Casting Sites of Bronze Bell and Iron Kettle in Ancient and Medieval Japan

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(Received on November 30, 2013; accepted on March 3, 2014)

From many excavated casting sites, preserved old casting objects and traditional casting factories, I have made clear the history of casting in ancient and medieval Japan. Above all examining casting pits and molds which were discovered in casting sites, casting technology can be precisely studied. In this paper, I explain that the change and regional difference of casting technology is an eloquent proof of history of metal production.

KEY WORDS: casting pit; mold; Imoji.

1. Casting Objects of Ancient and Medieval Japan

1.1. Bronze Buddhist Bells

In Japan from Nara Period (7–8 century), casting production of bronze and iron objects began on a large-scale. In those days the government took Buddhism as national religion and construction of Buddhist temples became popular all around Japan. These temples needed Buddhist bells (bonsho) for a ceremony and a time signal. In medieval and modern Japan, many sects of Buddhist temples experienced prosperity and decline. But traditional Buddhist temple still exists as a place of funeral ceremony, and is indispensable for Japanese in daily life. A good many Buddhist bells were carefully preserved in Buddhist temples and Shinto shrines, and Japanese not only watch these bells as cultural property but also ring on New Year Eve as yearly event. Thus Japanese preserve Buddhist bells as their traditional culture.

As to Japanese Buddhist bells, Ryohei Tsuboi (1897–1984) made a study on artistic style of bell, and completely made clear how form and ornament of bell changed all his life.1–3) Here I roughly explain his achievement of research. Fundamentally imitating Chinese bell, Japanese Buddhist bell casting had already begun in the end of 7 century in Kyusyu district and Kinki district. Then, being influenced by Korean bell, it developed in 9–11 century, and became to be a standard of subsequent Japanese bell. Besides it, Tsuboi deciphered inscriptions of bells by traditional epigraphy. By the style and inscription, he discovered many schools of casting craftsman who made bells. Thus Tsuboi made clear the history of casting production which continued till modern Meiji period.

And this writer discovered archaeological site of Buddhist bell casting (9–10 century) by chance at the excavation of Kyoto University Campus site in 1982. After this excavation, reading Tsuboi’s achievements of study on Buddhist bells which belong to ancient and medieval, I have continued the research on these Japanese bells for about 30 years. In these 10 years, I am intensively interested in technology of making mold and core and technology of melting metal and pouring into mold.4)

In 2006, examining many Japanese Buddhist bells which belong to ancient and medieval period, I studied productive technology of bells, such as mold division and gating system. As the result of it, I discovered the change of casting technology in the course of time, and several schools of casting craftsman whose technology are different each other. In this study, I succeeded in putting in order many bells which have no inscription.5) It is one jump ahead of the study which was until now made. Furthermore comparing Japanese ancient bells with Chinese bells, and recognizing their resemblance and difference, now I study many problems, such as when and where Japanese Buddhist bell parted from Chinese bell and what kind of influence did Japanese bell receive from Chinese bell and Korean bell in ancient period. For solving this problems, I made an investigation of Chinese traditional casting technology in casting factory in China with Syoko Yoshida.6,7)

By these works, the following perspective will come out. There was constant interchange in style and technology between Japanese bell and Chinese bell and Korean bell, and it was the important cultural interchange in East Asia, I think.

1.2. Iron Kettles

Except a few religious utensils, cast iron objects are kettles which are cooking tools for daily use. Compared with Buddhist bell whose material is bronze, cast iron is apt to go rusty, and once broken, it is not be discarded like pottery but is reused as metal material for casting another object. And we can find a few cast iron objects as archaeological
relic, and the study of cast iron objects was very difficult. I tried to look for not only a few materials of cast iron kettles which were found in consumptive sites, principally settlements, but also materials of casting molds which were found in casting sites. By this method, I made a study on historical change and regional difference of Japanese kettles during ancient and medieval period.9)

