Develop Creative Brick Kiln Cultural Products by Powder Metallurgy Process Technique

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Abstract. Brick is one of the most common traditional building materials in the world. Located at the foot of the Bagua Mountain in Changhua, Taiwan, Qiaotou community residents make good use of mountain clay to develop the brick kiln industry, and once created a glorious history. With the increase in building materials regulations, the chimneys of brick kilns no longer smoke, and the industry has gradually declined. This study hopes that the traditional brick kiln industry will be improved through technological technique and input a new generation of innovative thinking. The general brick kiln cultural products will be re-granted to new life from the decline and showing the creative thinking in the local culture. The materials test method was used to study the processing technology of brick powder. It is expected to improve the precision of brick products and reduce the production cost through the application of the powder metallurgy process technique. And applied to the brick creative culture product design to create unique merchandise.

1. Introduction

1.1. The history of brick kiln in Taiwan

During the Japanese occupation period, Taiwan's local brick production was earthen and less quality. Therefore, the mechanized brick kiln technology was introduced from Japan. Specially made bricks for the Japanese to instead Taiwanese local bricks. During the Showa era, there were as many as 80 folk brick kiln industries in Kaohsiung at that time, producing bricks used by the public (Chang, 2012)[1].

The Qiaotou community is located under the Bagua Mountain Range[2][3]. It is rich in natural earth and stone, especially the clay layer is the best material for making bricks. So in the 1960s, it began to develop into an industrial brick kiln area. At most, there were more than 20 brick kiln factories. The production of red bricks is well known throughout the Taiwan province, creating a regional economic development miracle for more than 30 years. However, in recent years, due to the advancement of building materials, it has been replaced by concrete, which is more fast, strong and durable.
After the red brick market was sluggish, the brick kiln in the community was transformed into a cultural teaching style in 1999 and create a special small brick and cultural product design. And actively revived the lost brick carving skill, to become a local characteristic craft. Community residents and brick kiln factory integrate brick carvings into their lives and are everywhere in the community. Step by step to create the "Red Brick Art Village" which combines with the history, crafts, and culture.

1.2. Commercial product analysis of brick culture products
At present, the collection and analysis of brick's culture products are shown in Table 1. Most of them are mainly formed by compression molding, and the price is between NTD. 500-2000.

Table 1. Commercial product of brick's culture products (http://www.sanhetk.com.tw/product_list.asp)

| Brick culture products | Function and description | Brick culture products | Function and description |
|------------------------|--------------------------|------------------------|--------------------------|
| Fireplace: Small brick for decoration. Promote red bricks in DIY activity, so that users can build their own fireplace. | Stove: Burning stove. Hand-made, although its unique, but the stitching is not easy, the price is relatively unfriendly. | Little doll: Decorations. Although it has a hand-made texture, but it is not refined enough and the price is expensive. | Window grille: Necklace or charm. Designed with a window grille as a charm. Simple and light, but the quality of the production is rough. |

In terms of commercial products, the study found that the application of other materials has developed rapidly and has opened the market (Lu, 2001; Lu et al., 2013) [4] [5]. Such as cement cultural products, The 22 Design Studio from Taiwan [6], including cement ring, cement clock, cement stationary group and so on. The popular watch “The 4th dimension” is the focus of attention.

These cements have successfully developed a variety of creative cultural products, and have been recognized by consumers (Lee, 2018; Hsiao, 2018) [7] [8]. The same building materials of the red brick should also catch up with the market trend as soon as possible.

1.3. The possibility of powder metallurgy molding technology
This study found that brick molding and powder metallurgy molding have many similarities, as shown in the following table 2:
Table 2. Powder metallurgy forming and brick forming process analysis

| Step | Powder metallurgy molding | Brick molding |
|------|---------------------------|---------------|
| 1    | Metal powder production   | Take soil, Sieve soil. |
|      | Stirring: mixing of metal components | Pug mill: mix of brick powder and other ingredients. |
| 3    | Compression molding (mould without draft) | Extrusion (mould without draft) |
| 4    | Sintering (Temperature: 1200-1300°C) | Into the kiln (Sintering temperature: 900-1100 °C) |
| 5    | Secondary processing: vibration grinding, surface treatment, heat treatment, machining. | Surface removal of sharp angle. |
| 6    | Finished processing---Quality inspection, cleaning, finishing. | Finished processing - graded and stacking. |

For the brick kiln industry, powder metallurgy molding is extremely similar to brick forming (Liao, 2003)[9]. Can brick powder replace metal powder? If it can be directly processed? It is a worthy issue of study. If it can, its production costs will drop 1/3 dramatically. It will help reduce personnel costs and the price and improve product competitiveness.

