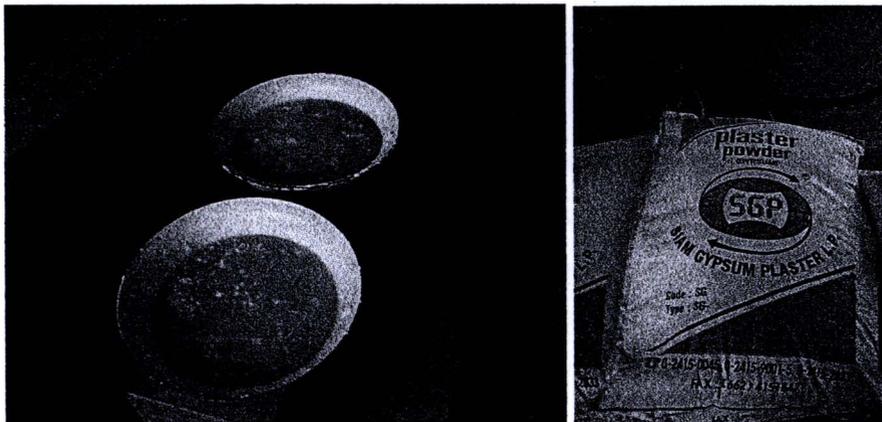
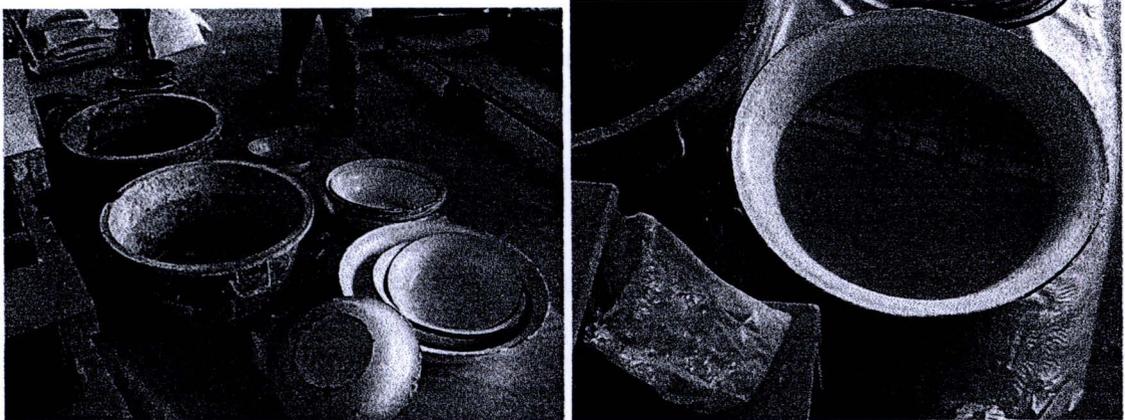


Figure 37 Gypsum Plaster mixed with water and color.

Spray colored Gypsum Plaster solution on the statue: To cover the statue with plaster mould, powder of gypsum plaster is soaked in water and yellow color is added to differentiate with the white plaster. Then the solution of the yellow plaster is poured into small bowls. Taking turn, the staffs of the cast section spray the plaster by hand all over the clay statue making sure that the plaster solution covers all the details and corners. After the statue is properly covered by the sprayed plaster, it is left for dry for that day. (Fig 38)

Apply thick white Gypsum Plaster upon the yellow surface: On the second day that is third of February 2010, the powder of Gypsum plaster is soaked in water let it settle a while. When it is thick enough to apply, the mould makers hold the plaster paste with the five fingers starting from the edge of the bowl and gently apply on the surface of the yellow plaster. While applying the plaster, they have to be careful not to leave air pocket for which they have to make the surface smooth with fingers from time to time. The thickness of the plaster as stated before is determined by the thickness of the zinc. With the help of sharp knife or with a flat scrapper, the zinc surface is marked and smoothed which reveal the edge of the zinc plate inserted before. With this process the plaster is applied all over the statue and zinc surface is carefully marked distinctly. (Fig 39) The plaster is allowed to settle and dry for one day.

For the small piece for example the piece of the jacket corner, at first a plaster mould is made and apply on the half portion of the piece. Then oil solution is applied on the surface and let it dry for a moment and then make lock by scrapping off some plaster from the edge portion. After the lock is made the rest of the piece is covered by the Gypsum plaster paste. Let the plaster to dry for a day and next day the plaster is split open into two halves. The lock makes the attached plaster easy to open. By this time the impression of the jacket tip is imprinted on the Gypsum plaster. Then the clay is removed easily for the plaster. (Fig 40)

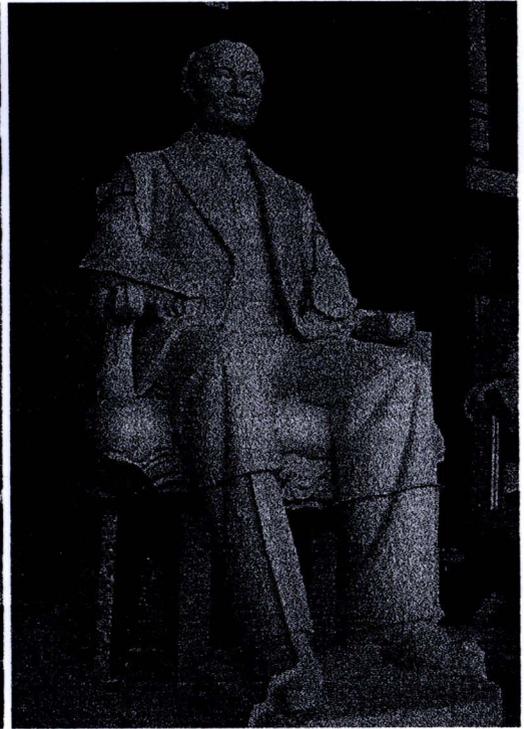
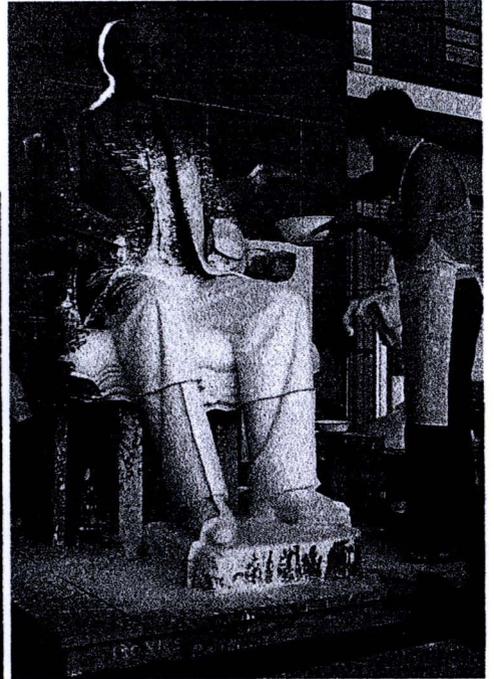
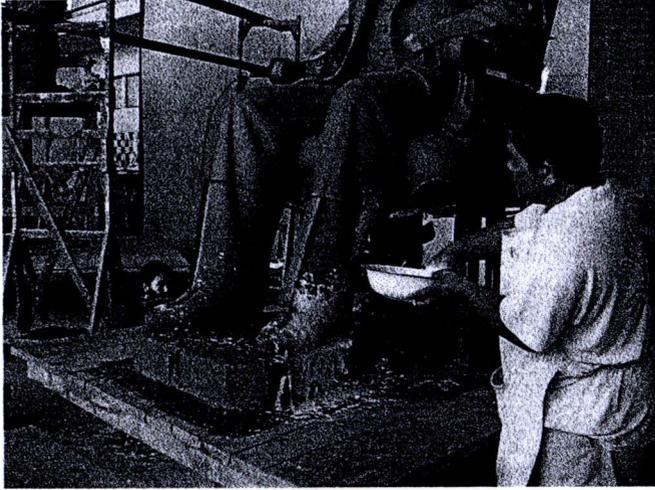


Figure 38 Spray Colored Gypsum Plaster Solution on the Statue.



Figure 39 Applying Gypsum plaster paste on the statue and revealing the edge of zinc plates

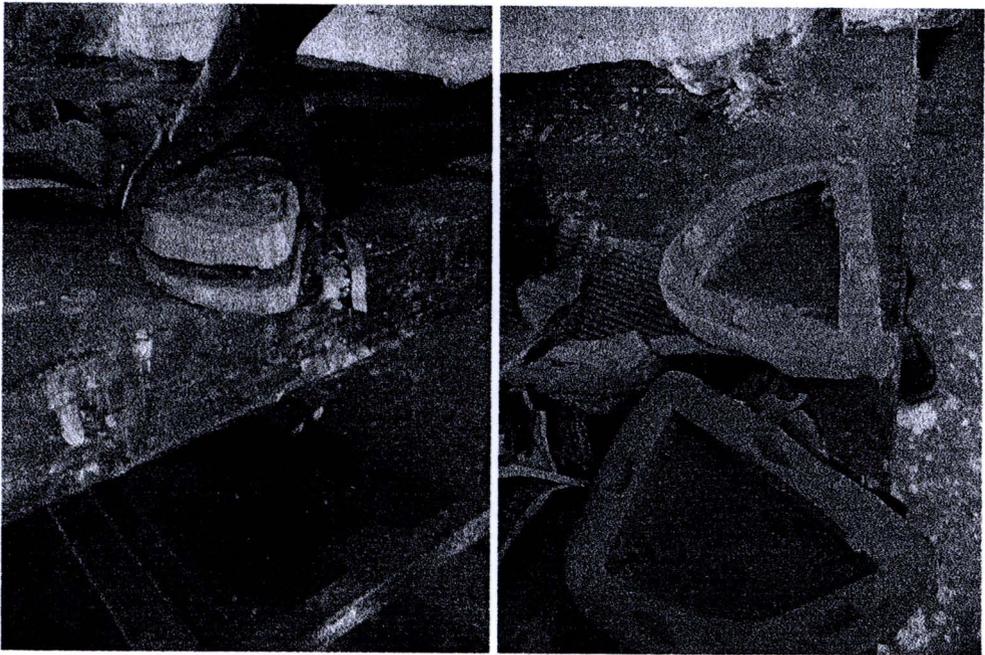


Figure 40 Taking out impression of the small piece.

Strengthen the partitioned portion of the statue with iron rods: On the third day 4th February iron rods cut into the required length and bend were stick to the zinc partitioned parts. To stick the rods same Gypsum plaster paste was used. The handful of coconut hair was soaked in plaster paste and the lump of the coconut hair was used as strong adhesive to stick the rod on the plastered statue. Iron rods do not need any wielding. Strengthening the pieces can make the plaster impression intact on place. While sticking the rods care must be taken that later the part can be removed easily from the statue. Then let the joints to set firmly for a day. (Fig 41) Before commencing the task of strengthening, the leg portion from under the knee was separated from the statue since it has to be mould separately. Since the leg part is quite small it does not need to be strengthened by the iron rod. The leg part was separated and opened from the zinc divider with spraying water on the joint. The clay inside the plaster is removed for the further process of making plaster mould. (Fig 42, 43)

Strengthen with zinc pipe: On fifth February, the fourth day of the molding process, the mold group usually gets ready early morning to finish the required work before noon to avoid the heat. On this day they were working on the four inch Zinc pipe for that they prepare a pipe cutting machine and some zinc pipes as well as the plaster paste and coconut hair for the adhesive purpose. (Fig 44)

The leader of the mould group guides the staffs to make approximate measure of the height of the statue from head to the ground. The pipes are cut with the electric machine in the required length and three cut pipes are kept vertically slightly slanted position from the ground to the head. The pipes are arranged on the two sides and on the center of the statue. The pipes are attached to the plaster with the help of coconut hair soaked in the plaster paste. Then other small zinc pipes are cut in smaller pieces to attach from the base of the chair to the ground. All the pipes are interconnected and attached with the adhesive plaster and coconut hair. Now the statue is much secure and can stand on the zinc pipe after the wooden base is removed for another process. (Fig 45)

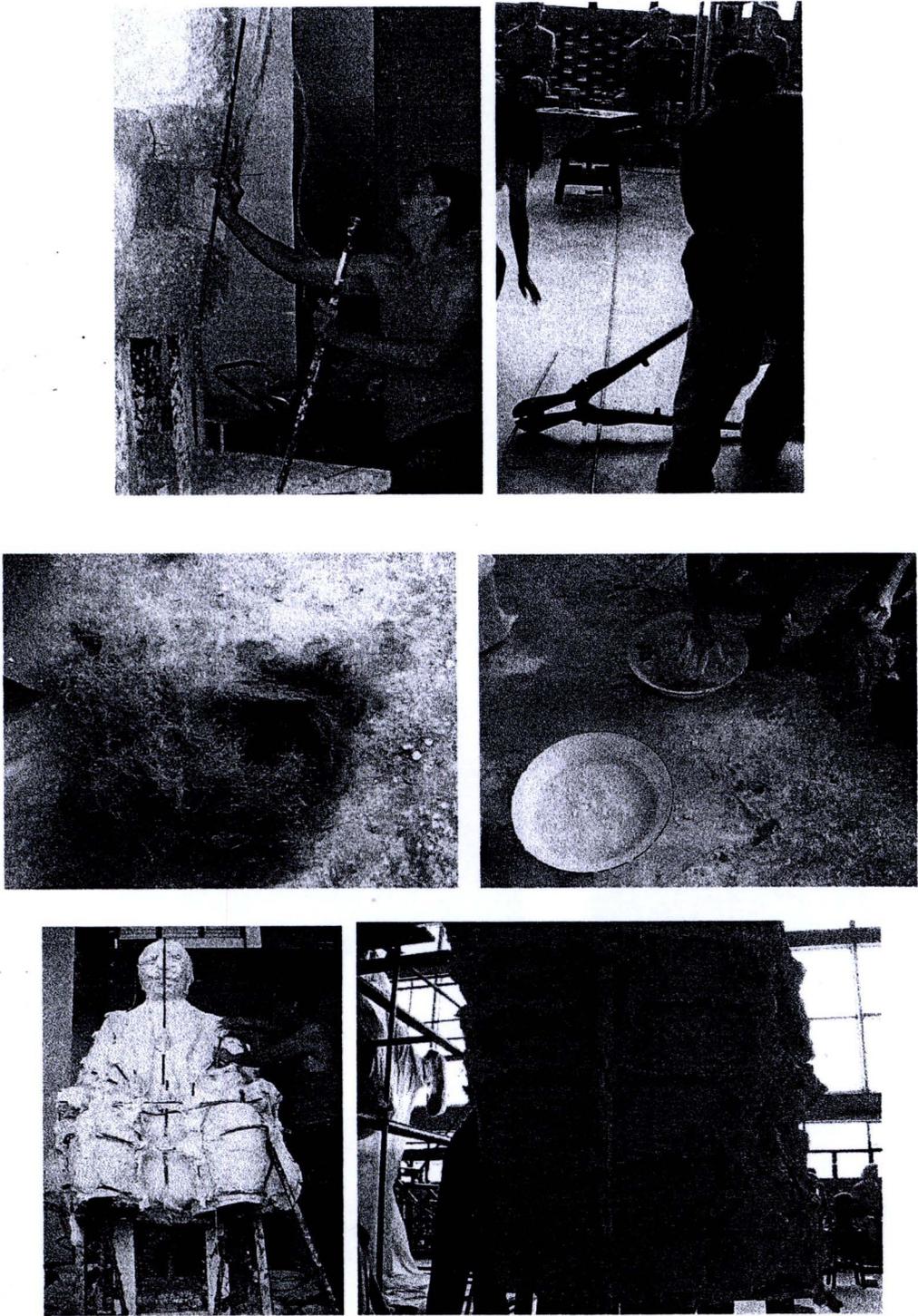


Figure 41 Strengthening the plaster with iron rods.



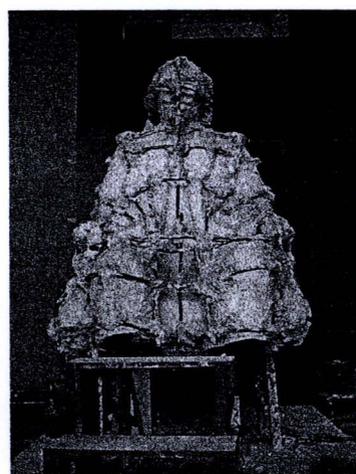


Figure 42 Strengthening the plaster with iron rods.

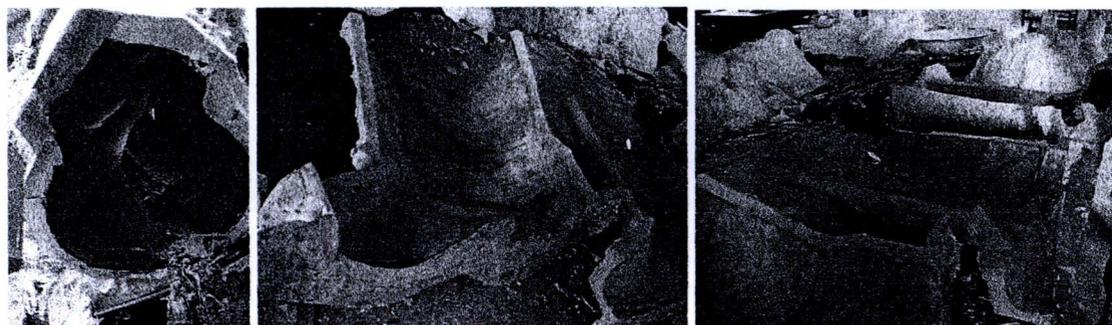


Figure 43 Detached part of leg.

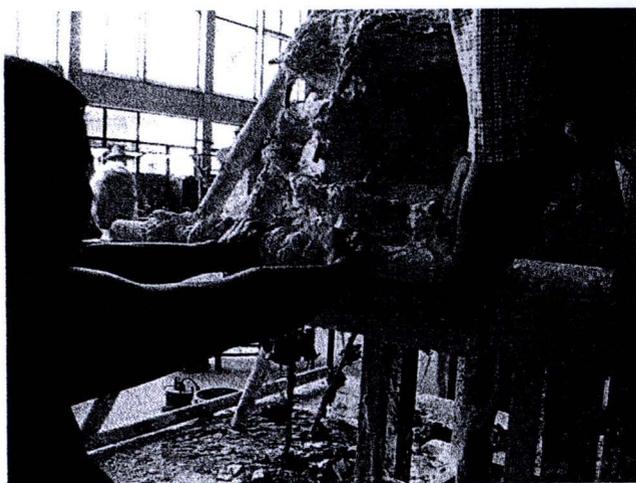
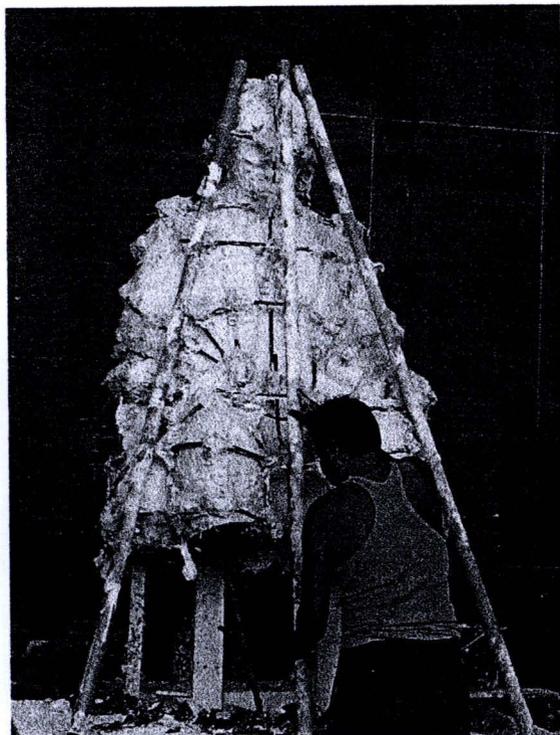


Figure 44 Attaching the zinc pipes for the strength and for stand.

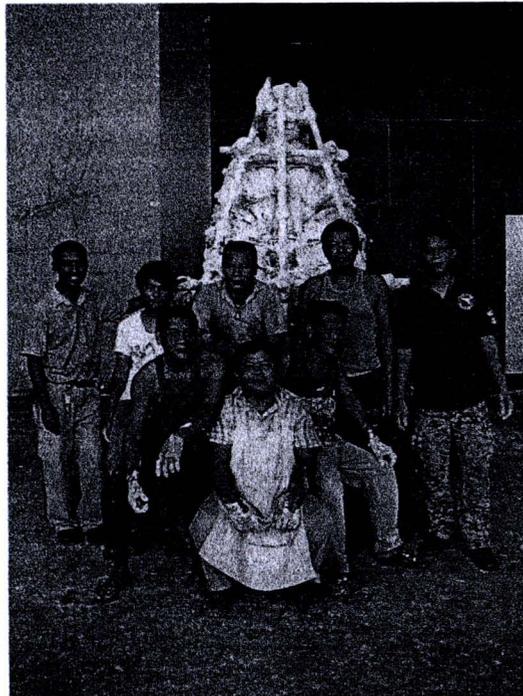
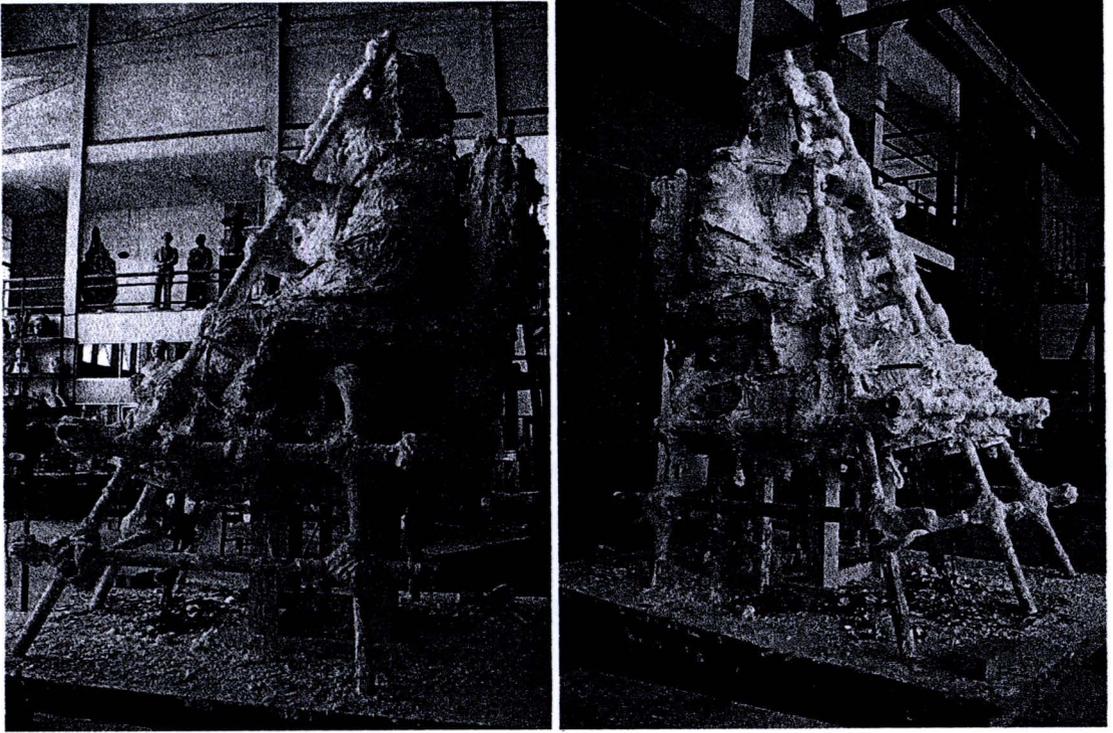


Figure 45 The finished strengthened plaster covered statue and the group of mould makers.

Separate plaster mould: On 8th February 2010 on the fifth day of the process, the line of zinc plate joints was smoothed with sharp blade to reveal the edge of the zinc plate. When taking out the mould first the upper portion and the complicated part is taken out. The joint of the plate is sprayed with water to make moist on joint to make easy to detach. Then slowly and carefully the mould is taken out. The inner side of the mould has the negative impression of the clay statue. The clay glued on the mould is taken out with the help of hand and iron tools and the mould is kept on the safe place. Heavy moulds are supported by pulley to make sure not to crash on the floor. For this process the mould section group works together at the same time to separate the mould from different part of the statue. (Fig 46)

In this statue of King Rama V the back portion of the chair was secured formerly by iron rod. The iron rod was taken out with the help of electric cutter. (Fig 47) The big piece of the remaining back part was carefully taken out from the statue lifting up to prevent from accidental fall with the roller lifters which is attached to the walls of the foundry. (Fig 48) After this the main part of the back of the body is exposed and the clay is taken out. Again the iron rod attached to it is cut off with the electric cutter. (Fig 49) The plaster mould is now ready to transfer to the mould section for the further process. With the help of the wheel trolley the mould is taken to the mould section. (Fig 50)

Clean mould with water: On 9th February 2010 on the sixth day of the moulding process, in the mould section the inner side of the plaster mould which has the negative impression of the clay statue, is washed with water spray to make sure that no residue of clay remains on the mould. Likewise all the small pieces of moulds are cleaned with water and let dry for a day or two.(Fig 51,52,53)

Apply soap mixed coconut oil on the plaster: For this process traditional Thai soap is boiled on a charcoal stove and after the soap boils coconut oil is mixed in it. The mixture is boiled for 25/ 30 minutes to its smooth texture. (Fig 54) The hot mixture, with the help of brush, applied on the surface of the mould which has the negative impression

of the model. The hot liquid helps water to absorb into the plaster which helps to strengthen the plaster mould and makes easy to apply oil.



Figure 46 Separate plaster mould from the clay statue.

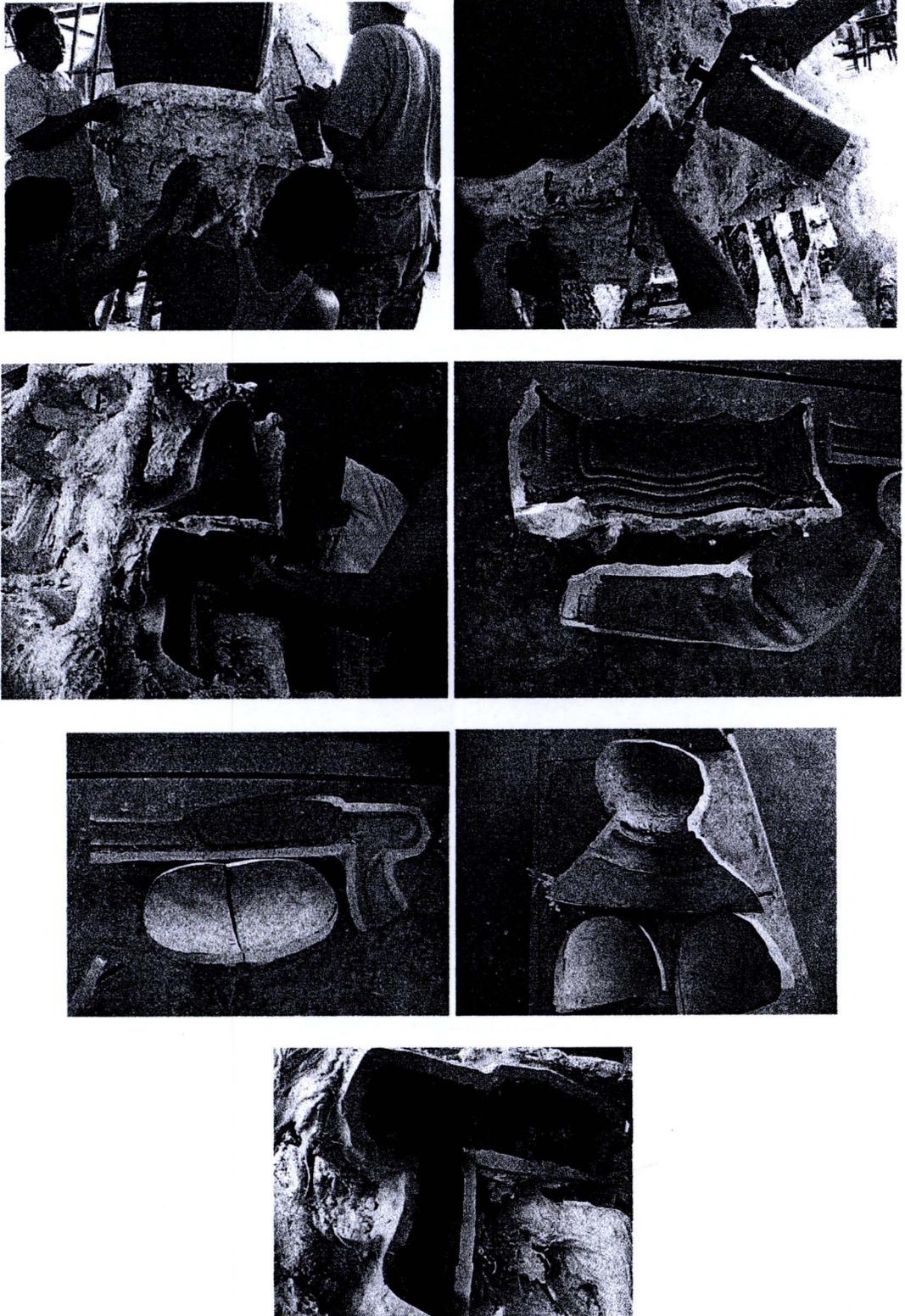


Figure 47 Separate plaster mould from the statue.

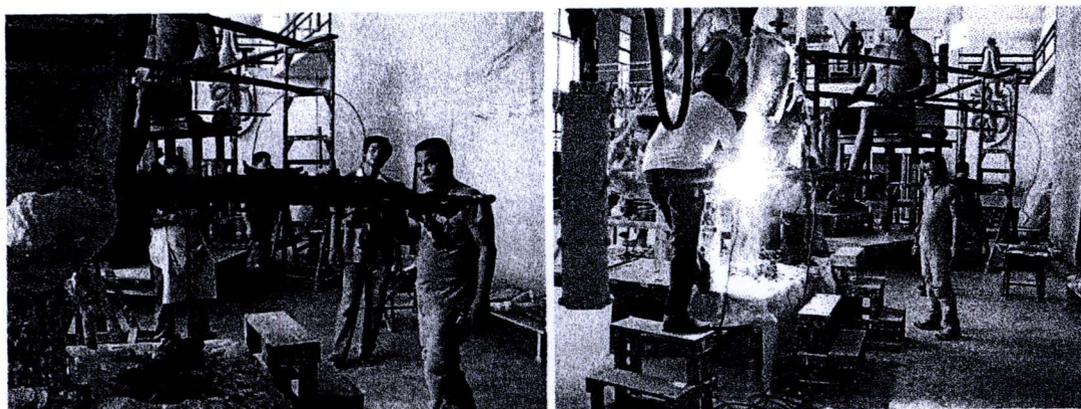
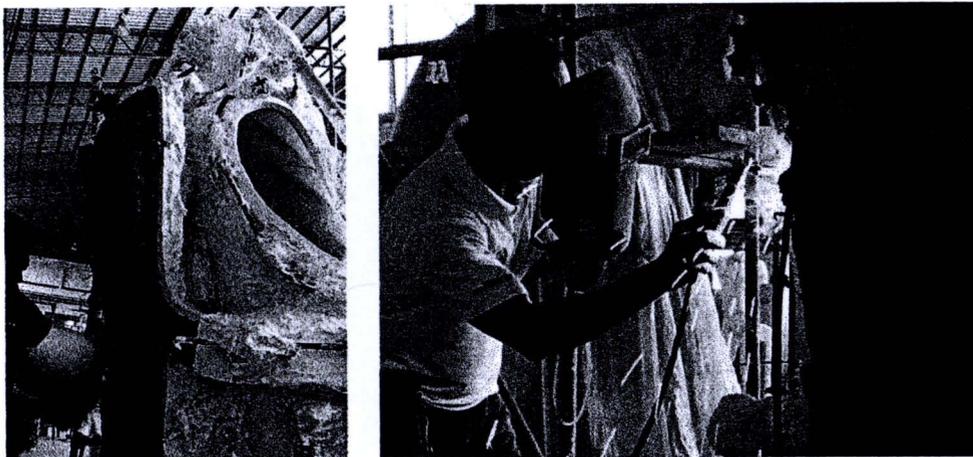


Figure 48 Iron rods taken out attached in the clay statue.



Figure 49 Separating plaster mould of the back of the seat.





Figure 50 Lifting up the separated plaster mould of the back of the seat.



Figure 51 Taking out the clay and iron rods from the plaster mould.

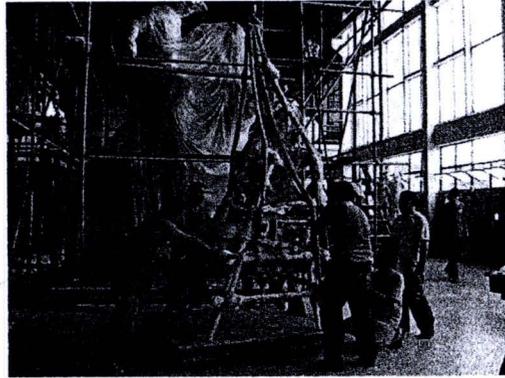


Figure 52 Transfer the plaster mould to the mould section for the further process.

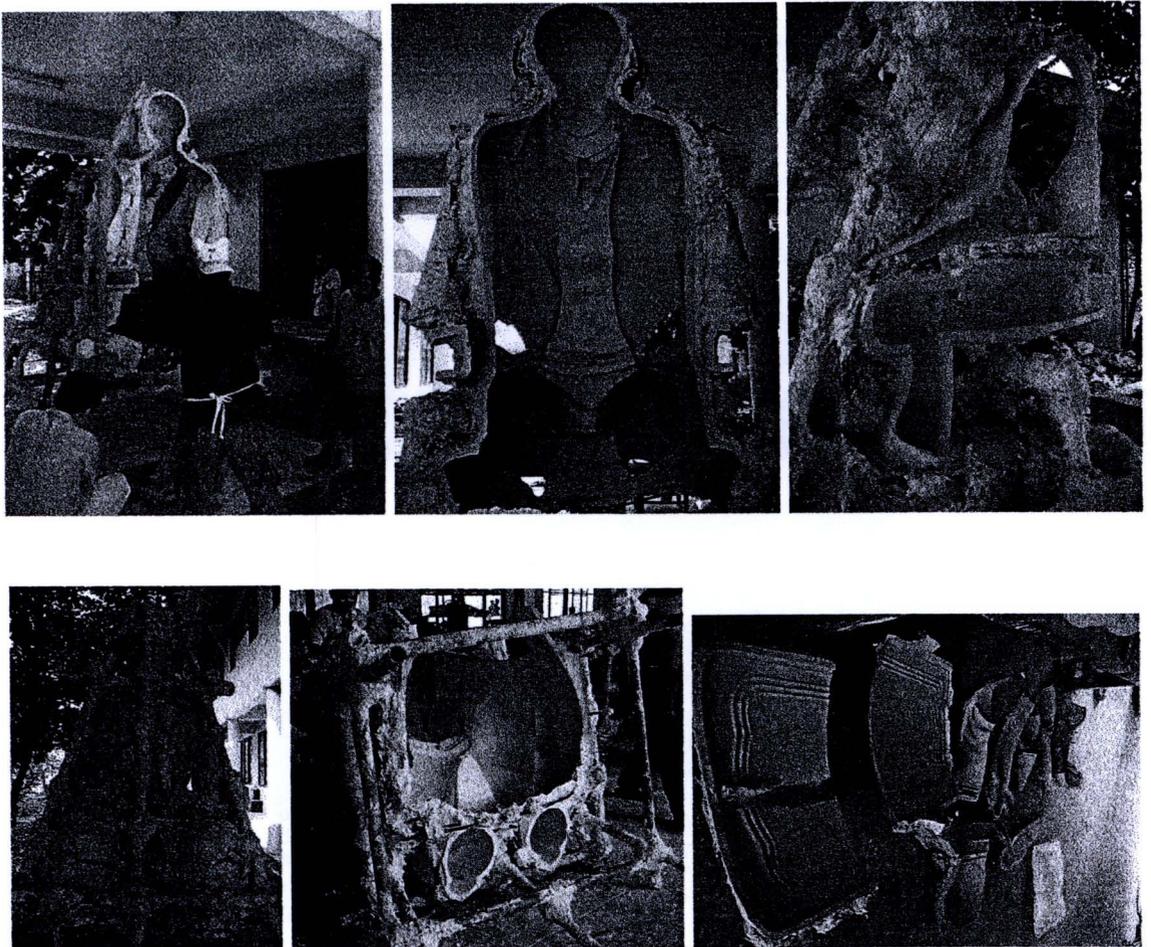


Figure 53 Clean the plaster mould with water spray.



Figure 54 Boiling coconut oil and Soap solution to apply on the plaster mould.

Apply first layer of liquid Gypsum plaster: The gypsum plaster which is a wonderful material for the casting is soaked with water to make a liquid solution in a bowl. Within a couple of minutes the liquid solution settle to its thick liquid texture and with the help of hand and fingers the mould workers apply on the surface of the previously oiled plaster mould. The liquid plaster is literally poured on the surface of the mould and smeared evenly on the surface of the small parts of the mould like head, chair back etc simultaneously. While applying the plaster they have to be careful not to leave any part and corner of the negative impression of the plaster mould.(Fig 55)

Apply second layer of liquid Gypsum plaster mixed with jute fabric: The second layer of plaster is very important to make the mould strong and thick to hold the impression of the statue for many process. Before the process the jute fabric is cut in small pieces. (Fig 56) The fabric is soaked in the liquid plaster and applied on the first layer of plaster. While applying the plaster the thickness have to be even and make sure not to leave any part of the mould. The jute helps to hold plaster and make strong and helps to determine the thickness of the plaster mould. Plaster is smeared upon the fabric mixed layer and with hand plaster is smoothed in all surface of the mould. (Fig 57) This process is done in all the big and small pieces of the mould.

Strengthen the mould with zinc pipe: After the above process the main big mould have to be strengthened. For this zinc pipe are cut in required pieces and placed vertically from the head to the bottom of the body with the help of the coconut hair and plaster mixed as joining adhesive. The pipes are supported with wood blocks sometimes with bricks as well. Again the pipe is supported and strengthened in several places with the coconut hair mixed plaster. In big statues pipes are placed in several places on cross section. (Fig 58) In small pieces for example for the leg and foot of the statue some brick and magazine paper was filled inside the cavity of the plaster mould.