In ancient period, cast iron kettles were rare objects. In Japan, production of the oldest cast iron object was made in the end of 7th century. It is a large-sized Hagama for particular use. And in 9–10 century, in ancient smelting factories of Tohoku, Kantō, Hokuriku, Kinki district, cast iron objects were made. In those days, most of kettles for cooking were made from clay, and these casting kettles could not supply a demand for cooking vessel on the whole, and were in circulation as particularly luxury utensils among a small number of people. In 12th century, production and supply of cast iron kettle increased to high level, and then iron kettles became to be daily necessities for people. There are many forms of vessels such as Nabe A, Nabe B, Nabe C and Hagama. Between west Japan and East Japan, there is a clear difference of form of cast iron kettles. In west Japan, medieval people used Nabe A, and in east Japan, people used Nabe C, and so we can say that west Japan is another world from east Japan in the form of Nabe. Nabe B appeared in west Japan in 14th century, and gradually spread over east Japan in the end of medieval period. Hagama was typical form which is characteristic of advanced area in west Japan. In this paper through casting sites of bronze bell and iron kettle, I try to examine the history and technology of casting production in ancient and medieval Japan.

2. Excavation and Study of Casting Sites

2.1. Discovery of Casting Sites and Research of them

In Japan, when already known archaeological sites are destroyed because of exploitation such as construction of road, railway, factory, house, rescue excavation of archaeological sites is pursued in advance by archaeological staffs of a public office. As exploitation of all over Japan was most frequently made from the nineteen-seventies to nineteen-eighties, a great many archaeological sites were excavated, and we are aware of not only sites of palace, public office, Buddhist temple, settlement, tomb, but also production sites such as pottery making and metal processing. Among them, there are casting sites of bronze objects and iron objects, and casting pits of bronze bell were often discovered in various districts. Excavation and study of these casting sites attracted archaeologist’s attention as a branch of study of metal production. For 60 years, the archaeological excavation and study of iron smelting site which is Japanese traditional Tatara, has been ardently pursued by the Society for Historical Iron and Steel Researchers (Tatara Kenkyukai). But for the study of casting sites, it was necessary to devise a new method of study.

On 14, September in 1991, many archaeological staffs who discovered casting site and archaeological specialists who were interested in history of metal production founded the Society for the Study of Casting sites. And examining the result of excavation of casting sites, and judging the casted objects from mold, participants of the annual meeting have tried to devise a new method of study on casting sites. From 2000 on, the annual report, Data book on Casting site Study has been published, and it contains not only data of annual meeting, but also recent achievements on study of casting sites, and discussion of the last year and so on.9)

2.2. Investigation of Traditional Casting Factory

What can we know from casting sites and its relics, and how can we develop a new historical study of metal production from archaeological study of casting sites, are very difficult problems. We want to know casting technology from casting sites. But it is not enough for us to examine archaeological sites of casting production. And we have to visit traditional casting factory and study its traditional technology. That is so-called ethno-archaeology. There are many casting factories which still make traditional casting production all around Japan. A few folklorists have recorded and reported casting technology, and I was much interested in the technology, and after reading these reports, I visited casting factory, and studied traditional casting technology. Especially in Nishizawa bell casting factory in Shiga Prefecture, traditional old-fashioned technology for casting bell remained till 2009, and this factory is very useful for us to understand casting technology. Thus this method became to be fundamental for us in order to make clear casting technology of ancient and medieval Japan. Syoko Yoshida (1956–2013) who was member of the Society for the Study of Casting sites, perfectly investigated casting technology of many traditional factories, and wrote many papers on casting production.10,11) Her brilliant achievement made me familiar with folkloristic knowledge.

2.3. The Manufacturing Process of Casting

Here I explain technology of casting of Buddhist bell and kettle according to their manufacturing process.12,13)

Making mold Both Buddhist bell and kettle are hollow objects. Mold with which outer form is made, and core with which inner form is made, are absolutely indispensable for casting. Combining them, casting craftsman pours molten metal into sprue (entrance of molten metal). In case of large-sized casting object, it has to be casted in the casting pit, and then we can confirm the place of casting by excavation. From casting pit, broken molds are excavated, and we can know the form of casted object from discovered mold.

