CHAPTER: 7
Methods and Techniques
1. Introduction

Metal art in Himachal Pradesh enhances the value of cultural beauty, and historically make rich this state. There are many metal products which elaborate and add the beauty to this place still. This can be possible only by the craftsmen of the Himachal Parades, who give much treasure to study and to analyze to the generations, scholars.

The metal crafts of Himachal Pradesh serve the religious purpose as well as the utilitarian items. As per the history¹, the metal craft in Himachal Pradesh grew because the courts of the Himachal kings had the craftsmen who were specialized in metalware in the 600 AD. The statuettes at temple entrances in Brahmaur, Chamba and the Vajreshwari Devi temple in Kangra are glaring examples of excellent craftsmanship. Even the temple doors of Vajreshwari Devi, Jwalamukhi in Kangra, Bhimkali in Sarahan and Chandika Devi in Kinnaur exhibit the Repousse technique in which the craftsmen excelled. The metalwork of Kinnaur portrays a unique fusion of Buddhism and Hinduism.

Monastery contain several strange looking utensils and other objects, which are made of different metals like copper, silver and gold and different alloys by skilled traditional crafts men by their innovative talent and back ground turn these rituals objects in to excellent pieces of art.

Even some items that include ritual cups, daggers, kettles, jugs, prayer wheels, conch, trumpets etc are also made of metals. Low settees made of silver or brass are another common ritual artifact used in homes as well as temples, besides bells, incense burners, lamps, jars, flasks, tridents, fly whisks and canopies. Not only for the religious purpose, is the metal also used for household purposes in Himachal Pradesh. Many implements and weapons must have been made by blacksmiths in olden times.

Traditional style jewelry is made in Chamba by goldsmiths. The jewelry is made in gold and silver both. The designs are traditional and metal jewelry is artistically created keeping in mind the tradition of the place.

Musical instruments are made in Himachal by craftsmen in small studios from silver, copper, brass sheet. ‘Singas’ or horns, both straight and curved are made in Chamba.
‘Nagaras’ or kettle drums are also made. Bells of different types are cast and sometimes decorated with engravings. Cymbals are also made of brass.

‘Mohra’ is a unique metal art of Himachal Pradesh. Mohra denotes the metal plaques. The metal plaques exemplify deities like Lord Shiva, the Devi and other god and goddesses. ‘Newari art’ includes bronzes with beautiful reddish patina.

Metal statues in the classical as well as rural traditions were cast by the ‘lost wax’ technique in both solid and hollow methods of casting were used. Sometimes small images are also casted through the sand method. Metal casting work in Himachal like Kinnaur, Kullu, Mandi and Chamba must have been done from the Bronze Age period. The presence of minor copper mines in Chamba district helped to obtain the necessary raw material. Alloy compound, brass, is commonly used for casting metal-ware in Chamba.

Metal workers make sheet metal articles too in repoussé technique with draftsmanship. Beautiful plaques (Repoussé) in relief method are done quite efficiently. The plaques, shaped like huge plates are used for wall decoration. Quite often designs from Chamba miniatures are used to make the relief work on the plaques. Decorations for temple cupolas are made in copper and brass. The old temples have golden kalasha or vessel on top.

2. Metals and alloys

Metals

A metal consists of atoms and electrons in a metal, atoms readily lose electrons to form positive ions (cation). Those ions are surrounded by delocalized/ mobile electrons, which are responsible for the conductivity. The solid thus produced is held by electrostatic interactions between the ions and the electron cloud.

They are one of the three groups of elements as distinguished, from the Periodic Table, by their ionization and bonding properties, along with the metalloid and non-metals.

An alternative definition of metal refers to the band theory in material science. If one fills the energy bands of a material with available electrons and ends up with a top
band partly filled then the material is a metal. Metal holds an important position in both religious and everyday life for the Indian people. Which enhance the standard of living through spiritual, mental and physical. Metal is deeply related in human life that one cannot think without metal.

**Extraction of Metals:**
Craftsmen are lucky that different ores containing gold, silver, and copper available in whole of the Himalayan reign including Himachal Pradesh, such places are Valleys of spiti, Lahul, and Kullu, around Chamba and Mahasu areas.

Metals are often extracted from the Earth by means of mining, resulting in ores that are relatively rich sources of the requisite elements. Ore is located by prospecting techniques, followed by the exploration and examination of deposits. Mineral sources are generally divided into surface mines, which are mined by excavation using heavy equipment, and subsurface mines.

Once the ore is mined, the metals must be extracted, usually by chemical or electrolytic reduction. Pyrometallurgy uses high temperatures to convert ore into raw metals, while hydrometallurgy employs aqueous chemistry for the same purpose. The methods used depend on the metal and their contaminants.

When a metal ore is an ionic compound of that metal and a non-metal, the ore must usually be smelted with a reducing agent to extract the pure metal. Many common metals, such as iron, are smelted using carbon as a reducing agent. Some metals, such as aluminium and sodium, have no commercially practical reducing agent, and are extracted using electrolysis instead. Sulfide ores are not reduced directly to the metal but are roasted in air to convert them to oxides.

**Properties**
Chemical: Metals are usually inclined to form cations through electron loss, reacting with oxygen in the air to form oxides over changing timescales (iron rusts over years, while potassium burns in seconds).

The transition metals (such as iron, copper, zinc, and nickel) take much longer to oxidize. Others, like palladium, platinum and gold, do not react with the atmosphere
at all. Some metals form a barrier layer of oxide on their surface which cannot be penetrated by further oxygen molecules and thus retain their shiny appearance and good conductivity for many decades (like aluminium, some steels, and titanium). The oxides of metals are generally basic, as opposed to those of nonmetals, which are acidic.