Join the pieces together: When the process of plaster smearing on the negative impression finishes, the main mould and the other small pieces are joined together. The other half pieces are lifted up with the help of electric pulley and carefully joined on the

exact places of the plaster. (Fig 59) The small separate mould pieces are joined with the same process as stated before. But if the mold is not so complicated and small, there is no need of joining instead the plaster covers the whole object as shown in the figure. (Fig 60)

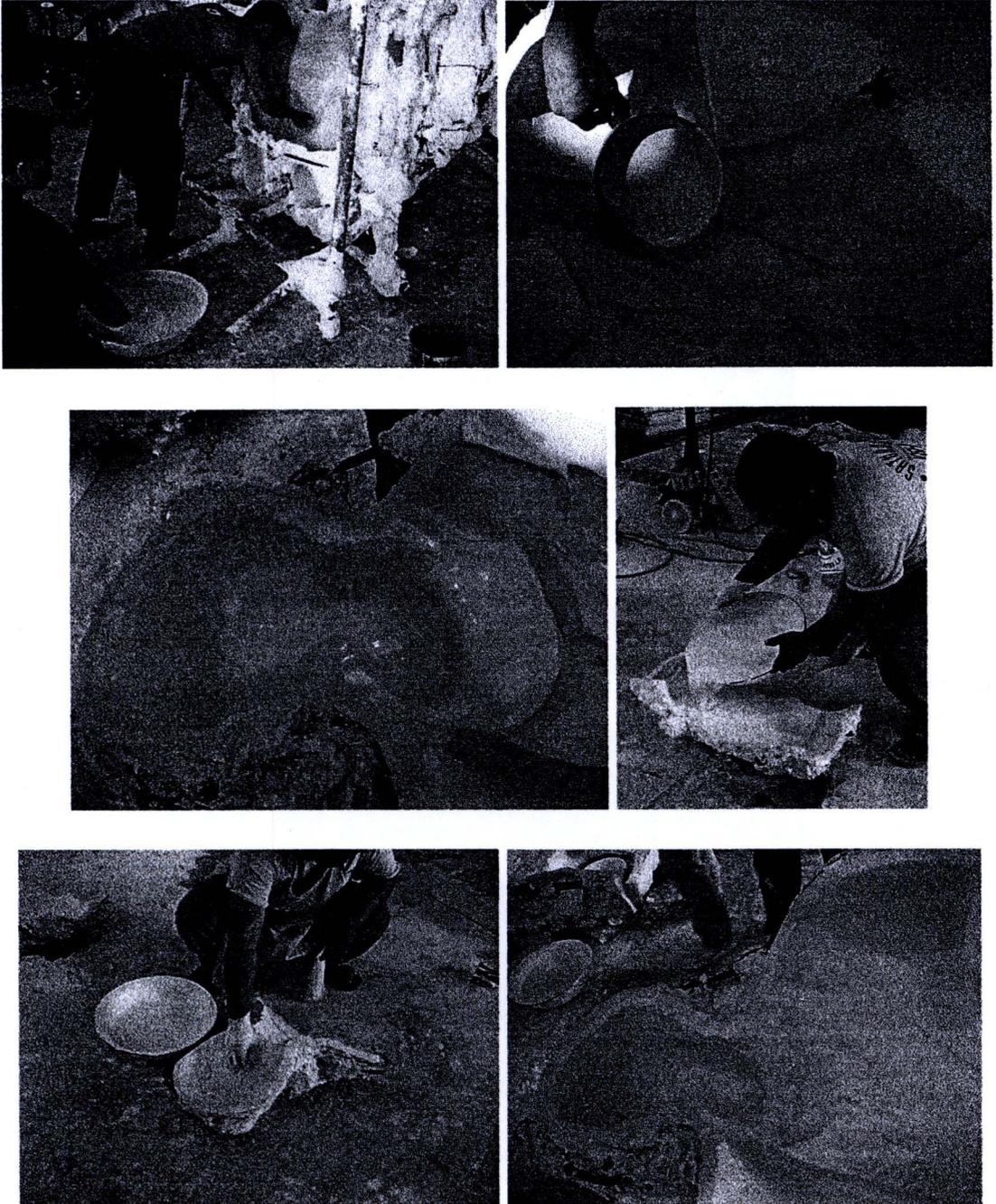


Figure 55 Applying first layer of Gypsum plaster solution.



Figure 56 Cutting Jute fabrics to small pieces.

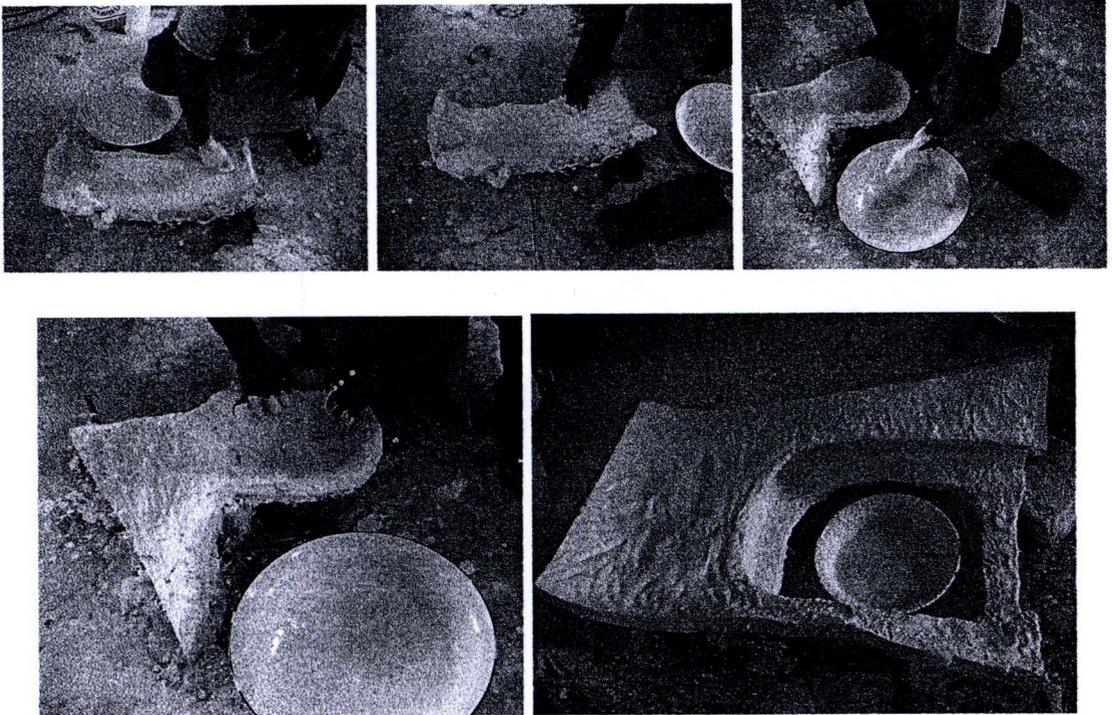


Figure 57 Applying jute fabric mixed plaster.

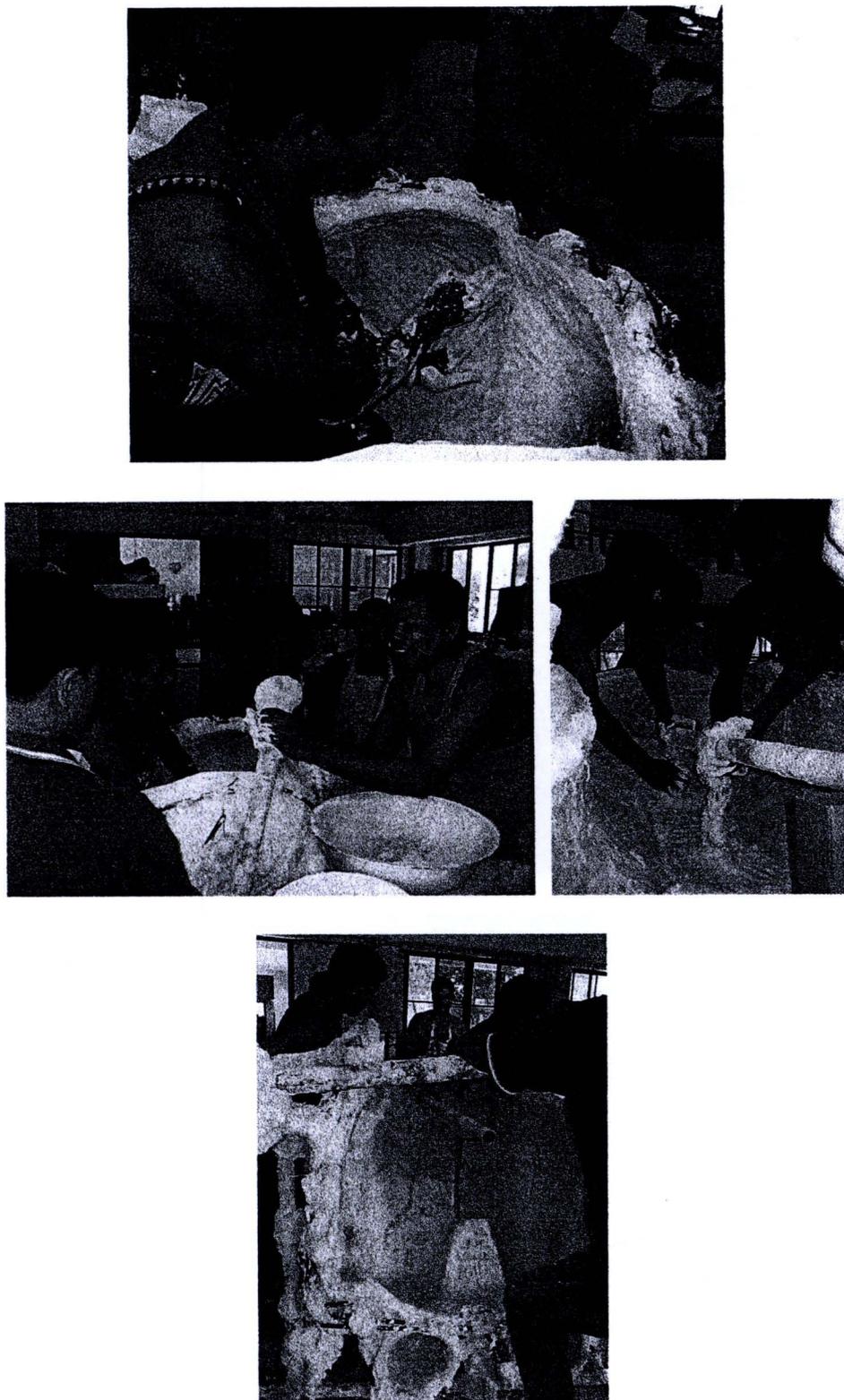


Figure 58 Strengthen the mould with zinc pipe.



Figure 59 Joining the pieces together.

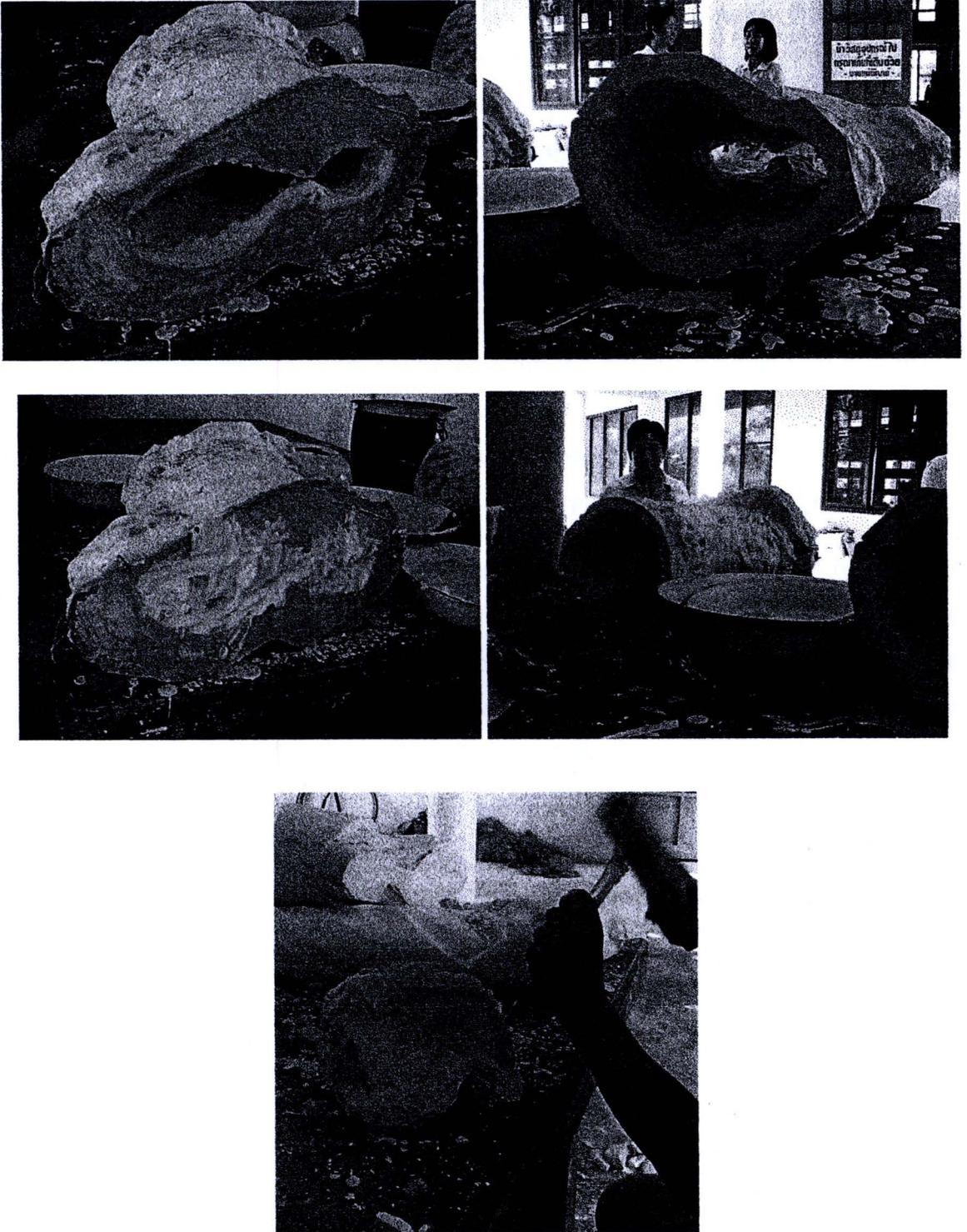


Figure 60 Small moulds joined together.

Strengthen and join zinc pipe to make stand for the mould: When the joined plaster mould dries it is strong enough to put into the upright position. On the next day with the help of pulley the big and with all the pieces intact mould is turned over on upright position which now stands on the zinc pipe which was attached before. Then again from inside the hollow mould zinc pipe is attached on the center pipe. The pipes are welded on the center pipe as two at front and another two at rear which will function as a stand for the other process. (Fig 61)

Detach the iron rod and zinc pipe from the mould: Another step is to detach the iron rod and zinc pipe which was attached to the mould at the beginning of the mould making process. The joints which were made of coconut hair and plaster are cut off by saw and with careful hammering all the iron and the pipes are taken off. (Fig 62)

Break off the first layer of Gypsum plaster coat: The exposed first and the outer layer of plaster are very hard to break off. The staffs gently tapping on the plaster break off the plaster with the help of hammer and sharp scrapper. With taking care not to damage the inner mould the plaster is chipped off from all part of the plaster mould. The oil applied previously helps to detach the inner and the outer mould. When touched with hand we can feel slippery oil on the exposed inner plaster. The plaster inner mould reveals the positive imprint and texture of the clay model. For the small mould for example the leg part in this case, the process is the same for taking off the outer plaster mould from the inner mould as shown on the figure. (Fig 63)

Detach parts of imprinted plaster mould from the main body: When the outer layer of the plaster is chipped off the inner mould with the positive impression is exposed. The mould makers detach the arms, chair rest which are previously planned to detach. Locks or joints are made when the plaster coat is applied on the negative impression. To make lock is very simple just they must have vision on which part it is made by scooping a bit of plaster when it is still wet and after the scooped plaster dries, then another coat of plaster is applied. The detached parts are kept safely aside. This process takes more than a day which depends on the size of the statue. (Fig 64a, 64b)

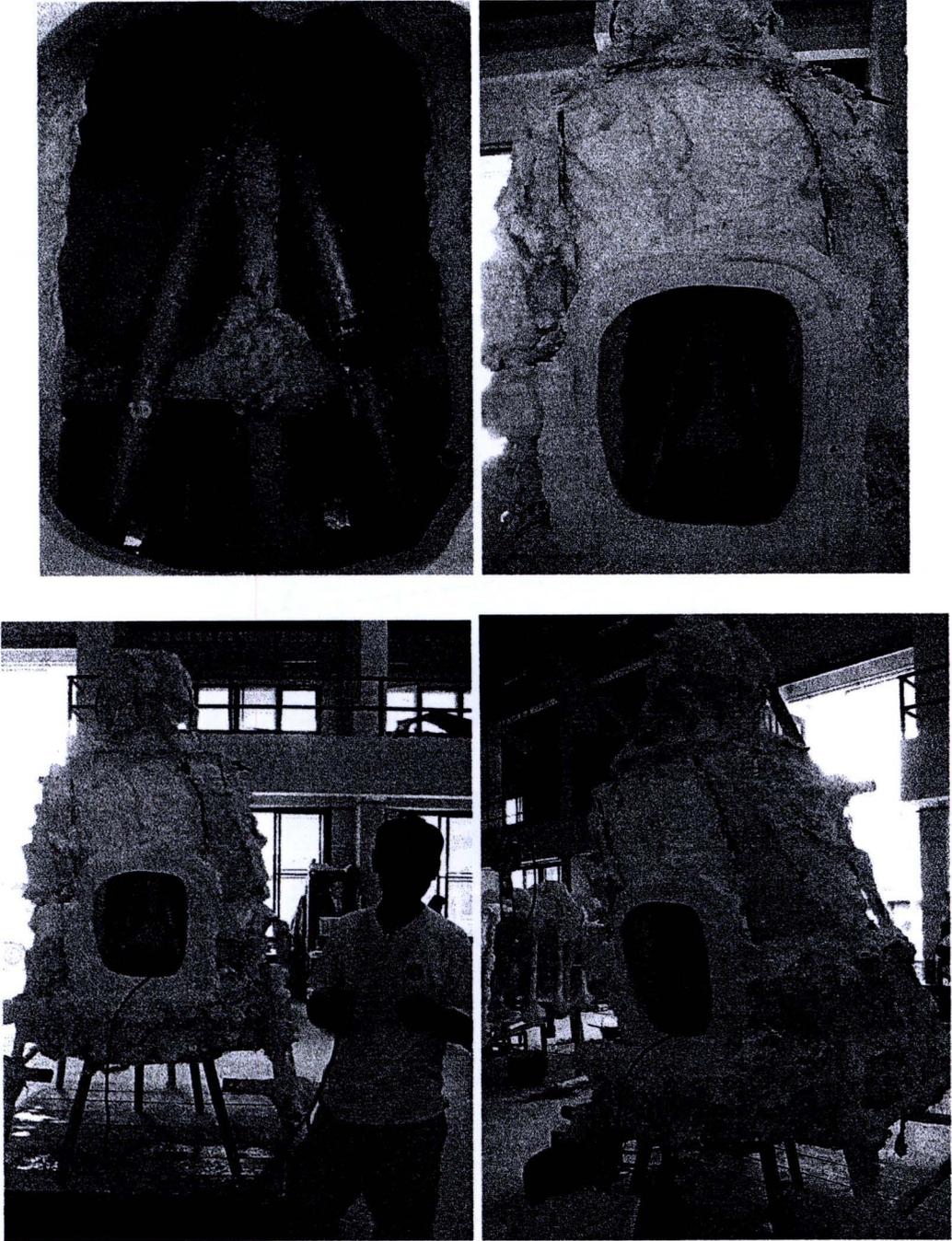


Figure 61 Strengthen and join zinc pipe to make stand for the mould.

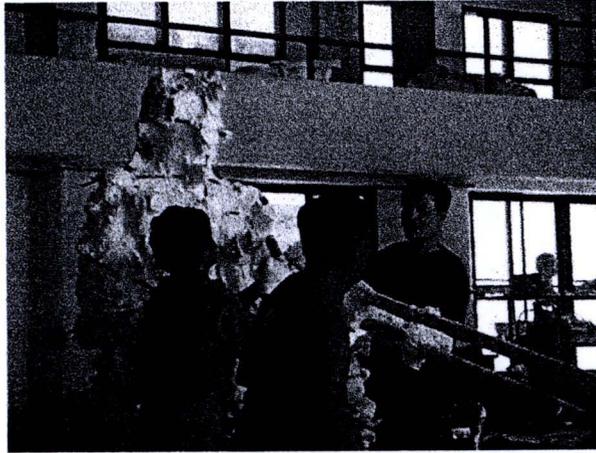


Figure 62 Detach the iron and zinc pipe from the mould.

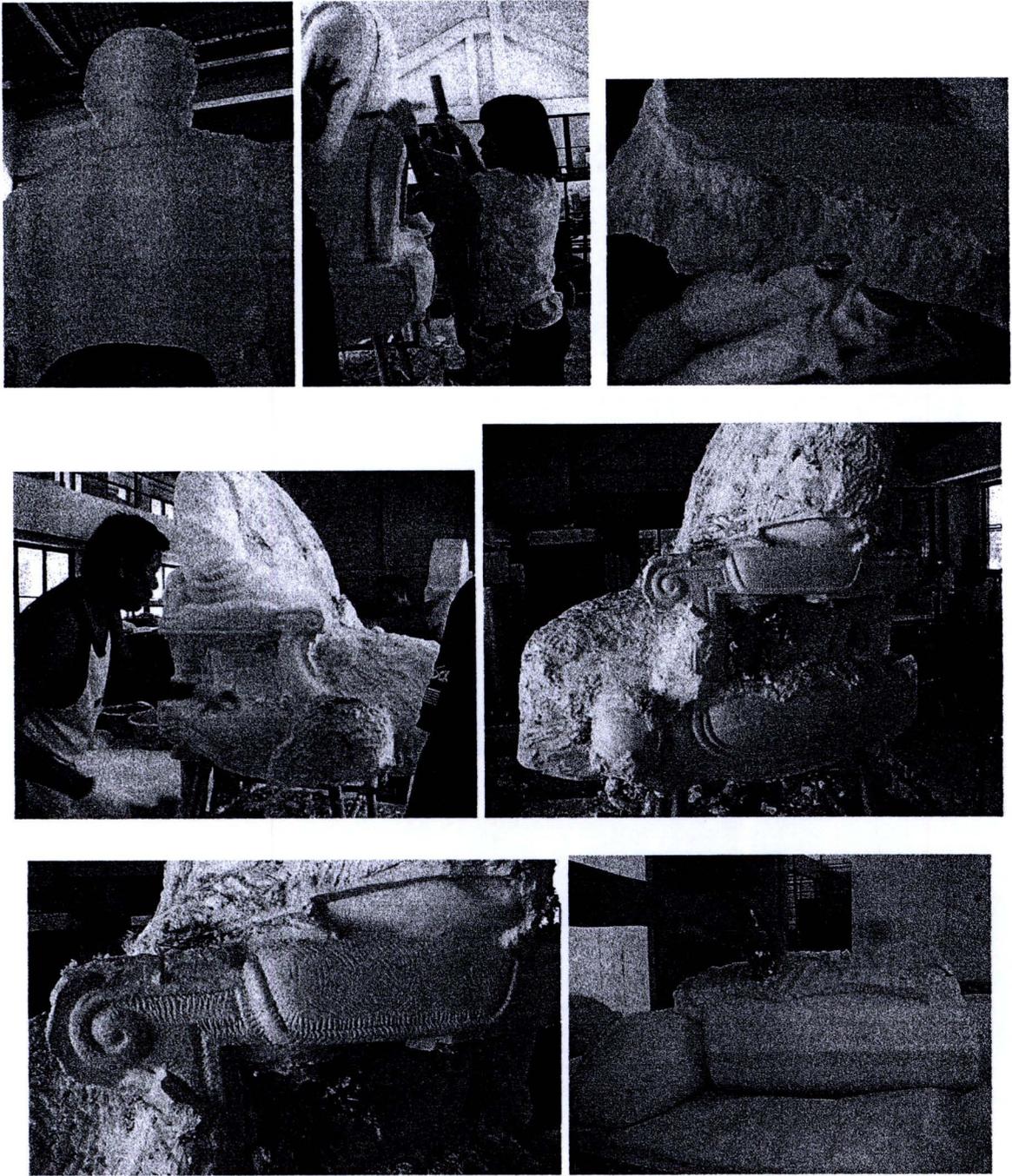


Figure 63 Break off the first layer of Gypsum plaster coat revealing the inner plaster mould.



Figure 64a Detach parts of imprinted plaster mould from the main body.

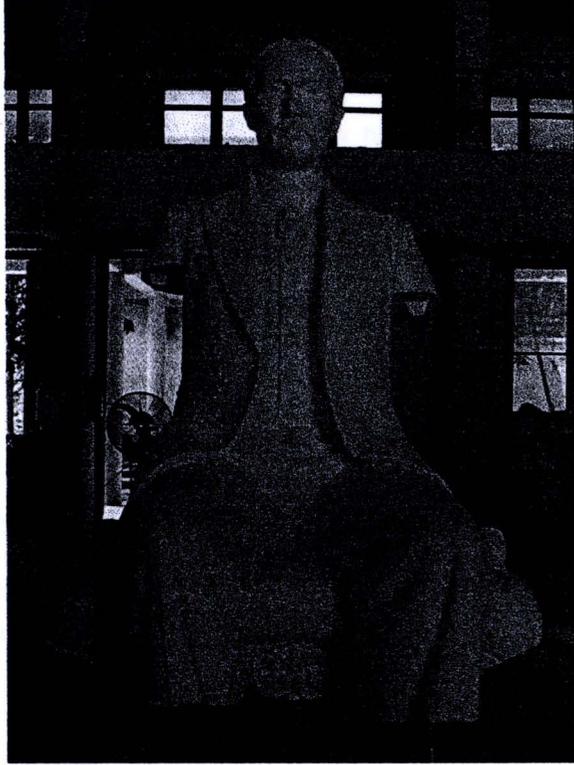


Figure 64 b. Plaster Model.

Make a pedestal for the statue: For the statue of King Rama V of which the molding process is being followed, was supposed to attach another standing statue of Prince Mahidol at the side. After both the plaster mould statue was ready the pedestal to stand the statue was made with plaster and zinc pipe and iron rod strengtheners. (Fig 65)

Join the separated parts of the plaster mould for retouching the detail: After the plaster mould with positive imprint is exposed making sure not to leave the outer mould intact, the main mould is again moved to the sculpture area for the retouch by the sculptor. Here the detached parts are joined with the iron clamp. (Fig 66)

Give finishing touch on the plaster statue: The plaster sculpture is the exact imprint of the clay model which is made at the beginning. This is very important in the process that all the damaged and other details must be carved in the plaster mould because the details on this mould is imprinted on the finished bronze statue. This process takes very long time depending on the size of the statue. The finishing touches are given by the sculptor himself who made the main clay mold and others are the experts on carving personnel. (Fig 67)



Process of making silicon mould

Apply silicon on the plaster mould: The finished plaster statue is transferred to the mould section for the process of silicon mould. To start the process the statue is laid down on the ground with proper support of brick and wood blocks. The statue is surrounded exactly on the halve section by ply wood and news paper is laid on the plywood. Mixture of coconut oil and soap is applied on the surface of the paper to make easy to pull out from plaster. Then liquid plaster is applied evenly on the surface of the paper. (Fig 68)

According to the lady mould maker Mrs Boondharik Yodnval silicon plaster are imported from German and United Kingdom. Silicon made in the United Kingdom is little bit cheaper than the German silicon. German silicon is used for detail of the statue.

Both silicones are found in the liquid form and there are not such rules or ratio of amount mixing the silicon with the standard blue or pink catalyst for high tear moulding rubber. The molders of The Fine Arts Department are very professional and experienced that they mix both silicon and the color catalyst as required for the silicon rubber mould. (Fig 69, 70,) Coconut oil and soap mixed liquid is applied on the partition line and on the base of the board which is placed on the middle line of the statue to separate the halves. A line is made with thin clay line to mark the partition line. The colored silicone is applied on the thin and loosely woven cotton fabric laid upon the statue. Silicon is applied at least three times before apply silicon layered with cloth. The fabric can be seen in Figure . Around the edge one square inch rubbers are nailed to make locks. (Fig 71)

Partition to cover silicon coat with plaster and iron: For the big statues partitions are made to make easy to separate the portion for separate cast. Silicone applied surface is covered with liquid Gypsum plaster piece by piece. While applying the gypsum plaster, the area of complicated curves on the statues are separated with thick plaster partition. The edge of the plaster partition must be smooth in straight clean line and locks are made around with scooping plaster while it is still wet. Upon the plaster piece another layer of plaster is applied upon which iron rods are attached with the help of coconut hair and plaster to strengthen encase of silicone mould. Same process is repeated on the other side of the statue. After finishing this process the mould is left to dry for several days which depends on the size. (Fig 72)

Take out Silicone rubber sheet from the plaster mould and insert on the outer plaster mould: From the above mentioned process dried plaster mould is prepared for the process in which the outer layer of plaster is taken out carefully with the help of several people and in some case with the help of pulley. This block is kept aside with the inner side up. After this layer comes out there remains the block of plaster partition stated at the former process. The partition pieces are taken out form the silicon layer and places on the exact position of the outer plaster layer. Then the sheet of silicon layer is peeled off from the plaster sculpture and laid down on the outer plaster on the exact position upon the partition pieces which reveals the inner impression on the silicon layer. This

inner layer is the main negative imprint of the plaster sculpture. When seen from above the form of the statue can easily be recognized. (Fig 73)



Figure 65 Making pedestal for statue.



Figure 66 Joining the separated plaster pieces together.

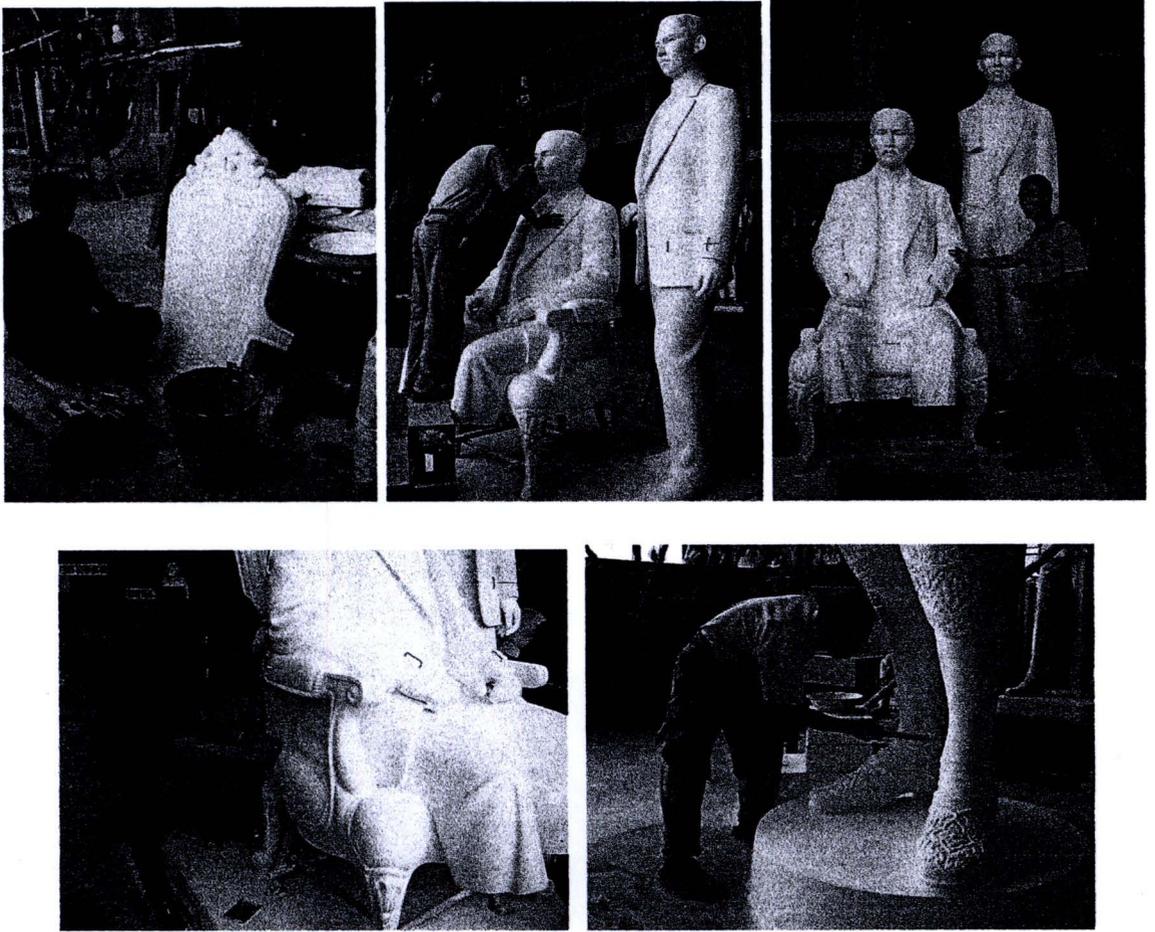


Figure 67 Giving finishing touch on the plaster statue.



Figure 68 Preparation for silicon mold.

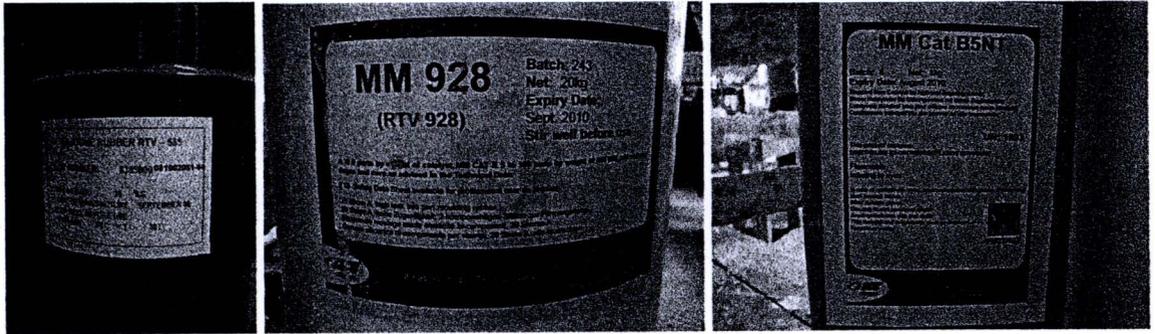


Figure 69 Silicone Rubber and Standard Blue Catalyst for high tear moulding rubber

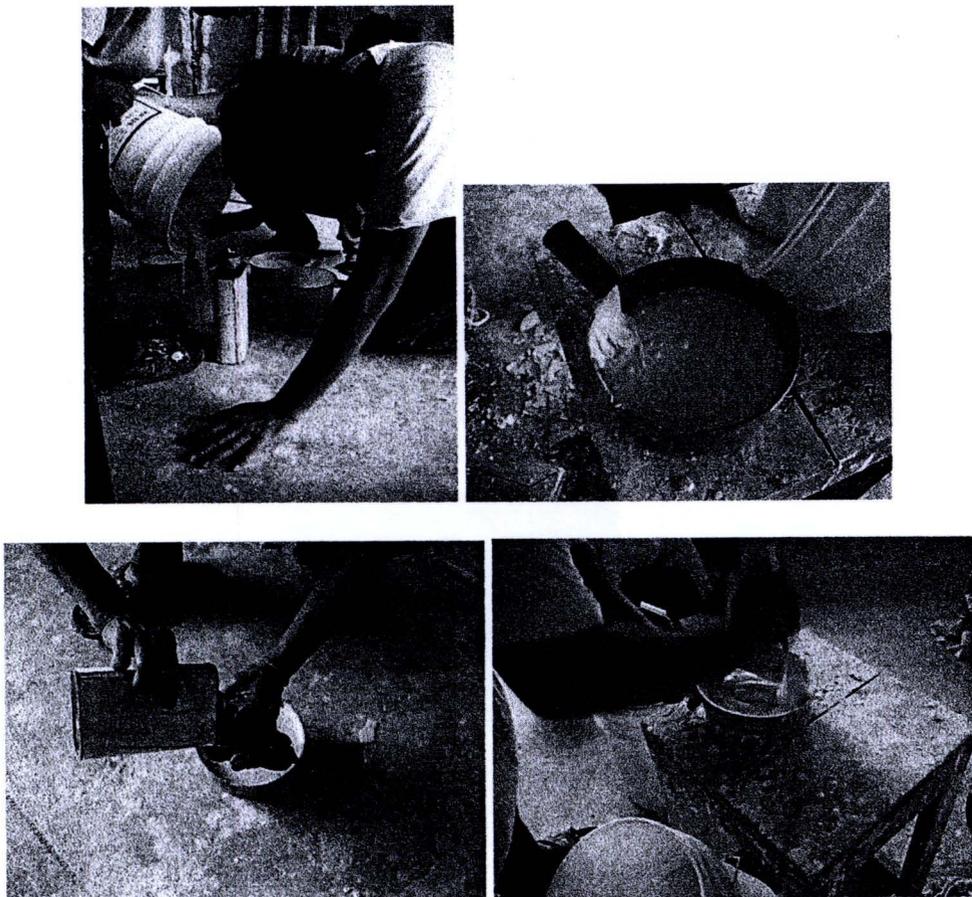


Figure 70 Mixing MM 928 Silicon Rubber and Standard Blue Catalyst.