Melting metal In order to melt bronze for bell and cast iron for kettle, casting craftsman has to charge charcoal and metal materials into melting furnace and melt them with sending air. From casting sites, many broken melting furnace are excavated. From them we can make clear the form and structure of melting furnace.

Pouring metal Pouring molten metal into sprue (entrance of molten metal) of combined mold and core is the climax in the manufacturing process. In Japan, before pouring, a special ceremony for wishing success of casting was sometimes held.

Finishing casted object After casting object, sprue, flow off (overflowed metal) and fin (projected metal between molds) are left on its body, casting craftsman has to cut them off with cutlery, and polish surface with a file. Thus he completes casting objects. Examining traces of sprue, flow off and fin on the surface of casting object, we
can make clear gating system and division of molds.

3. Casting Technology of Bronze Bell

3.1. Discovery of Casting Site of Bronze Bell

As Buddhist bells are large-sized bronze casting objects, they had to be cast in casting pit because of pouring a large amount of molten metal at a time and avoiding danger. In 1982 at Kyoto University Campus site (AP22 region), I unexpectedly excavated two casting pits for bronze bell, SK257 and SK245 (9–10 century). This encounter with casting pits of bronze bell interested me in casting sites and made me decide to study the history of casting production of bronze and iron objects in Japan. Examining sites and relics, I sometimes draw the imaginary picture of casting and Fig. 1 is the scene of bell casting in medieval period.

On the bottom of casting pit SK257, clay round platform for setting core and mold perfectly remained. On the round platform there is projecting circle, 4 cm in width, 104 cm in diameter (Fig. 2). At first I could not understand the role of this projecting circle. Under this round platform, there are traces of logs which fastened molds. On the bottom of casting pit SK245, two parallel ditches were found. These ditches are the traces of logs for fastening molds.

3.2. Other Casting Pits of Bronze Bell Excavated

Many casting pits were discovered during these forty years all over Japan, except Kyoto University campus site SK257. The followings are well-remained examples of casting pits. Paying attention for the combination of clay round platform, core and mold, I explain precisely them.

Hyogo Prefecture Takadera site archaeological feature(A) (Fig. 3) belongs to 8 century. The upper part of this feature was destroyed, but the lower part perfectly remained. In the bottom of casting pit, round platform, core and mold were combined together for pouring molten metal. In this case, core was safely set on the center of the round platform, but the mold was unsafely set on the end of the round platform. That is, clay round platform does not stably receive the foot of mold.

Fukuoka Prefecture Kourokan site SK15027 (Fig. 4) belongs to the first half of 9 century. The core has already disappeared, but mold which is 50 cm in height remained. This mold was barely caught by brim of clay round platform, and adding soil under the mold, the mold was accurately set. In this example, clay round platform do not stably receive the foot of mold, either.

Oita Prefecture Bungokokubunji site SK 002 (Fig. 5) belongs to the end of 8 century–9 century. On the bottom, round platform, core and mold were well preserved, about 20 cm in height. In the inner part of the projecting circle, core is closely set, and in the outer part, mold is closely set. From this example, I could recognize the role of the projecting circle on the clay round platform of Kyoto University Campus site SK257.
Nagano Prefecture Teradaira site the 3rd archaeological feature (Fig. 6) belongs to 15 century that is medieval period. In this case, clay round platform for setting core and mold perfectly remained. On the round platform, black circle which is 9 cm in width clearly remained. This circle must be the bottom of the bell. And on the inner part from black circle, trace of core can be seen, and on the outer side, the trace of mold can be seen. That is, core and mold were both stably set on the platform. There is no such an example in ancient period. I presume that the development of setting of mold on the round platform was made in medieval period.\(^1\)  

3.3. Technological Change of the Combination of Clay Round Platform, Core and Mold  
Examining the technology of many traditional bell facto-
ries which still produce Buddhist bells in Japan and China, both core and mold are stably set on the round platform. It reminds me that late Syoko Yoshida frequently said that core and mold must be both stably set on the round platform for casting of bell. But such a setting was not done in ancient bell casting.