Painting, anodizing or plating metals are good ways to prevent their corrosion. Metals in general have high electrical conductivity, thermal conductivity, luster and density, and the ability to be deformed under stress without cleaving. While there are several metals that have low density, hardness, and melting point.

Mechanical: It includes ductility, which is largely due to their inherent capacity for plastic deformation. Reversible elasticity in metals can be described by Hooke's Law for restoring forces, where the stress is linearly proportional to the strain, within the elastic limit. Forces larger than the elastic limit, or heat, may cause a permanent (irreversible) deformation.

Categories

**Base Metal:** Copper is considered a base metal as it oxidizes relatively easily, although it does not react with HCl. It is commonly used in opposition to noble metal.

**Ferrous metal:** This can include pure iron, such as wrought iron, or an alloy such as steel. Ferrous metals are often magnetic, but not exclusively.

**Noble metals:** These are resistant to corrosion or oxidation, unlike most base metals. They tend to be precious metals, often due to perceived rarity. Examples include, gold, silver, platinum, tantalum and rhodium.

**Precious Metal:** It has rare metallic chemical element of high economic value. Chemically, the precious metals are less reactive than most elements, have high luster and high electrical conductivity. Historically, precious metals were important as currency, but are now regarded mainly as investment and industrial commodities. They are better known for their uses in art, jewelry, and coinage. Other precious metals include those from the platinum group.
Gold\textsuperscript{9} is the oldest precious metal known to man. There are many physical characteristics of this yellow metal which are truly amazing. Gold is the most malleable (able to be hammered into very thin sheets) and ductile (able to be drawn into a fine wire) of all metals. It is so malleable that a goldsmith can hammer one ounce of gold into a thin translucent wafer covering more than 100 square feet only, and of five millionths of an inch thick. It would be so thin that 1,000 sheets would be needed to make up the thickness of one newspaper page. Its ductility is equally amazing. One ounce of gold can be drawn into a wire 50 miles long. Furthermore, only one ounce of this marvelous metal is required to plate a thread of copper 1,000 miles long. Gold is also one of the heaviest metals known. It has a specific gravity of 19.3, which means it weighs 19.3 times as much as an equal volume of water. Therefore, one cubic foot of gold weighs 1,206 pounds. More than half a ton. Since time immemorial the noble metal's luster allows it to be designed into the world's most coveted and exquisite jewelry that decorated queens or kings in old days.

The demand for precious metals is driven not only by their practical use, but also by their role as investments. Palladium was, as of summer 2006, valued at a little fewer than half the price of gold, and platinum at around twice that of gold. Silver is substantially less expensive than these metals, but is often traditionally considered a precious metal for its role in coinage and jewelry.

**Metal Alloys**

**Bronze** sculpture is three-dimensional metallic artwork shaping through combining hard materials and softer metals. As such, Bronze is an alloy of copper and tin, sometimes having traces of other non-ferrous metals. Bronze with low tin content (less than 16%), called \textit{alpha} bronze is soft and malleable with a melting point varying from 1083°C (that of copper) to 950°C. It can be worked with \textit{delta} bronze (with 32% tin) which is hard and brittle. The hardness of bronze with low tin content can be increased by cold hammering.

Bronze is easier to cast than copper because it has a lower melting point and is more liquid than copper at a given temperature. Common bronze alloys have the unusual and desirable property of expanding slightly just before they set, thus filling the finest details of a mold. Their strength and lack of brittleness (ductility) is an advantage
when figures in action are to be created, especially when compared to other (ceramic or stone) materials.

Its colour is affected by the proportion of tin or other metals (zinc, lead, silver, arsenic) affecting patination. Bronze is a very responsive, strong and enduring substance, readily workable by a variety of processes. Its great tensile strength makes possible free extension or protrusion of unsupported parts and the easy balance of large masses over a narrow base. It may be given a surface texture to suggest the flow of the molten metal or it may be wrought and chiseled to suggest sharp and hard-edges metallic planes. It can convey the effect of plastic, glyptic carving (bronze is cast from a carved wooden original and therefore is called glyptic technique), toreutic (metal working).10

The earliest techniques of bronze casting the figures were mostly solid casting. However, the disadvantage is that it is impossible by this method to produce large or monumental sculpture because if a large mass of bronze is cast solid, it shrinks unevenly and pulls out of shape. The invention of hollow casting enabled larger works to be cast with greater accuracy. It also reduced the weight and made it easier to cast free-standing parts separately and assemble them in the completed work.11

Bronze casting has existed for millennia, and is still used in the creation and reproduction of art. The ancient Indian, Egyptians, Greeks, Romans, and many others used it in the creation of art as well as the musical instruments of everyday life.12 It was highly used in many industrial purposes, such as for pots and pans, furniture, belts and brooches, armor, and other military equipment. Furthermore, it was also used for decorative purposes such as in figurines and states of gods, athletes, heroes, and government officials.

Indian artisans and craftsmen have long been masters at extracting and shaping metals and alloys, as proven by archaeological finds from the 2nd-3rd millennia B.C. The Bronze casting in south India and Bangladesh is a skill passed on from generation to generation. Lotus Sculpture's artisans are the descendants of the famous Chola and Pala schools of bronze casting of 8th to 13th centuries. Lost-Wax method is the only technique used by the artisans of Lotus Sculpture to create statues. Himachal Pradesh is the main centre, where metal sculptures are made by Lost-wax method.13
Panchaloha: Panchaloha (an alloy of five metals - copper, gold, silver, lead, and zinc) is widely used to cast icons and idols for worship because of its auspicious nature.14

Ashtadhatu: Ashtadhatu or Octo-alloy is a very sacred and sattvic alloy of eight metals namely, gold, silver, copper, zinc, lead, tin, iron and mercury. Some of the idols are made during back to the 6th century AD.15 Ashtadhatu has very high value in Hinduism and is widely used for making idols of Hindu gods and goddesses. The process of making the alloy is quite difficult and hence ashtadhatu idols are rare. Ashtadhatu idols are made so as to be durable and keep away decaying. The eight metals are mixed in roughly equal proportions and the idols that are created are initially of rough finish. A lot of polishing work is done afterwards in polishing and to make ashtadhatu idols beautiful and as natural as possible.16

It is also interesting to mention some subsidiary alloys17 materials used by jewelers in producing ornaments:

Alum, blue vitriol and common salt: The mixture in the ratio 8 gm: 1 gm: 4 gm, made out of these is called 'banni' and its solution (in boiled water and then on cooling) is used to provide luster to ornaments, only after keeping it in pickle for about 15 minutes. Finally, the ornament is washed in the solution of soap nuts and red sand with a hard brush to give a final finish.