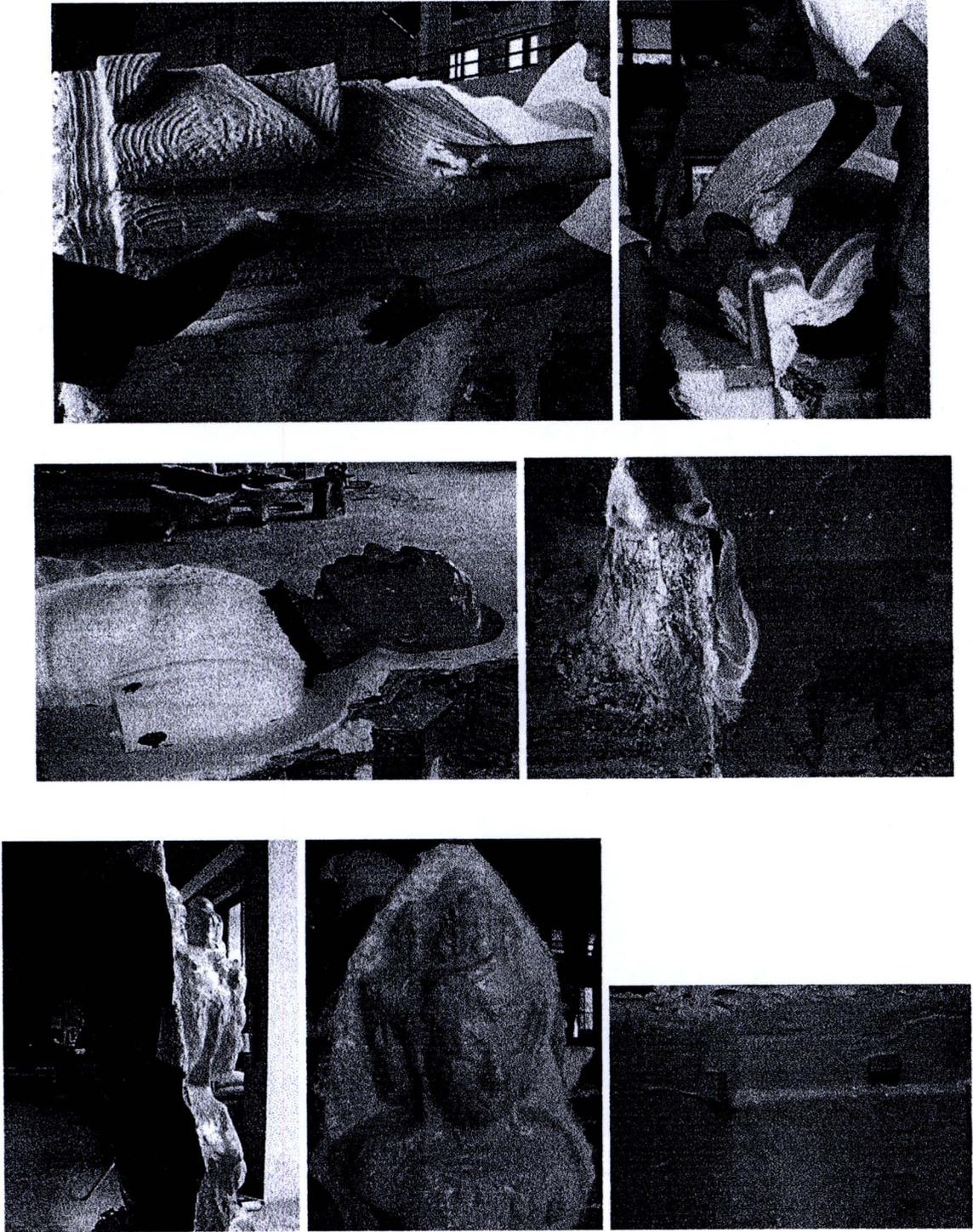


Figure 71 Apply Silicone Rubber on the thin cotton fabric.

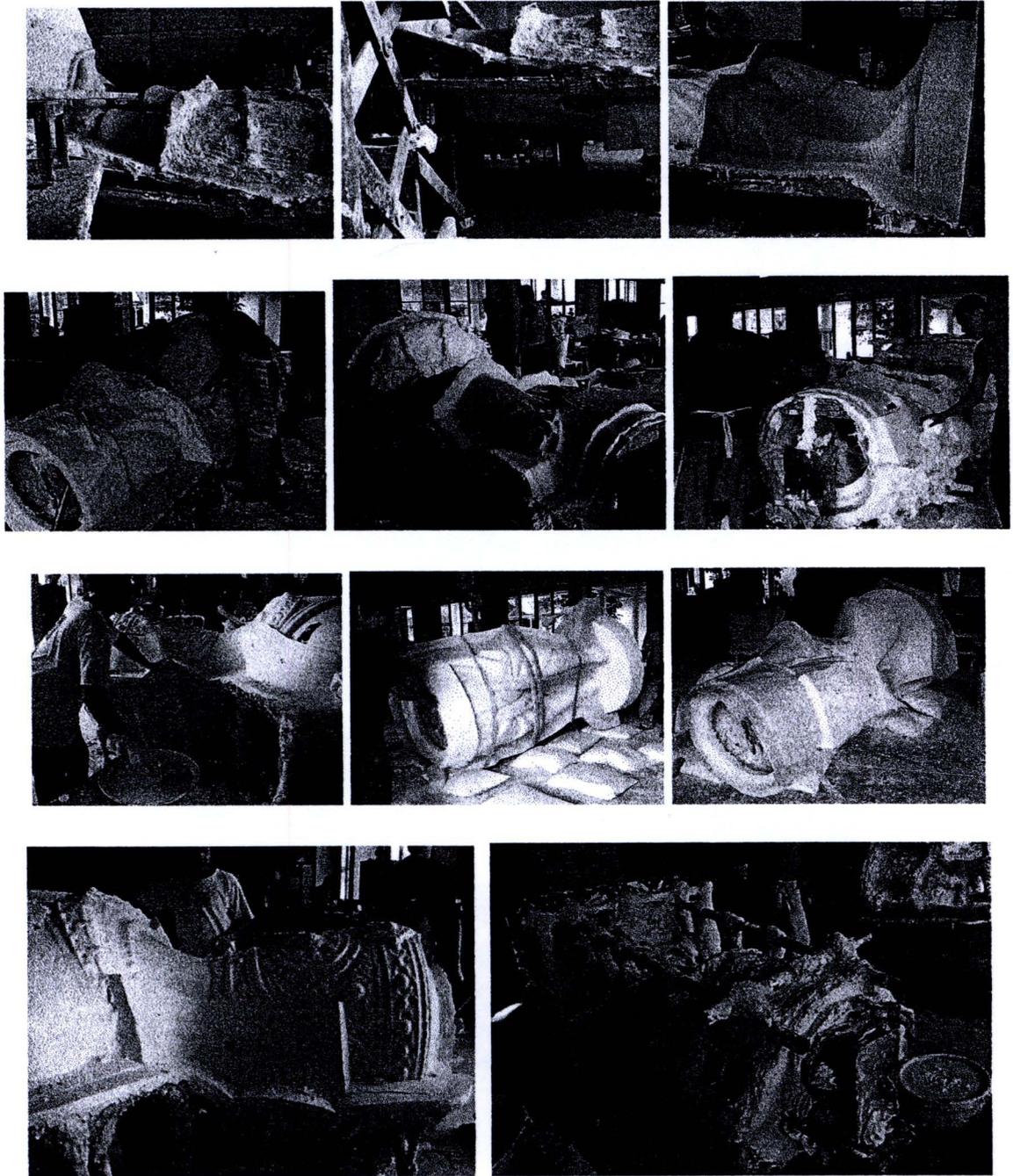


Figure 72 Apply Silicone and strengthen with Gypsum plaster and iron rods.

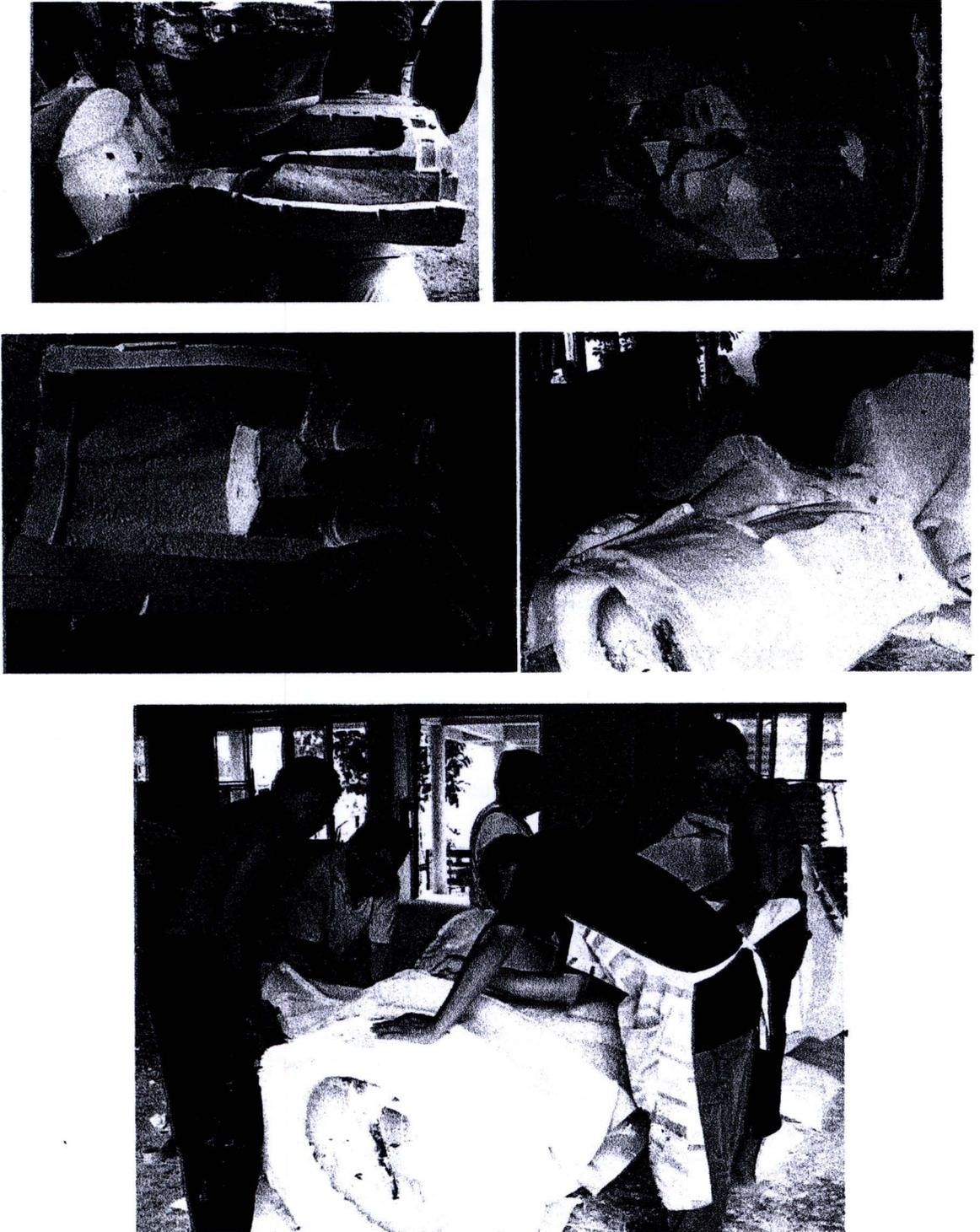


Figure 73 Take out Silicone rubber sheet from the plaster mould and insert on the outer plaster mould.

Process of making wax mould

Apply first layer of liquid wax on the silicon: Main process of lost wax process commences from the further process. At the beginning of this process colored wax is boiled on a pot to melt. Then the melted wax is applied on the exposed silicon sheet with the help of brush and makes sure all the surface is covered with wax. (Fig 74)

Apply second layer of liquid wax on the first layer: A good quality wax is melted on a pot and applied evenly on the surface of the first layer of colored wax. The reason to use melted wax is it helps to give details of the sculpture.(Fig 75)

Stick wax sheet on the second layer: For this process a good quality wax, same used for the above mentioned process, is melted on a tin pot and after the wax melts and boiled for some time, the liquefied yellow wax is poured on a pool of water. Wax semi cools in the water and floats on the surface, then the wax taken out from water by hand and mashes firmly to make a ball. The ball of wax is rolled on the wooden board which has half to one centimeter raised boarder on the edge. Wax is rolled until it become as plain as a uniform layered sheet. Then the sheets are dipped in the pool of water to cool and after taking out, the sheets of wax are cut in square shapes. (Fig 76)

The most important part of making the sheet of wax is, the thickness of wax determine the thickness of the bronze. The thickness of bronze varies the cost and quality of the bronze sculpture. The thicker the bronze, more expensive and more durable and strong it becomes.

The wax sheets are again cut in required pieces to stick on the second layer of wax. Before sticking the wax, the adhesive made of vegetable oil and resins are boiled and the hot liquid is applied on the surface with the help of brush. (Fig 77)Then the wax sheets pre heated to its softer form is stick to the adhesive. Wax sheets are pressed by hand in all the corner and folds with the expert hands of the mould makers. They have to make sure that the wax sheets are laid firmly and evenly on the surface.(Fig 78) same process are repeated on the other halve portion of the plaster sculpture.

Joining the halves together: After the silicon mould is covered by the wax sheets the two halves of the mould is joined together. Since this is the hollow cast the hollow part of the mould is strengthened with iron rod and if necessary insert the wax rod for strength afterwards and filled with mixed solution of sand, mud and Gypsum plaster solution. The liquid when dries is very hard enough to hold the wax on place and heat resistant when heated to melt the wax off for the lost wax process. (Fig 79)

Take off silicon sheet from the wax revealing the wax sculpture: The ceramic plaster and sand filled silicon mould covered with wax sheet is left for some days to dry. Then the plaster cover encased silicon is taken off and the silicon cover reveals. The silicon is then peeled off revealing the wax sculpture with positive impression of the sculpture. (Fig 80, 81)

Finishing touch on the wax sculpture: The wax statue stands firmly because inside is the plaster sand mixed block. The sculptors again have to give the finishing touch on the wax not to leave any defects. The texture on the statue is refined. (Fig 82, 83)

Attach wax rods to make runner and channels

Wax rods join on the sculpture to make runner and channels: To make the channels of wax, wax is heated in a pot. When wax melts, some portion of wax is poured in a pot of cold water and when the wax cools a bit is taken out and mashed with hand until it becomes soft without any lumps. Then with hand wax is rolled on a wooden board with hand to make uniform parallel rod as channels and some conical rod as sprues of about one inch in diameter. An iron rod is heated on the fire, then the rods are cut in required length and heating the bottom of the rod and the exact spot of the statue with the iron rod where the wax rod has to be attached is heated and soon the wax rod is attached on the same spot. One or more wax sprues are added to conduit the molten metal into the sculptures which typically directs the liquid metal from a pouring cup to the bottom of the sculpture, which is then filled from the bottom up in order to avoid splashing the

turbulence. Additional sprues may be directed upward at intermediate positions, and various vents may also be added where gases could be trapped.(Fig 84)

Apply methyl alcohol: The finished wax statue with wax runners and channels are coated with methyl alcohol. Methyl alcohol helps the wax not to attach on another mould or shell going to apply in another step. The alcohol coat helps to smooth the surface of the bronze as well. (Fig85)

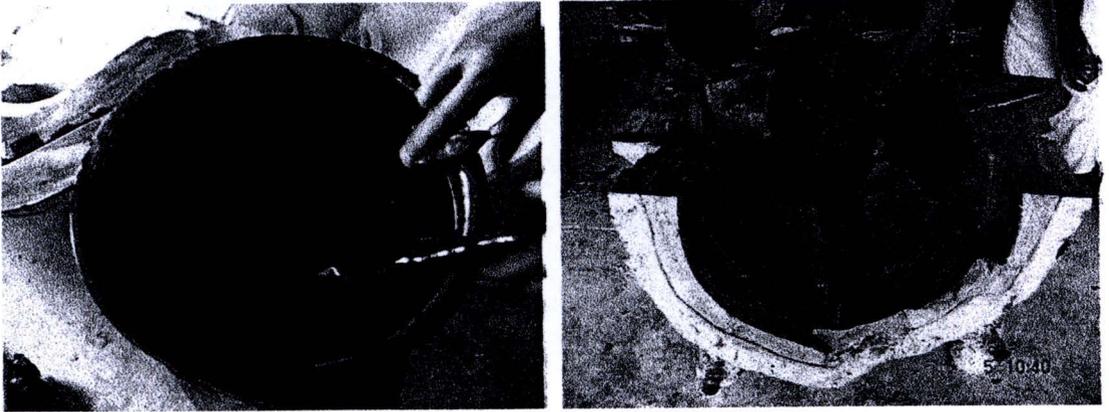


Figure 74 Apply first layer of liquid wax on the silicon.



Figure 75 Apply second layer of melted wax.



Figure 76 Making wax Sheet.



Figure 77 Apply adhesive solutions on the second layer of wax.

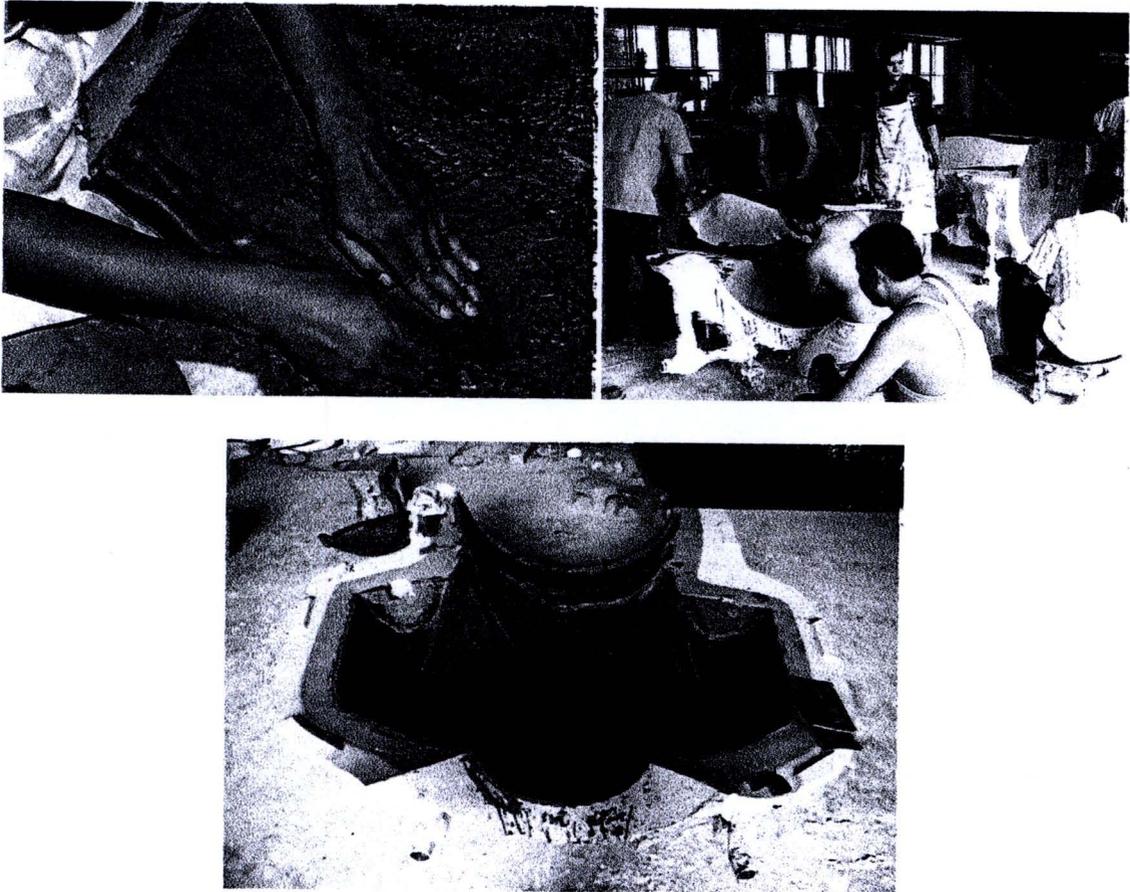


Figure 78 Stick wax sheet on the adhesive solution.

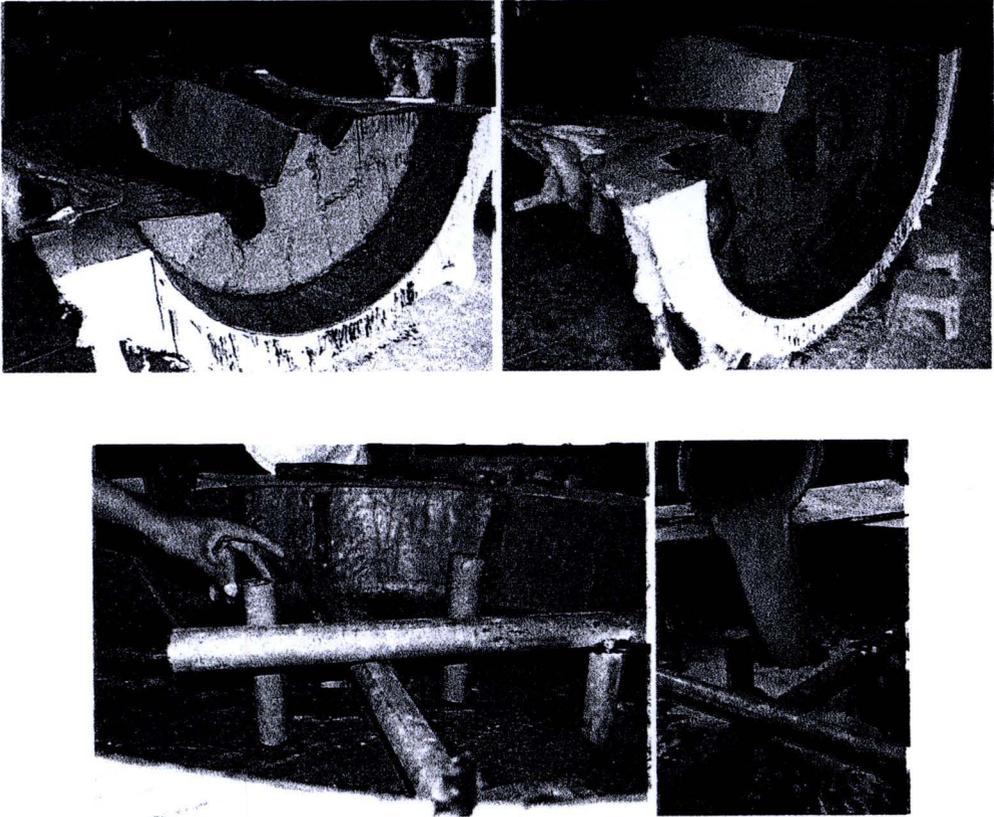


Figure 79 Join the two pieces together and strengthen the hollow with pipes and pour plaster and sand mixed liquid.



Figure 80 Separating the outer plaster incase revealing the silicon.



Figure 81 Peeling off the silicon sheet revealing the wax statue with the positive impression.

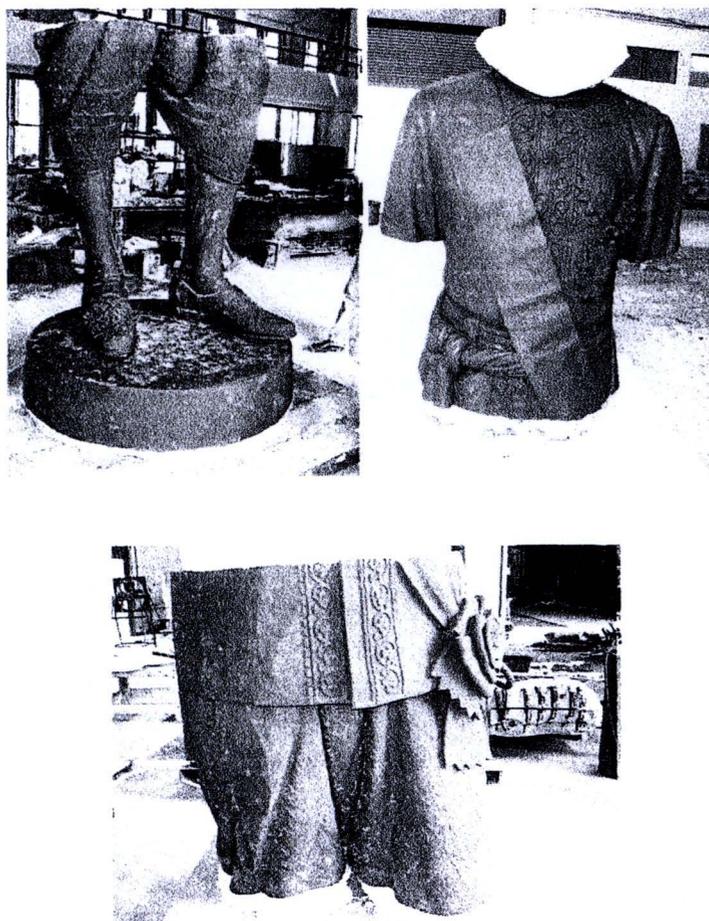


Figure 82. Wax Sculpture exposed from the silicon encase.

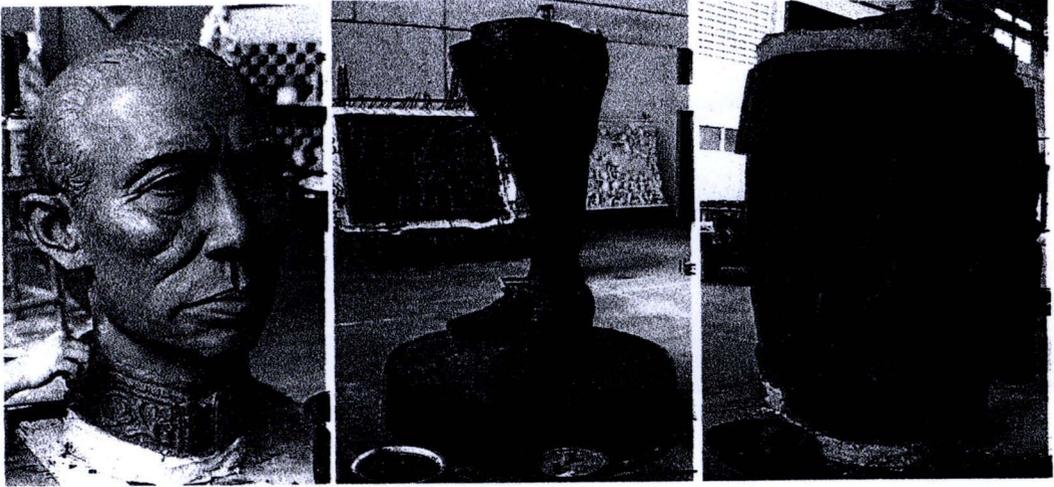


Figure 83 Final retouch and refine the texture on the wax.

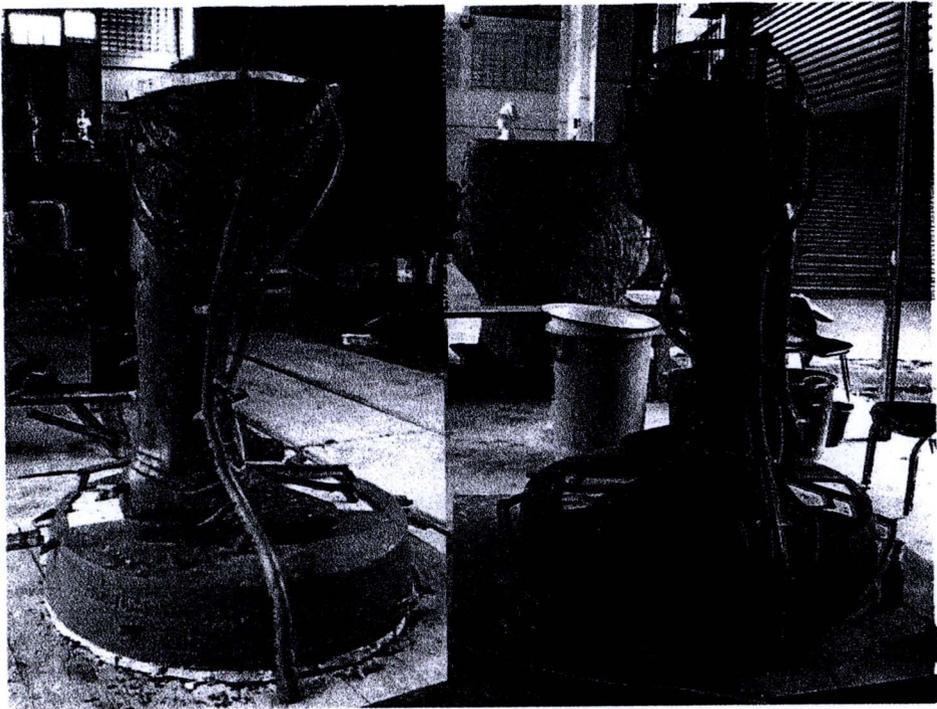


Figure 84 A Attach wax channels and runners.

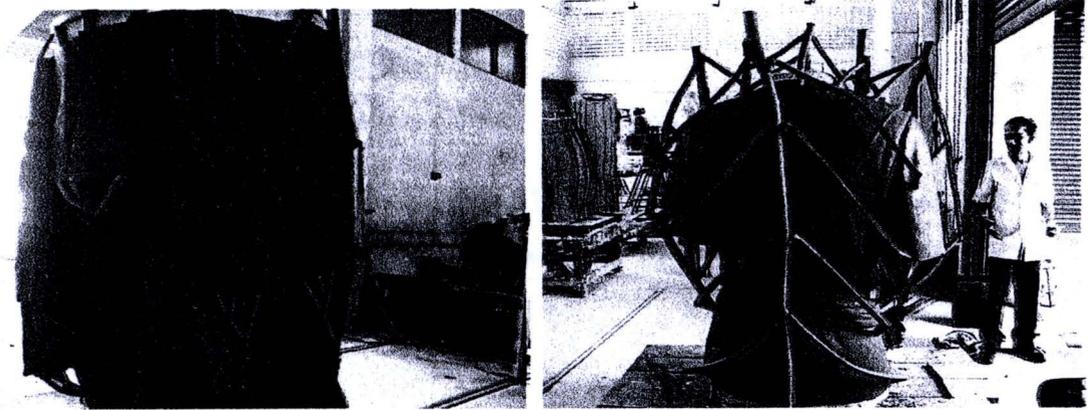


Figure 84 B Attach wax channels and runners.

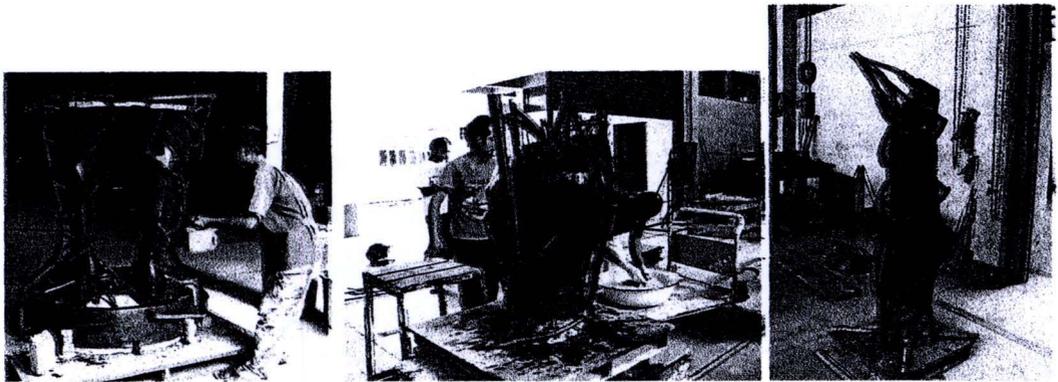


Figure 85 Applying methyl alcohol on the wax sculpture.

Wax structure invested in another mould or shell: The complex structure and previously added core is then invested in another kind of mould or shell. Before the process begins at least two inch long iron nails are hammered gently on the wax which has to penetrate a bit into the core plaster as well. The nails are not fully inserted on the wax but leave at least one inch outside. The nails help to put together the plaster of core and outer mould at place during wax melting and bronze casting. Next process is to make a solution of plaster and sand mixed with water. The liquid solution with hand is sprayed on the wax structure. With several coats of solution which covers the wax and its attached wax channels, the outer layers are made thicker and thicker so that the encasement become more hard with heat resistant ability. Outer layer of plaster is literally pasted and smeared by hand to make the layer of plaster thick and even at all places. (Fig 86)

Strengthen mould with iron rods: Plaster layered wax sculpture is strengthened with mesh of iron rods. Rods are tied and welded together from top to bottom of plaster with horizontal and vertical mesh of iron rods. (Fig 87) For once again iron rods are encased with the sand plaster mixed paste evenly to make the mould strong. While applying the plaster the wax sprues and pouring channels are keep open. (Fig 88)

Heating Process to lost wax from the invested mould

Make kiln to melt wax: The mould prepared with above process is arranged to melt out wax. For this the mould is places on a base of brick and clay. An iron or zinc pipe is attached as a channel to help run out wax at the bottom of the mould where previously wax channel is exposed. At the mouth of the hole where wax comes out a spout is made of clay to make easy melted wax fall on the pipe. Then the invested mould is surrounded by brick wall leaving holes to send fire inside from two directions and a small hole to check the status of melting wax just above the flowing pipe. Small holes are covered with loose bricks which can easily be removed to inspect the wax flow. Usually brick walls are made round on two side and straight with corner is made at the side of the burner. Round walls helps hot air of fire go around the mould which enable heat move to

all direction of the mould. (Fig89, 90) Brick walls are made high to the top of the mould which can be covered with tin sheet to prevent heat leak while heating process goes on. To prevent possible heat loss, holes on the brick and cover are closed by applying mud paste inside and outside of the brick wall. (Fig91)

Give heat by burning gas or firewood: When the kiln gets ready to heat, firewood or gas is burnt directing the flame from the hole into the space around the mould. At present gas is easy to use for burning out wax and it save time and can control the heat as well. Fire wood is used in some special cases as to heat gas cylinder or to heat the mould before casting bronze. The temperature of heat has to exceed more than 1000 degree centigrade to melt wax and liquefy to run out easily from the channels created by sprues.. The mould is heated for several hours to melt wax and flow out of the mould. The flow can be checked from the small hole which was prepared before when kiln was made. Wax is collected on bowls. If steam comes from the hole from where wax runs out it is understood that there is no more wax in the mould. When all wax runs out, the space in the place of wax in the mould becomes hollow and heating the mould longer enables to get rid of moisture inside. The removal of all wax and moisture prevents the liquid metal from being explosively ejected from the mold by steam and vapor. (Fig 92)

Turn the mould upside down to prepare for bronze cast: After the wax in the mould is lost completely, the mould has to turn over to prepare for the casting bronze. The holes on the bottom of the mould is closed with plaster and sand and other holes exposed at the top of the mold will be used as pouring hole for bronze and air vent. The pouring funnels are made on the holes with attaching funnel surrounding with plaster. Moulds are again places on a brick pedestal and strengthen with zinc pipes to stand erect until the casting process finishes. Pouring holes and vent holes are covered with brick which can be taken out time to time to check the air inside the mould. The mould is again pasted with clay mixed plaster to close cracks occurred by heating to melt wax. Then the mould is surrounded by a wall made of brick. The brick wall also has to cover by plaster and clay to close the holes between the brick joints. There have to be space left between the mould and brick wall inside. On the day of casting bronze in the space inside, burnt

charcoal is placed to preheat the mould before pouring the melted bronze into the mould. (Fig 93). Before pouring the melted bronze, the brick walls are dismantled and the invested mould is again pasted with clay plaster to close cracks and make as strong as possible to make heat resistant. (Fig 94)



Figure 86 Applying Gypsum plaster and sand mixed liquid on the wax.

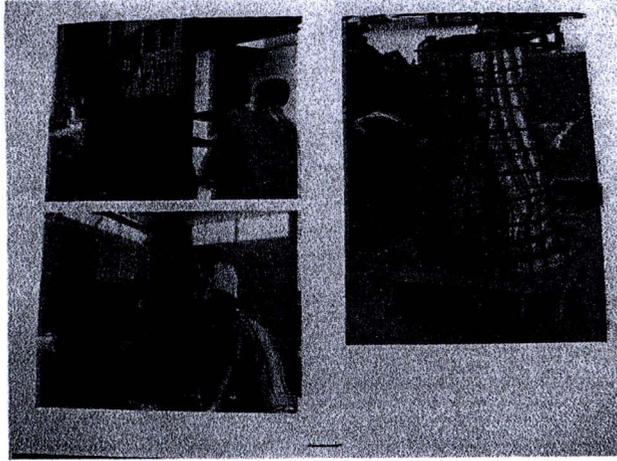


Figure 87 Strengthen wax mould with iron rods.

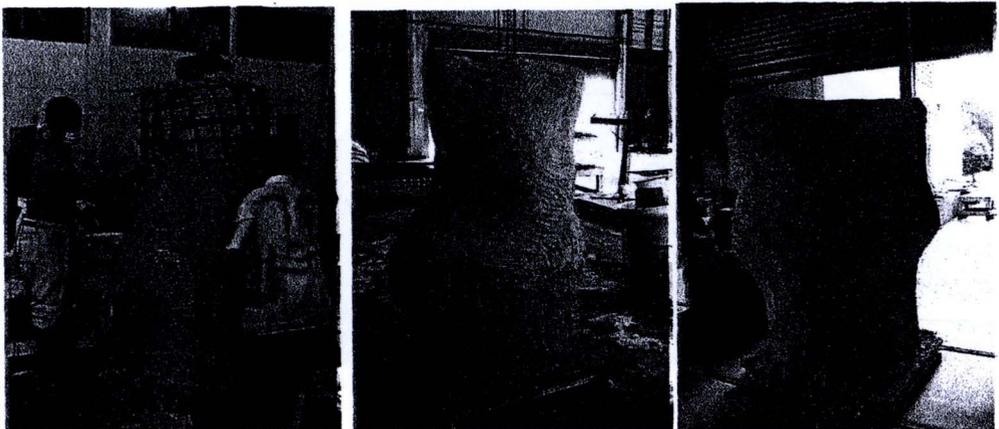
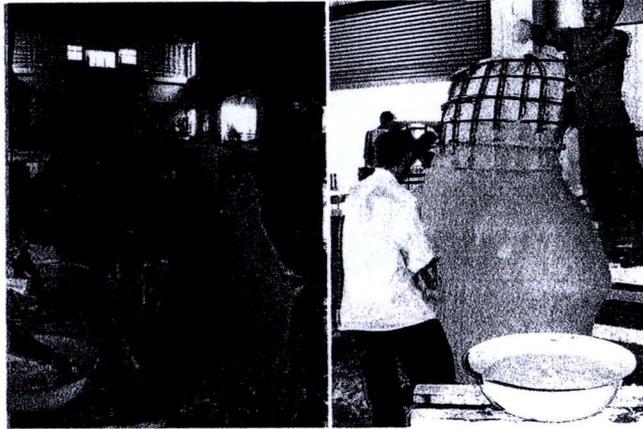


Figure 88 Applying Gypsum plaster and sand mixed plaster on the iron frame.

