Structure and craftsmanship of highly-effective smoke-free wood fired kiln

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Abstract:
With the Chinese trans-editing of the book of *Japanese Wood Fired Ceramics* co-authored by Masakazu Kusakabe, a Japanese fired ceramist, and Marc Lancet, the concept of modern wood fired ceramics has attracted widespread attention from China's ceramics community and has gradually become an emerging creation direction in the field of China's ceramics. While the study on the structure of highly-efficient smoke-free wood fired kiln and firing technology is able to help ceramists have a better understanding about its design concept, firing method and unique aesthetics concept. In addition, features of the highly-effective smoke-free wood fired kilns such as smoke-free, easiness to operate and enriched characteristics of ceramic products perfectly meet the experimental teaching method and exploratory practical requirements on disciplinary frontier development of art colleges. At the same time, the studying of highly-effective smoke-free wood fired kilns is able to grant students in art colleges a true understanding about the newly-developing artistic creation direction of modern wood fired ceramics, which is undoubtedly of great significance.

Key words: wood fired, ceramic, kiln, smoke-free, kiln filling, highly-effective

I. The Concept and Origin of highly-effective Smoke-free wood fired kiln

The name of highly-effective smoke-free wood fired kiln was firstly introduced in the book of *Japanese Wood Fired Ceramics* co-authored by Masakazu Kusakabe and Marc Lancet, which detailedly introduced the origin, current situation and aesthetic features of modern wood fired kilns as well as the construction method of two kinds of modern wood fired kilns. Among others, the highly-effective smoke-free wood fired kiln is also intruded in this book.

The design of the highly-effective smoke-free wood fired kiln was born in Canada when Masakazu Kusakabe was invited to construct a wood fired kiln for Burnaby City. Since the location of this kiln was in the downtown, which required the kiln to be free from smoke. Thus, Masakazu Kusakabe designed and established his first large-scale back pack two-room smoke-free wood fired kiln①, which is now commonly known as the highly-effective smoke-free wood fired kiln.

However, before that, in terms of both modern and traditional wood fired kilns, it is extremely common to have smoke, which is also a leading reason for the gradual phasing out of wood fired kilns by the ceramic production industry.

For this reason, the location of modern wood fired kilns would usually be remote suburbs or in forests to avoid densely-populated regions, which also brings a lot of troubles to the creation of modern wood fired ceramics and limits the development of modern wood fired ceramics industry. While the birth of highly-effective smoke-free wood fired kilns offers an appropriate solution to modern wood fired ceramics.

The special structure of the highly-effective smoke-free wood fired kiln is based on the improvement of Masakazu Kusakabe's back pack kiln structure. On the basis of a large-scale additional combustion chamber, the traditional cross-fired structure of back pack kiln is added with a laigh apex of arch, so that the original simple cross-fired structure was replaced by half inverse-flame low vault structure. Besides, the added large-scale chimney contributes to both the smoke-free and warming functions.

II. The Firing Features and Structure Analysis of highly-effective Smoke-free wood fired kilns

"Advantages such as easiness to operate, good firing effect and smoke-free during the process of firing of the highly-effective smoke-free wood fired kilns make it well-received. And the word of highly-effectiveness also perfectly describes the sound performance of such kind of kilns"② Just as what Masakazu Kusakab has described that smoke-free, easiness for firing, and abundant characteristics of ceramic products are the three leading features of highly-effective smoke-free wood fired kilns.

i. Smoke-free

"Smoke-free" serves as a design basis for highly-effective smoke-free wood fired kilns. Based on the design requirement of smoke-free, the designer chose a large-scale back pack combustion chamber to make the firewood to be fully burnt in the chamber.

And in the second furnace of the additional combustion chamber, the carbon bed would facilitate the

second burning of the smoke that hadn't been fully burnt. Except for a light smoke at the beginning due to the lack of quality of heat in the combustion chamber, the whole burning process of highly-effective smoke-free wood fired kiln has truly realized the smoke-free effect.

The designs of "smoke-free" and chimney are closely connected. In this design, Masakazu Kusakabe chose a large-size kiln that was usually only used in large-scale kilns for the smoke-free kiln with a capacity of only one cubic meter or so. This 34.5-cm diameter of the chimney enables a bigger emission draught power, and averagely speaking, a chimney with a height of 7 to 10 meters is capable of completely dispersing all particles of smoke in the chimney flue.

"If there is some smoke when you use the highly-effective smoke-free wood fired kiln for the first time, you only need to heighten the length of the chimney to stop the smoke." ③. This method is summarized by Masakazu Kusakabe through a host of experiments in designing the highly-effective smoke-free kiln, and at the same time, it has been repeatedly verified by the author in his multiple experiments of constructing the highly-effective smoke-free wood fired kilns.

ii. Rapid Warming and Easiness to operate

In accordance with the different natural dusty glaze effect of the ceramics, the burning time of the highly-effective smoke-free wood fired kiln ranges from 30 to 48 hours, which has largely narrowed the time in comparison with the traditional kilns with 3 to 7 days of burning. So it deserves the word of highly-effectiveness in its name.