From some examples above, I can classify the combination into type A and type B. Casting pits, which are found at Kyoto University campus site, Takadera, Kourokan and Bungokokubunji are ancient features and belong to type A. In this combination, core was safely set on the center of the round platform, but the mold is unsafely set on the end of the round platform. Casting pits of Kyoto University campus site and Bungokokubunji have a projecting circle on the clay round platform, and in these examples, it is easy to put core and mold, but round platform do not stably receive the foot of mold.

Casting pit of Teradaira is medieval feature and belongs to type B. In this combination, both core and mold was safely set on the round platform, and round platform stably receives the foot of mold and in addition, a step is set for fixing mold onto round platform. And the combination of them in traditional bell factory belongs to type B. Therefore, the combination of clay round platform, core and mold has changed from type A to type B in medieval period. This change from A to B means a device for safety and must be one technological development. In some ancient casting pits such as Kourokan site and Buzenkokubunji site, the space between mold and wall of casting pit was filled with soil, but in the technology of traditional bell factories, there is no filling with soil. After mold was safely set on round platform, filling with soil has vanished, I guess.

4. Casting Technology of Iron Kettles

4.1. Mold and Furnace of Iron Kettles

There are many kinds of kettles in ancient and medieval Japan, and they originate from Chinese kettles. We can roughly classify these kettles into Nabe and Hagama (Fig. 7). In order to make Nabe and Hagama, mold and core are indispensable. But casting of Hagama needs especially two kinds of molds because of its form. Hagama has a round body, a narrow mouth and a broad brim on the body. This brim is useful for putting Hagama on the kitchen range. Therefore the mold of Hagama consists of upper-part mold and lower-part mold. Consequently Hagama was more expensive than Nabe in medieval Japan. Of course, casting of a large-sized kettle inevitably needs many partial molds, whether Nabe or Hagama. Compared with casting of Buddhist bell above mentioned, there are some differences in technology of casting kettle. That is, the molds of Nabe and Hagama are poured in the upside down direction. Therefore we can recognize the trace of sprue (entrance of molten metal) on the center of outside bottom. In addition, there is no round platform on which core and mold are set, and so mold is combined with core by core print (connecting surface).

In order to melt metal material, cast iron is charged with charcoal into melting furnace and is burned with sending air. Molten metal is poured into sprue by ladle. In case of large-sized object, casting craftsman let molten metal flow through gutter (shallow channel for molten metal) into sprue. Melting furnace clearly resembles Japanese traditional melting furnace (Koshikiro). Its shape is cylinder, and it has 60–70 cm inner diameter, and is about 1.5 m in height. And it has one tuyer (mouth for blast) through the middle of its body. Inner diameter of tuyer is about 20 cm. This melting furnace has the almost same shape and structure with the melting furnace for Buddhist bell. It melted a large-quantity of metal at a time and furnished many molds of kettles with molten metal one after another.

4.2. Kettles in Ancient Japan (7–11 century)

The oldest production of cast iron object in Japan was pur-
sued at casting factory of the north region of Kawaharadera Temple of Asuka, Nara Prefecture, in the end of 7 century. This is a large-sized Hagama, and was casted in the casting pit. In those days the bathroom for priests was annexed to Buddhist temples, and iron Hagama for boiling water were prepared there. This Hagama is not a kettle which is used as a cooking vessel, but a particular religious tool, and it was maybe made by the special technology which was imported from foreign country along with popularity of Buddhism in Nara period.