Ammonium chloride, borax and crystalline nitrate: A special powder called flux is prepared by mixing up these ingredients, which are used in soldering processes.

Copper, lead and zinc: Lead serves as cleaning agent for impure silver. Zinc and copper are the soldering agents used in silver and gold ornaments.

Nitric acid: It is required for purifying impure gold and silver.

Pickle: The mixture of sulphuric acid and water, in the ratio 1:10 by volume, is known as pickle. This solution is used to remove the oxide layer deposited on the ornaments while heating in burner flame, to regain luster.
3. Methods and Techniques

3.1 Lost-Wax Casting Technique

Different casting techniques that have created metal treasure of Himachal Pradesh are described below.

- Lost-Wax Casting Technique
  - Solid Method
  - Hollow Method
    - Direct Process
    - Indirect Process
- Sand Casting Technique

Lost-wax bronze casting is one of the oldest and one of the most popular. According to all study in India, casting is a 6,000-year-old process. (Fig.1). The method of metal casting has been the cire-perdue (cire and perdue meaning wax and lost, respectively) or the lost wax process. The lost-wax process is attained by casting after a thorough modification. Lost-wax has been the name used for all types of casting. Lot-wax process is almost the same not only in India but also in the world over differences only can be seen in external details, in the way of modeling and the material used. Material using depends upon the availability and varies from zone to zone. In various parts of India, old casting process is still being practiced, without any major modifications.

August Rodin, the famous sculptor, described the bronze icons of South India as “the most perfect representation of rhythmic movement in art.”

Rig Veda refers to ‘lost wax’ casting technique as 'maduchchista vidhana'. And Manushya Purana, another hoary text, refers to Viswa Karma’s five skills as those of, Manu (iron monger), Maya (wood worker), Twastha (vessel maker), Viswajhan (gold smith) and Silpi (icon maker). A practitioner may call himself a Sthapathy if he is proficient in at least three of the five skills.

A detailed description of the casting methods is to be found in ancient Sanskrit texts such as the Shilpa-Sastra has great description about the composition of alloys used to cast both sacred icons and mundane utensils and with Lost-wax bronze casting and its
Fig. 1: Bronze casting by Cire-Perdue or lost wax Process

A. Wax model: a. wax layer (outer surface modeled); b. heat-proof core; c. metal pins. B. Heat-proof mould surrounding wax model; d. wax, cone-shaped mass; e. thick wax rods; f. thin wax rods; g. enveloping plaster and grog. C. Reversed mould with wax pouring out; h. air vents; j. wax runners; k. cone-shaped funnel from which the melting wax escapes. D. Molten bronze being poured in the runners; l. air escapes; m. molten bronze.
grammar, tools, techniques and metallurgy. The Manasara, the Vishnu-Samhita, the Samarangana Sutradhara, the Agni-Purana, and Patanjali’s Mahabhasya. The Yukti Kalapataru is a mediaeval Indian encyclopedia, the Vishnudharmottara refers to solid and hollow casting methods, and the Matyda Purana has extensive chapters on the casting of bronze images and on the selfless concentration which the image-maker must bring to his work.\textsuperscript{25}

Metal working is deeply infused with religion. In fact, before an artisan even begins a project he prays for guidance to Tvastram, the son of Visvakarma,\textsuperscript{26} who worked with copper, brass, and other metal alloys. The history of metals and their shaping is as ancient as the history of civilization.

Many artifacts that have been excavated and preserved, as well as some of the metallurgical arts still being practiced, are examples of advanced, yet ancient, metallurgical skills. Historically, the Indian subcontinent was on par with the rest of the world in its metallurgical skill and expertise, and its artisans and craftsmen were masters at extracting and shaping metals. In fact, Indian knowledge of metallurgy predates technologies of many other civilizations, as shown by archaeological finds from the 2\textsuperscript{nd} and 3\textsuperscript{rd} millennium B.C.\textsuperscript{27}

Numerous ancient metallurgical arts and artifacts provide evidence of Indian excellence in the shaping of ferrous and nonferrous metals and alloys, including:

- The dancing girl of Mohenjo Daro, the earliest known Indian lost wax process cast bronze figure (3rd millennium B.C.).\textsuperscript{28} “The intricate pattern and designs reproduced in casting the ‘dancing girl’ would, however, indicate that moist probably the lost-wax process was employed, as direct casting a mould would not produce a bronze of such a fine finish”\textsuperscript{29} According to the archeological survey of India, no evidences of mould is found, used for casting the bronze at Mohanjo-Daro. Bronze Chola statue of Nataraja.

- The bronze Chola icon of Lord Nataraja (8–15\textsuperscript{th} century A.D.) is preserved at the Metropolitan Museum of Art, New York City\textsuperscript{30} and the bronze figurine of a Mother Goddess\textsuperscript{31} are found at Adichanallur in the Tirunelveli district of Tamil Nadu South India and belong to the Iron Age and may probably be 3000 years old\textsuperscript{32} both are cast by the lost wax process.
• There are two examples of cire-predue casting bronzes belong to Sunga Satavahana period (circa 2nd century B.C.-2nd century A.D.). Former one is the delightful juvenile figure of Harpocrates with extraordinary specimen of Indo-Greek art of the first century B.C.