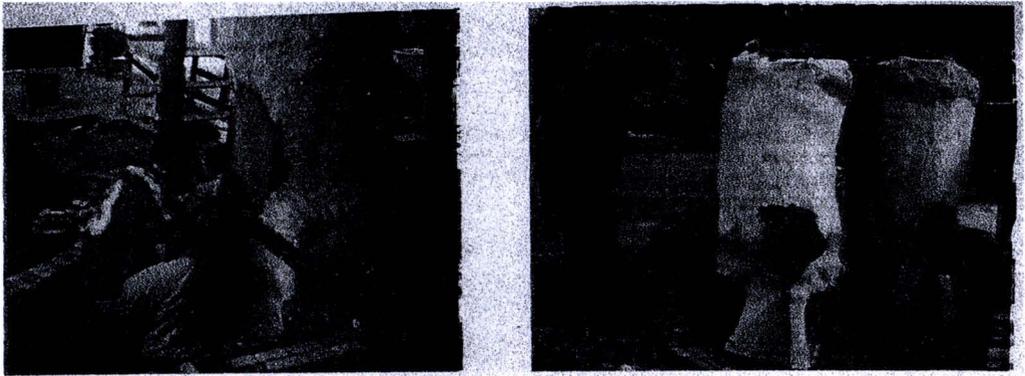


Figure 89 Prepare mould and kiln for melt wax.



Figure 90 Brick Kiln to heat mould and melted wax flowing out.

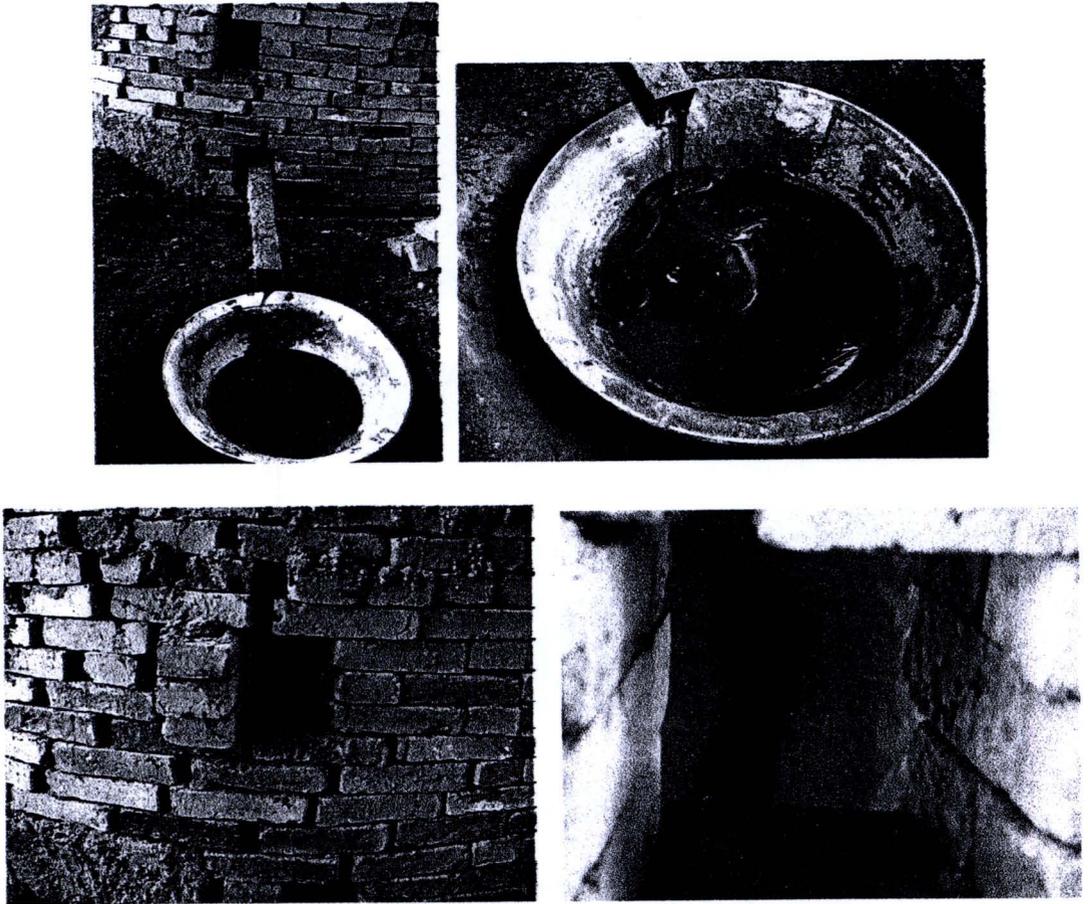


Figure 91 Wax running out from pipe and tiny hole to see the status of wax running out.

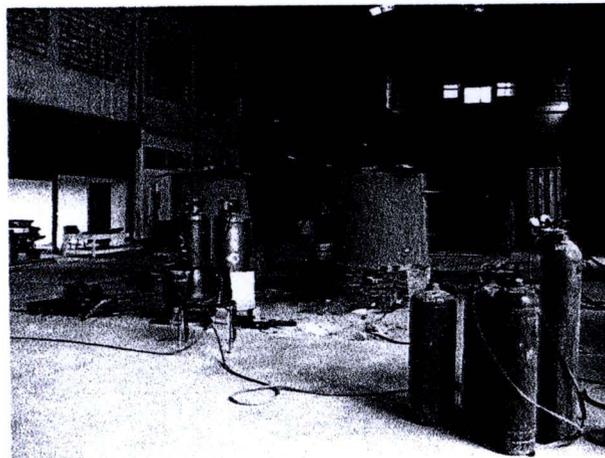


Figure 92 . Gas cylinders on boiling water to make easy flow of gas

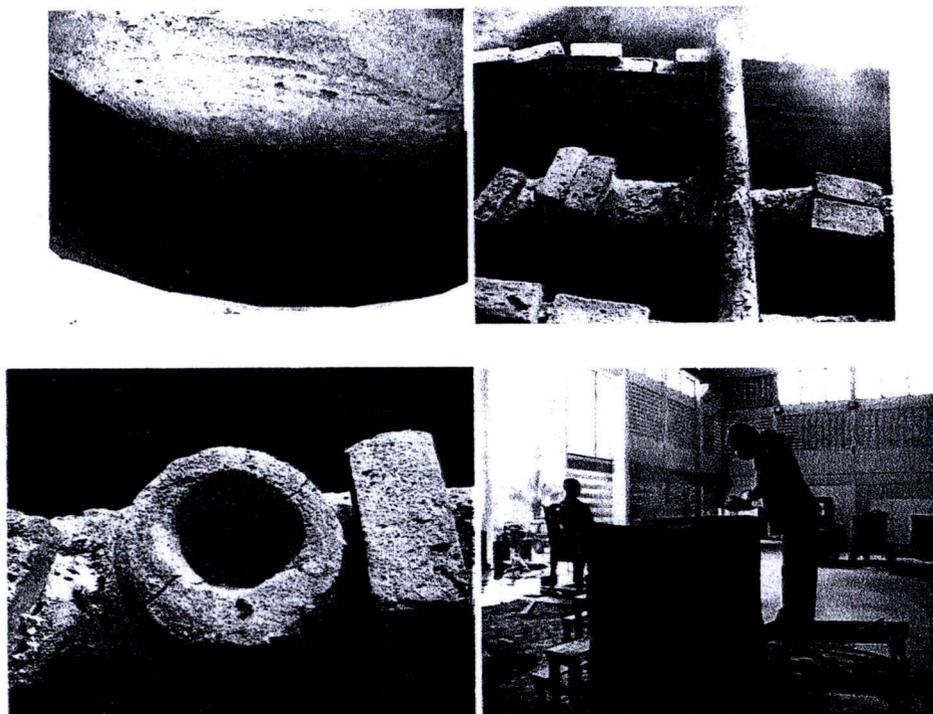


Figure 93 Pre heating the mould before casting bronze.



Figure 94 Dismantle surrounding brick wall and close possible holes with wet clay plaster.

Process of melting Bronze

Prepare crucible: In the traditional casting process, the crucible used to hold the molten bronze is made of clay that is very pure and plastic type as used for making the clay statue. Clay is mixed with sand, cow dung and rice husk. The higher percentage of rice husk together with the use of a more plastic type of clay produces a much stronger vessel which can withstand the very high temperatures required to melt the bronze. In the contemporary process the crucibles are made of silicon, cobalt and graphite. The crucibles are about fourteen inch in height and eight inch in diameter, with one inch thick walls. The crucibles are conical in shape with flat base with smaller diameter than the rim of the crucible. (Fig 95)

Get ready tools and furnace: Different kinds of tools are needed to cope with high temperature of heated metal and for safety of the people involved in the process. Tools are usually made of iron because iron melts in high temperature more than the temperature needed to melt bronze. (Fig 96) The foundry of the Fine Arts department used to make brick furnace to melt bronze. When the study was on progress the foundry used the gas furnace to save time and safety. (Fig 97)

Melting the bronze: A block made of cement is placed inside the gas furnace. An inch thick layer of wet mud is spread upon the cement block. Then three to four pieces of bronze ingots are kept in the crucible which is placed upon the cement block inside the gas furnace. (Fig. 98) The mouth of the furnace is covered with lid which has small hole for the inspection. Some ingots are placed on the hole to pre heat to add in the melting bronze. At the bottom of the furnace the air hole and fire hole is prepared with air machine and gas burner. When all is ready and time to give fire into the burner, the head of the metal cast group does some religious pray to god of fire and the god Vishwakarma for the success of the task. He burns incense sticks and offer flower garland or *malaai in Thai* to the gas furnaces. (Fig. 99)

Then the furnace is set afire. To bring the fire to the temperature needed to melt the bronze, air is forced from electric blower into the gas fire in the furnace. The fire is

burnt continuously and when the bronze melts the impurities are taken out by iron spoons and stir time to time with iron rods. The molten bronze does not stick to the stirring rod due to iron's higher melting points. The cast members constantly monitor the melting bronze for three to four hours until a bright orange glow with brownish crust is achieved. The bronze used to make the project of fine arts, contained copper with 95 percent, zinc 1 percent and silicon 4 percent which is called silicon bronze. Silicon bronze are strong and flow easily in the details of the mould. (Fig. 100)

Pouring the molten bronze: Two person lifts up the crucible of molten bronze with the help of iron clutch. The crucible of molten bronze is placed in the holder with long handles which is held by two persons. Then the liquid bronze is poured in the pre heated mould until the liquid can be seen on the surface of the pouring funnel. Bronze flows through the hollow parts of wax lost channels and runners. The pressure of molten bronze push air to the air vents which flows outside. (Fig. 101) This act is very dangerous and the persons involved in it have to cooperate and take utmost care not to spill the molten metal in any case otherwise the consequence might be very hazardous. (Fig. 102) The remaining bronze left on the crucible is poured on the crucible tray to reuse later. (Fig. 103)

Breaking off the mould: The mould with bronze is left some days to cool down. Since the mould is made of plaster, it takes time to cool. In traditional process the material of the mould is made of mud, sand and cow dung which cools sooner than in the contemporary process. The plaster coat and iron strengtheners are cut open and break to detach from the bronze inside. (Fig.104) Remaining plaster attached to the bronze is sprayed with water to clean the surface and take out inner core plaster as well. Any fragments of the ceramic shell are removed by sandblasting. The sculpture is also carefully inspected at this point. (Fig. 105)

Cut off the bronze channels and sprues: When the plaster coat is taken out from the mould, the bronze structure reveals from inside the mould. The bronze is attached with all the channels which was made of wax and after casting with bronze all are

converted into bronze channels. The sight of this new manufacture is very interesting and one can understand how the molten bronze might have flown into the channels. (Fig106) These bronze channels are cut off from the main sculpture for the further process of cleaning and finishing. (Fig. 107)

Assemble the bronze pieces together: All the pieces of the sculpture are welded together by the skilled craftsmen, who are artisans themselves. The bronze statue after cast is very rough so that the metal worker have to work on the statue for several days to grind the uneven parts and if there is any accidental holes or cavities, it has to be welded again with repairing agents. (Fig. 108) Pieces of the other parts of the statue which are casted separately are joined together with bronze flux and welding rod a material for welding bronze. For welding gas oxygen and DA gas is passed from a nozzle with fire at the welding rod and the rod melts to adhere on the edges of the bronze statue, which helps to join the two pieces together. Welding rods are the same material as of the bronze statue which can be merged with the same color of the statue. All the weld marks are chased, re-detailed and sanded for the Sculptor's inspection and approval before the finishing processes. (Fig 109)

Glass Beading and apply patina on bronze: Glass beading is similar to sand blasting, the glass beads are extremely fine to ensure an even bronze finish prior to patination. When all the process of joining and cleaning finishes the statue is now ready for its final process. The statue is erected for the first time after casting. In this occasion the casting member along with the head caster prays to the statue and offer flower garland to the statue. Then for the finishing touch the bronze patina is applied on the statue to give required color which gives the statue its classic and exotic look. The bronze is first heated. The patina chemical is hand applied by the skilled foundry artist, with the Sculptor's oversight and directions, to obtain the desired colorization. Patinas are different in color such as green, black, ash color etc. Patina gives the statue look antique. For patina, Ferric Chloride ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) and Potassium Sulphide (K_2S) chemical is used on the bronze sculpture. Ferric Chloride is mixed with water and the color of water become yellow. (Fig. 110) Yellow solution with the help of a brush, apply on the bronze

sculpture and let dry on sunlight or giving heat with electric heat. Then Potassium Sulphide is mixed in water which becomes greenish color solution.(Fig. 111) The solution of Potassium Sulphide is applied upon the ferric Chloride coat on the sculpture. The chemical reaction changes the color of the bronze to blackish bronze. If the bronze need more antique look, Kiwi shoe polish is applied on the upper coat. (Fig.112) Chemicals are applied several times to required color giving heat in all intervals. After applying patina wax is applied on the surface to ensure protection of the patina and together it gives beautiful lustrous look then, the statue now is ready to consecrate on its pre-decided location with special ceremony.(Fig.113)

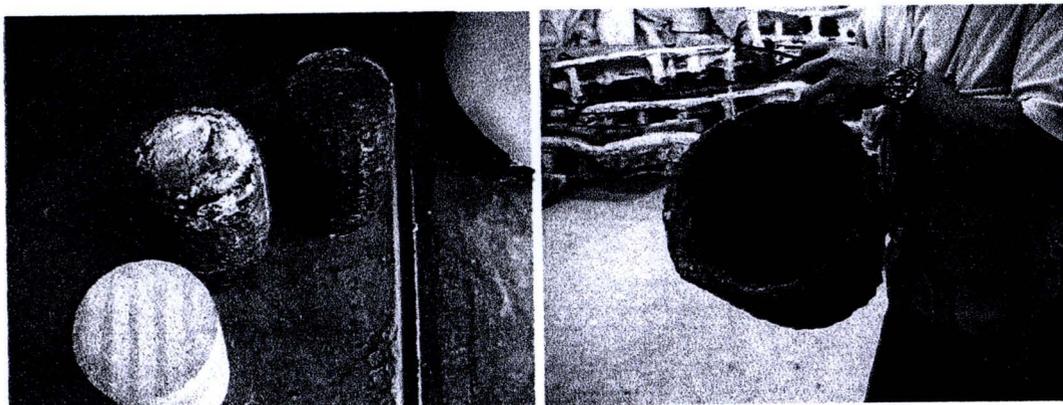


Figure 95 Rice husk tempered crucibles and cement stand for crucible.



Figure 96 Different tools and utensils for casting bronze.

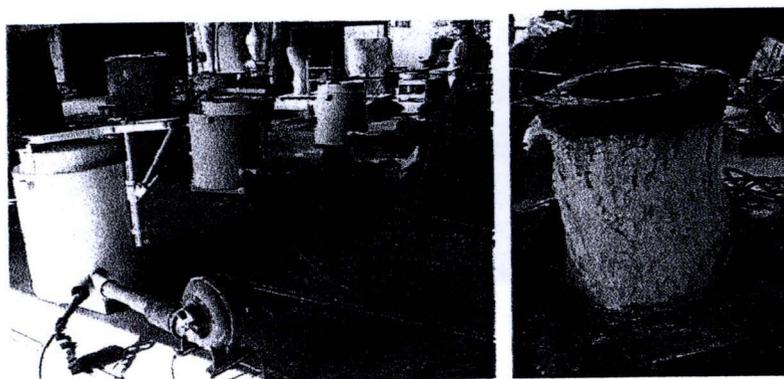


Figure 97 Modern gas furnace and traditional brick furnace for melting bronze.

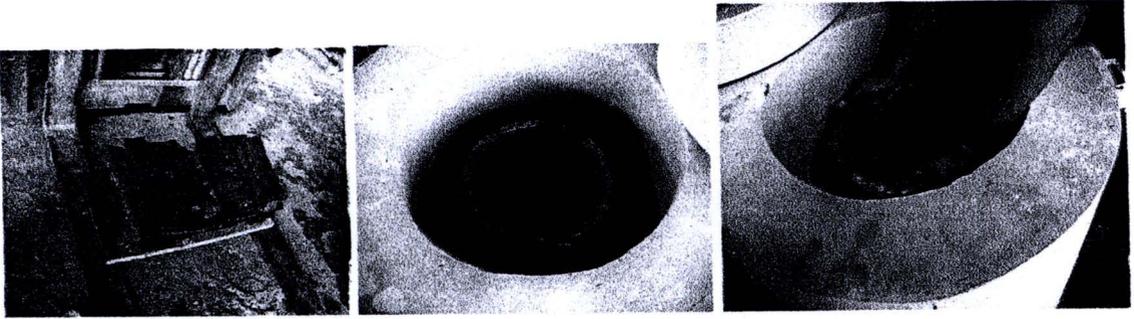


Figure 98 Bronze ingots placed in the crucible inside the gas furnace.



Figure 99 Pray to fire god and firing the bronze ingots.

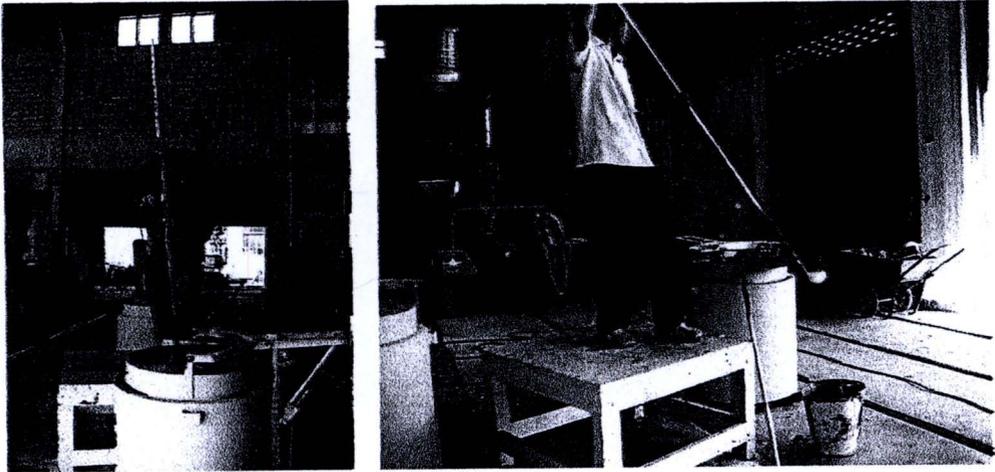


Figure 100 Stir and take out impurities.



Figure 101 Pouring liquid bronze in the mould.

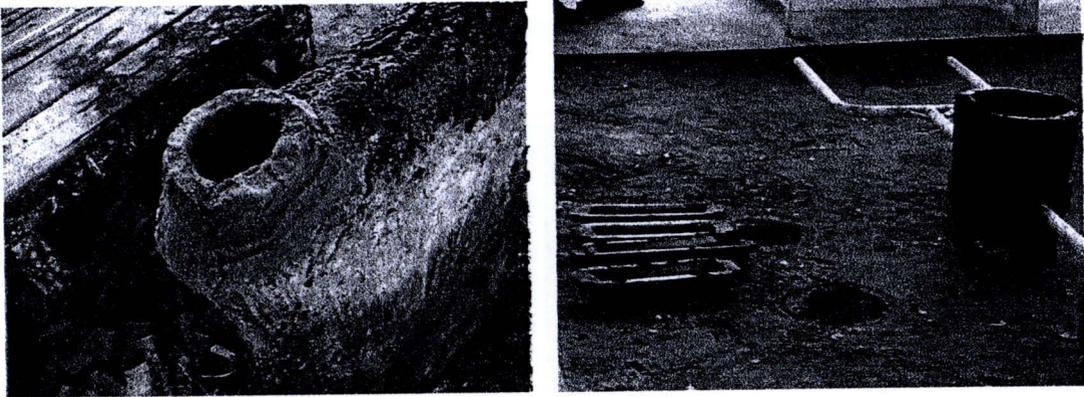
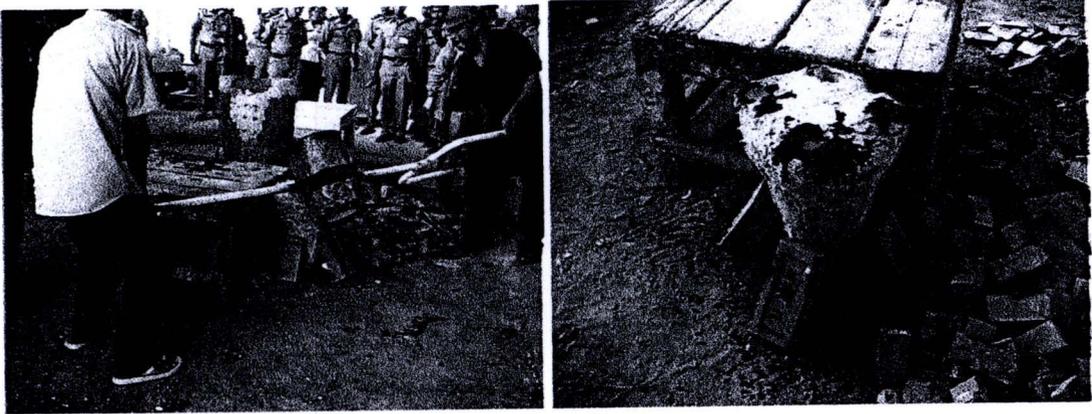


Figure 102 Liquid bronze seen in the pouring cup. Figure 103 Pour remaining bronze in ingot tray.

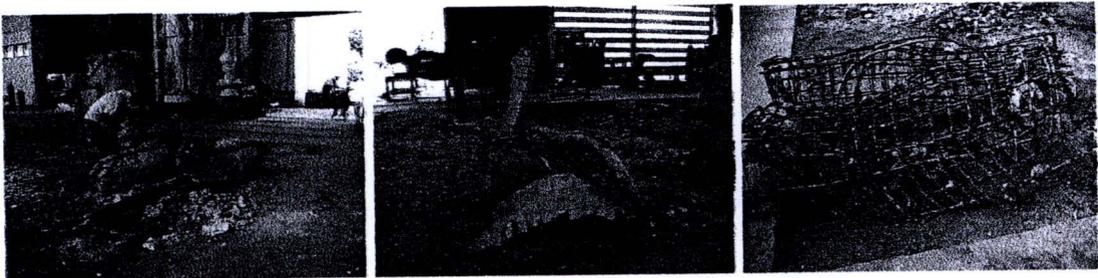


Figure 104 Cut out outer layer of plaster and iron strengtheners.

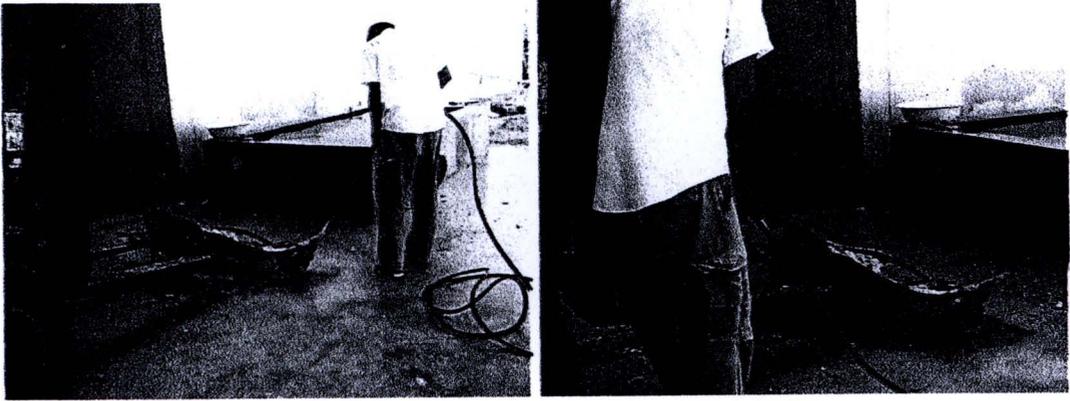


Figure 105 Clean inner and outer plaster with water jet spray.

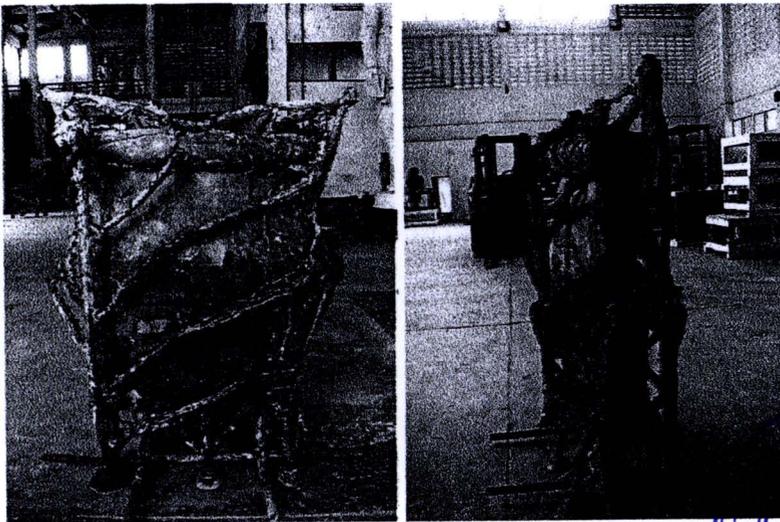
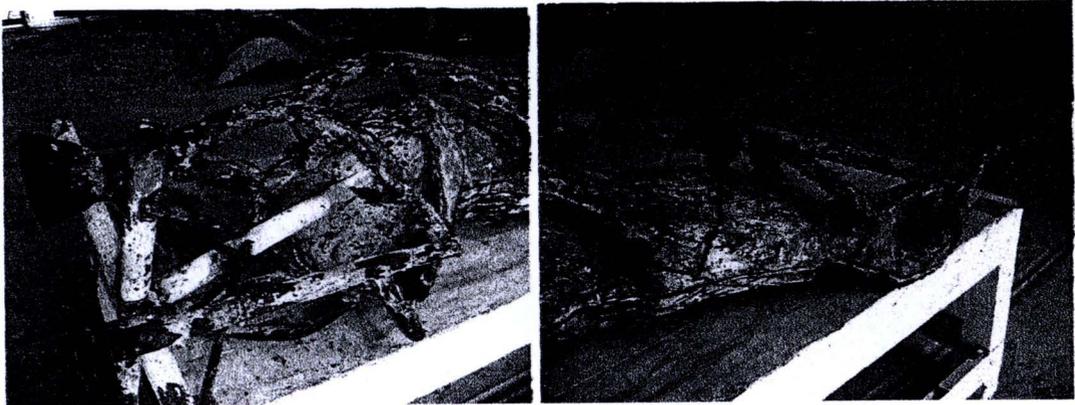


Figure 106 Bronze layer on the place of wax layer.



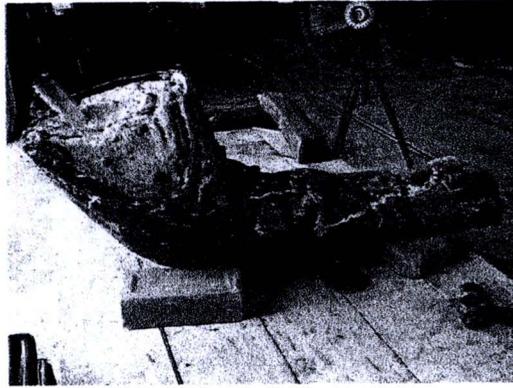


Figure 107 Cut off the bronze channels and runners.

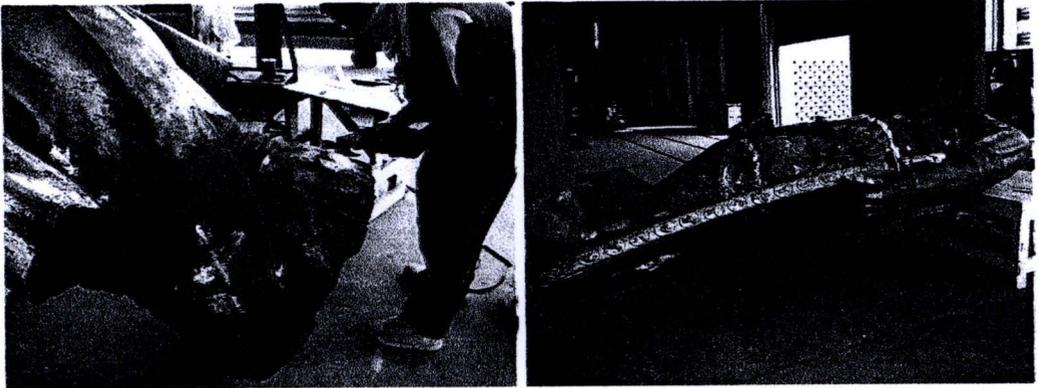


Figure 108 Grind uneven parts to make shine.

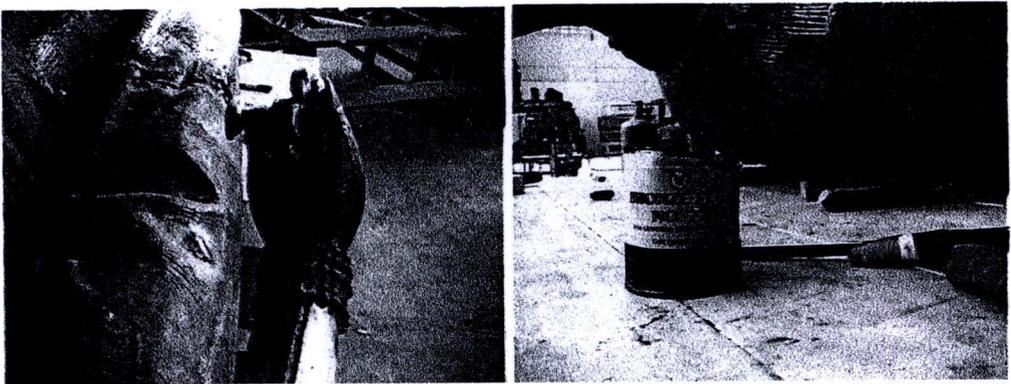


Figure 109 Joining the pieces together with Bronze Flux, a material for welding bronze.

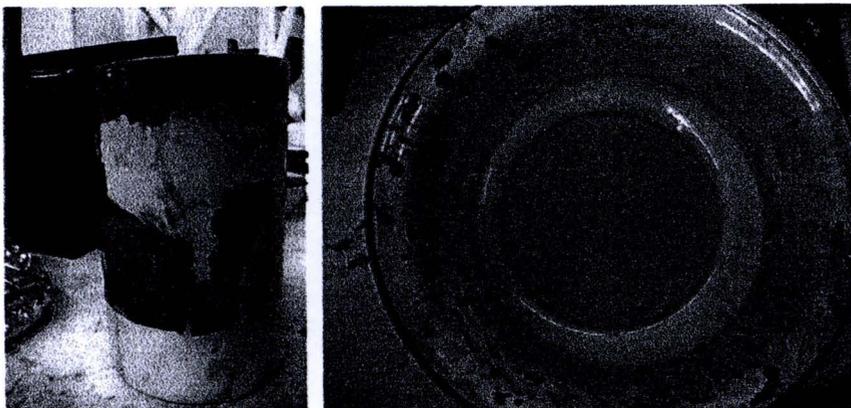


Figure 110 Ferric Chloride solution mixed with water.

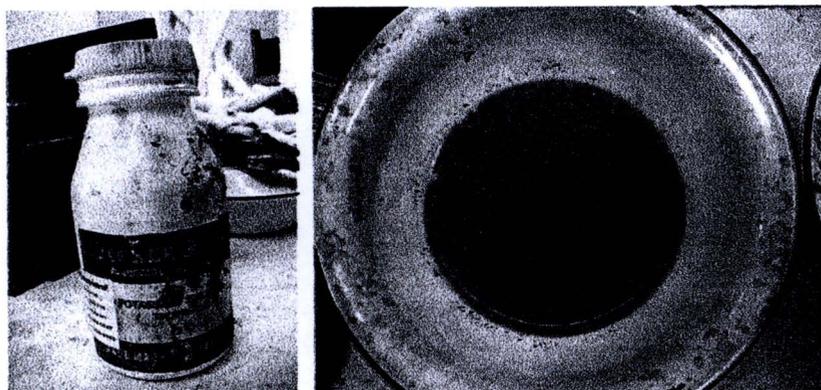


Figure 111 Potassium Sulphide solution mixed with water.

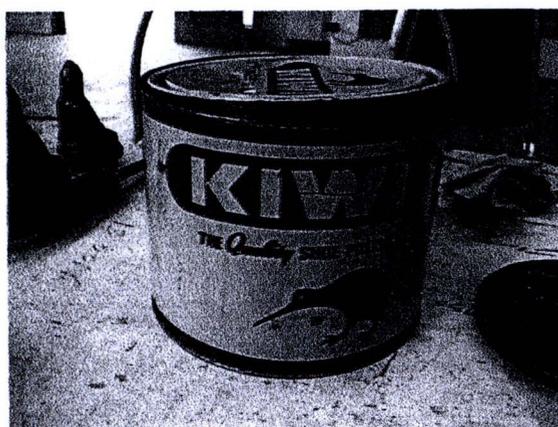


Figure 112 Kiwi black shoe polish.



Figure 113 Giving finishing touch with bronze patina.

Consecration of statue

The statues manufactured are taken away from the foundry with religious rituals. In the case of the King Mongkut or King Rama IV's statue was ordered by the Royal House Hold to establish in front of Wang Saranrom Palace outside the Grand Palace. The palace was built by King Rama IV. The open space in front of the palace boundary wall was converted as a park to consecrate the statue. (Fig.114) The present King Rama IX wanted to make this statue to honor King Rama IV as he is the ancestor of the present king and as a great modernizer UNESCO had honored him as important historic personnel.¹¹ The foundation stone was laid on 1st June 2007 by Her Royal Highness Princess Maha Chakri Siridorn. Her highness was present at the time of pouring bronze on the mould of the same statue in the foundry of Salaya. The statue was financed by the Ministry of Science, so on the auspicious day of 6 July 2010 the honorable Minister was present to perform the rituals. The head sculptor of the Sculpture Group Mr. Somkuan Oumtrakul modeled the sculpture in this project.

At the foundry, the statue is places safely on a pickup truck decorated for the occasion. (Fig.115) The chief Royal Brahman and his group of priests are present to perform religious rites before taking away from the foundry. Candles are burnt before the effigy of the statue in front of the big statue, with Vedic enchants and a flower garland is offered to the statue with blow of conch shell and clappers. (Fig.116, 117)Then the statue is taken away from the foundry to its actual destination on a grand procession followed by the foundry members. Before establishing the statue on the pedestal high above the ground, final respect is given by the sculptor and cast groups by offering holy scents on the foot of the sculpture and bowing head *wai*¹² at the statue to take blessing from the soul within, then the guests and officials from the ministry follow to pay respect at the king's statue. (Fig. 118) The Brahmin priests and Buddhist monks perform the religious rites to sanctify the statue while drums beaten and conch shell are blown to purify the

¹¹ http://portal.unesco.org/en/ev.php-RL_ID=18529&URL_DO=DO_TOPIC&URL_SECTION=201.html, Accessed on July 2010

¹² Wai is the gesture of joining palms of two hands together with slight bow head while doing this. This is also known as Namaste and Swasti pose in India and Nepal.

atmosphere. (Fig.119) The statue is again paid respect by offering garlands after it is established and sanctified on the main pedestal forever. At last the closing contract is signed by the head sculptor and the coordinator of the project. (Fig. 120) The sanctified statue stands on the tall pedestal for ever to be respected by the people. (Fig.121)

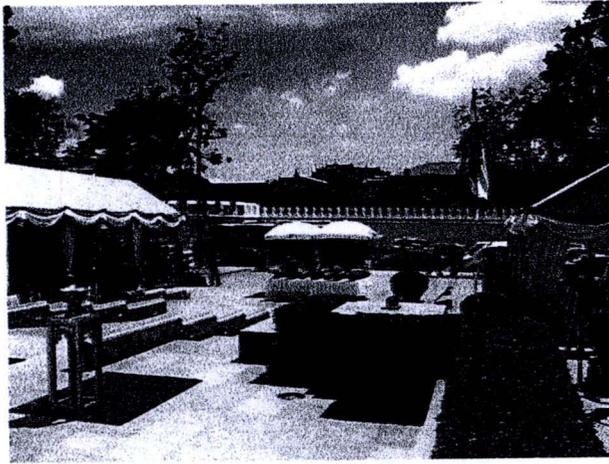


Figure 114 Decorated garden for the monument and preparation by Brahmin priests.



Figure 115 Decorated vehicle for the grand procession.