According to the practical experiment gained by the author, the burning process of the highly-effective smoke-free kiln can be generally divided into five stages:

1. The stage of drying the kiln. It generally lasts around 12 hours with a temperature of 150 ^{o}C. At this stage, we only need to keep the burning of the fire and looking at the readings of thermoelectric couple, which stands for the easiest stage of the whole burning process.

2. The Low and Middle Temperature Stage. It usually has 8 to 10 hours with a temperature of 150^{o}C to 800^{o}C. This stage needs people to stoke the fire with middle-sized firewood at a certain frequency. If the majority of the green bodies are biscuit firing billets and the chamber is relatively dry, the temperature of the kiln will rise up at a quick speed.

3. The High Temperature Stage. This stage would involve 6 to 8 hours and the temperature would rise from 800^{o}C to 1200^{o}C. At this stage, the speed of temperature rise would slow down, and the kiln burnt brick begin to absorb the heat so that the temperature of the kiln might keep unchanged for several hours. But once the temperature node is over, the temperature would raise again. The fire worker might gradually adjust the relation between the fire and temperature within the chamber through pushing the flue shutter to reduce the emission draught power and cleaning redundant carbon deposition, keeping the temperature in the chamber above 1200^{o}C.

4. The Constant Temperature Stage. It often has 4 to 12 hours with temperature being kept from 1150^{o}C to 1250^{o}C. In keeping with different firing strategies, we have different firing methods. We are able to keep the temperature stable with regular firing method, or make its temperature to be dropped for several time and then make it rise up again through the method of temperature zone fluctuation.

After this stage, we can close the kiln and put out the fire.

After viewing the whole firing process of the highly-effective smoke-free wood fired kiln, it can be concluded that the kiln basically belongs to a controllable state with a clear regularity of firing. It is also possible that we are able to subtly adjust the temperature and firing atmosphere, and guide the direction of fire and the dust trend by cooperatively carrying out these different operative surfaces.

iii. Rich firing effect

The highly-effective smoke-free kiln is transformed from additional cross-fired combustion chamber and at the same time has been added with another inverse-flame structure, so it combines the features of both cross-fired and inverse-flame kiln.

The highly-effective smoke-free wood fired kiln is capable of realizing a series of different firing effects of the inverse-flame, the cross-fired as well as the half cross-fired and half inverse-flamed so as to achieve various fire marks and glaze effects through setting the fire barrier with different locations and heights.

Via the adjustment of operative surface like flue shutter and air inlet, we are able to choose different firing atmospheres such as oxidation firing, neutral firing and reduction firing, and the highly-effective smoke-free wood fired kiln can produce a series of firing strategies with different firing effects by combining operations. This offers ceramists abundant opportunities of creation.

III. The Kilnfilling and Firing Craftsmanship

Kiln filling is also called as kiln placing, namely to pile up the mud billets of ceramics into the kiln with kiln furniture like sagger and refractory slab with a certain norm. “Once the green bodies or saggers have been placed, the flow condition of flame when the burning of the kiln is finished has been determined.”④

Therefore, kiln filling lays the foundation of the wood fired kiln firing, decides the firing method of a kiln and the general effect of the work and affects the firing state of kiln during the process of firing.

The highly-effective smoke-free wood fired kiln generally adopt the method of unglazed firing, so the mud billet of the work would have direct contact with flame in the kiln. For this reason, the direction of fire would have a direct impact on the appearance of the final products.

Before the burning, the operator of the highly-effective smoke-free wood fired kiln would first decide the kiln firing strategy in keeping with the size, number and the expected effect of furnace transmutation of works. In the following part, the paper will focus on the analysis and exploration of firing craftsmanship and and kiln filling of highly-effective smoke-free wood fired kiln through three kinds of commonly-used kiln firing strategies.

i. The Strategy of Inverse-flame Oxidation Firing strategy

The Method of Kiln Filling: A fire barrier with a height of 69 to 80 cm needs to be placed close to the direction of chimney in the kiln, and the mud billets of works be piled up through kiln furniture like refractory slab, keeping a short distance among billets to let flame to cross.

The arrangement of works in kiln filling should follow the rule of "High-Short-High", which means to put works of 15 to 20 cm high on the bottom level to facilitate the passage of fire, and to closely place the relatively short works in the middle level to contribute to the storage of temperature in kiln. And on the top level, we place the highest works along the shape of the vault, which can usually produce a sound firing effects.

The Firing Method: The firing method of inverse-flame oxidation firing requires the operator to pay attention to the matching between air inflow and air exhaust. When the temperature reaches 1100^{o}C, the number of air intake could be properly reduced, and meanwhile the flue shutter could not be pushed for less than one third. When it comes to the constant temperature stage of 1200^{o}C, the method of temperature zone fluctuation could be employed in order to produce abundant dusty glaze effects through the continuous warming and cooling processes.