• Unearthed at Taxila another, unique example representation of mithunas on elephants from the chaity-pillar capitals in Karle, preserved in the Kolhapur Museum, Maharashtra.

• Bronze figures are having been manufactured at Amravati and Nagarjunakonda in the Guntur district of Andhra Pradesh. Lord Buddha image has unique specimen characteristics of stone work in metal. The prince with a bow is considered lord Rama and Kartikeya bronzes are recovered in recent excavations.

• Lost-wax technique is used to produce gold, copper ornaments and other objects predominantly of Hellenistic design styles, according to Sir John Marshall's reports. Two bronzes of Pasvanatha are now preserved in the Prince of Wales and Patna Museum respectively, belonging to the first century A.D. and standing Tirthankara from Chausa, Bihar (2-3rd C A.D.), are casted by cire-perdue technique.

• Both hollow and solid casted bronze and copper icons are found in Golden Gupta period from Mathura, Sarnath, and some other places of Eastern, Northern and Western India. Sultangaj Buddha icon is considered most finely and notable of all the bronzes of the Gupta Period, was cast in pure copper in two layers which are clearly visible and the inner layer was moulded on an earthy, cinder-like core composed of a mixture of sand, clay, charcoal and paddy husk. The segments of this inner layer were held together by corroded iron bands originally three-quarters of an inch thick. The outer layer of copper seems to have been cast over the inner one, presumably by the cire-pérdue process. The unique, remarkable, classical Buddha bronze with virile and bold characteristics is known for its proportions and spontaneous gracefulness of Gupta period, now preserved in the Boman Behram Collection, Bombay. Famous Brahma, finest bronze icon with high craftsmanship of Gupta Period is found from Mirpur Khas in Sind, now preserved in the Lahor Museum, Pakistan of 5th c A.D.

• Bronze and copper images are found in both hollow and solid process, from Nalanda, Kurkihar (Bihar), Sirpur (MP) during the post Gupta and the early mediaeval period. An independent school of metal craftsmen practicing both
casting techniques flourished from the 8th-11th c A.D. in the region which is now Raipur district. A description of M. G. Dikshit about Sirpur bronze icon of Avalokitesvara Padmapani, "in the first place, the pedestal (pitha) and the main image are cast separately, the bronze caster, taking advantage of the vertical stems in the delicate karnika, so fits it into the lotus on the pitha that the joint is almost invisible, the grooves seen on the karnika helping him considerably in this. The head-dress of the figures, the ornaments and other appendages are also made separately and subsequently attached at the appropriate places. The high head-dress, for instance, is always made by twisting a coil of long-drawn wires to a suitable shape and then attaching it to the bare head. The yajnapovita and the jewelry worn round the legs and neck are also made separately and fitted to the main image. And it would appear that the cire-perdue process by which these images were cast gave little scope for the delicate finish which is characteristic of the jewelry which was carved later on when the figure was cast in full." Lost-
wax casting reached far beyond Eastern India, right to Nepal, Tibet and North-Western India during the Pala Dynasty.\(^43\)

- The Pallava and Chola periods (4\(^{th}\)-13\(^{th}\) c. A.D.) is considered the most creative period for the icon productions by cire-perdue process in the South India.\(^44\) Solid casting bronze icons are found in Tamil. One of the famous Natraj is notable example recovered from Tamil. The standing Tripurantaka and Natraj with the flame in the upper left hand and carries a snake, is probably the only representation in this particular dancing mode, are placed in the Gautam Sarabhai Collection, the Madras Government Museum respectively.\(^45\) Chola metal icon art is got less artistically distinguished one of the Vijayanagar period 14\(^{th}\)-16\(^{th}\) c. A.D. The Chalukya (Deccan) and the Chola bronze styles coalesced in the elaborate and highly conventionalized Vijayanagar images after had been developing side by side over the centuries.\(^46\) Different categories of bronze icons were mainly prevalent in South India and different parts of the country during the period between 1501 A.D. and 1800 A.D.\(^47\) Ruth Reeves in her book on 'Cire-perdue Casting in India' has not only parts of the country, but also given a list of important centres where the craft is practiced.

- Lost wax process was used for Dhokra ware and other items of central and eastern India, Dhokra metal casting, the oldest traditional techniques of metal casting in India, which has been practiced in India for over 4,000 years.\(^48\) It is still used by Dhokra Damar tribes which the traditional metal smiths of West Bengal. The tribe extends from Bihar to West Bengal and Orissa, a few hundred years ago the Dhokras of Central and Eastern India traveled south as far as Kerala and north as far as Rajasthan. Their technique of lost wax casting is named after their tribe, hence Dhokra metal casting follow traditional method of hollow casting and uses the clay core. In addition to these artifacts, during the reign of Alexander the Great, swords manufactured in the Middle East and Europe were made of steel imported from India. These metallurgical works were evidence of a high degree of technical excellence in shaping metals and alloys in general and copper-base alloys in particular as a single system.

- Cast metal work in Himachal like Kinnaur, Kullu, Mandi and Chamba must have been done from the Bronze Age period. The presence of minor copper mines in Chamba district helped to obtain the necessary raw material. Alloy compound,
brass, is commonly used for casting metal-ware in Chamba. Metalworkers make sheet metal articles too. Beautiful plaques (Repousse) in relief method are done quite efficiently. The plaques, shaped like huge plates are used for wall decoration. Quite often designs from Chamba miniatures are used to make the relief work on the plaques. Decorations for temple cupolas are made in copper and brass. The old temples have golden kalasha or vessel on top.