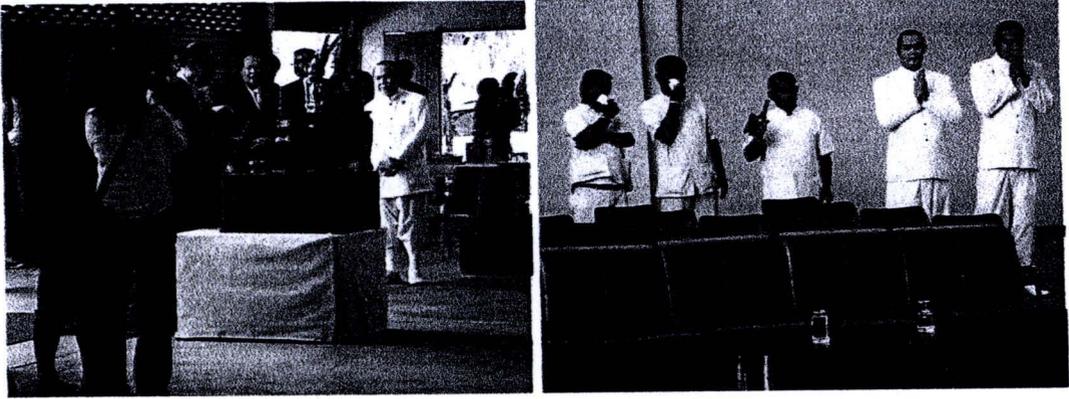


Figure 116 Performing worship and chant Vedic mantras with blowing conch shell and clapper.

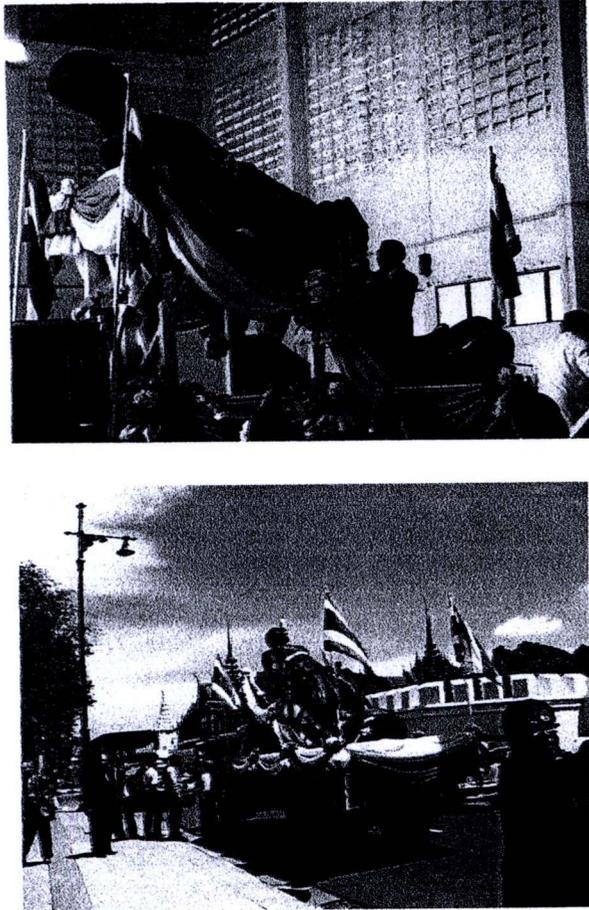


Figure 117 Offering *malaai* by the minister and grand procession in front of Grand Palace



Figure 118 Paying respect to the statue.

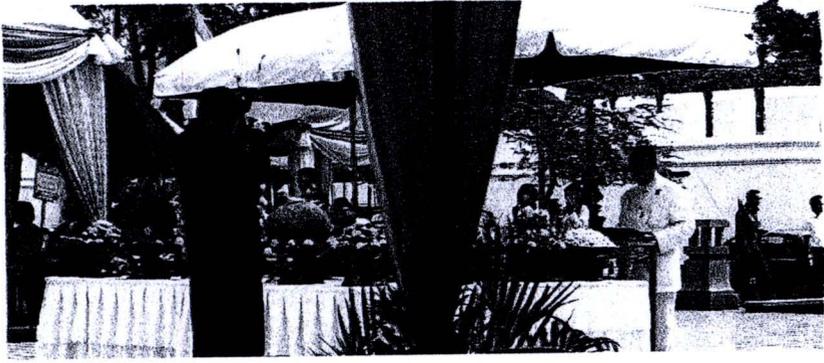


Figure 119 Brahmin and Buddhist religious recitals to consecrate the statue.



Figure 120 Replica going back to the office and signing the closing contract.



Figure 121 Sanctified statue standing forever.



3.4 Traditional Bronze Casting Technique in Thailand

Silpa Bhirasri argues¹³ that during his time in Thailand contemporary sculpture followed the traditional techniques. The most important is bronze casting which since remote times had reached a technical perfection in Thailand. According to him traditional statuary was confined to creating images of the Buddha, and in this art the Thai of Sukhothai, created magnificent statues from the 13th to the 15th century. From the traditional sculpture, the modern sculptors could transmit in their new work the principal characteristics of the old which are an extreme understanding of the simplified and synthesized human forms and a harmonious delicate outline.

A study of Isan and Lao¹⁴ (Niyon, 2009) revealed the fact that the development and history of bronze alloy product in Isan adjoining Lao of Thailand dates back to pre historic age and is still evident in modern times. There is similarity between the moldings processes of replacing wax from other places of south East Asia. The local indigenous knowledge for selecting natural material in locality by applying animal dung, soil, termite hill, and paddy husk in producing process in the north eastern region still conserves the ancient producing process. Similar process is found from south India at present. This testifies the technique spread from one place to other.

Everly¹⁵ had described in detail the process of lost wax casting of bronze object which was practiced by the bronze smiths of Ban Pba Ao. The process entirely follows the traditional lost wax process which was supposed to be prevalent from the prehistoric period.

¹³ Bhirasri, Silpa, *Contemporary Art in Thailand*, Fine Arts Department, 1963, Bangkok, p. 11

¹⁴ Niyon Wongpongkam, Songkon Chantachon, and Subun Ieamvijarn, A Study of Isan and Lao Indigenous Knowledge in Making Bronze Brass Products for Commercial Purposes, *Medwell Journal*. 2009

¹⁵ Everly, Daniel Eugene, *The Relevance of Contemporary Bronze Casting in Ubon, Thailand for Understanding the Archaeological Record of the Bronze Age In Peninsular Southeast Asia*, University of Houston, 2004

3.4.1 Process of Traditional Lost Wax process

For the purpose of the study a practical case study on traditional lost wax technique was conducted in the foundry of Fine Arts Department in Salaya. For this a head of Buddha was prepared for casting, because to create Buddha statue is easier, than to create any realistic human feature. Also for the spiritual back force that lead me to start my case study by paying my respect to the Lord.

Prepare core model of sculpture with clay mixed with sand: Preparation for the traditional bronze casting technique case study started from 16 June 2010. At first the most important was to determine the sculpture to be made. For the case study a head of Buddha was taken from the numerous plaster replicas scattered all over the foundry of Fine Art Department in Salaya. (Fig. 122) The clay we used for sculpting was collected from outlying areas around Bangkok and pounded by hand into a smooth consistency. This clay is being used in the foundry for all the sculptures. The clay is taken in proportion of one part wet clay and three part of fine sand and mixed together to make dough.(Fig.123,124)

For the preparation of the clay the Khun Pongpan,(Appendix 5, Bio-data 2) the sculptor takes help from the intern students of Arts Institute. When the clay is mixed and pounded properly for its malleability, the sculptor places the clay on a wooden base and starts with his expert hand to shape the head. At first it is just rough shape of a head and at the very moment he pierce through a wooden stick from the top of the head to strengthen the head, then reshaping of the head follows with several hands until the shape of head is completed. The center line is drawn from forehead down to nose and mouth. Then the sculptor mark facial line for the eyes, nose and mouth at the front of the face portion with a sculpting tool. (Fig125)With the help of finger and tools the detail of nose and eyes and mouth is carved. Since this is for the case study the sculpture wanted to show only the impression of eyes and nose not the detail distinct character. After a couple of hours the sculpture seems complete and it has to be left to dry completely for three to four days on shed. On the fourth day the sculpture is completely dry. (Fig.126)

Prepare wax sheet to stick on the core sculpture: Another procedure for the process of traditional lost wax casting is to apply wax upon the clay core. On 22nd of June the preparation for wax sheet commenced. Thickness of the wax determines the thickness of the bronze to be cast. At first a wooden board was prepared and two strings of iron 2/3 mm. thick were nailed on parallel line on the two edges of the board as shown on the picture. After the board was ready wax was melted in a tin vessel on a charcoal stove. After the wax melt unto liquid, a bowl filled with detergent mixed cold water is prepared. Some portion of liquid wax is poured into the detergent water. The wax cools at the mean time the texture of wax changed to yellowish. Same detergent water is spread upon the wooden board to make sure that the wax does not stick when it is rolled upon and easy removal of the wax later. The semi cool wax shaped into a ball was placed upon the previously prepared wooden board then to be rolled flat until the wax surface is smooth. The wax sheet is rolled until the sheet is as thick as the iron rod nailed along the border of the board. The thickness of the wax is important, since it determines the thickness the metal will be afterwards. If it is too thin, it will lose strength and cracking or breaks will occur. If it is too thick, it results in a heavy and more costly statue. The sheet of wax is cut from the uniform surface into a square shape. The sheet of wax is immediately dipped in cold water to let it cool quickly. For the purpose of the study three sheets of wax is prepared. (Fig. 127,128, 129)

Stick wax sheet on the core sculpture: On 25th June, as Khun Pongpan was supposed to stick the wax upon the surface of the statue, he ordered one of his colleagues to prepare glue (*Therk* in Thai)to stick wax sheet on the statue.(Fig.130) To do this, vegetable oil mixed with natural resin used as an adhesive agent is prepared in a bowl ready to be heated before apply on the statue. When the glue was ready and hot enough to be applied on the surface of the statue, Khun Pongpan cut the wax sheet in half and put upon the charcoal heat and sometimes upon the steaming glue to melt the wax little soft that to make easy to apply on the surface and stick malleably. With a brush, the melted hot glue is applied upon the surface of the statue and immediately the softened wax sheet is stick with taking care that the impression of the core comes out on the wax when

pressed gently with the fingers. With utmost care wax sheet was glued upon the head taking care not to overlap the sheet. The excess sheet was cut out with the cutting tools. After finishing the wax coating it has to be left to set for a day or two for the further process.(Fig.131,132,133,134,135)

Smoothen the wax surface and joints and make texture: As this case study was being done with the sculptor's free moments the days was not accountable because I have to ask for his free time for all the process. He called me to come on 29th June to document another process on the statue. On that day the statue was smoothened on the wax joined parts and the seams were filled with wax. The sculpture was scrapped take out the texture on the statue. (Fig.136)



Figure 122 Prototype plaster statue of Buddha head.

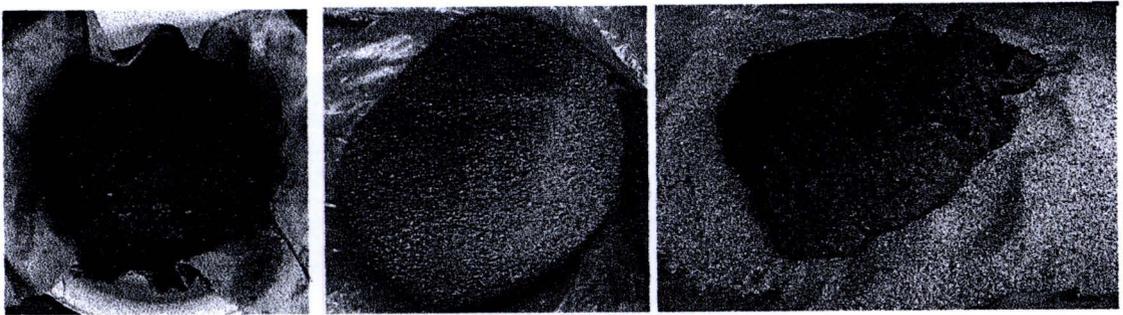


Figure 123 Wet clay and sand mix to make core of head of Buddha.



Figure 124 Mixing sand and wet clay.



Figure 125 Outline facial proportions and make shape of head.

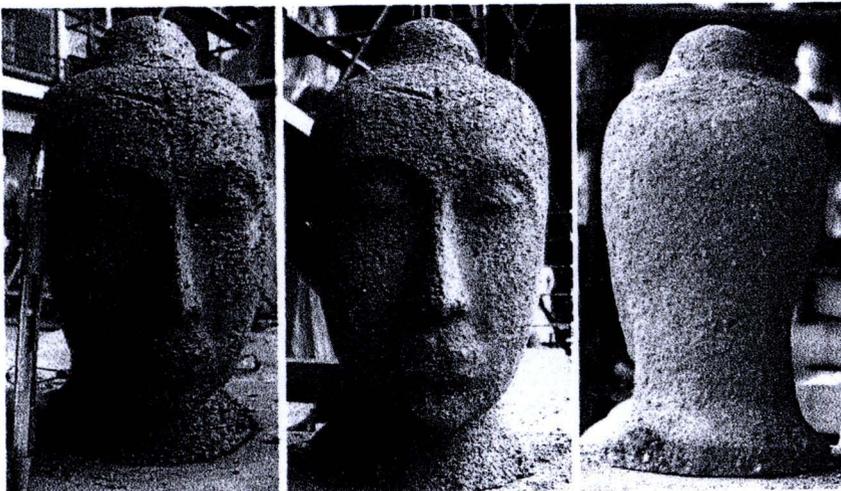
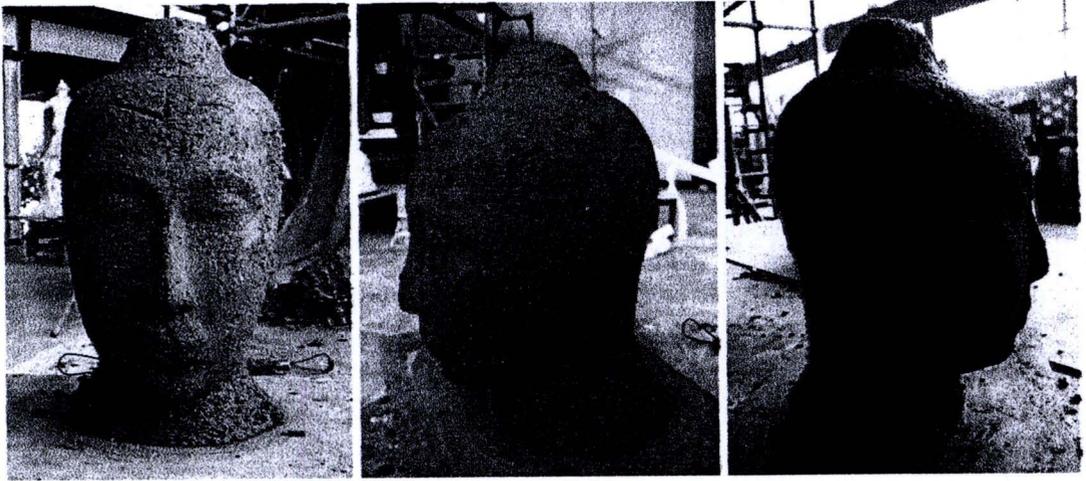
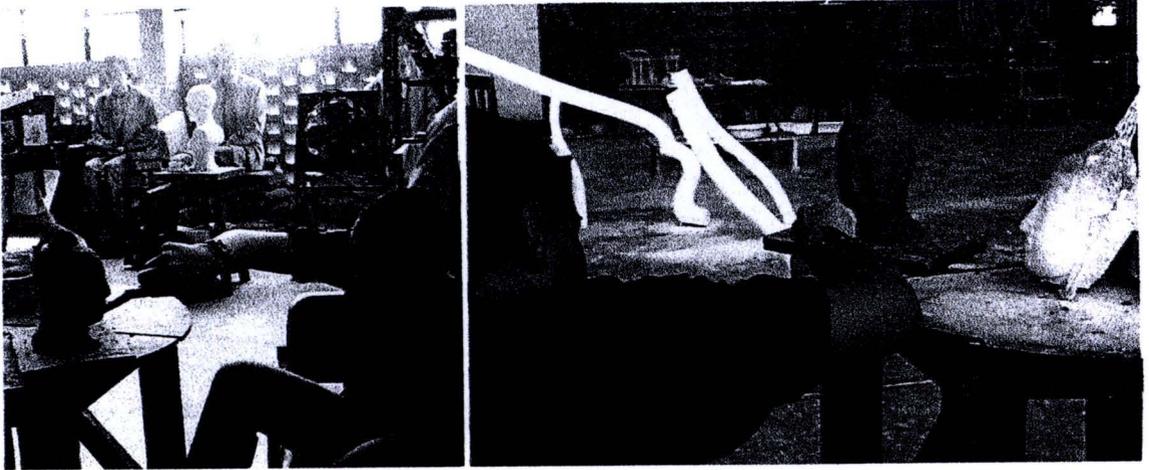


Figure 126 Mr. Pongpan giving finishing touch on the sculpture.

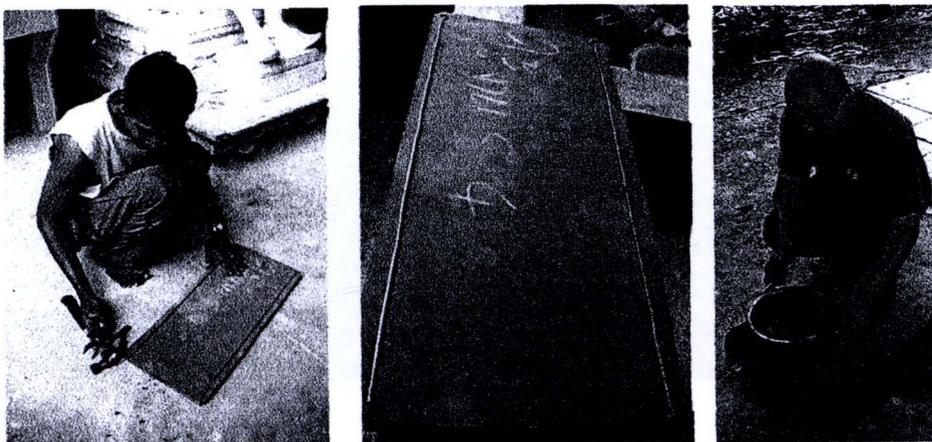


Figure 127 Prepare a board to roll to make wax sheet and melt wax on fire.



Figure 128. Melted wax poured in cold water and rolled on the board.

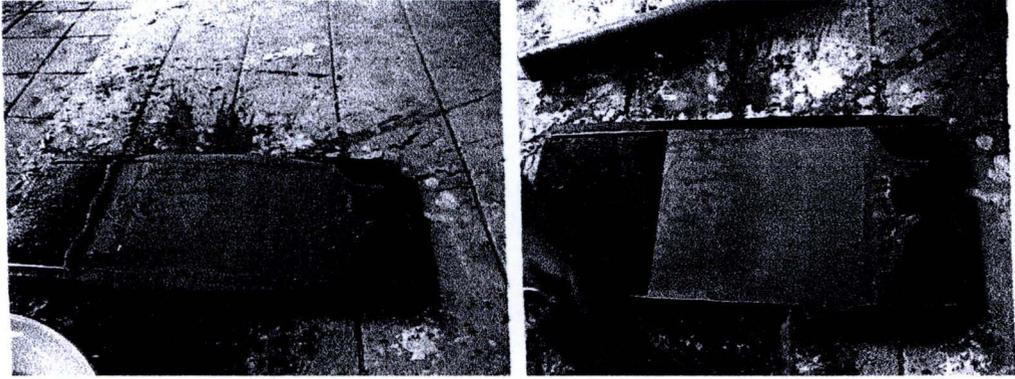


Figure 129 Wax sheets cut in square shape.

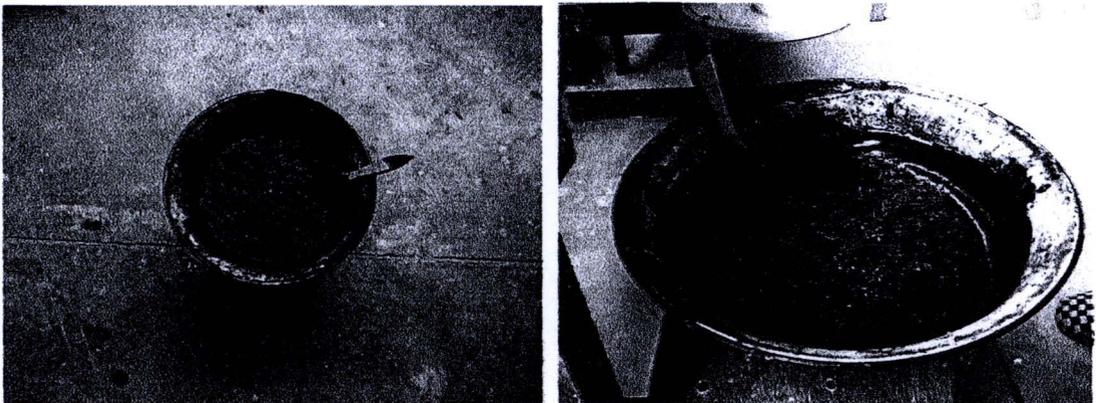


Figure 130 Boil traditional glue name as *therk* made of tree resins

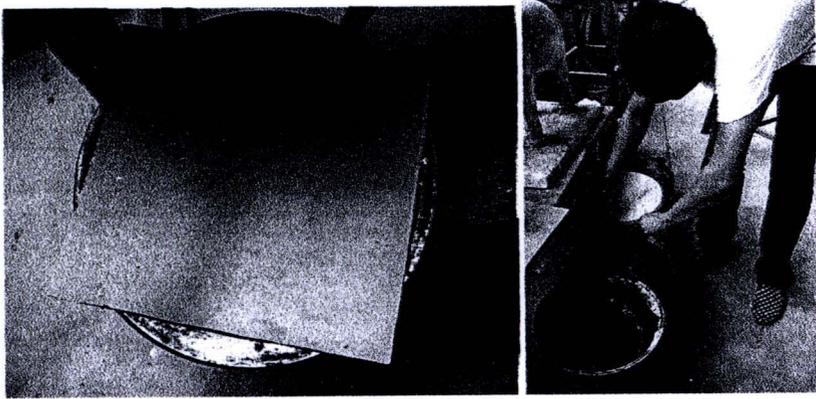


Figure 131 Wax sheet make warm and cut into required size.



Figure 132 Apply glue on the sculpture.



Figure 133 Wax sheet sticking on the glue.

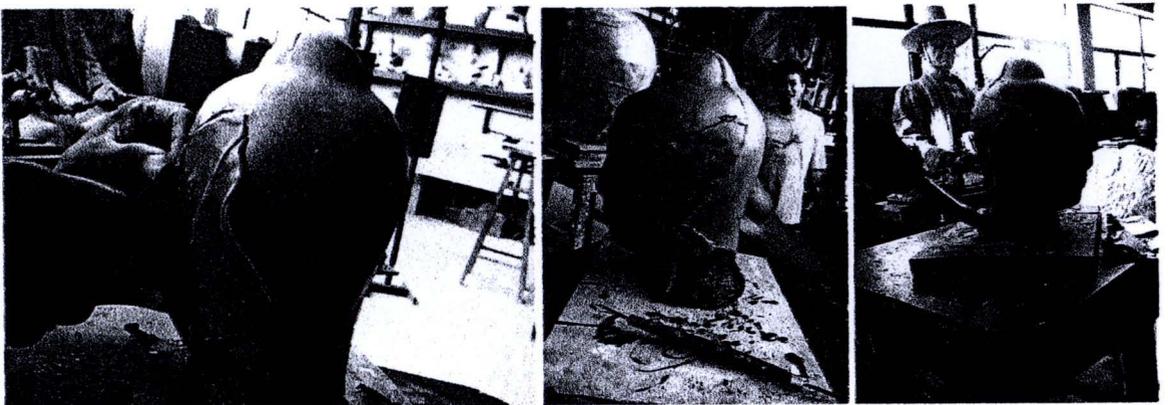
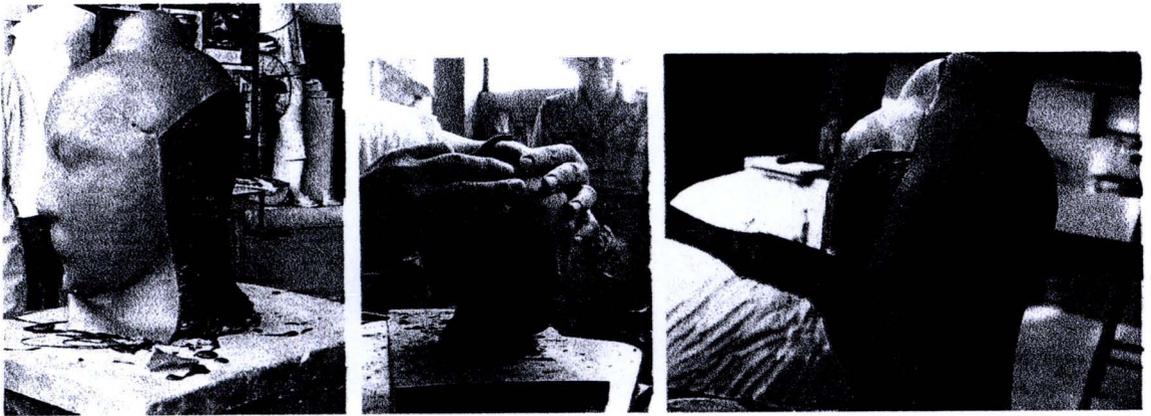


Figure 134 Wax sheet sticking on progress.

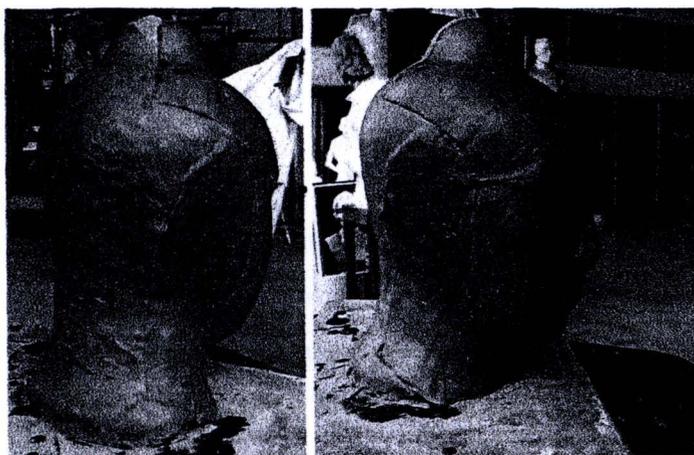
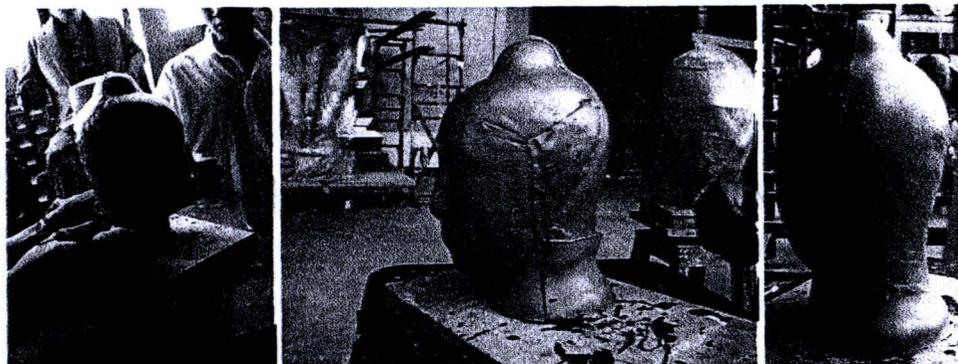


Figure 135 Wax coated sculpture.

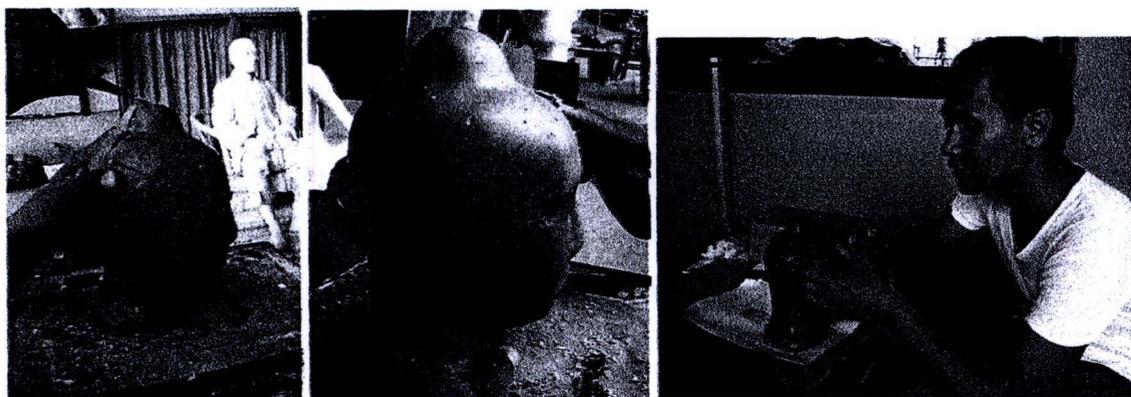


Figure 136 Refine joints and make texture.

Mix cow dung and clay to apply on the sculpture: After long waited days, on 29th July some arrangement was done by the expert in traditional mould method, Ajarn Nikorn Koehapong. On that day we went to collect cow dung in the village of Nonthaburi. To search the cow that only eats grass was very hard to find. Because dung quality is very good for casting for its heat resistance and adhering quality if the cow eat grass only instead of straw and modern readymade food. It took about an hour to search such cow and finally we were able to get the cow dung required for the process. (Fig. 137) Back in the foundry, cow dung was mixed with water and mashed very hard by hand to make a fine mixture. (Fig. 138, 139) The liquid contained in the mixture is strained and squeezed by thin cloth. The liquid obtained from this is used to make fine paste of clay to apply on the wax coated statue.

To make the paste very fine quality clay called *Din Nuan* mean soft clay is beaten into fine pieces and again strained by a flour strainer to get the fine dust of clay. (Fig. 140) this type of clay have sticking quality and have to dig out from several feet under the ground. This clay is yellowish in color. The clay is mixed with the cow dung liquid in a ratio of four cup of liquid and one cup of clay. For the purpose of this mold eight cup of cow dung liquid was mixed with two cup of fine clay to make a paste. (Fig. 141) Before applying the paste on the wax coated sculpture, the wax is cleaned with soap water with the help of brush to clean dust from it. Then let it dry or wipe with a clean cloth. (Fig.142) Then with the help of fine brush, the liquid paste is applied on the wax. Wax coat is applied two times a day for seven days. In each coat the former coat must get dry to apply another coat. The outer investment is dried slowly in the shade to prevent any cracking as this would show in the final bronze image. On the seventh day the coat on the sculpture looks quite thick and almost the feature covered with the paste. (Fig.143)

Creating wax channels and runners: Mr. Mana Sukkhe or nick name as Ding who has been working on the casting process since he was 13 years and at present he is one of the senior most casting official of the Traditional Arts section of the Fine Art Department, gave me honor to demonstrate the following process. On 4th August, the seventh day, wax was melted to make wax channels and sprues. Some portion of melted

wax is poured in cold water and it gets a little bit cool. Then the wax is kneaded by hand for fine texture and rolled on the wooden board to make cylindrical rods and conical rod as sprue. Conical wax rod is made longer than the cylindrical rods. (Fig. 144, 145) The diameters of the rods are approximately two centimeter and lengths are thirty to thirty five centimeter long. The sculpture is placed on the raised platform made of brick and iron rods are heated on the gas stove for another process of attaching the wax rods on the sculpture. (Fig. 146)

Attach wax channels on the statue: To attach wax channels, the tip of an iron rod is heated on the gas stove. Then with a sharp knife the place where the rod has to be attached is scratched gently to take out the cow dung coat to reveal the wax inside. Wax rod is cut in about two and half inch long. The end of the rod is heated with the heated iron rod tip and the also the place where it is going to attach. After attach the wax rod at the sculpture, it is allowed to cool for some minute. Wax rod is placed on top of the head, at the back and upon the ears on the both side. Rod kept at the back head upward and the two on the both side of the ears head downward. One bent as C shape rod is attached on the front bottom of the statue and another bent in S shape is attached on the back bottom of the statue. Both C and S shaped wax rod have to touch the base of the board not on the brick on which the sculpture mould is placed. (Fig. 147)

Insert nails on the mould: After the wax channel is attached on the sculpture, two inch long nails are inserted on the mould in different spots. The nails have to penetrate the base core to be strong enough to hold the mould intact while heating wax and pouring the melted bronze in. Due to religious and aesthetic belief nails are not inserted on the fore head of the god statue. (Fig.148)

Sealing the mould with first coat of sand and clay plaster: For the next process, a pot of sand and water based clay is prepared (Fig. 149) and both sand and clay is strained by a strainer to obtain fine sand and clay.(Fig150) Since this is the first coat of plaster, the combination of mixing sand and clay is three part sand and one part clay (i.e. 3:1). (Fig) The combination of fine sand and fine clay is mixed together and pressed by

hand until it gets soft and sticky enough to apply on the mould. Since the clay already have water, there is no need to add additional water on the mixture.(Fig. 151)After the sand and clay plaster is ready, the cow dung solution previously prepared to apply on the sculpture, is applied on the surface by brush and the thick layer of clay and sand mixed plaster is pasted upon the cow dung which here too act as a strong adhesive agent. (Fig.152, 153)



Figure 137 Collecting cow dung in a village in Nonthaburi.

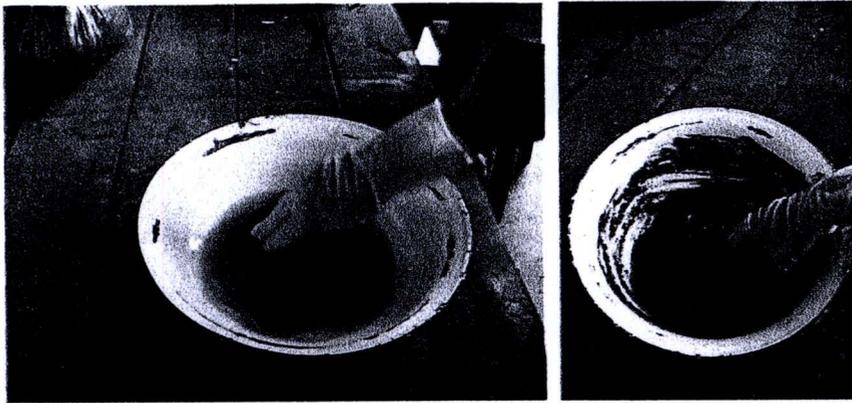


Figure 138 Smash cow dung with water.



Figure 139 Strain water from cow dung from a thin cotton cloth.



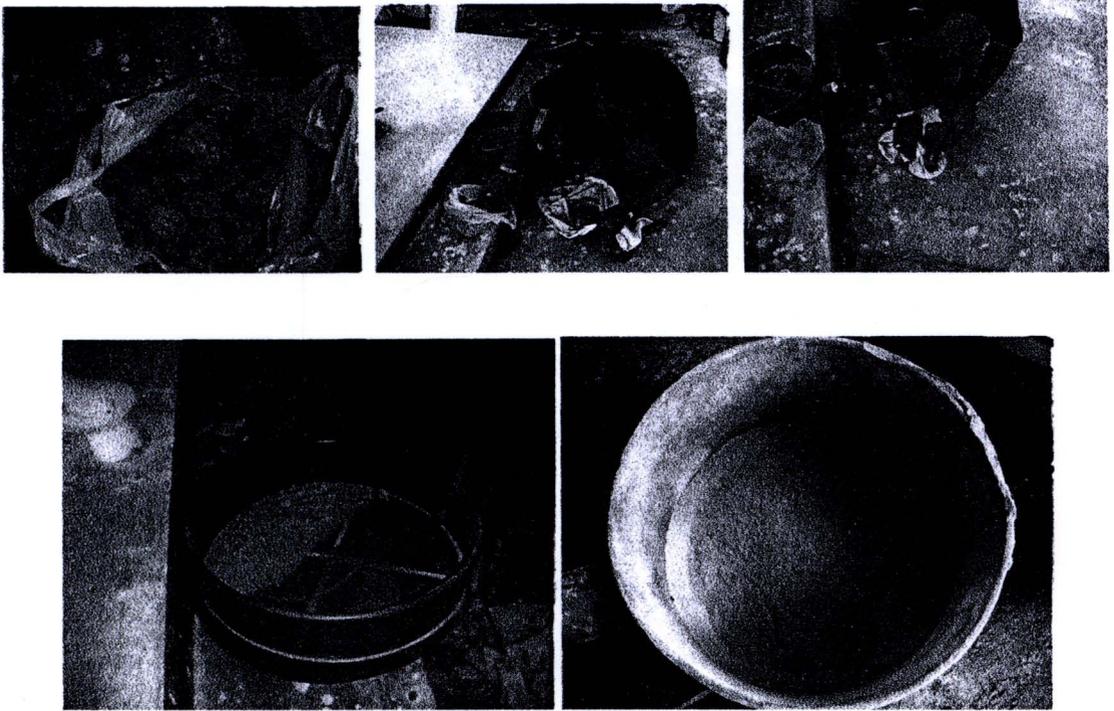


Figure 140 Strain soft clay dust.

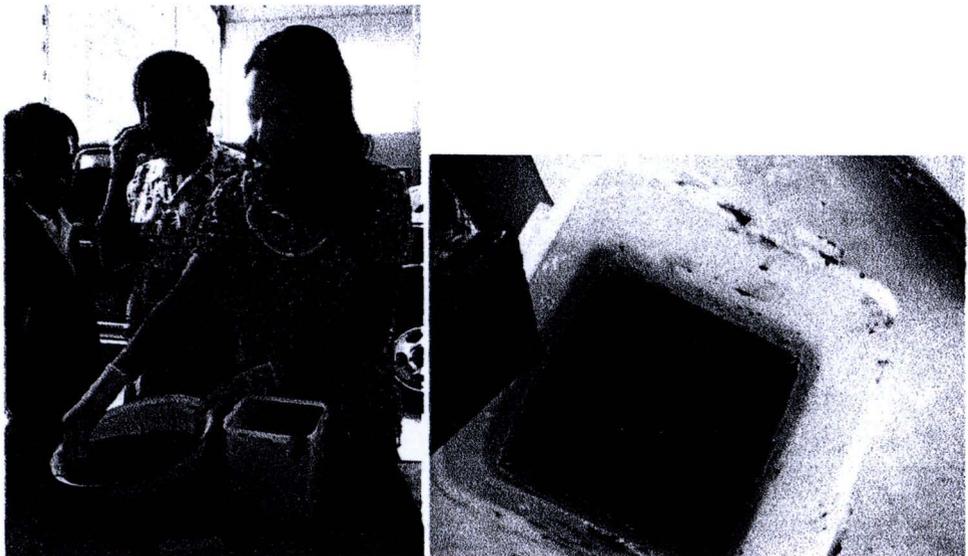


Figure 141 Mix soft clay dust with cow dung water.