The firing effect: When the inverse-flame oxidation firing was applied, the flame flow up and down in the kiln, so the temperature also flows evenly and the furnace transmutation effect is basically the same, namely the dusty glaze effect in the vertical direction. When the pinus densiflora is used as the firewood, the side of works facing the flame would be brownish yellow or eel yellow, while the opposite side would be brownish red and crimson.

ii. The Inverse-flame Reduction Firing Strategy

The kiln Filling Method: The kiln filling method of inverse-flame reduction firing is basically in line with that of inverse-flame oxidation firing, except for the lateral stoking hole on the central part of the kiln.

The Firing Method: The firing steps before the constant temperature stage are the same with that of the inverse-flame oxidation firing. While when the temperature comes to the range from 1150℃ to 1200^{o}C, the operator begin to put a wealth of firewood into the main stoking hole and the lateral stoking hole at the same time, which is followed by the closing of the flue shutter as well as the closing of majority of the air intakes.

At this time, the reduction reaction would start out of the lack of sufficient oxygen for combustion in the kiln, and the temperature of the kiln begin to sharply drop. When the temperature reduces to 1000^{o}C, the flue shutter might be reopened to recover the oxidation firing method by continuing to add firewood to make the temperature reaching about 1200^{o}C. Later on, the previous reduction reaction steps should be repeated once again. This process could be repeated for four to six times during six to twelve hours.

The Firing Effect: When the reduction firing strategy is applied, a dense block of smoke would linger in the kiln to make the flame to show a kermesinus appearance. Contacting with this flame for a long time, these green bodies of ceramic whiteware would have a layer of gray glaze in paint-splashing style.

When the stressed reduction firing is conducted for several times, the long-time high-temperature firing would grant the green bodies an kind green drop effect. "When the pinus koraienis is fired, its alkali metal flame would erode the green bodies, making the surface of the quartz materials to be fused

into glassiness. It usually comes with clear flowing traces with semicircular cubic and transparent deep green-colored glaze. ”⑤

iii. Half Cross-fired and Half Inverse-flame Firing strategy

The Method of Kiln Filling: The fire barrier is placed in the middle place with an appropriated height of the opening of fire intake. The higher the fire barrier is, the bigger the temperature difference between the front and the rear parts of the kiln would be.

While if the kiln furniture and works are piled up on the relatively low fire barrier, an unexpected horizontal direction of fire would be produced.

It is also feasible to put a lateral stoking space between the fire barrier and the rear works so as to give an unique smoked effect to the work behind the fire barrier.

The Firing Method: The firing method of half inverse-flame and half cross-fired firing is similar to that of inverse-flame oxidation firing. It means to stop the heat from going out of the kiln and into the chimney at the middle temperature stage, and to reserve the stable flame atmosphere in the kiln at the high temperature stage in order to promise a stable deposition of iron element, which acts as an necessary condition for the crimson fire mark.

The Firing Effect: In the front half part of the kiln, works would gain the effect of drop glaze, vertical glaze and full glaze with some the brownish red fire marks. While for the rear half part, except for works close to the fire hole, majority of the works would have a mat half molten glaze effect coupled with crimson fire marks. If the overlapping firing method is employed, more colorful and flamboyant flame will be generated.

Conclusion

The production of highly-effective smoke-free wood fired ceramics marks a small revolution in the history of wood fired ceramics. And its well-targeted structure design enables it to meet the strict requirements of sites and gas emission, endow artists with more flexible firing methods and make it easier to control.

Nevertheless, in terms of China’s modern ceramics community, the introduction of highly-effective smoke-free wood fired kiln has an profound impact on the creation concept and methods of of ceramics. With the establishment of the first highly-effective smoke-free wood fired kiln in Jingdezhen, the concept of modern wood fired ceramics is completely demonstrated in front of Chinese ceramists in the form of material object.

The work features, creation process and aesthetic basis have been analyzed by Chinese ceramists, who are arguing and communicating their ideas on modern wood fired creation with each other. This process has also facilitated the thriving of modern wood fired ceramics, as an emerging artistic category, in China and created a new opportunity for the exploration of developing China’s modern ceramics in the context of the new era.

References

[1] Masakazu Kusakabe/Marc Lancet, *Japanese Wood Fired Ceramics*, Shanghai Science and Technology Press, 2011, P126

[2] Masakazu Kusakabe/Marc Lancet, *Japanese Wood Fired Ceramics*, Shanghai Science and Technology Press, 2011, P126

[3] Masakazu Kusakabe/Marc Lancet, *Japanese Wood Fired Ceramics*, Shanghai Science and Technology Press, 2011, P137

[4] Masakazu Kusakabe/Marc Lancet, *Japanese Wood Fired Ceramics*, Shanghai Science and Technology Press, 2011, P49

[5] Wuhao,*Study on the Craftsmanship and Materials of Modern Wood Fire Art*. New Arts, 2016 (4), P22

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