- Late classical and folk are made by solid casting process. Two distinct kinds of folk style images are to be found in three dimensional and two dimensional, flat plaque-like images such as Kulu masks or of similar approach in the image. Sometimes, instead of the lost-wax process, craftsmen make a replica of the image in lacquer (Lakh), which is commonly used in repousse work. The result is got through the sand process of casting.49

- The finest examples of metal sculpture can be seen in the ancient temples of Shakti Devi, Lakshana Devi, Narsingh Temple and Bhuri Singh Museum, Chamba. Besides these, the life size brass bull of Brahmour further reflects the high achievement of Chamba.

**Solid Casting:** Following are the four steps in solid casting,

- Creation of the wax model
- Forming the mold around the wax model
- Preparation of alloy and casting
- Finishing: Mold opening; finishing, engraving, and polishing and coloring.

(i) Creation of the wax model, the first step in the process is to create a wax model. The wax model is an exact replica of what the finished bronze piece will look like. Initially, the artisan takes note of the proportion and measurements (tala-equal into 12 finger width) as laid down in Silpasastras for icon making and makes a pattern rule, the artisans make an individual pattern rule for a given size and shape of an icon.50

Wax required for making the model or pattern of the icon is prepared by mixing pure bee's wax, resin from the tree Damara Orientalis, and ground nut oil in the ratio 4:4:1. The powdered resin is mixed with ground nut oil and the mix is heated until a thick liquid forms. In Bangladesh a combination of 60% paraffin and 40% bee's wax is
used to create the wax models and in South India the percentage of bee's wax is
greater giving the wax more of a golden coloration.\(^1\) Next, bee's wax is added to the
thick liquid and stirred until it liquefies and gets well mixed. This wax melt is strained
through a fine metal sieve or coarse-woven cloth into a container of cold water, thus
allowing it to solidify. The wax mix is then used for wax model making.\(^2\) Most or all
of the work in the creation of the wax mold is done outdoors especially on larger
pieces. This makes the artists very dependent on the weather.

Wax model making is a crucial step wherein the craftsman's creativity decides the
excellence of the model, and, in turn, of the icon to be cast. In larger pieces the details
of the piece are done separately to maintain the integrity of the piece in the heat of
India. Once the various pieces are completed they are carefully assembled to form the
final wax model. The head, body, and limbs of an icon are made separately by hand,
using the wax mix after making it malleable by warming it and later shaping it using
spatula, iron tool and the flame of a lamp the connecting points are heated so that
knife, and scraper. The finished parts of the icon are joined by using a hot they can be
melted together. The model for the icon's pedestal is made as an essential part of the
icon if the icon is small, or individually if the icon is large. To strengthen the wax
pattern as well as to facilitate the flow of molten metal into various parts, a few wax
cross strapping and a wax rod ending with a funnel shape are also joined to the pattern
at appropriate locations.\(^3\) Once completed, the wax models are placed into water to
ensure that they do not loose shape in the Asian sun.

Forming the mould, there are three steps required to make the actual forming the mold
that covers the wax figure for casting of the bronze statues. The term 'mold' refers to
the hollow clay form that will be filled with molten bronze to form the figure. In the
first step, white clay known as 'China Clay' is mixed with water to make a thin
solution. This solution has a fine consistency which allows it to pick up the finer
features of the wax model. This solution is then painted onto wax model using a
paintbrush and then allowed to dry for two days. This process is repeated twice. For
the second step, a one to two centimeter pasty mixture is applied to the outside of the
model by hand. Once the paste is dried, holes are made at the bottom of the mold,
which allow thin rods of wax, or vents, to be attached to the wax base of the statue.
Vent serves as a passageway; they allow for the molten bronze to be poured into the
mold and as an avenue for displaced air to escape out of the mold. For the third step, a third and final coating of rice husk, sand and clay is used to cover the entire surface of the piece. This is the final coating of the mold, applied to increase the thickness of the mold and to cover the drain, which were inserted in the previous step. Small, cup like reservoirs are formed above each vent to allow the metal to be poured into the mold.
without spilling it. Further, no air bubbles should be allowed on the surface of this first coat, since they can spoil the mold cavity surface finish, and, in turn, that of the icon. During the clay-coating application, the wax model is kept on a piece of paper or cloth on the floor or a table, depending upon the size of the model, to avoid its deformation. The coating is applied to half the model, allowed to dry, and then the model is turned to coat the other half. It is crucial that the clay coating is dried either in mild sunlight or in the shade to prevent the wax model from melting. The monsoon season greatly affects the speed in which the molds dry. It is very difficult to dry large pieces because of the abundance of moisture in the air.

(ii) Casting the Mold, in reality, kings, the wealthy, and temples were the only people and institutions with enough money to create true, five metal (panchaloha), bronze deities. The five metals were gold, silver, copper, brass and lead. For contemporary bronzes; copper, brass and lead are the three main ingredients. Copper contains small amounts of gold and silver so technically today’s bronzes are four metal bronzes. Copper is a necessary element in bronze because copper offers more malleability than other metals. This gives the sculptor a metal he can work with after the casting process to make the subtle alterations needed for a beautiful, finished piece. As a general rule, approximately 220-260 pounds of bronze are casted at one time. The raw, unheated bronze is placed into egg shaped containers called crucibles. South Indian artists use much larger crucibles. Once the molds and bronze containers are ready for firing, they are placed into the oven with the molds on the top and the containers on the bottom. The molds are positioned with the drain facing downward allowing the wax to burn out after the oven is heated. Hence the name lost-wax method. To melt the bronze a temperature of at least 1800 degrees Fahrenheit is needed for approximately two to three hours. Once the firing is completed, the molds are removed with the vent facing upwards. Forceps are used to pick up the containers with the melted bronze so that the bronze can be poured into the molds through one of the drain.