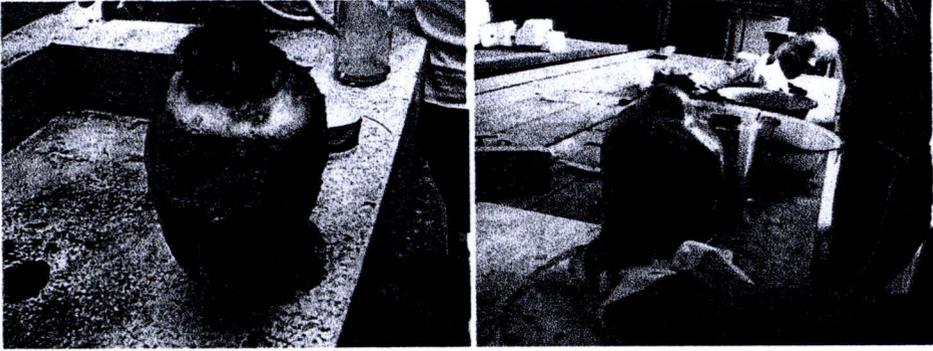


Figure 142 Wash the wax with soap water and dry with cloth.

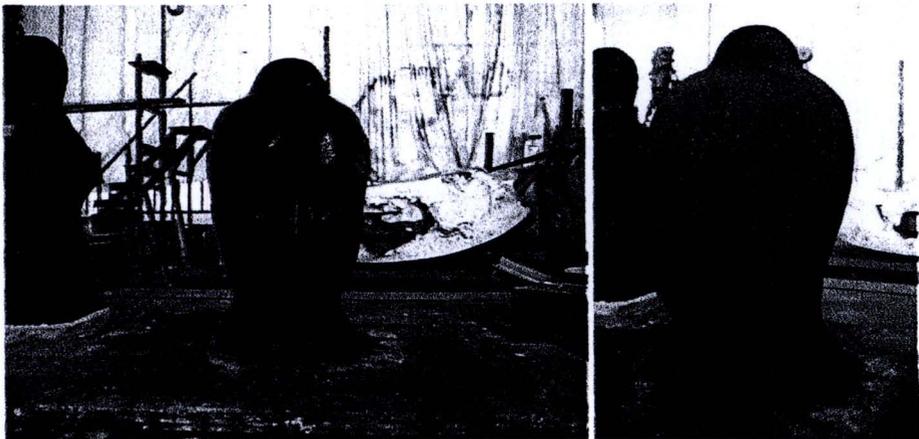


Figure 143 Apply cow dung and clay solution on the wax of sculpture.



Figure 144 Melt wax and pour in cold water and kneaded by hand to make soft.



Figure 145 Wax rolled on a wooden board to make conical and cylindrical wax rods.

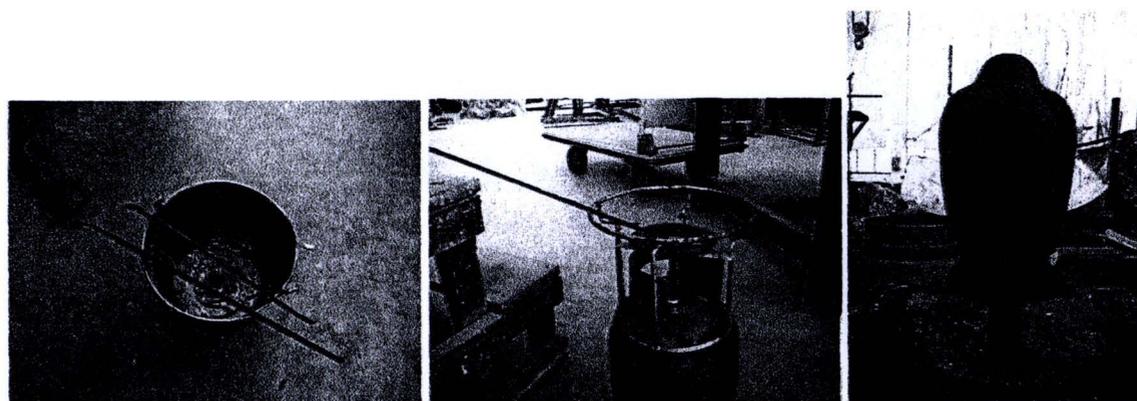


Figure 146 Heat iron rod and place the statue on a raised platform.



Figure 147 Attaching the wax rods on the statue.

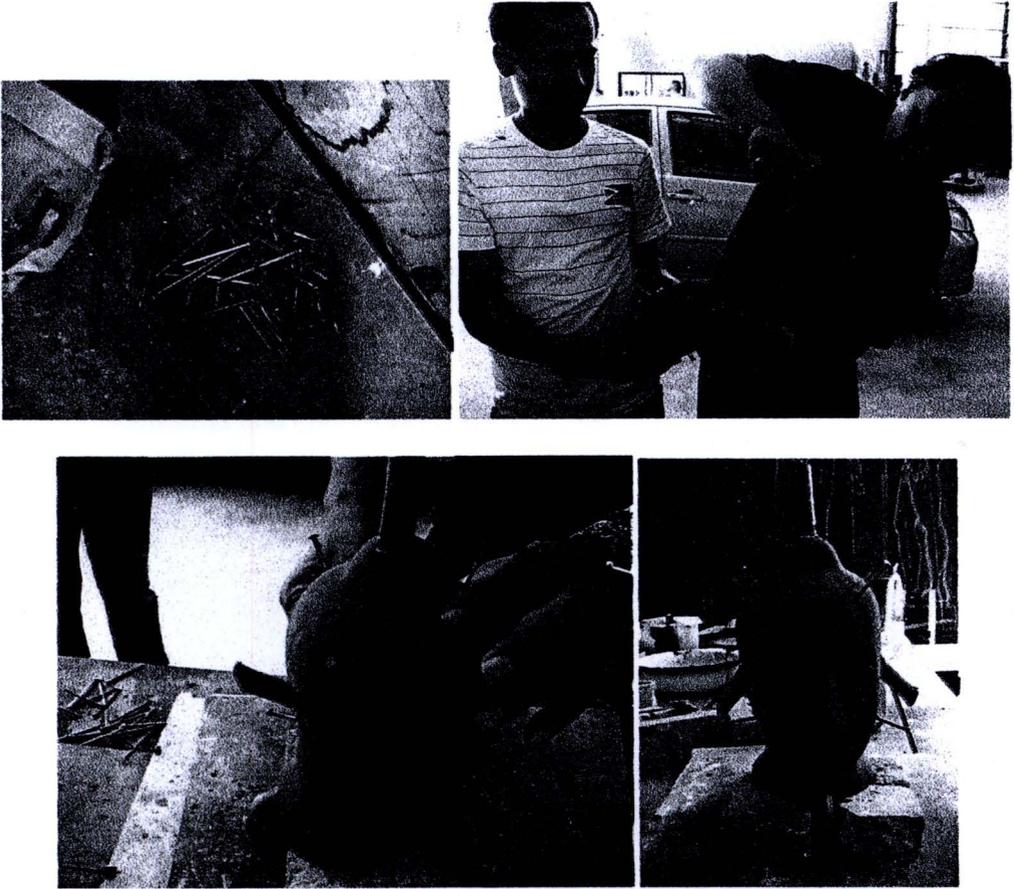


Figure 148 Insert nails in different places of the mould.

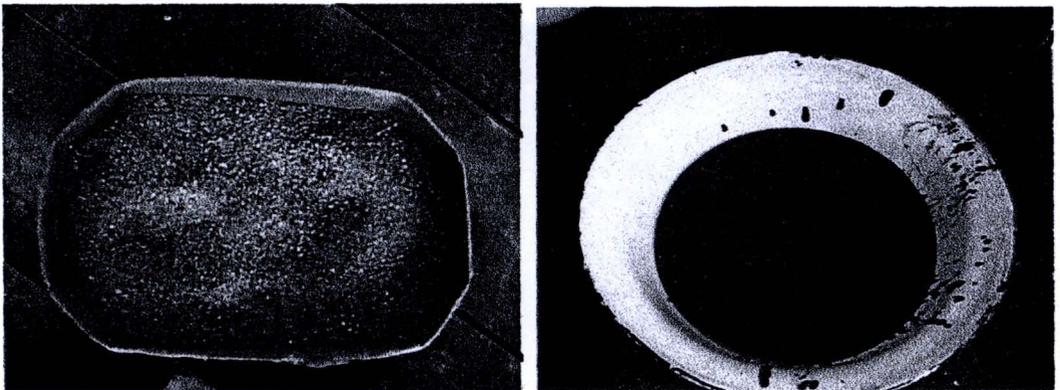


Figure 149 Sand and water based clay.

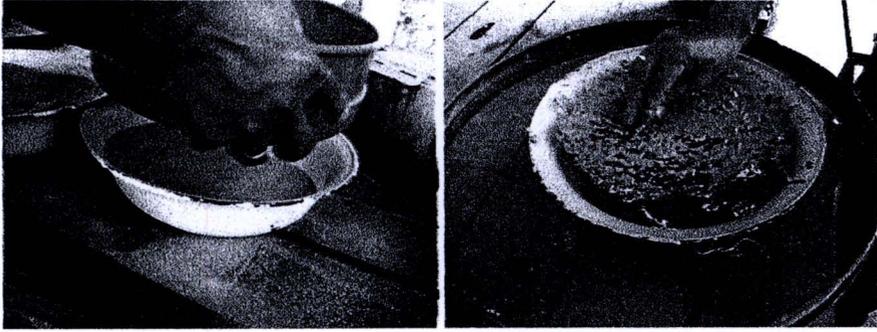


Figure 150 Strain sand and clay to get finer material.



Figure 151 Mix sand and clay together.

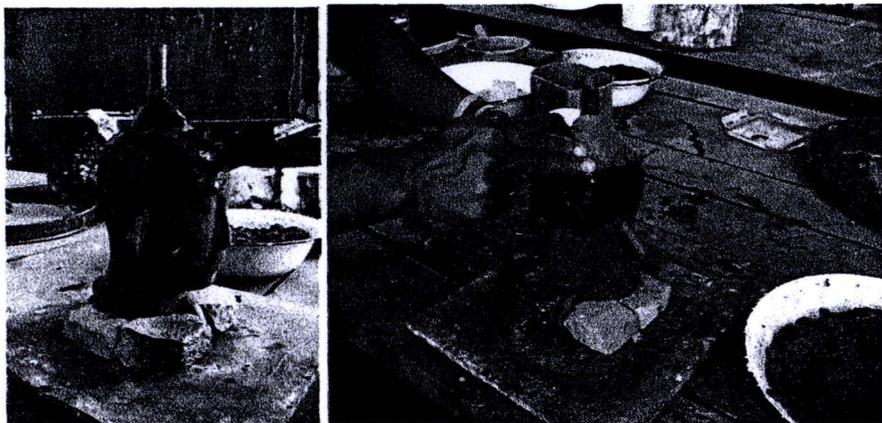


Figure 152 Apply cow dung and clay paste as glue and stick clay/ sand mixed plaster.

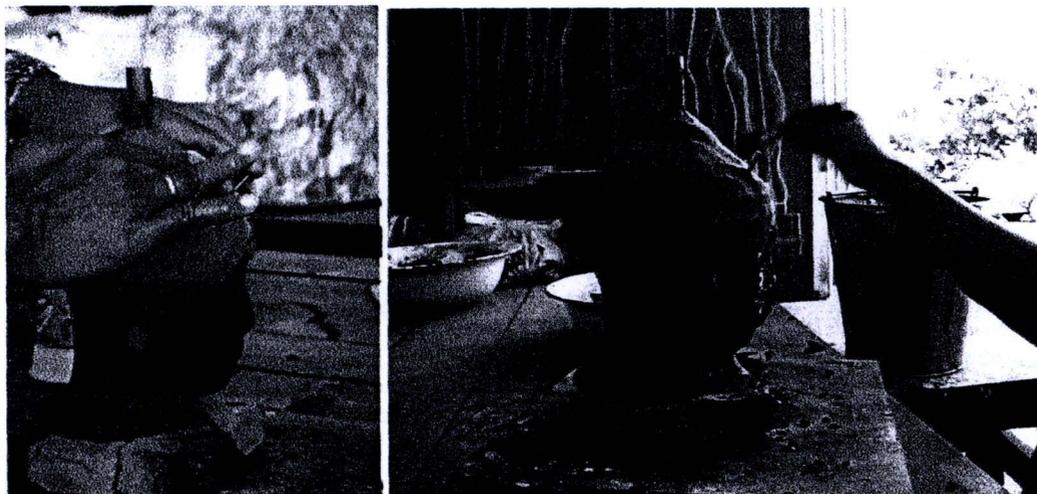


Figure 153 The clay mould covered sculpture.

Attach wax sprues, channels and runners: On 6th August the clay plaster coat dried and another process commenced on this day. The wax rod with the shape of cone at one end is attached at the back of the head of the sculpture where S shaped wax rod also known as wax gates, is attached previously. The cone shaped end is turned down while attaching and melting the joints at the same time with preheated iron rod. (Fig. 154, 155) The wax rod is fixed with the S shaped wax rod and the wax rod places at the top of the head. (Fig. 156) Then another wax rods are attached to the wax rod placed at the two sides of the head above the ears, one end is joined at the bottom of the cone shaped wax rod. Another slightly bent wax rod is attached to the side of vertical wax rod placed at the top of the head as shown in the figure. (Fig. 157)

Seal the mould with second coat of sand and clay plaster: After attaching the sprues and wax channels, the mould is invested in another layer of clay and sand plaster. The combination of sand and clay now is five portion of sand and two portion of clay mixed together. (Fig. 158) While applying the plaster, the wax rod on the top (Fig. 159) and at the bottom of the mould is not covered. The bottom two wax channels will help to flow away the molten wax to go out and the top wax rod edge helps to inspect the status of molten wax while heated to lost wax. The bottom two wax channels later will be converted to pouring metal and for air vent. While applying the clay and sand mixed plaster the mould is smeared with water to make easy to stick the plaster. The sand and clay plaster have to cover the nails and the wax rods completely. At the top of the plaster cover, four or five steps are made for a purpose which will be described on another process. (Fig. 160) Then the mould is left to dry for four or five days on shade to dry slowly. The moulds are not dried on direct sunlight since the heat may cause cracks on the mould.

Strengthen the moulds with iron wires: On 9th August the mould was dry enough to perform another process. For commencing the process iron rod and a roll of iron string was prepared. Iron rod was tied on four sides of the mould from top to bottom in vertical line as shown on the figure. (Fig. 161) Then around the iron round iron string was tied around starting from the bottom to the top and tied with the same iron

wire in different places. The step structure at the top of the mould was made to hold the iron strings at place. (Fig. 162)

Seal the mould with third coat of clay and sand plaster: After the iron wires were surrounded around the mould, to strengthen, the mould, once again needed to be covered with clay and sand plaster. The combination of sand and clay is sand five portions and clay two portions. The wet clay and sand is kneaded properly to make good mixture. Then wetting hand and also the mould with water, the clay plaster is applied on the mould covering the iron wires with thick layer. On the top of the mould where the wax rod is exposed, a cup shaped structure is made around with the same clay plaster. Inside the cup the wax is exposed for inspection during the firing the mould to lost wax. The mould is left to dry for two days to commence further process.(Fig. 163, 164, 165)

Make air vent and pouring cup: On 11th Aug the mould was dry enough and the mould was turned upside down. The brick bats attached at the bottom of the mould is taken out (Fig. 166) and the mould is secured upside down on a secured place surrounded by bricks. (Fig.167) The hole reveals the base of the core of the mould and the wax rods are now exposed on the two sides of mould base. The base also reveals the thick layers of mould applied before. In the core of the mould two inch long iron nails are gently hammered. The nails are inserted just four or five millimeters in the core. (Fig.168) The exposed nails and empty hole is covered with the same combination of sand clay plaster mixed with water. (Fig.169)With the expert hand of the mould maker the base of the mould is modeled for lost wax and casting bronze. The exposed two wax rods are surrounded by the clay cup securely modeled to make easy to pour the molten metal. The mouth of the cup is made in cone shape to give pressure which enables the molten metal flow smoothly into the gate or the channel which is hollow after the wax is lost. The finished mould is let dry for four days to do the lost wax process. (Fig.170)

Build kiln to lost wax: Until the mould gets dry, the kiln for the melting the wax out was built on the same day. The kiln was made in a traditional way to use firewood for melting the wax inside the mould. The bricks with 14 x 7 x 3cm in size are used to make a

single parallel line brick wall. The bricks are stalked in order to the height of 45 cm and 126 cm long.(Fig.171) Upon the brick wall seven pieces of zinc pipes80 cm long and diameter of 6cm is placed across the brick wall at the center. Two pipes on either side are tied together with iron string and the pipes in between are secured with brick bats in equal intervals.(Fig.172) Then brick masonry is built upon the zinc pipes attaching with equal portion of clay and sand mixed with water used as mortar.(Fig.173) The round shape brick wall is built to fit the mould inside the empty space. The brick wall is plastered with the same combination of clay and sand mixed plaster. (Fig.174)





Figure 154 Showing how the wax rod as sprue is going to be attached before attaching the wax rods.

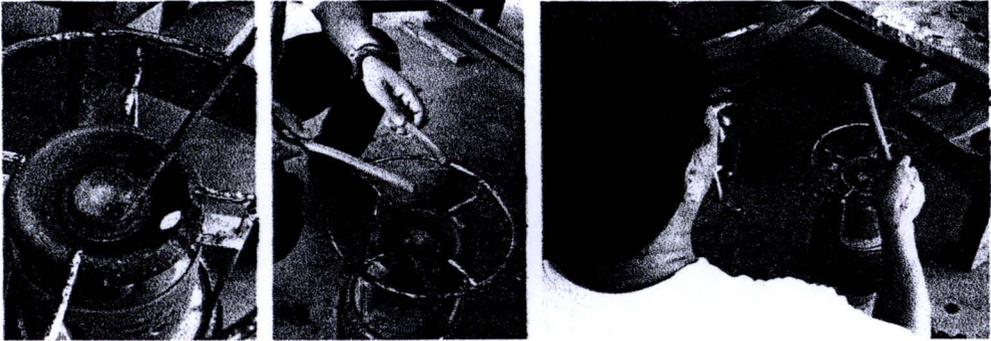


Figure 155 Heating iron and wax rods

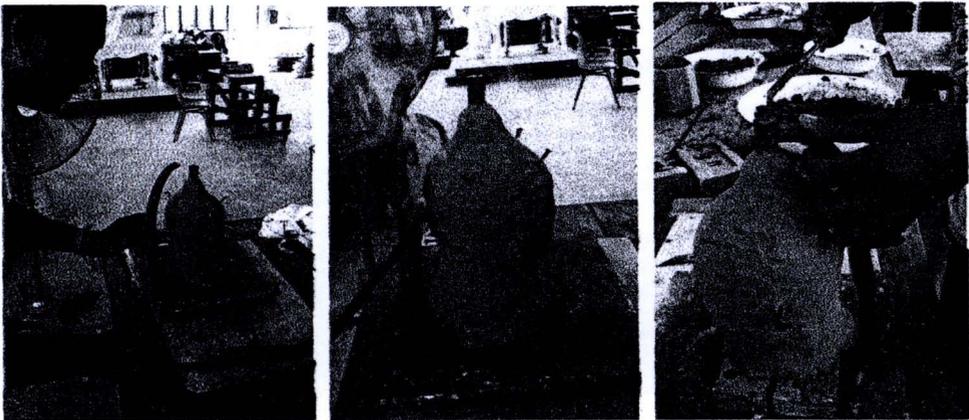


Figure 156 Attaching wax sprues.



Figure 157 Attach wax channels and runners.

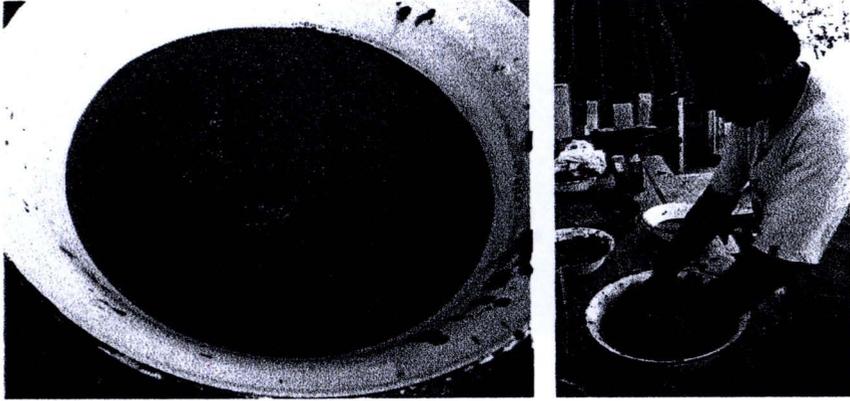


Figure 158. Mix water based clay with sand.



Figure 159. Apply second coat of sand mixed clay on the mould to cover wax rods and nails.

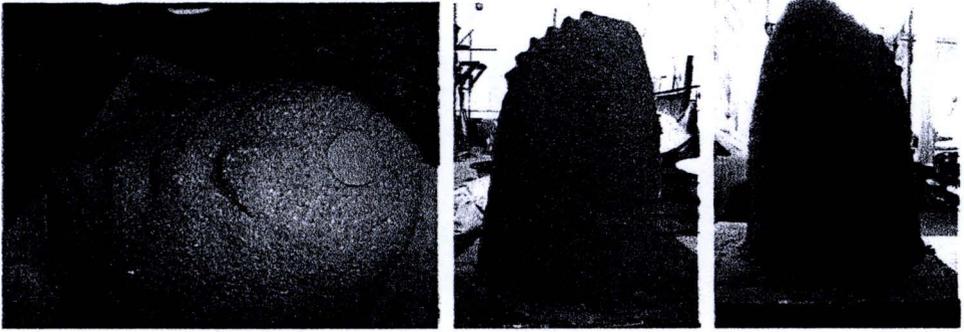


Figure 160 Wax channel exposed and finished second layer of clay and mud plaster.

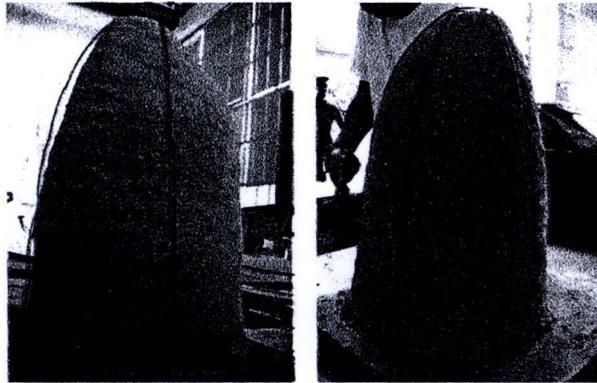


Figure161 Tie iron rods.

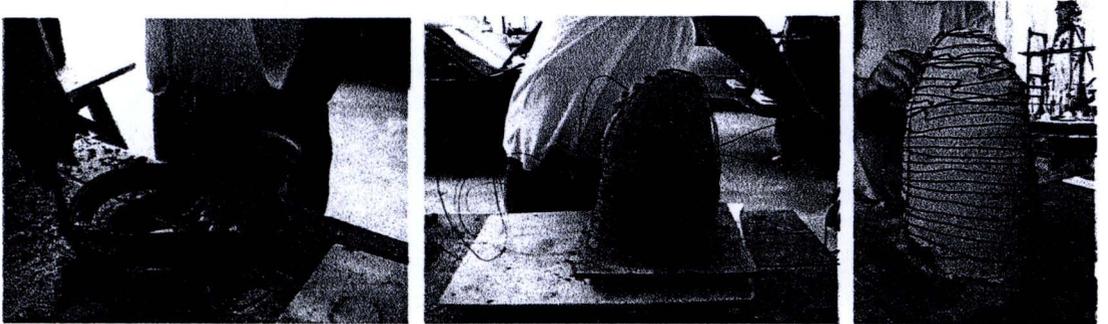


Figure162 Surround and tie iron wires around the mould.



Figure163 Applying sand and clay mixed plaster on the iron wire.



Figure164 Exposed wax rod and preparing to make cup on the wax rod.

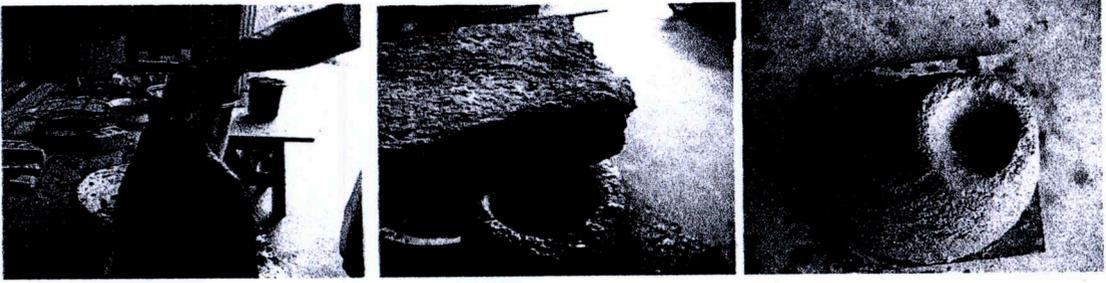


Figure 165 Making inspection hole on the exposed wax rod which will be covered by brick while melting wax out.



Figure166 Taking out brick bats from the base of the mould.

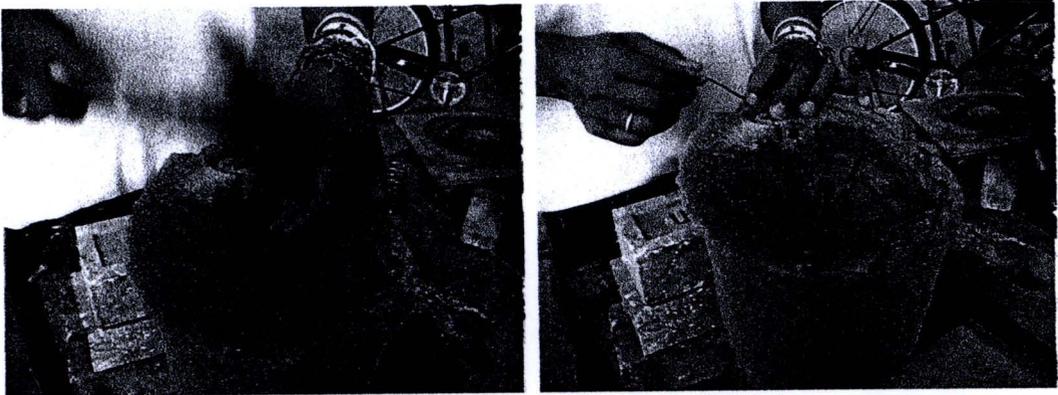
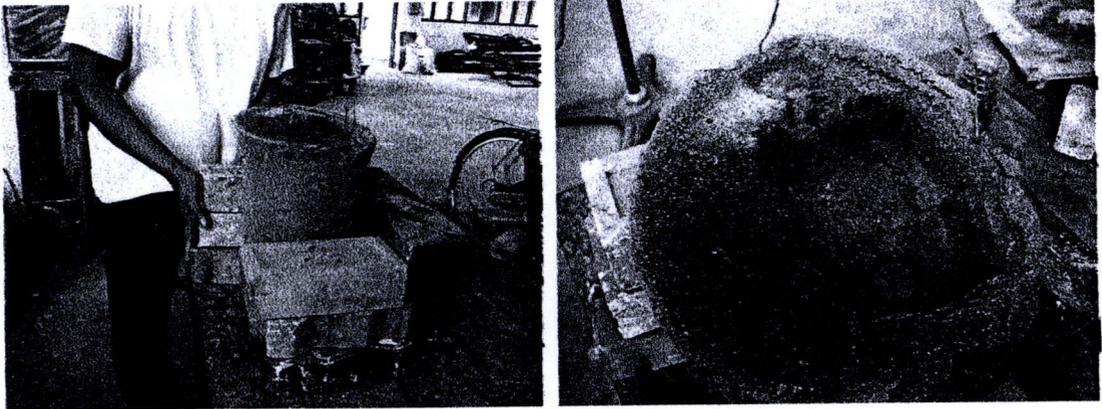


Figure167 Exposed wax rods and inserting the nails on the base of the core.



Figure168 Fill the hole on the base with clay and sand mixed plaster.



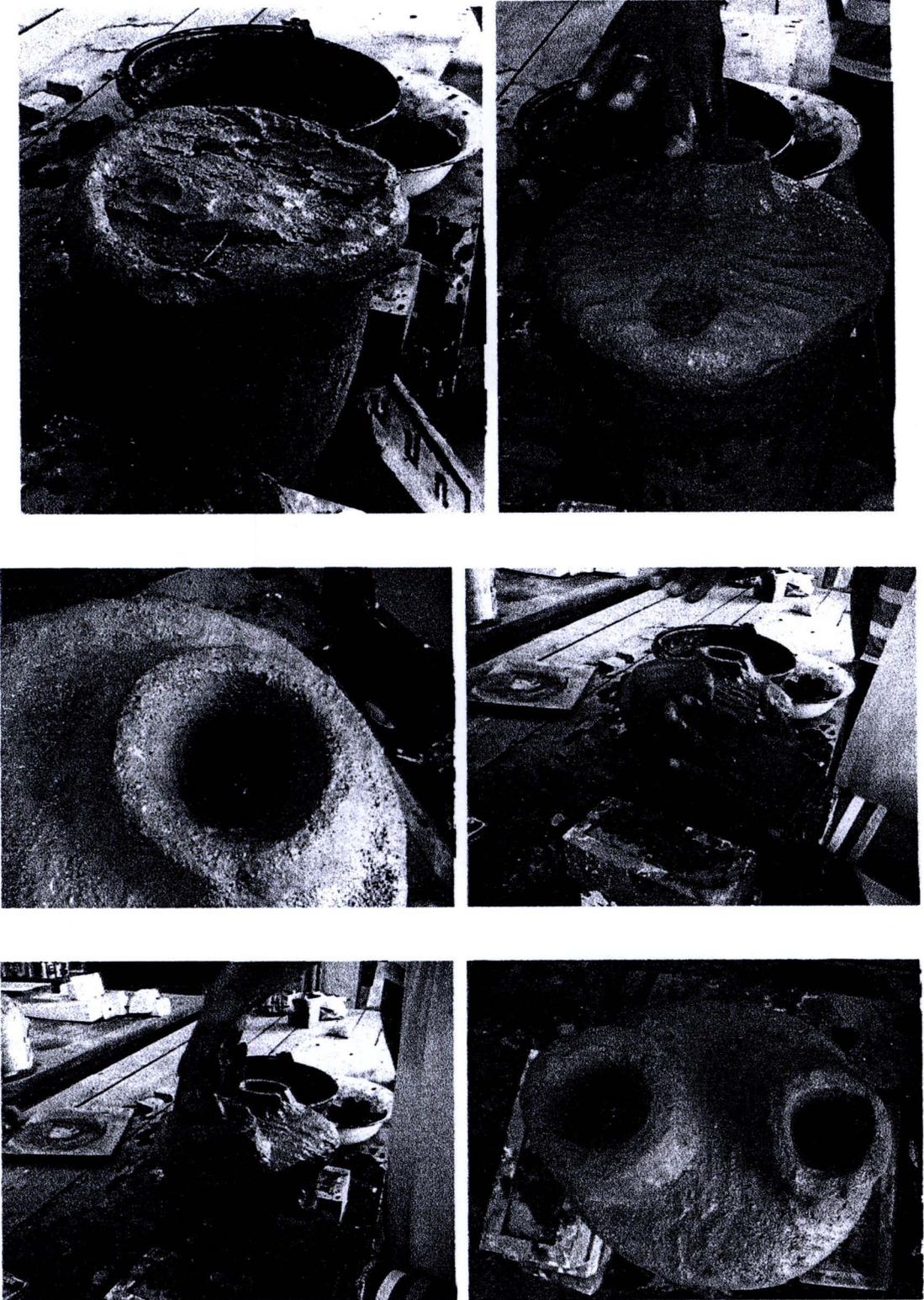


Figure169 Make air vent and pouring cup with clay and sand plaster.



Figure170 The finalized mould left for dry.

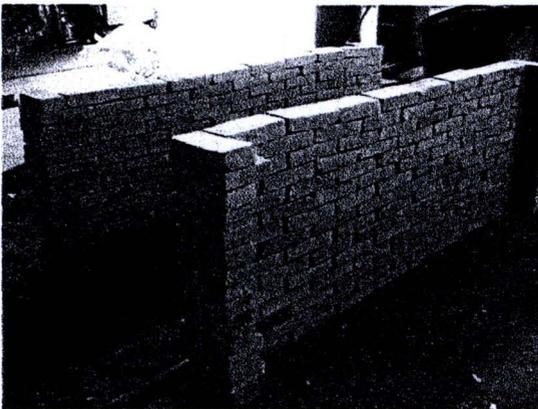
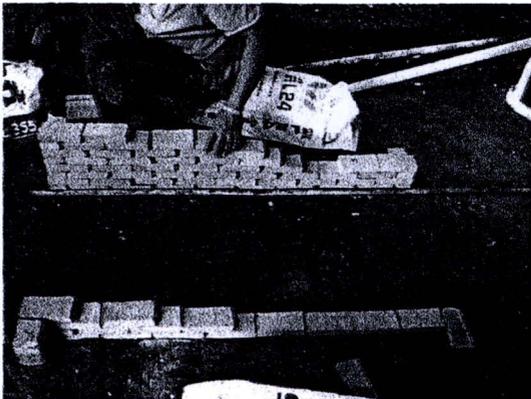


Figure171 Constructing Kiln with brick.

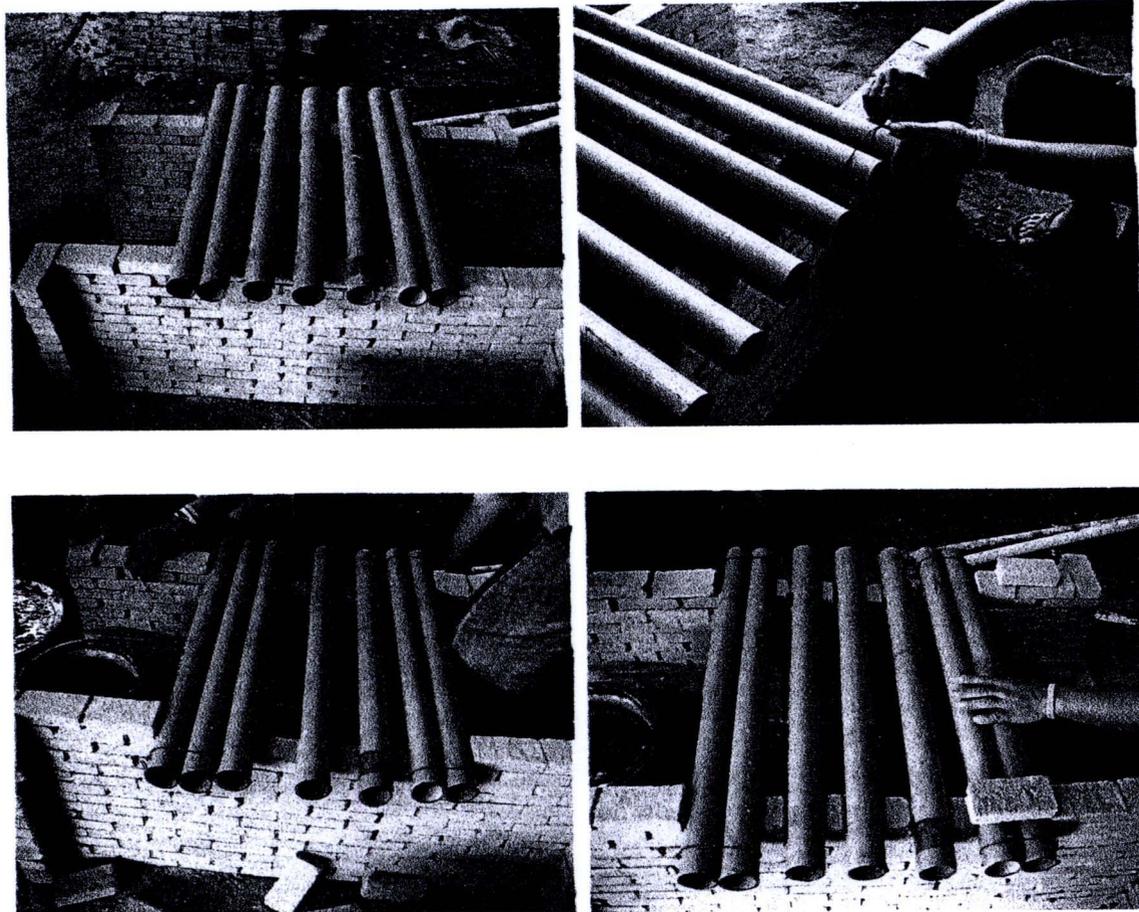


Figure 172 Tie zinc pipes and strengthen with brick.