From many smelting sites which were located on gently sloping hill of Souma (Fukushima Prefecture), Kashiwazaki (Niigata Prefecture), Imizu (Toyama Prefecture), Kanto Plain, and Konan (Shiga Prefecture), many molds of kettles of 9–10 century were excavated. Recently in Kawatodai site (Ibaraki Prefecture), a large-sized site of casting factory in Kanto district was discovered, and a great many molds of kettles were excavated.21)

Common point in kettle casting sites of 9–10 century is that cast iron production was pursued in the smelting factory or in the surrounding area. From excavated molds, products are Nabe and Hagama, and they have three legs under their bottom. They need not be put on kitchen range, but independently used. They belong to small-sized object, and so casting pit for large-sized objects has never found. Although these casting sites of cast iron kettle broadly spread from Tohoku to Kinki, there is no regional difference of form of vessel. Precisely examining these ancient molds of cast iron, core print by which fix mold and core is not clear. This is a different from medieval mold of kettle. As ancient casting sites are located considerably in north-east Japan, ancient casting production was influenced by Bohai or Liao which ruled north east district of China, Y. Kojima thinks.22) But it was influenced by Korean casting production. 23)

4.3. Kettles in Medieval Japan (12–16 century)

Medieval cast iron kettles were excavated from consumptive sites, and medieval casting molds of kettle were discovered in casting sites all over Japan. This means that the production and supply of cast iron kettle have increased to high level in medieval period, and iron kettles became to be daily necessities for people. The form of these medieval kettles is different from that of ancient kettle, and is made in the style which is adaptable to medieval cooking (Fig. 8). As mentioned above, core print by which fix mold and core is clearly made in medieval mold and core. It is the development of casting technology.

Combining molds and core, cast iron craftsmen usually poured molten metal into mold on the ground. But when casting a large-sized kettle, he had to set molds and core in the casting pit like Buddhist bell casting. For example, the upper part mold and lower part of mold of medieval Hagama were discovered in a round casting pit at Hada site at Oita city in Kyushu in 2010 (Fig. 9), and a large-sized Hagama was casted in 12 century there. Upper-part mold upside-down was found under lower-part mold. From this fact, I presume, casting was truly done in this pit. This site excellently showed us the technology of producing cast iron Hagama.24,25) Thus medieval production of casting kettle which considerably completed in 12 century became to be the principle of traditional casting production in Japan.

5. Casting Production in Ancient and Medieval

5.1. Ancient Casting Production (7–11 century)

The oldest Buddhist bells, well preserved at present, are bell of Kanzeonji (Fukuoka Prefecture) and bell of Myoshinji (Kyoto Prefecture), and they are considered to be casted in Kyushu in the end of 7 century. Chinese bells of tang period (8 century) which I recently investigated resemble to ancient Japanese bells in form and ornament of outer surface, but casting technology is considerably different from Japanese bells. Therefore these Chinese bells of tang period are what have changed from the prototype of Japanese bell, and Japanese bell parted from Chinese bell in earlier than the end of 7 century, I think.26,27) As Buddhist bell is large-sized object among ancient bronze casting objects, the highest casting technology of those days was introduced and established in Japan in 7 century, and this fact has an important
meaning. But the route of introduction and the school of technology of ancient bell making are important problems to be studied in the future. Ancient bell was made by order of temple, and many bells were casted in the ground of the temple. But in Bokerahara site (Shiga Prefecture), production of casting bell is pursued with the other industrial productions such as pottery making and iron smelting, and so it is the combinatory factory which is rare example.28) In addition, in Kyoto University Campus site (AP22 & AO22 region), six casting pits were discovered in all, and there is no ancient Buddhist temple around this site. But, as this site is located near Heiankyo, capital of those days, and around there many temples that want bell were built, ancient casting craftsman continued casting bell in his factory for a long time, I presume.29)

Being different from bronze casting objects, there is almost no cast iron object of ancient period left, and so, we have to investigate casting sites. Production of cast iron kettle began in the end of 7 century, and considerably developed all over Japan in 9–10 century. Examining ancient casting sites, bronze casting object and cast iron object were not made together in the same casting factory. That is, a characteristic of ancient casting production is the fact that there was difference of production system between bronze and cast iron. The cast iron production was pursued in the smelting factory or in the surrounding area where there was metal material in 9–10 century. In medieval period, the technology of iron processing is divided into smelting, refining, forging and casting, and different craftsmen were separately engaged in respective work. And cast iron production in smelting factory indicates that division of production has not enough developed in ancient period.