(iii) Finishing the Piece, after allowing the molds to cool for at least two hours, the bronze can be uncovered by chipping the layers of coating away. The entire statue is filed. There is almost always some small defect associated with the entire casting process. Air can be trapped in the mold creating a gap in the bronze or a piece can break off when the bronze is freed from the mold. Delicate reconstructive surgery
takes place by heating up strips of metal to fill in the holes. This process is difficult and does not always succeed in solving the problem. For this reason a perfectly cast sculpture with no defects and perfect proportion is a prized piece since only masters of the art of bronze casting can achieve perfection in the entire process. After being repaired and further filed down, the statue is sanded and buffed to remove any scratches and give the finished piece a shine. Care, precision, time and above all artistic ability are vital ingredients to practicing the lost wax method of bronze casting. This all process takes approximately six weeks to complete a 24 inch piece.57

For the metal casting, the craftsmen use traditional tools that are same everywhere in India. Most of which, traditionally, were made by them, such as Spatula, knife, and scraper, drills, blowers, and files. Now with the development in technology, electrically operated tools like electric drills, blowers, and files are being used.58

Solid casting ('ghana' in Sanskrit) is still prevalent in South India. The North Indian bronzes, i.e. early Kashmir bronzes, late Chamba and other Pahari bronzes, both classical and folk, are also made by the solid casting process.

The folk images are wrought very much in the same way as the clay image is modeled. They appear three dimensional, look round from front but their backs are unfinished or two dimensional. The North Indian craftsmen chisel and hammer the images after casting them, and remove the supports and the extraneous protuberances on the images.59 The three dimensional images look round from front but backs are unfinished. It seems that sculptors are devoted themselves entirely to make focused attention and concentration only on the front portion of the image without bothering about its artistic perfection.

In case of solid casting the figure is made of wax without using the clay core so that when the wax model is extracted from the shell. The rest of operation is similar to hollow casting. Other parts of the model is casted separately, parts like hands, face etc. and joined to the main body later.

Hollow Casting: Hollow casting ('sushira' in Sanskrit) method produces a hollow sculpture by pieces-casting, which, as its name suggests, involves the construction of pieces rather than as a whole.
There are two processes used for hollow casting,

- Direct Process
- Indirect Process

**Direct Process:** The direct method is practically simple; however, it has the restriction that it can only create one finished icon product from the original. The following steps are what would have to be done.

- A core of clay is made to form a basic shape of the icon but slightly smaller.
- A layer is applied to cover the core with wax, and it is modeled with details to the wax.
- After the details, metal pins are inserted through the wax to hold the core in place when the wax is melted out. (Add wax sprues, gates, and vents as discussed in solid cast above).
- A mould or investment is built to cover the wax with clay which will shrink or crack as little as possible during firing such as a mixture of ground pottery and plaster, but before doing that, paint the wax model with very skinny clay to lift up fine details. Add a coarser clay mantle, and attach it to the inner clay core by iron or bronze pins, called chaplets.
- The mould is baked at 1350-1450 degrees Fahrenheit until the waxes melts out, and then raise the temperature and bake until the mould hardens.
- At this point, there is a space left from the lost wax in which to add liquid bronze at temperature 1100° C. (same as step 3 of solid cast)
- When the bronze cools for a couple of days, break the clay mantle and remove the chaplets, vents, and gates. Finish the surface through cool-working techniques. Any faults in the casting are repaired and surface is polished as required.

**Indirect Process:** This process has the advantage that the original model can be preserved, so that more than one icon can be created from the original model.

A few more steps are required for this indirect method which are:

- Original model sculpted out of suitable material (such as plaster, clay, marble, stone, or wood).
Coat the model with a special protective substance and put it into fine elastic material.

After the model makes an impression (that acts as a mould), take it out to leave just the elastic. Place fire-proof clay into the impression, making a duplicate of the sculpted original. Remove this clay and scrape off the surface slightly. When this is returned to the impression once again (to the elastic), there is a gap into which the hot wax is poured (same as step 3 in solid cast).

or alternately,

- A plaster piece mould is taken from the model without doing any damage to the model.
- The piece mould is removed, the inside of which is lined with wax sheet or painted with wax to an even thickness.
- Apply granulated ceramic (fine clay) to the surface until it is thick and coarse. This becomes the “Investment layer/ mould”

Following this step, heat until the wax melts out. Then add a layer of cladding i.e. pour molten bronze into the investment mold in the space the wax used to occupy. (same as step 3 in solid cast)

Then, after cooling, break the cladding and investment molding, removing the sprues and gates etc. Finally, go for a hand-finish the bronze to perfection.

When the bronze is finished, an outside patina may be added to change the color. The heat and chemicals used here can make the exterior green, brown, black, or white like the statues of ancient times. Other paint-like effects can also be achieved through patinas, though they are in general less opaque than paints and allow the original color of the metal to show through. A coating of wax is applied to protect the surface because patinas tend to change color over time because of the effects of oxidation, and wax slows this process.

Today, bronze casting is not only done by artists but also to preserve original works of art. Recently, however, there have been efforts to limit the number of copies that are allowed of sculptures. Could be purchased by anyone, the use of bronze has been reduced since the invention of iron and steel, but it continues to be important today.
because of its durability and stability. Modern bronze artists carry the art into future generations.

3.2. Sand Casting

This method is a very ancient, which was practiced in many parts of the world. Craftsmen of Himachal used to make small images through the sand casting. This particular process is still being practiced. Goldsmiths and craftsmen find this method easier and cheaper than the lost-wax process. The lacquer is used much in the same way as the wax, whose melting point is also lower. This particular process is generally used for the two-dimensional images.69

It is useful for making metal casts for machinery and equipment for building construction. These results are found to be good & precise/accurate but has certain disadvantages for the artist.