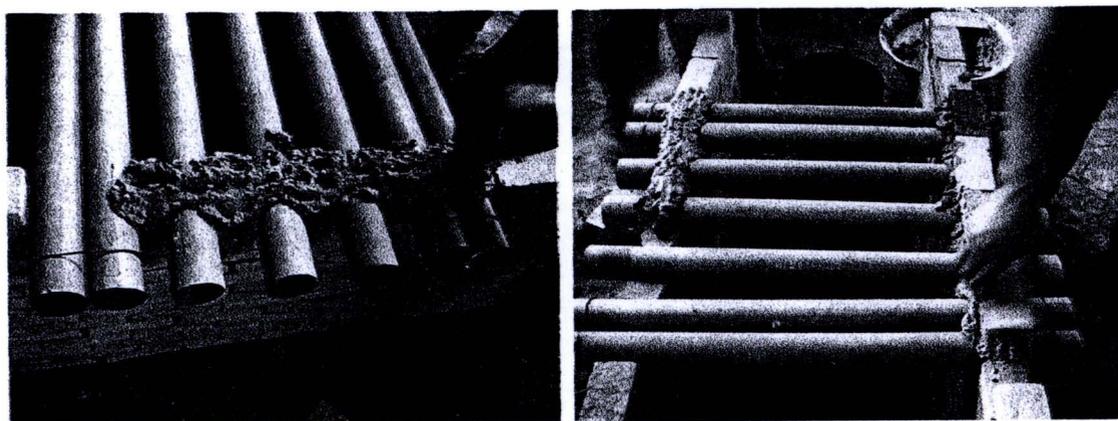


Figure173 Build brick masonry on the zinc pipe.

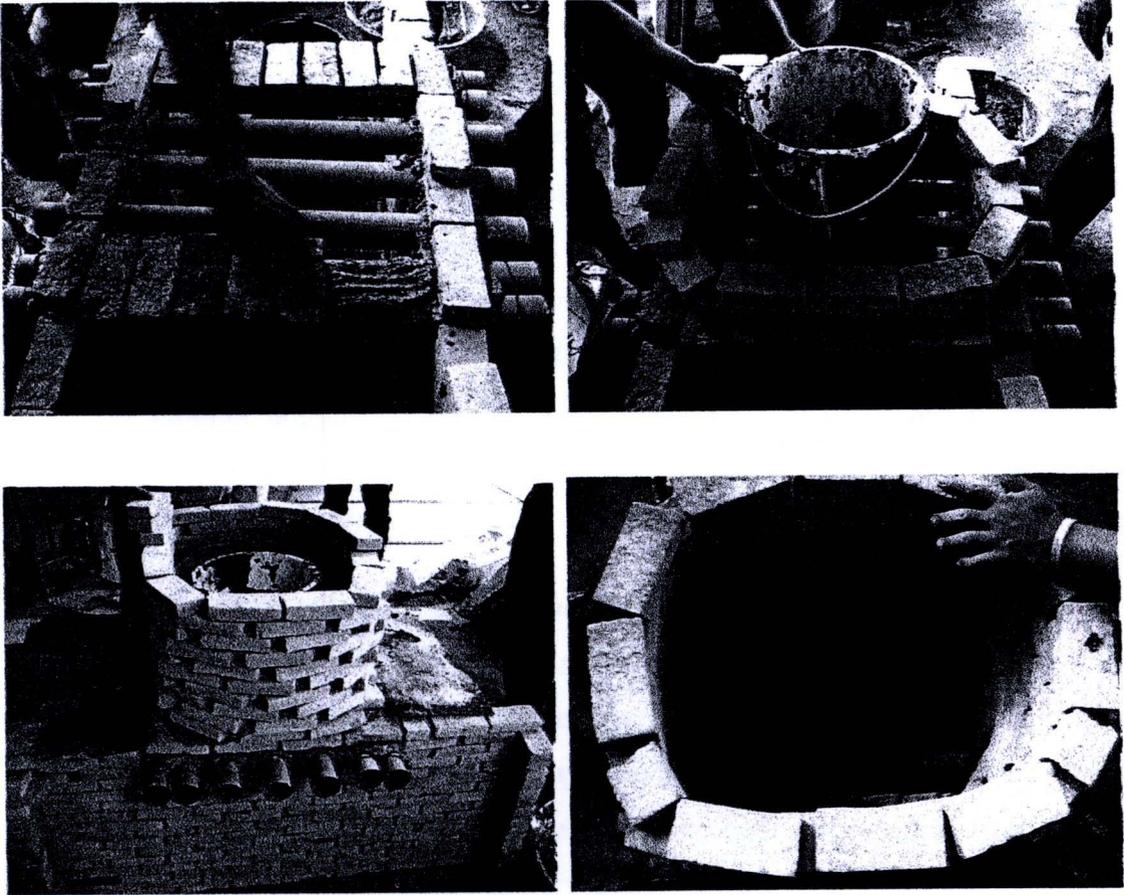


Figure174 Round brick masonry for placing the mould inside.

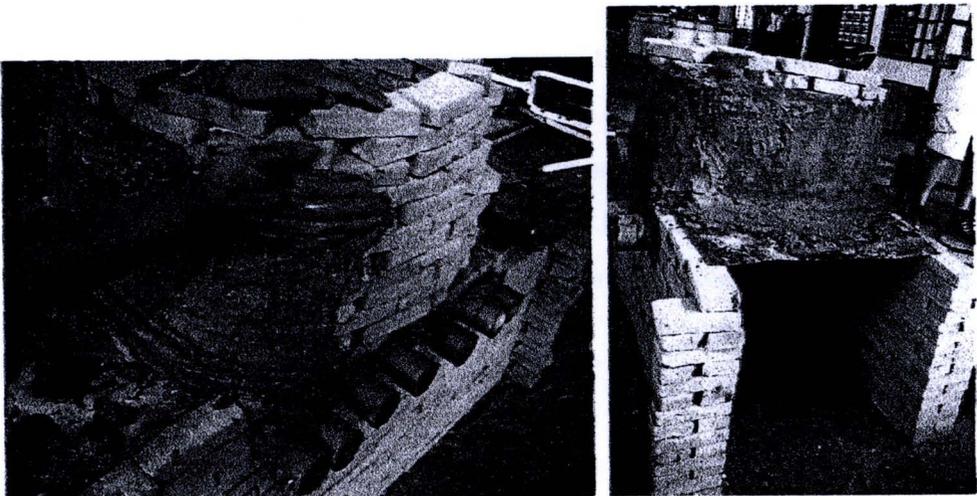


Figure175 Apply clay and sand mixed plaster on the brick wall.

Lost wax from the mould: The day was fixed for 16th August to lost wax and cast with bronze. The mould was dry enough on this day to prepare for further process. Early in the morning, Ajarn Ding(Full name: Mana Sukkhee) at 6.0 AM placed the mould on the previously made kiln. The single hole side of the mould was faced up and two sprue holes side was faced down which was erected upon the zinc pipe. The hole on the top was covered with a new brick which is used later to check if the wax is completely lost or not. (Fig.176) Then for temperature control and monitoring, a temperature monitor is prepared and the sensor rod was fixed inside and the kiln. The temperature measuring device is operated by electricity. And temperature is displayed on the temperature indicator. (Fig. 177,178)

At 6.30 AM by offering a flower *malaai* to the fire god and praying to the spirits for safety and any ask forgive for unknown misbehaves, on both side of the kiln fire was ignited on the special wood prepared for the process. According to Ajarn Navin the fire wood name as *Kongkang* has specially quality. The trees of these kinds are found near the sea water and it has salty quality which helps to give high heat when it is burnt. The charcoal obtained from these woods is very good for high heat. They grow fast after planting and also can be found on the seashores of Petchaburi province of southern Bangkok. The trees are very nutritious that fish, crab and small water animals stay near the tree roots as well as it helps to protect tsunami to some extent.(Fig.179) The process of giving fire on the mould is very unique because the fire is not burned directly under the mould at the beginning. But the fire is burnt on the mouth on the both side of kiln. After fire starts to burn properly, the fire burning on the mouth of the kiln is partially covered with a zinc sheet which helps to redirect the heat of fire inside the kiln. The heat and flame goes inside the center of the kiln from both side which helps to heat the mould. (Fig. 180)

At 8.0 AM at the temperature of 140 degree centigrade wax started to melt and dropped on the floor through the wax sprue holes which are melting at this point. From this very moment phenomenon of lost wax from the mold starts. Melted wax dropped on the floor and allowed to evaporate since the quantity of the wax is very small in this case

otherwise in the case of big statues melted wax are collected on a pot through an iron pipe which can be reused for other statues. When wax starts to melt the temperature of the kiln is raised by adding more fire woods and at 8.30 AM the temperature indicated 153 degree centigrade. (Fig. 181)



Figure176 Dry mould placed in the kiln and covers the hole on the mould with brick.

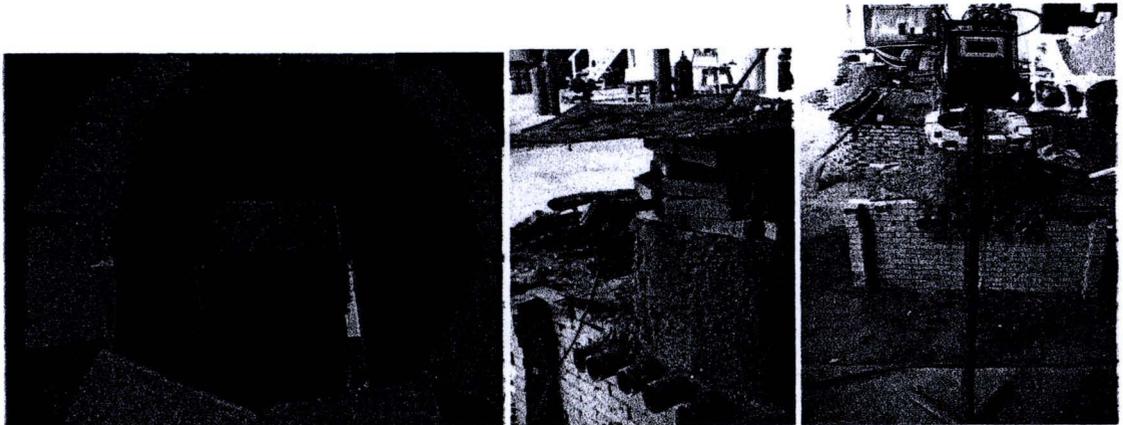


Figure177 Insert temperature measure rod in the kiln.

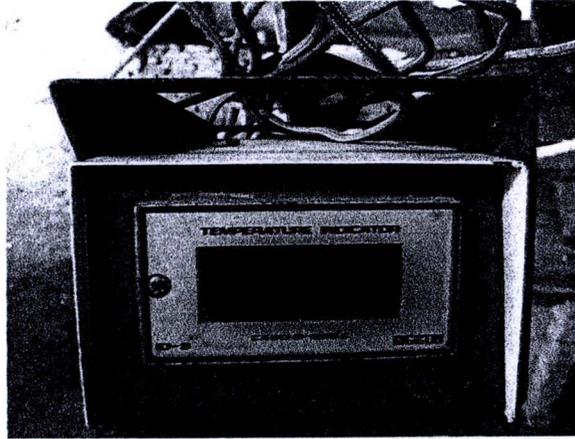


Figure178 Monitor of temperature indicator.



Figure179 Offering Malaai to God and spirit to start fire in the kiln.



Figure180 Giving heat under the mould from fire burning at the two mouth of the kiln.



Figure181. Wax melting down from the mould.

Phenomenon of fire ball: At 9.0AM temperature indicated 245 degree centigrade. Melted wax seems not coming out at this moment. Ajarn Ding increased heat but too much heat is not good for mould which may crack in sudden high heat. The constant heat moves through the hollow part of the mould and makes it dry from inside. At 9.30 AM Ajarn Ding put charcoal and wood directly under the mould. In different interval of time temperature of the mould increased and decreased such as, at 9.50- 203 degree, at 10.0 AM heat was increased and at 10.20 AM temperature was 390 degree, at 10.34 AM- 320 degree to 388 degree and increased to 409 degree. At 11.15 AM temperature was 524 to 536 and at 11.30 temperature of the kiln was 542 degree centigrade. At this moment the phenomenon of the fire ball occurred inside the kiln. Fire ball occur at some point after the wax melts, the gas goes inside the mould and from the cavity gas comes out and the gas burns when it comes out. The gas comes out underneath the brick which is covering the hole on the top of the mould. The wax residues stick inside the brick.

When the fire balls happen fire is increased to 542 degree centigrade to take out gas completely. If the gas burns that means there is wax gas or residues remaining inside.(Fig.182,183) If the fire ball does not occur that means there is no wax inside the mould. The heat slowly decreased to 385degree at 11.45AM and 380 degrees at 11. 50 AM, again fire wood was added to raise heat and covered the mouth of kiln with zinc sheet. During this process a crucible made of Graphite and clay, which has high heat resistance, is places on the mouth of the kiln to pre heat the crucible. The crucible is small with height of 10 inch and when it falls on the ground it can break into pieces.(Fig.184) At this moment the brick placed on the top of the mould is inspected if there is any waxy residue left. The brick was very clean as a new brick at the part of the cover. (Fig.185)If the brick is clean it is understood that the mould has lost wax and there is no wax left inside. This is the traditional way to check the process of lost wax. Then some time the heat was very high then allowed to cool down slowly and the heat were 178 degree at 1.45 PM and 129 degrees at 3.00 PM.

Build furnace to melt bronze: When the heating process of the mould is going on and after the wax is lost, a furnace was built to melt the bronze. The furnace was made of brick and an air hole was made at the bottom center of the furnace. The furnace is made according to the size of the crucible in every case. The size of the furnace is calculated by putting the crucible in the middle of the brick wall in the initial stage. (Fig.186)



Figure182 After wax stops to melt give fire directly under the mould.

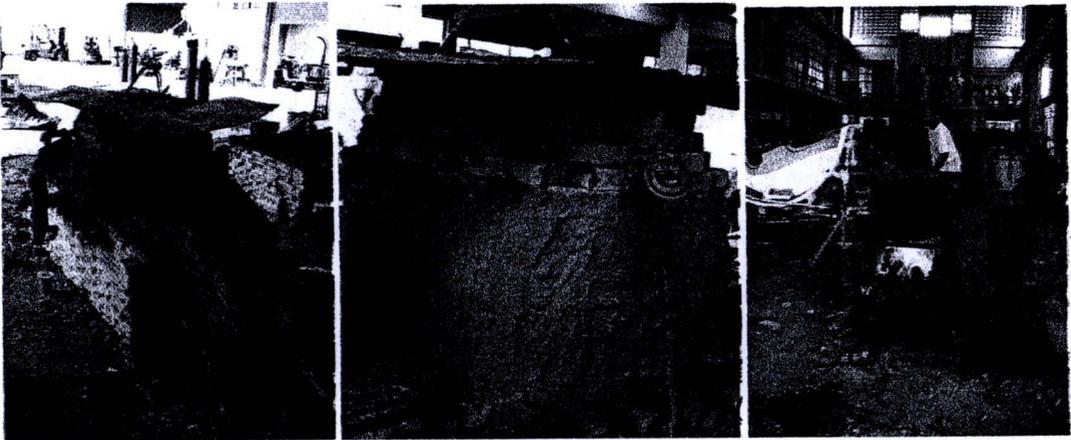


Figure183 Increase fire heat until the fire ball stops to appear from the mould.

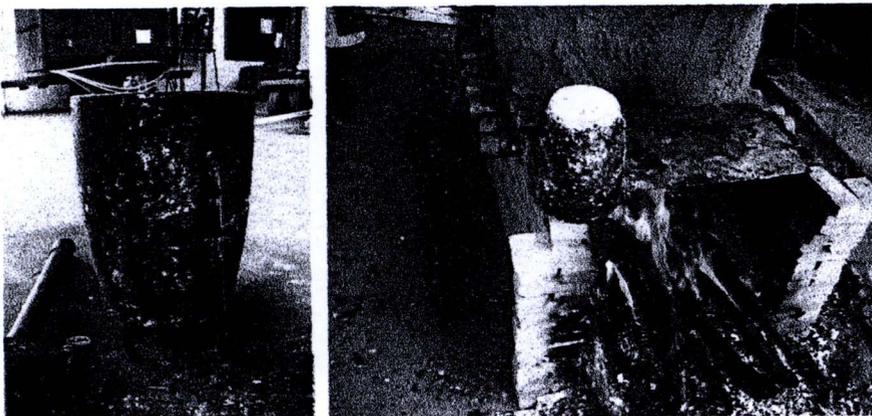


Figure184 Crucible and pre heat on the heat of fire.

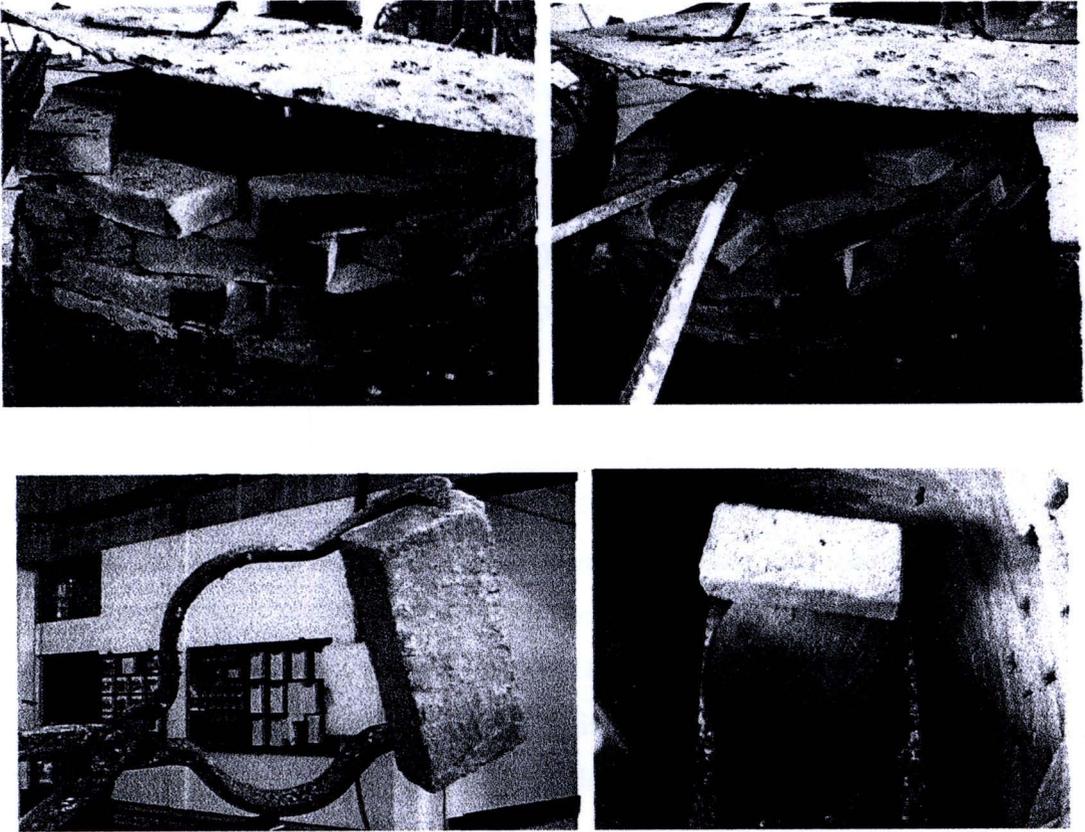


Figure185 Checking the brick placed on the upper hole of the mould.

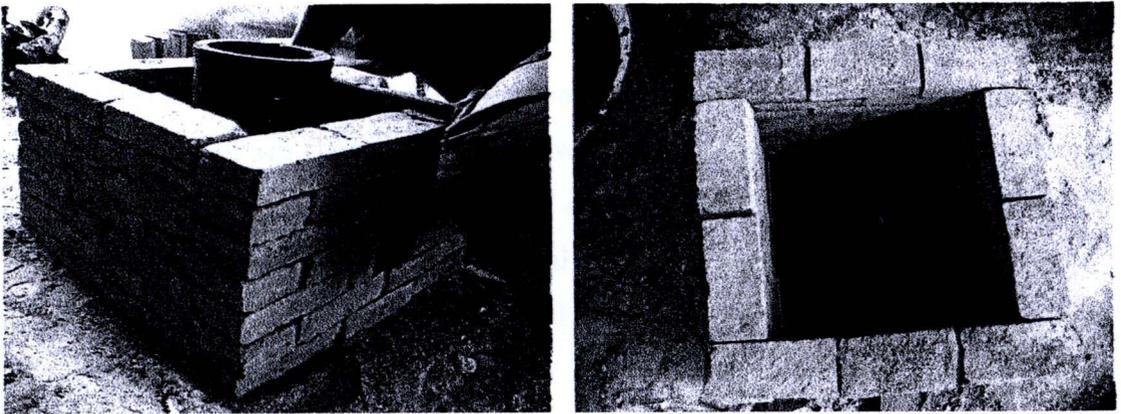


Figure186 Making brick furnace with air hole at the bottom to melt bronze.

Plaster with sand and clay paste and make air circulation placement: When the brick wall is tall enough to the level of the crucible mouth, the walls are plastered with wet clay mixed with sand on the upper part of the furnace. The clay paste is applied in all the places of the inner part of the furnace. (Fig.187) Then a brick is raised on its wide side right at the center of the furnace in front of the air hole. Then another four pieces of bricks are placed in front of the corner of furnace facing the to the corner direction as shown in the figure.(Fig.188) The arrangement of the bricks helps to circulate air inside the furnace and make coal burn more to high temperature when the bronze is being melt.

Place zinc sheet on the air circulation brick and strengthen with brick and clay: Upon the air circulation bricks inside the furnace base, a zinc sheet fitting the width of the brick arrangement is placed as shown on the figure. Then small brick pieces are places in slanting position at the edge of the sheet touching the wall of the furnace which surround the sheet from four directions. (Fig.189) The bricks are covered with the clay paste and the base of the zinc sheet as well. This helps to strengthen the sheet at its place and the holes made by the bricks helps to circulate air around and give more intense heat. The wet clay is dried by putting some burning charcoal taken out from the wax melting furnace. (Fig.190, 191)

Place crucible with the bronze ingots inside and surround with charcoal: The furnace dried after an hour and the crucible was placed at the center of the furnace and the height of the furnace rose by adding more bricks on the wall and then plaster with clay paste. Two pieces of bronze ingots were kept in the crucible, then empty place around the crucible filled with burning and dry charcoal layers.(Fig.192,193,194) The crucible is completely covered with charcoal. When air blows through the air hole at the bottom of the furnace, the burning charcoal starts to burn more and other dry charcoal also starts to burn. The mouth of the furnace is covered with zinc sheet to make sure that heat do not go out and wasted. The intense heat inside the furnace starts to melt the bronze ingots and liquefy slowly. When there is enough space in the crucible another ingot of bronze was added. The temperature inside is nearly 1500 to 1700 degree

centigrade when all the metal melts in the ingot. The heat in the furnace can be seen from above the zinc sheet which at this point is intensely heated that the sheet is red and looks like it will melt too. (Fig.195)

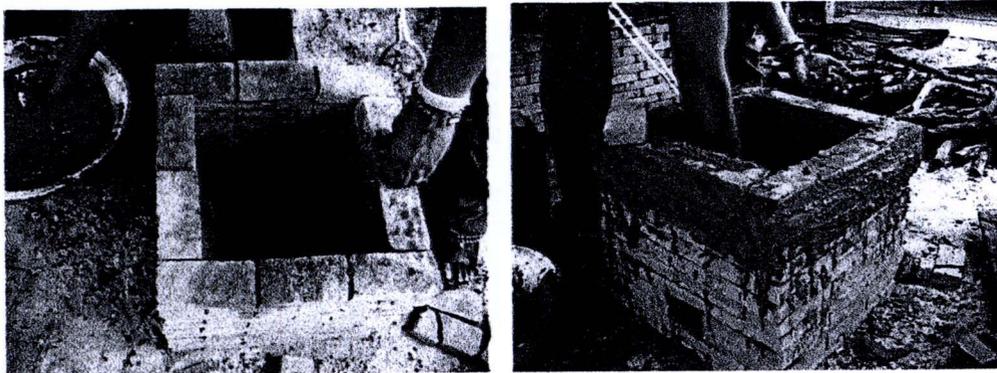


Figure 187 Plaster upper part of furnace with clay paste.

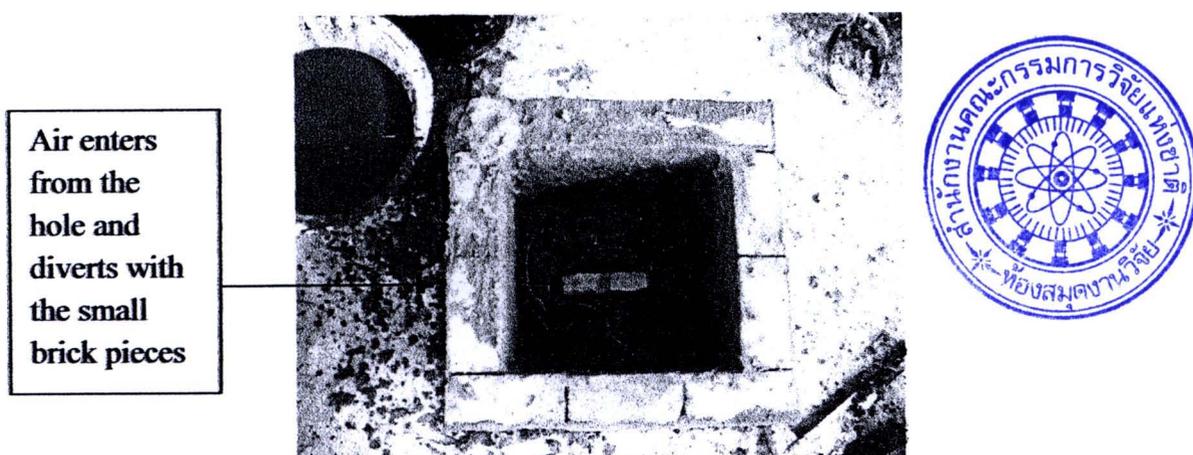


Figure 188 Arrange brick for air circulation right in front of the air hole.

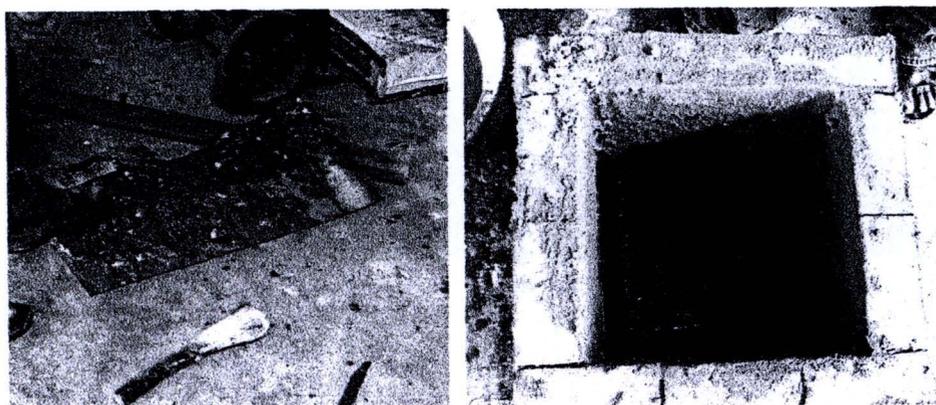


Figure 189 Place zinc sheet on the air circulation brick.

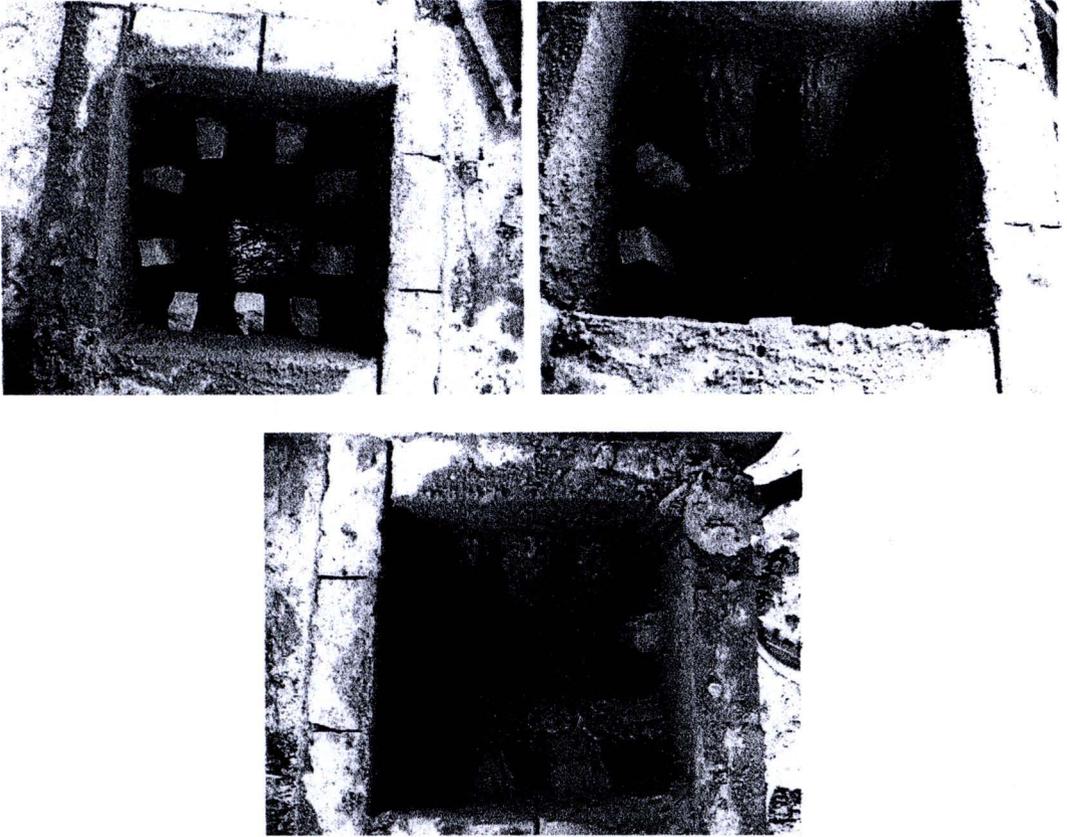


Figure190 Another brick arrangement of air circulation and plaster with clay paste.

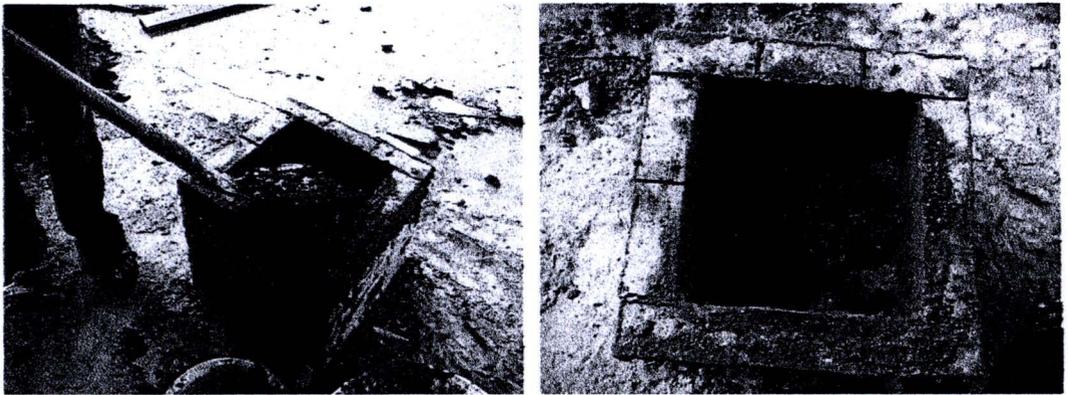


Figure191 Put burnt charcoal on the wet clay to dry faster.



Figure192 Secure the crucible at the center and raise the furnace height by adding brick layer.

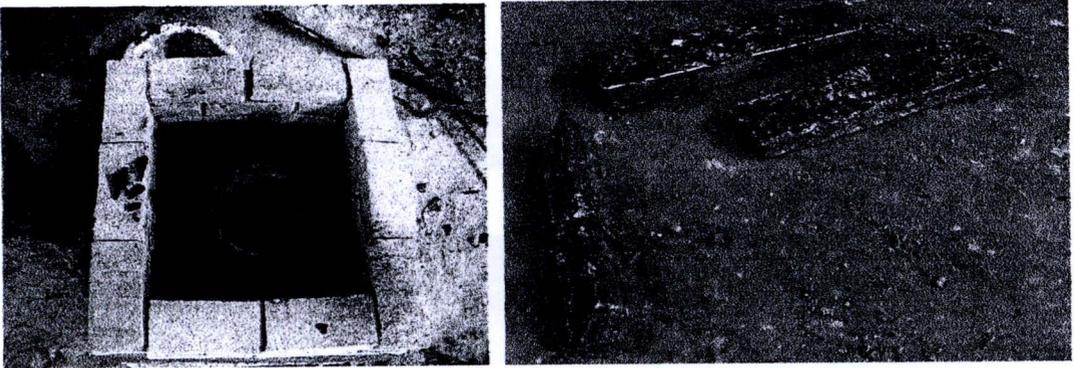


Figure193 Surround the crucible with big charcoal pieces and bronze ingots.

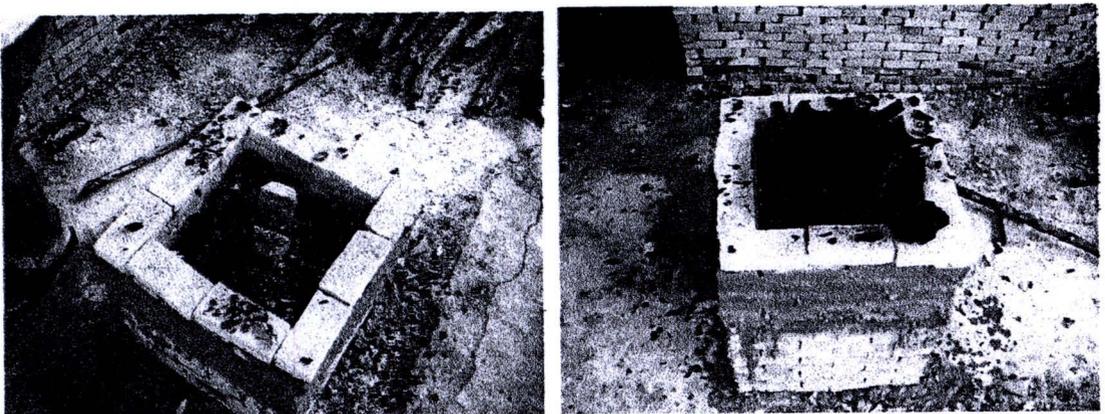


Figure194 Bronze ingots placed in the crucible and cover with burnt charcoal.

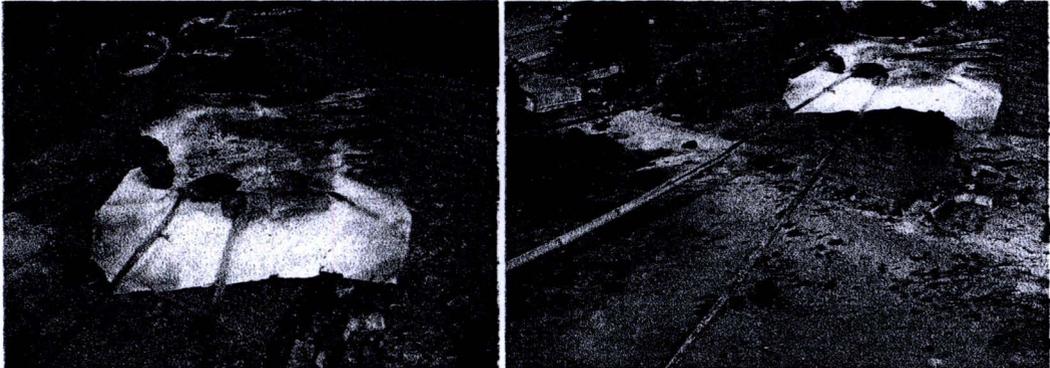


Figure195 Air blow makes the charcoal fire burn to its highest temperature.

Prepare the mould for pouring bronze: When the bronze is melted and boiling to its highest temperature, the mould is taken out of the kiln and placed carefully on a jute cloth.(Fig.196)

Close cracks and hole of the mould: The mould develops cracks in the heat. It must be covered before pouring the liquid bronze. Ajhan Ding closed the cracks with clay paste and the single hole of the mould was closed with a lump of clay paste and smoothen the surface with hand. This side of the moulds was faced down when the mould was securely placed on the ground surrounded by bricks and iron ingot frames.(Fig197) When the mould is secured to pour bronze, air pressure increased at the covered furnace where the metal is melting. When the heat is sufficient enough for pouring, the impurities in the melted bronze are taken out with a long handled spoon. (Fig.198)

Take out crucible from the furnace and pour bronze into the mould: To take out the crucible from the furnace some layer of bricks are dismantled to take precaution and for easy to clutch the crucible. It was nearly 4.0 PM in the evening then Ajarn Ding now wearing a heat protecting gloves on his both hands, took out the crucible with melted bronze from the furnace and placed on the ground.(Fig.199) With another clutch with long handle, the red hot crucible is hold up to get ready to pour into the mould. When the liquid metal is about to pour, another person stir the liquid with iron rod. Then the liquid is poured from one pouring hole of the mould and came out from another air vent hole. The liquid bronze pushes out air inside the mould while it comes out from the air vent vole.(Fig.200) Then both holes are filled with the bronze and the remaining bronze is poured in the ingot pot. (Fig.201)

This whole process of pouring the bronze takes only one to three minutes. It seems so quick and fast that time has stopped and the atmosphere of the moment is very intense and all pray for safety while pouring the metal and believe the task will be without any error. And of course this is the climax of the whole casting process which starts from clay model and going through different phases of mould and end up in the

bronze sculpture. There we can see red hot metal and fire all over the places cooling down from the climax moment.(Fig.202,203)

Break the mould: Since the sculpture for this case study was very small, the bronze in the mould can cool faster than the big ones. We waited for one and half hour for the liquid to settle in all the hollow part of the mould and after one hour one of the staff started to break the mould. (Fig.204) While breaking the mould was still hot and revealing all the layers of the plaster, wires until the sculpture within starts to reveal. Sculpture was shining golden in color which rejoiced the onlookers who were anxiously waiting to see the bronze sculpture. (Fig.205, 206)

Bronze sculpture with channels: The sculpture revealed completely from the broken mould with the channels attached to it which was made of wax before the mould was manufactured. The molten bronze went through these channels to all over the empty cavity of the mould. To our disappointment nose and forehead part on the face of the Buddha sculpture was missing. (Fig.207) Ajarn Nikorn Koehapong, the senior sculptor informed us that it was the fault of the thin layer of wax applied at that part. According to him wax layer play the vital role which makes the difference on casting bronze. Due to very thin layer of wax there was almost no cavity in the mould. (Fig.208a)

The fault can be corrected by welding at the missing part. The nails and channels attached on the sculpture are cut and taken out to do another process of finishing. The rough joints are smoothed with a hand tool. To take out shine and get rid of access residue on the surface, electric shiner as shown on Figure 208b is used.