5.2. Medieval Casting Production (12–16 century)

Inscription of Buddhist bell often tells the time of production, but there is no Buddhist bell recorded the year in inscription from the latter half of 10 century to the first half of 12 century. We cannot still decide whether there is really a blank of two centuries, but in the middle of 12 century, Buddhist bells which became to be a new form appeared, and this style became to be the standard of subsequent Japanese bell. Characteristics of these bells are the followings; bell is smaller than ancient bell, the number of mold division is more than ancient bell, improved gating system has appeared, and almost all bells have inscription. Thus casting technology became considerably easier, and craftsmen who can cast Buddhist bell probably increased.

In 12–13 century, except traditional casting craftsmen of Yamato (Nara Prefecture) and Kyoto, there was a new casting craftsman who has the home base of production at Kawachi (Osaka Prefecture). The sites of casting craftsman of Kawachi were found in and around Sakai City (Osaka Prefecture). In the latter half of medieval period, casting craftsmen of Kawachi declined, and many regional craftsmen increased all over Japan. There are two types of bell production in medieval period, namely production in the distant place and production at the factory of home base. Examining casting site of bells, production at the home base factory were actively pursued, and only leading craftsman went to the distant temple, and casted Buddhist bell for the temple. In the distant place, casting craftsman made bell production in cooperation with regional craftsman, I think.30)

As above mentioned, in 12 century, medieval kettle became the style which is adaptable to medieval cooking, and the production and supply of cast iron kettle increased to high level, iron kettles became to be daily necessaries for people. There is no cast iron factory which is located in and around smelting factory, except few sites which belong to the beginning of medieval period. Thus division of production has considerably developed in medieval period, and metal material was circulated all over Japan as item for sale, and using this metal, casting craftsman made a production of kettles.

We have a few documents on casting production of medieval period. Yoshihiko Amino (1928–2004), a famous philologist on medieval study, has made a magnificent research. According to his research, the craftsmen who engaged in casting production were called Imojo, and among them, Kawachi Imojo who played leading role in the first half of medieval period had some connection with the housekeeping office of Emperor family. And freely itinerating all over Japan with the document which the housekeeping office of Emperor issued, they made casting production.31) But they had fixed home base for casting production in Kawachi, and they not only produced cast iron in his factory but also went to distant place and made casting activity and trade activity, I think. From inscription and casting sites, we can recognize that leading Imojo, such as Kawachi Imojo, made the production of bronze Buddhist bell as well as cast iron kettle. Leading casting craftsman could operate both copper and iron, and production system in the factory was co-operation of craftsmen, and on the day of pouring, many craftsmen operated in a group.32)

6. Conclusion

From casting sites which were discovered in Japan, we can recognize the technology to make casting objects in ancient and medieval period and also a change of casting technology.

For reconstruction of casting technology, we had better investigate traditional casting technology, so-called ethno-archaeology, in addition to archaeological study. For this purpose, I have often visited traditional casting factories in Japan and China and studied casting process of work from casting craftsman. But the traditional technology which is now preserved at the traditional factory is not always same with that of ancient or medieval period.

Japanese bronze bell is a large-sized casting object and so for casting it, casting craftsman has to prepare casting pit and set molds on the bottom of the pit. Therefore we can discover casting pit as clear remains at casting sites. Studying the structure of casting pit, I discovered there was a big change of technology in medieval Japan.

Except bronze objects, such as bell, mirror and others, there are cast-iron kettles, Nabe and Hagama, in Japan. These kettles are rarely found in sites of settlements, but many molds of kettles are discovered in casting sites. From these molds, we can imagine the form and technology of ancient and medieval kettles. After making analysis in detail, I discovered that Japanese kettles had a change in the
form and technology in the course of time, and there was a regional difference in medieval period.

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