The mould is made in sections (called 'pieces') and although only two pieces may be necessary for a very simple shape, a large number may be needed for the complicated forms of some figure (human being or any other object). Complicated figures have to be cut up and cast in sections, in one operation by cire-perdue method. The process will, therefore, be laborious. However, it has the disadvantage that the joints between the pieces leaving seams on the cast, have to be carefully removed afterwards. There are following steps for the Sand Casting.70

- A plaster model/mould is cast from the artist's original wax or clay model. The mould is made of very fine cohesive sand which contains a little clay. Each piece is molded separately.
- The pieces are arranged in two box-like frames which can be fastened tightly together and have a funnel at one end. The sand of each piece holds together firmly.
- Assembled pieces are surrounded with a thin layer of powdered graphite and sand is packed around this up to the edges of the frames.
- Completed mould, in two halves, is made entirely of sand, iron construction is fixed in the middle of the hollow space.
o Take out the new sand model and scrapes the top layer off to a depth of about ½ inches or whatever the thickness of the final cast is intended to be. Shallow channels are scratched in the surface of the mould to serve as air-vents.

o The reduced sand model in size, representing the core, is fitted back in place between the two moulds, the iron holding it in position.

o The two parts of the frame are screwed together, placing it up with the funnel at the top. The molten metal is poured in, filling the narrow space (same as step 3 in solid cast).

o After cooling the metal inside, the mould is removed and seams where the piece moulds met are removed by filing and chasing, towards final finishing .(same as step 4 in solid cast)

**Defects in casting** can be minimized by strict observance to prescribed procedures, which are generally being divided into:

- Distortion
- Poor surface finish- fins/spines, nodules, veins and ridges, rough surface
- Porosity
- Voids
- Incomplete casting

**Distortion:** This defect of distortion can be mainly attributed to distortion of the wax model, which can be minimized by careful manipulation/ handling of the wax model. There may be other reasons like improper hardening of the investment mould, type of the wax, thickness and configuration of the model.

**Poor surface finish:** One of the requirements on the castings is that its surface should be as smooth and precise imitation of the wax model surface as possible. A failure in maintaining this condition leads to such a defect.

**Porosity:** Porosity in the casting can spread within and towards its surface, adding to surface roughness. The internal porosity could weaken the casting, may cause discoloration if spread to the surface. The main causes of this defect in casting are due to localized solidification/ shrinkages (by about 1%), trapped gases and residual air.
If the Sprue is not properly designed (at the junction) and implemented then solidification may occur before the feeding is complete thus preventing a continuous supply of the molten alloy.

Trapped gases: Many metals dissolve gases when they are molten. On solidification, these gases are forced out of the casting causing additional pinhole porosity. Larger voids could also be caused but by the gases or air mechanically trapped within the molten alloy during the casting procedure.

**Incomplete casting:** If the molten alloy is prevented from proper filling of the mould due to the insufficient and fast venting of air in the mould.

### 3.3. Repousse and Chasing

Repousse is used to create gold and silver jewelry, plate armour, decorative architectural panels or can be pieced together to produce sculpture in the round such as the Statue of Liberty.

There are few techniques that offer such diversity of expression.

Chasing is the opposite technique to repousse, process working from the front of the work often with the same tools. The term chasing is derived from the noun ‘chase’, which refers to a groove, furrow, channel or indentation. Chasing is used to refine the design on the front of the work by sinking the metal. Small tools for creating decorative textures and patterns are also called chasing tools and the two are used in conjunction to create a finished piece. It is also known as embossing.

The techniques of repousse and chasing utilize the plasticity of metal, forming shapes by degrees. There is no loss of metal in the process, as it is stretched locally and the surface remains continuous. The process is relatively slow, but a maximum of form is achieved, with one continuous surface of sheet metal of essentially the same thickness.

There is direct contact of the tools with the working sheet. A famous contemporary sculpture created with this technique is the Statue of Liberty in Upper New York Bay. The statue was formed by copper repousse in sections using wooden structures to shape each piece during the hammering process.73
The majority of the Himachal mask was formed using the technique of repousse from what appears to be a single sheet of gold. The repousse techniques date from Antiquity and have been used widely with gold and silver for fine detailed work and with copper, tin, and bronze for larger sculptures.

This technique is used for the most famous classical pieces of bronze Greek repousse armor plates from the 3rd century BC. The use of patterned punches for coins dates back to the first half of the 2nd millennium BC. Punching coins were cut for filler in out of metallic sheets of silver and then punched with various symbols. Kautilya, the minister of Chandra Gupta Maurya, has referred in a passage to the counterfeitors of coins (Kootaroopakaara) in his Arthashastra, the book on state administration, compiled in the 4th century BC. Combined punches and dies were in use 323 BC to 31 BC. The Egyptian during Amarna period (1400 BC), resin and mud for repousse backing were in use. In 400 BC, the Greeks were using Beeswax Repousse and chasing is commonly used in India to create objects such as water vessels. These vessels are generally made using sheets of copper or silver.

The Method
It can take some time to create jewelry using Repousse and chasing, although with practice, complex and delicate pieces can be made which would be virtually impossible to complete using any other method. It takes a lot of time due to the repetition of a number of time-consuming stages, the preparation of a sheet by annealing, cleaning to remove the pitch between annealing and work, setting up; and careful work with punches.