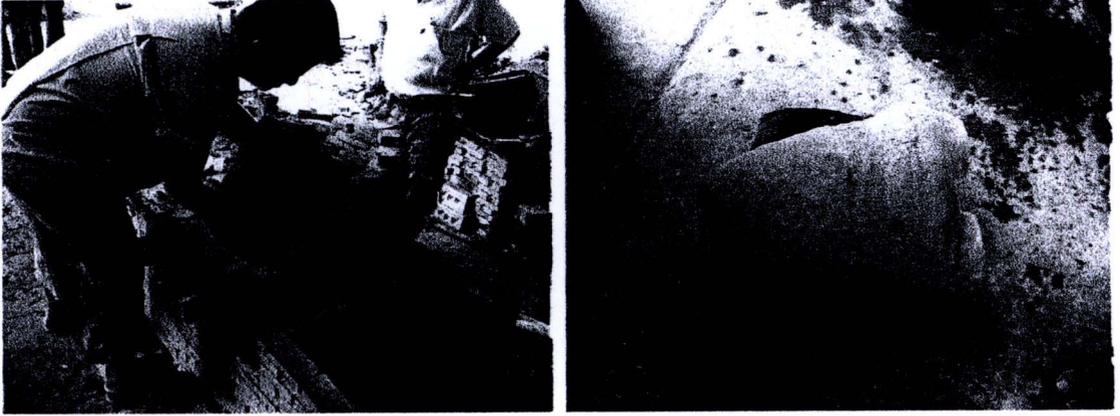


Figure196 Carefully taking out the hot mould from the kiln and place on the ground.



Figure197 Close cracks and the single hole with wet clay plaster and securely place upright with the two holes facing up.

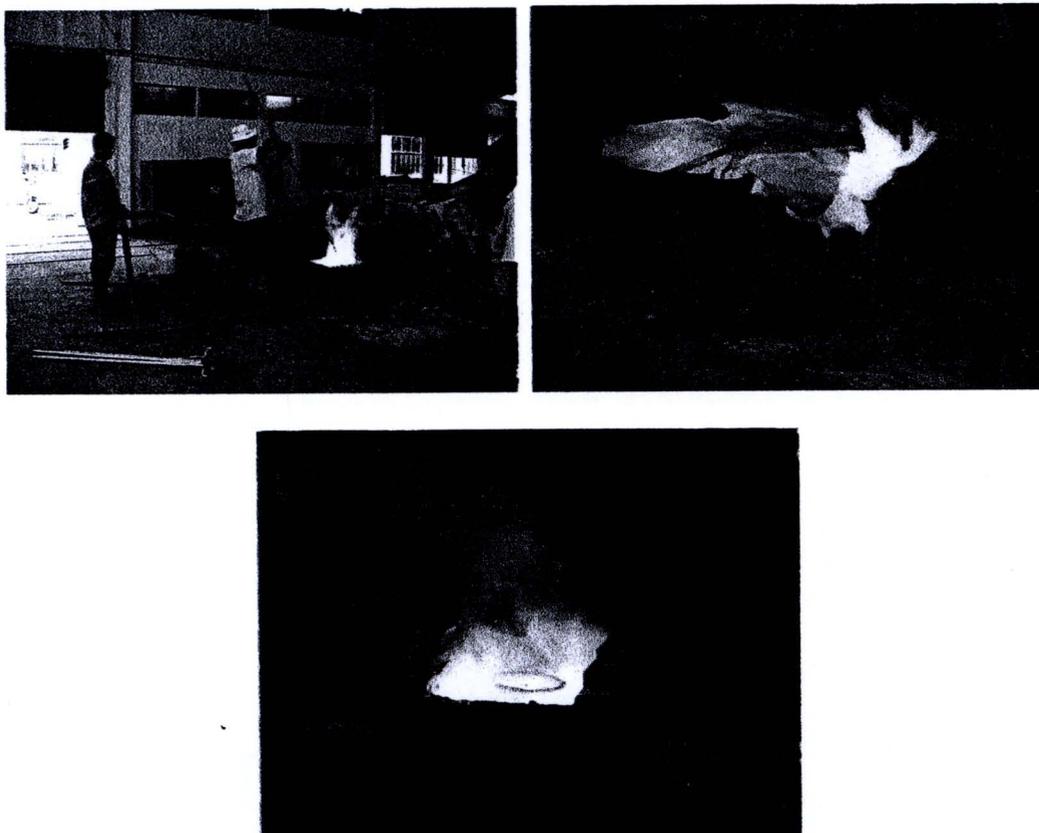


Figure198 Taking out impurities and raise air blow to prepare for pouring the melted bronze.



Figure199 Take out crucible from the furnace and place on ground.

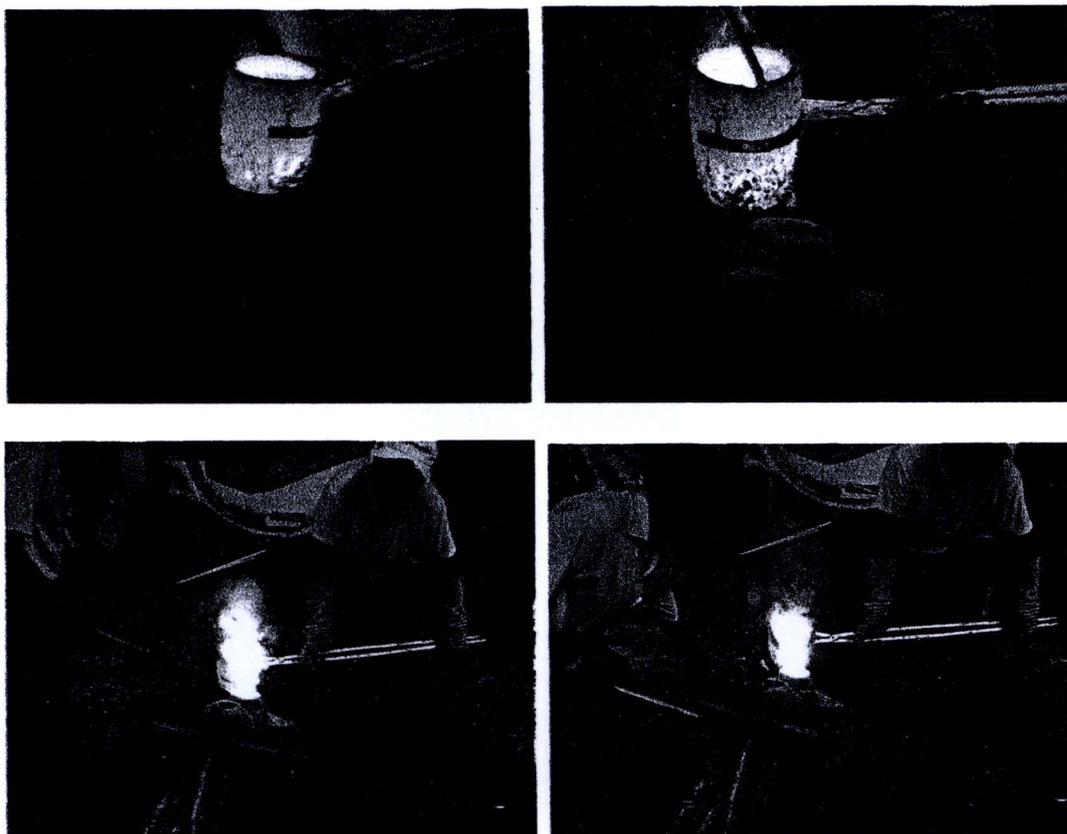


Figure 200 Hold up the crucible from the ground and pour molten bronze into the first hole.

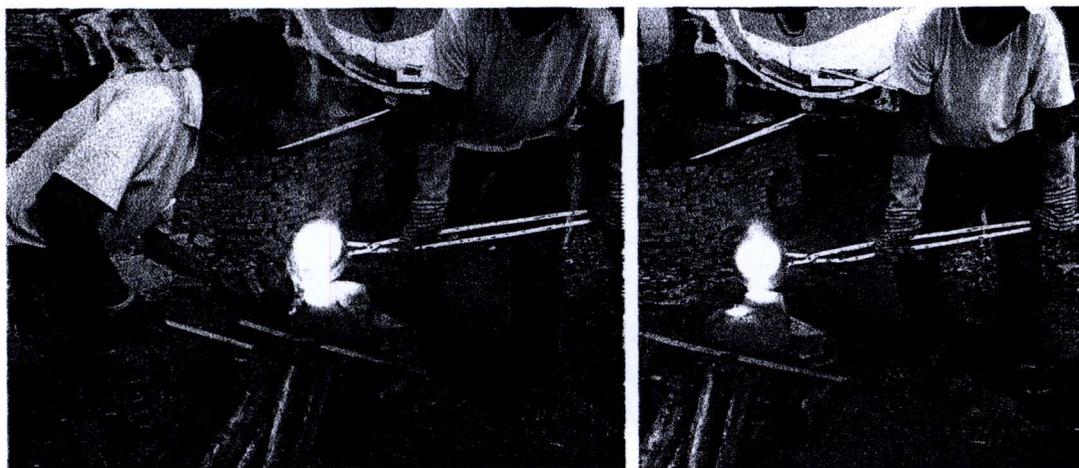


Figure 201 Pouring molten bronze on the air vent after the air is pushed out from inside bronze.



Figure 202 Pouring remaining bronze in the ingot pot.

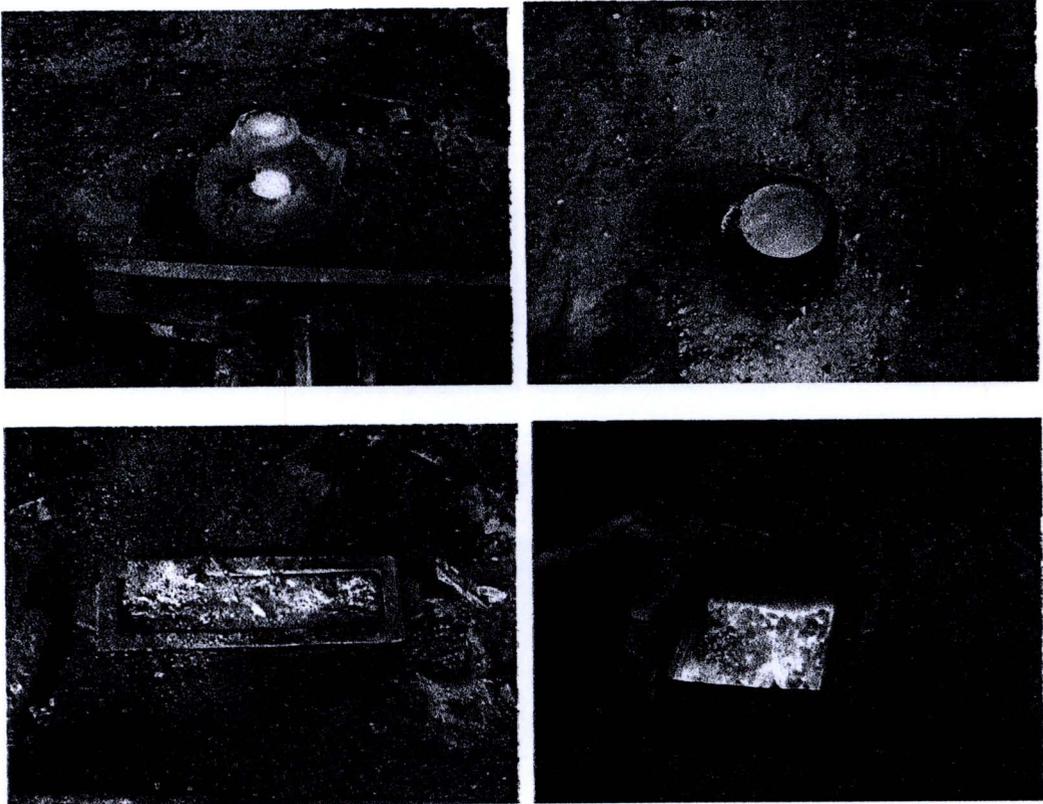


Figure 203 Hot liquid metal and with hot crucible and furnace.



Figure 204 Breaking the mould after it cools.

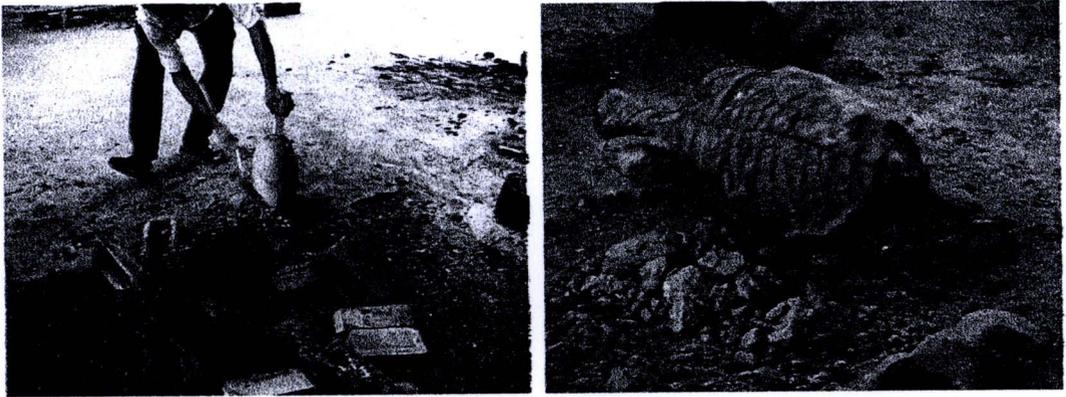


Figure 205 Breaking the mould revealing the layers of burnt clay and sand plaster.



Figure 206 Revealing the bronze figure from inside the mould.



Figure 207 Bronze head of Buddha with missing forehead and nose.

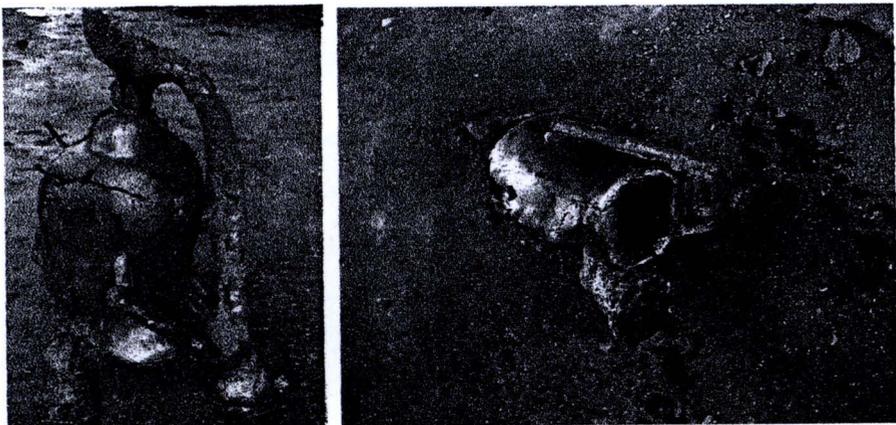
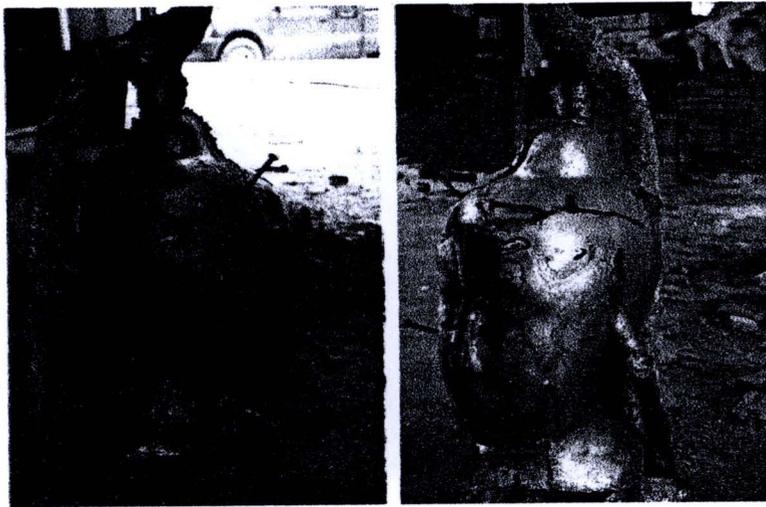


Figure 208a Bronze Buddha head with bronze channels and nails revealing.



Figure 208b Different stage of finishing process.

3.4.2 Traditional Bronze Casting in Nepal

Ulrich von Schroeder¹⁶ gave detail description of the lost wax or the *cire Perdue* process. He gave comprehensive detail of wax modeling, casting mould, casting, finishing, and gilding in the process of bronze casting technology. He deals with the traditional method of bronze casting. According to him casting image is a delicate process which is always executed by specialized artisans of India and Nepal belong to specific sub cast. Due to the fact that the entire manufacturing process is divided into several stages, the artisans specialize in particular skills according to their individual ability and qualifications. There is always a chief artisan who supervises and coordinates the complete process, and also responsible for contacting patrons and suppliers of the requisite raw materials.

For reference to the traditional casting technique which is similar to India and Nepal, an example from the statement of Ian Alsop is relevant in the context of bronze casting. Ian Alsop¹⁷ states that Nepalese metal sculpture has continued without a break from the earliest metal sculpture known until present time in the Newar heartland of the Kathmandu valley. The patrons were likely to be either royal or members of the richer elements of the diverse and energetic Newar society. It seems that Nepalese metal sculptors¹⁸ were taken from the ranks of the Buddhist elite or priesthood, in particular the Sakyas of a Buddhist monasteries of Patan. It is likely that they provided fine metal icons for the Hindu and Buddhists.¹⁹

¹⁶ Schroeder, Ulrich Von, *Indo Tibetan Bronzes* (Visual Dharma Publication, South China Printing, Hongkong, 1981).

¹⁷ Alsop, Ian, *Metal Image casting in Nepal*, www.asianart.com., 1 December 2009

¹⁸ In some cases Newari Jyapu caste used to work on metal caste. The Newari word Jyapu is the name of the farmer caste, whose members are likely among the oldest inhabitants of the valley. Although there are several noted Jyapu metal sculptors, the majority of the metal sculptors of the valley are member of the high Buddhist Sakya caste, and are largely concentrated in two Buddhist communities in Patan, Oku Bahal and Nag Bahal.

¹⁹ 1. For general studies of the technique and process of image casting in Nepal, see Ian Alsop & Jill Charlton, 'Image Casting in Oku Bahal', in *Contributions to Nepalese Studies*, vol. 1, no. 1, December 1973 pp. 22-49, and Marie-Laure de Labriffe, 'Etude de la Fabrication d'une Statue au Nepal', in *Kailash*, vol. 1, no. 3, 1973 pp. 185-192

Ian further states that Newar casting techniques differ from the standard casting practice in the rest of the world. They have always cast their precious icons almost exclusively in a nearly pure copper.²⁰ Pure copper is rarely cast in the west in modern times because the molten copper, no matter how strongly heated, never flow easily and produces abundant gases, which tend to flaw the casting. They avoided some of the defects through the use of relatively porous mould materials. Modern casting technique calls for relatively on porous mould materials. To vent gas, the pour is directed first to the lowest point of the casting via a main pour channel; the metal, once reaches the bottom of the mould, then moves up through the rest of the sculpture while the gases produced by the process escape through the vents at the top. The Newar casters avoid the relatively complex system of pours and vents that this system requires, instead opting for a simple system usually incorporating a tripod of channels for the pour leading directly to the sculpture, which does not have further venting.

This system works largely because the mould material used by the Newars is a composite of fine clays mixed with various organic materials, notably rice husks in the outer layers and cow dung in the fine inner layers. These organic materials are burned out of the mould during the firing of the mould prior to casting and the mould becomes somewhat porous, allowing the gases to escape without vents.

Similar materials are used in the traditional casting method of Thailand. At present due to introduction of modern materials like plaster and silicon mold, above mentioned materials are rarely used in the foundry of the Fine Arts Department.

The first step in making a cast metal image in the lost wax process, called *thajya* in Newari²¹, is sculpting the image in the wax that will hence be lost. The wax mixture is prepared by melting together beeswax, vegetable oil, and resin from sal tree (Sorea

²⁰ In the past the Newars generally cast their sacred images in almost pure copper, the best metal for fire gilding, which was almost always carried out after the casting and finishing. Indian metal sculpture traditions more commonly used variations on bronze (generically the term refers to any copper alloy, more specifically an alloy with tin predominant as the second metal after copper) or brass (where zinc is the second metal); often brasses and bronzes would have trace elements of the other metals of the pancha dhatu combination.

²¹ *Newars* are the ethnic group originally concentrated in the Kathmandu Valley. Their language is called Newari which is descended from the Tibeto- Verman Language stock.

Robusta), a tropical hardwood tree.²² After the wax hardens, lumps of it are warmed and pounded into thin, flat sheets. The wax sheet is further warmed over a charcoal brazier and the artisan begins gently to mold the image with the tips of his fingers. He first shapes the rough contours of the face and neck and then sculpts the facial features.

The excess wax of the sheet is cut away with a thin, heated steel blade, leaving just the contour of the face and neck. The facial features are further refined with a sculpting spatula made of buffalo horn, called a *silayku* in Newari. Using the different shaped ends of this versatile tool the artist articulates the facial features. The front and back halves of the Buddha head are produced from separate sheets of wax, allowing the artist to manipulate the wax from behind. Then the halves are joined, the head covered with small beads of wax which will be refined to represent hair, and the face completed. The head of an image of Buddha is covered with small beads of wax representing short curls. This is a tedious process because for each curl a precise amount has to be assessed and pinched from a soft piece of wax. It is rolled between the thumb and forefinger, heated over a brazier and attached by pressing it to the head. To further complicate the process the beads in each row change in size depending where they are placed on the head, and then must be further refined by hand using the *silayku* tool. (Fig.209)

To join the halves of the head their edges are heated over a brazier, called a *milayca* in Newari, and pressed together. A long thin bamboo stick with one end wrapped in cloth, called a *sikathica* in Newari, is dipped into a small pot of liquid wax. The liquid wax is dropped onto the unfinished seam which is worked smooth with the *silayku* tool. While molding a bust, the head, ears and shoulders are always made separately and joined together. With a full body sculpture the torso, arms, hands, legs, feet and pedestal would also be done in halves, joined and finally all assembled. (Fig.210) Seams are completely smoothed out with the buffalo horn spatula. Final adjustment to the image are made by adding and shaping thin layers of molten wax or scraping it off with various sized and shaped knives. The last step in the wax modeling process of the bust of the

²² The use of clay for the original sculpture, while customary in Western metal-casting traditions, is relatively rare in the religious sculpture of Nepal where the sculptors more frequently model the original image out of the same wax combination used for casting.

Buddha for example is to attach wax channel to connect chin to chest and ears to shoulders. (Fig.211) These channels help distribute the molten metal evenly throughout the mold during the process of casting. Finally the artist carefully goes over the wax image to make sure that no excess wax is present and that the surface is smooth. Refinements can be done at this stage by adding soft wax or by cutting away wax with thin steel blades. The completed wax image is what will be “lost” and replaced by molten metal and must therefore be perfect in all its details.

The clay mold to surround the wax is made in four stages. First the wax model is dipped in a fine sieved mixture of clay, cow dung, and water. If the sculpture is to be hollow the mold is also coated inside and requires a clay core. The mold is dried in the shade, dipped in a second layer of the shade, dipped in a second layer of the same clay mixture and dried again. Third and fourth clay layers with increasingly higher proportion of cow dung and added rice husks are applied by hand and dried in the sun. For hollow-cast images, iron nails are driven through all exterior clay cores. The nails keep the core from displacing when the wax is removed and the molten metal added.

The cow dung has an adhesive quality that ensures proper binding of the clay mixture to the wax. It also regulates the temperature- its nitrogen element keeps the mold at the high temperature required for casting and its porosity allows the heat of the molten metal to escape so that the metal can be solidify rapidly. When the mold is complete, its bottom layer is scraped away to just expose the wax and waxen channels. Pouring spouts are attached and mud-coated. On the casting day, the clay mold is heated and drained off the wax which is not actually lost but collected and saved for future work.

The empty molds and metal-laden crucibles are stacked in separate kilns and fires for several hours. With well-honed intuition the master assesses when they have reached the right temperatures. The heated molds are removed with 4 foot metal tongs and placed in position to receive the molten metal. With dramatic timing the master rapidly fills each mold with the exact quantity of molten metal needed while an assistant throws resin into it to prevent the metal from oxidizing as it cools.(Fig.211) To complete the cooling, the

metal-filled mold is immersed in water, then removed and broken open to reveal the image.

After rudimentary cleaning the rough cast image, in this case copper, is taken to another craftsman for finishing. With special scrapers he removes any residue of the blackened mold and soaks the image in sulfuric acid to complete the cleaning process. The excess metal of the pouring channels is removed with hammers, chisels, and dies. Then the entire surfaces are pounded with hammer and die in a cold forge process to condense and harden the metal. This process is generally done by an apprentice who has been taught the process by the master.(Fig212,213,214,215)

The smoothing of the surface is begun with files and sandpaper, usually by an apprentice. The master then uses various shaped dies and hammers of different weights to refine the details. This process is called chasing. The finest tools are used to finish ornaments, such as the earrings, and to engrave delicate textile patterns like those on the folds of the robe over the left shoulder. If an image is to be gilded a goldsmith does it by process called fire- of mercury gilding. (Fig.216)

The process of gilding is a lengthy, complex, and dangerous one. Highly toxic mercury is first combined with gold foil to make it adhere to the metal but then driven off by heating to leave only the gold. By various processes the gilded surface is then burnished and polished to achieve a rich golden color. As an ultimate step it may be immersed in a red dye obtained from tree bark which produces a warm reddish glow, a finish particularly appreciated in Tibet.

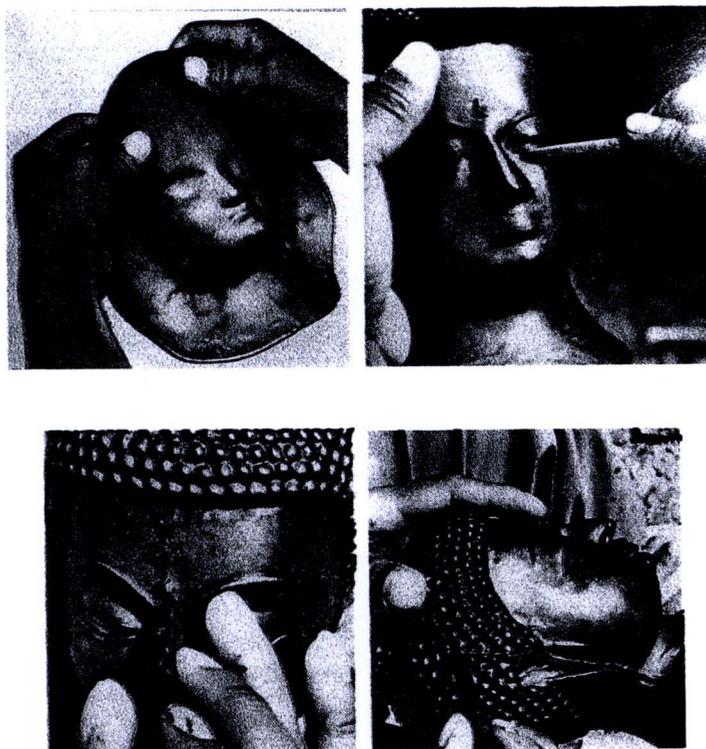


Figure 209 Shaping and joining the wax model of the sculpture.



Figure 210 Wax models being developed, Collection of Patan Museum.

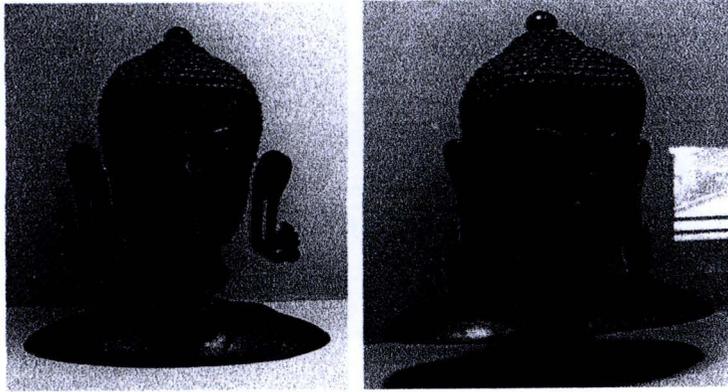


Figure 211 Join separate pieces together and wax channels on chin and ears.

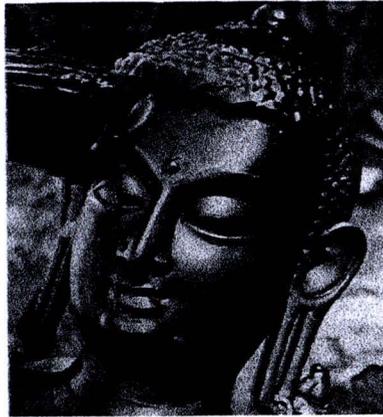


Figure 212 Wax coat before applying clay mould.

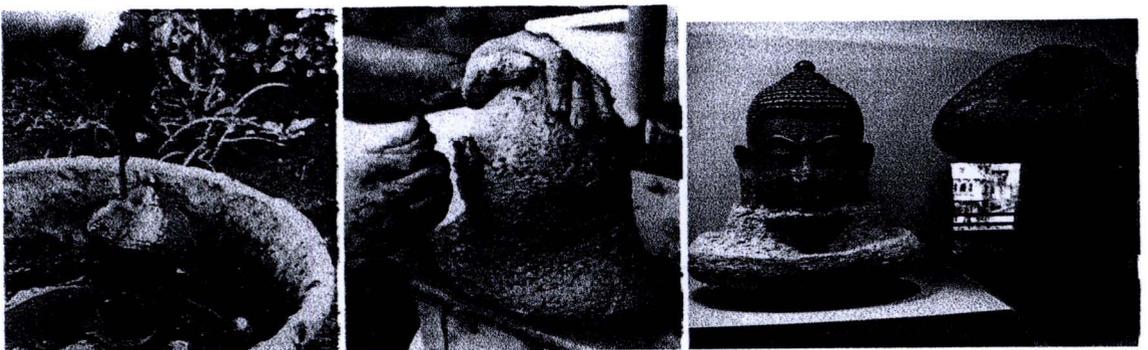


Figure 213 Different layers of mould.



Figure 214 Pour liquid bronze into the mould and bronze statue inside the broken mould.



Figure 215 Cutting off channels and hammering for refinement

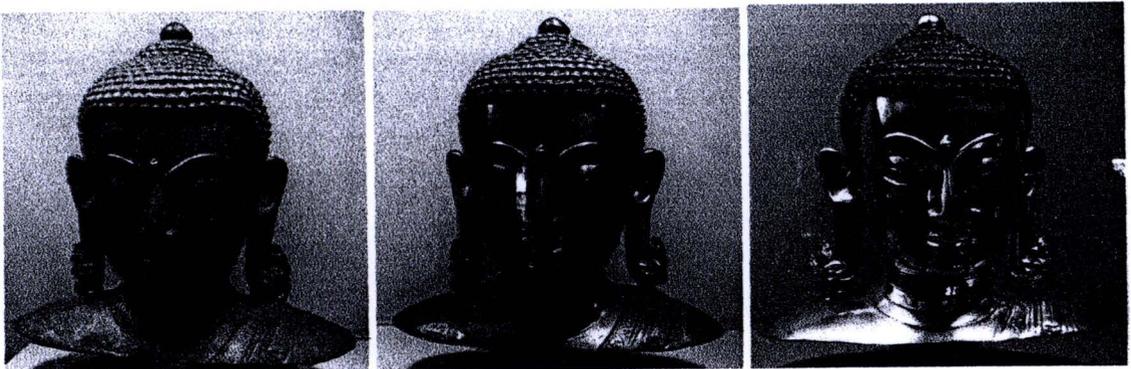


Figure 216 Different stage of refinement for finished product.

3.5 Difference between Traditional and Contemporary Bronze Casting Technique

Silpa Bhirasri argues²³ that during his time in Thailand contemporary sculpture followed the traditional techniques. The most important is bronze casting which since remote times had reached a technical perfection in Thailand. According to him traditional statuary was confined to creating images of the Buddha, and in this art the Thai of Sukhothai, created magnificent statues from the 13th to the 15th century. From the traditional sculpture, the modern sculptors could transmit in their new work the principal characteristics of the old which are an extreme understanding of the simplified and synthesized human forms and a harmonious delicate outline.

A study of Isan and Lao²⁴ (Niyon, 2009) revealed the fact that the development and history of bronze alloy product in Isan adjoining Lao of Thailand dates back to pre historic age and is still evident in modern times. There is similarity between the moldings processes of replacing wax from other places of south East Asia. The local indigenous knowledge for selecting natural material in locality by applying animal dung, soil, termite hill, and paddy husk in producing process in the north eastern region still conserves the ancient producing process. Similar process is found from south India at present. This testifies the technique spread from one place to other.

Everly²⁵ had described in detail the process of lost wax casting of bronze object which was practiced by the bronze smiths of Ban Pba Ao. The process entirely follows the traditional lost wax process which was supposed to be prevalent from the prehistoric period.

²³ Bhirasri, Silpa, *Contemporary Art in Thailand* (Fine Arts Department, Bangkok, 1963). p. 11

²⁴ Niyon Wongpongkam, Songkon Chantachon, and Subun Ieamvijarn, *A Study of Isan and Lao Indigenous Knowledge in Making Bronze Brass Products for Commercial Purposes* (Medwell Journal. 2009).

²⁵ Everly, Daniel Eugene, *The Relevance of Contemporary Bronze Casting in Ubon, Thailand for Understanding the Archaeological Record of the Bronze Age In Peninsular Southeast Asia* (University of Houston, 2004).

After completion of the case study of traditional and contemporary modern bronze casting technology in the foundry of the Fine Arts Department in Salaya, some similar and different technique was revealed. (See Appendix 9 for table)

The main differences between Traditional and Contemporary Bronze casting could be summarized as follows:

Raw Materials

Although materials such as sand and clay are used in both traditional and contemporary methods of bronze casting, the traditional method involved more natural substances such as firewood, cow manure, etc. whereas in the Contemporary method, materials such as Gypsum, Silicon rubber, iron were more often used.

Time Factor

This is one of the major factors which resulted in the evolvement of today's contemporary method of bronze casting than the traditional method. In the traditional method the moulds were made by a mixture of clay, sand, cow manure took longer to dry, whereas the contemporary method used materials such as gypsum and silicon which would dry faster and normally took half of the time as in the traditional method.

Quality

Although the issue on quality of the bronze statue is based mostly on a sculptor's skills and dexterity, it is however debatable as to which method makes the work of a sculptor easier and perhaps complete the statue to perfection.

The use of only clay on the core statue in the contemporary method, rather than a mixture of clay and sand, helps the sculptor to make appropriate modifications to the core to get the desired result. Similarly with the use of gypsum, it can also be modified over and over to get the desired result. This foundry's focus has been on making realistic statues and it has also been easier for the sculptors to do so with the use of modern equipments, technology and the knowledge of human anatomy.

Technique

Both traditional and contemporary method although use similar technique yet the steps involved in the process differ. The steps involved in the contemporary method are a lot more than the traditional method and is also more complicated. For example, in the initial phase of making a bronze statue, in the contemporary method, the core moulds are cut and divided into many parts prior to applying the gypsum. It is up to a sculptor's intuition and insight as to how and where to make these distinct cuts, which are complicated and also requires a lot of experience. After cutting these different sections the parts are reassembled using iron nails and screws. The traditional method also does involve this process of cutting and dividing, however it is basically done by cutting huge sections of the major parts of the statue, such as the whole arm of a statue. In the contemporary method, this would be done by cutting of several sections from the arm.

Cost

As the process of traditional bronze casting slowly evolved to new contemporary methods, the materials used and the process has also differed. Materials such as gypsum and silicon which are mostly used in the contemporary method are more expensive than the materials such as clay, sand and cow manure, used in traditional method. As firewood was used in the traditional method to melt the bronze, etc. now days the contemporary method mostly uses gas furnaces and coal which tend to be more expensive. However, even though the contemporary method is more expensive, one advantage of using silicon moulds is that these moulds could be reused to make other statues hence reducing the cost and time taken to re-do the process all over again.

Most important in traditional and contemporary lost wax process, apart from other materials, wax plays a vital role which was demonstrated when the traditional process commenced. The wax coating makes difference on the quality of the sculpture. If wax coat is very thin there is a chance to develop a hole when bronze is poured. The pores can be welded later but the quality of weld cannot compete with the first hand bronze figure.

The traditional bronze casting technique has its own value which cannot be compared to any new and so called contemporary techniques. With the demand of change and by the circumstances, introduction of new technology and scientific way of learning and creating art gave new dimension on the bronze art creation. When the equestrian statue of King Chulalongkorn and the art itself acted as an appetizer to go into new course of creating bronze art, entry of Corrado Feroci in the world of art in Thailand took its main course for the development of modern art mainly the bronze monumental art. The inborn ability of the Thais in understanding art and its aesthetics, gave sustainable workmanship and ability to retain the effort of Feroci. The introduction of wonderful materials like gypsum plaster and silicon by Feroci gave more intricacy in creating realistic bronze art. Moreover, the ability of the workers can be seen when they use their intuition and experience while performing their task of designing, modeling, molding and casting. The experience makes them perfect to smell and feel the condition of the mould while being casted and the whole lost wax process. They seldom use the temperature measuring equipments; rather they can interpret by touching the heated mould and smelling the wax and molten metal vapor in the air. The older generation of sculptors and casters speak very highly and kindly of the essence of traditional casting method. Their kind words seem very short and easy, but their echoes are truly endless. Since they are acting for the increase of goodness and happiness of the society, in this way the world of bronze sculptures ceases to be one's object, but the object of the whole world.