Facing the difficulties of traditional industrial, this subject boldly assumes that tradition can be innovation in other industries? Can two traditional industries have new opportunities? Can two traditional industries create together? There is no gap in generations, just lacking a bridge. The project tried to find the bridge and let the design become an opportunity for co-creation.

2. Methods
Material testing and characterization is a key function in assessing and ensuring the quality, properties, and behavior of a polymer or composite, and is thus an important step in guaranteeing the quality and success of finished product.

This research hopes to bring the creative cultural products of the red brick through powder metallurgy molding technology. Powder metallurgy molding technology is similar to the brick burning process. This research uses brick powder as raw material, combined with powder metallurgy technology, to shape the red brick products. The case study is conducted on the bricks in central Taiwan.

3. Results

3.1. Material testing process
The experimental test focuses on the feasibility of molding. The first step is to test with an alternative simple mold. The results are: Using water as an adhesive can be replaced by extrusion mold. But it is also easy to disintegrate because of the reduced water. However, the press molding can be more detailed of the brick surface.

The second step is to use the existing mold for the molding test. First, discuss the molding problem with the powder metallurgy practitioner, set the molding pressure, mix the appropriate proportion of brick powder and iron powder. Select the appropriate mold for testing, and then perform sintering after the test. The test situation is shown in the following table 3, the final results show that the brick power metallurgy is quite successful.
### Table 3. The material testing process of brick power metallurgy

| Step | Image  | Description |
|------|--------|-------------|
| 1.   | ![3D modeling](image1.png) | 3D modeling |
| 2.   | ![Simple mold](image2.png) | Simple mold |
| 3.   | ![Discussion](image3.png) | Discussion |
| 4.   | ![Brick powder feed](image4.png) | Brick powder feed |
| 5.   | ![Press forming](image5.png) | Press forming |
| 6.   | ![Pressurized product](image6.png) | Pressurized product |
| 7.   | ![Dimensional measurement](image7.png) | Dimensional measurement |
| 8.   | ![Sintered product](image8.png) | Sintered product |

#### 3.2. Design positioning

This study uses innovative molding methods to allow bricks to escape the image of the past. Not only the shape becomes more delicate and degenerate, but it also shrinkage the capillary pore of the bricks. We also found that the improved small brick is very suitable as a raw material for the diffused stone.

The principle of the diffused stone is mainly to absorb moisture and adjust the humidity by many tiny pores. When the humidity of the diffused stone is lower than the humidity in the air, the moisture is absorbed into the air; conversely, when the humidity of the diffused stone is higher than the humidity in the air, the moisture is discharged to the air. Therefore, when the incense stone drops on the essential oil, it is diffused by the adjustment of humidity.

Through the combination of diffused stones and accessories, many problems with perfumes can be solved. Perfume is usually sprayed on the back of the ear, neck and other parts, through the higher temperature of the body, so that the fragrance can spread more effectively, but the fragrance also disappears quickly only about two to three hours.

Some users are allergic to the ingredients of the perfume, so some people will spray the perfume on the clothes to make the fragrance last longer and not directly touch the skin. But another disadvantage is that some perfumes are prone to dyeing light-colored clothing.

The diffused stone brick jewelry designed through this study allows users to spray perfume on the jewelry to create the "brick" jewelry that belongs to their own fragrance and memories. It can also effectively solve the above problems, and reduce the amount of perfume. When you feel that the aroma is insufficient, you only need to sprinkle a small amount of water on the surface to continue to spread the fragrance.

The flow of the study from analysis, sketching, 3D drawing to questionnaire survey and mold opening is shown in the table 4 below.
Table 4. The flow of the study

| 1. Design analysis | 2. Sketch drawing | 3. 3D drawing |
|--------------------|-------------------|--------------|
| 4. 3D printing     | 5. Questionnaire  | 6. Confirm product style |
| 7. Mold design     | 8. Mold opening   | 9. Mass production |

3.3. Design results
Using the above-mentioned brick powder metallurgy technology, this study designed several bricks of cultural products, mainly necklaces, and earrings, as shown figure 1.

Figure 1. Creative brick kiln cultural products design

4. Conclusion
After the import of the powder metallurgy process technique and design project, it helps to activate the brick kiln industry. And obtained the following results.
- The surface roughness is greatly improved by brick powder metallurgy pressing.
• Reduce manual labor and reduce costs significantly.
• Promote the combination of different industries and create new opportunities for brick cultural product design.
• Bricks made of powder metallurgy, with high public acceptance.
• Innovative formulations and processes have been proven to be viable.

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