One method of repousse and chasing is to place a thin sheet of metal on a bowl of heated Pitch. The pitch is slightly soft, and hardens when cooled, or becomes liquefied when heated. The purpose of using pitch is to provide solid base to work on, whilst allowing the metal to be pushed out and shaped without obstruction. The pitch is best worked on in a pitch bowl. This is a cast iron bowl which sits on a bag stuffed with sand or a similar substance. This allows for greater stability, rotation and angling. The pitch is heated using a hairdryer, or an industrial blow-dryer. If the pitch is too hard, the metal will be thinned. If it is too soft, you have very little control over the form. Good pitch is hard enough to hold its shape, but soft enough to yield.
Fig. 5: Thal for engraving the Design

Fig. 6: Craftsman embossing & Repousse the Thal

Fig. 7: Prepared Chamba Brass Ritual Thal

Fig. 8: Craftsmen Washing Thal with chemicals after preparing
Steel tools are used to work on the metal. The initial lines can be created on the metal by a ‘liner’, steel rod with a very thin, slightly rounded end. The liner is hit on the end with a chasing hammer, pushing a thin line of metal into the pitch. The side facing up will consequently be the front of the piece. Once all the lines have been chased, the metal is then turned over on the pitch, and repousse is then used to push the metal so that it extrudes on the front of the finished piece. The piece of metal is turned and worked many times, with numerous tools, before the final design is achieved.\textsuperscript{76}

Once a fairly large shape is inverted, it can be filled in with warm pitch to help maintain its shape. The pitch should be allowed to set in the forms before the piece is placed back on the pitch. Every time the metal is removed from the pitch bowl, it needs to be cleaned and re-annealed.\textsuperscript{77} Turpentine is used to remove the pitch, and a blowtorch can be used to burn it off.

This \textit{repoussé work} is also carried out mostly in gold/ silver ornaments. Much of the jewelers’ job is done by using steel and bell metal dies having different patterns and shapes that are used to create impressions of the gold/ silver sheets in the form of embossing.

It is normally used in making metal reliefs\textsuperscript{78} which may be categorized in \textbf{four} types depending on the degree to which the form is projected out or the depth is hollowed out. These types are: i) lowest (Stiacciato) - relief, ii) low (bas) - relief, iii) high relief and iv) Carvo intaglio.

\textbf{The Tools}
There are plenty of using tools, are typically made from bars of steel, which is forged and tempered at the tip by the jeweler/ crafts person. A Saw can be used to cut designs into the tip for making patterns. The end of the tool, which is to be hammered that should be beveled to allow for expansion of the metal from repeated hammering.

Some of the main styles of tool include: Liners, planishers, matting, and doming.

- Liners have thin tips with slightly rounded. They are too thin they will cut the metal. They are used in the initial marking out of the design, and in the finishing stages to refine any thin outlines.
Fig. 9: Himachal Jeweler is Making a Nath

Fig. 10: Himachal Jeweler is making Kangan

Fig. 11: Himachal Jeweler is making a Traditional Nath
• Lavishers have smooth, level tips which are used for pushing out large, flat areas of metal.

• Matting tools have patterns cut into them, and provide detail to areas of the design. This will result in a fine grain pattern.

• Doming tools push out rounded areas of metal, and can either be round or oval, quite pointed or almost flat.

• An oxyacetylene torch is essential for heating the steel satisfactorily for forging.

• The more tools available, the easier it is to create a detailed, accurate piece.

The traditional working surface is chaser's pitch which is generally a composition combine three substances: pure pitch, a filler (or stiffener), and an emollient (softening medium). There are a number of different recipes for making chaser's pitch. One example is 16 parts pitch, 20 parts plaster of Paris, 4 parts resin, 1 part tallow. The pitch is heated until molten. Plaster of Paris is added a small amount at a time. Resin and tallow are then mixed in.

3.4. Carving and Engraving

The attractive contrast in color and texture of metals has been the basis for the evolution of many decorative techniques such as enameling, inlaying, overlaying and fusing of various colors. The technique of metal ornamentation has a far wider range than wooden ornamentation using metal inlaying. The ornamentation work on metalware may be divided into hammered, repousse (embossing) & chased, perforated and pierced.

Repousse is one of the specialties of Varanasi and Jaipur, which is done by raising the design in relief. In addition, chasing is the art of engraving of a design on the surface of metal with a blunt chisel or a dye. Sometimes the brass is encrusted with figures of copper, fixed on the base metal by hammering supported with further punching on the boundary. Tanjavur in Tamilnadu has a fabulous style of encrusting metal (gold or silver) on metal (copper).

Carving in India has been experimented and perfected upon various materials like metals, stone, wood, ivory etc. Traditional Indian designs carved into these materials created the most wonderful pieces of artwork. This technique is used in making
sculptures. Hard (semi-precious) stone carving has also been very popular among artists to get engraved gems. Kashmir is famous for metal engraving with quality, precision, ingenuity and gaiety.

**Enameling**

*Enameling* is often done on the metal ornaments. The material Enamel is a type of soft glass (meena glass) composed of sand (flint) with soda (potash) the fusion of these ingredients produces a transparent colorless glass, which is inlaid in metallic sheets. Some time gold, silver and copper and also precious stones are inlaid on a different metal sheet/work. The stone inlay work is quite interesting in projecting eyes in a figure. Moradabad is specially known for its colored enameling and intricate engravings. Delhi, Jaipur and Nathdwara & Pratapgarh in Rajasthan, are the chief centres of enamelling. **Damasceening (Koftagiri)**, laying of a light metal on a dark one, is practiced in Kerala. **Bidri** is another form of this technique in which silver/brass metal wire or an alloy of zinc, copper, tin and lead is used on zinc as the base metal, which has been practiced in Hyderabad in Andhra Pradesh, Bidar in Karnatak, Kerala, Jaipur and Delhi.

**Silver- filigree** is a style by itself in high quality ornamentation which Cuttack in Orissa and Karimnagar in Andhra produce in pure metal.

**Etching** process of making a design on metal (or glass) is similar to engraving but is done using powerful acids. The non-operational area is protected with acid-resistant coating.

These techniques are mostly used for creating art pieces for decoration, for making mohras, ritual articles and musical instruments used at the time of worship in respective houses, temples and monasteries in Himachal Pradesh.
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