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Research On The Generation Of Decorative Patterns On Product Surfaces Using Paneling Combined With Islamic Patterns

Hui-Chin Chang
HungKuo Delin University of Technology, Department of Creative Product Design, Taipei, Taiwan
chang.hcjang@gmail.com

***Abstract*—Decorative patterns are an artistic expression that originated very early in human history. Under the influence of different regions and cultures, each place has developed its own cultural style and will interact with neighboring regions. Therefore, behind the beautiful patterns, there is usually a story of historical development or even national spirit. The decorative style of Islamic patterns has been influenced by Islamic religious ideas since its inception. Its main feature is the beauty of abstract patterns. Although it is complex and varied, it gives people a unified and harmonious visual effect. Therefore, it is based on some basic graphics, which continuously form new decorative forms through regular arrangement, reconstruction, transformation cycle, repeated extension, etc., and combine into all-encompassing, tightly organized, exquisitely complex, and ever-changing Islamic geometric patterns. The paneling technique is to unfold a pattern with an independent closed appearance on a plane in a continuous, repetitive, non-overlapping and gapless manner. Therefore, this article uses parametric design tools as the main axis of product creation, and Islamic patterns as the design basis, and applies these patterns to the decoration of the product surface according to the paneling technique. Finally, by combining the currently popular 3D printing technology, the product prototype was quickly materialized, hoping to show a new look for Islamic culture that is different from the past, and thus achieve the ideal of continuing and promoting Islamic cultural creativity.**

***Keywords*—Paneling method, Islamic patterns**

I. INTRODUCTION

The development of decorative art is a manifestation of the progress of human civilization. Through historical materials, we can understand that it starts from rock paintings in prehistoric times, to decorative patterns on utensils and even on fabrics and buildings. It is a slow and gradual transformation. It is a record and symbol of human thought and symbols, reflecting people's thoughts and aesthetic concepts at that time. Therefore, even though the emergence and development of many different civilizations have caused changes in the expression of patterns, it has also promoted the diversity of patterns. Patterns are living shapes. From the evolution of patterns throughout history, we can see that patterns reflect people's depiction of life [1]. The development of decorative art is a manifestation of the progress of human civilization. Regarding the development of decorative art, Ye Liu Tianzeng [2] mentioned that from the perspective of the history of human art and cultural development, decorative art can be said to be the earliest artistic activity and aesthetic display of mankind. The decorative art presented in different periods reflects the thoughts, aesthetic concepts and religious beliefs of the time. From the perspective of historical evolution, human beings have not only created scientific and technological civilization, but also created artistic culture. At the beginning of civilization, people invented and manufactured various tools and utensils to meet their living needs. With the improvement of wisdom and the accumulation of experience, humans became more and more sophisticated in the production of utensils. At first, utensils were made for the need to make a living. With the improvement of production techniques, in addition to practical purposes, aesthetic concepts gradually emerged in the shape. Therefore, the patterns on the utensils also changed from their original practical functions to artistic expressions.

From the evolution of Eastern culture, we know that pattern elements in Western culture entered the Eastern world through activities such as ethnic migration, cultural exchanges, wars and trade, thus increasing the diversity of pattern expression in the Eastern world. Western patterns also have a history and evolution. Compared with the gods, ghosts, religions, mythical beasts, flowers, plants, people, birds, insects, auspicious patterns, auspicious objects and auspicious words in Eastern culture, the patterns of Western culture are mainly plant patterns and geometric patterns in nature; it changes from simple patterns (squares, circles, diamonds, text shapes and curve shapes, etc.) to complex changes. The composition type has evolved from a two-sided continuous composition to a four-sided continuous composition, and can even expand infinitely outward, and has evolved from simple line expression to complex interwoven pattern presentation. Regarding this evolution process, Riegel[3] divided the patterns into four styles: geometric patterns, heraldic patterns, plant decorative patterns and Arabic decorative patterns.

The so-called Arabic decorative pattern is a complex decoration with repeated geometric shapes. It is an important element of Islamic art and is often seen on the wall decorations of mosques. The way its geometric figures are composed must be based on the Islamic worldview. For Muslims, the combination of countless geometric figures means that there is an infinite existence beyond the visible material world. This geometric style of arabesque did not become widely popular in the Middle East and the Mediterranean basin until the Golden Age of Islam. Therefore, geometric patterns and symmetry are the main themes of Islamic artwork, which naturally give rise to the abstract concept of symmetry. Pattern and symmetry are two of the most profound and pervasive concepts conceivable by the human mind, and no other concept unites science, art, and nature as they do. Patterns and symmetries are equally fascinating and meaningful to kindergarten children and physicists constructing complex theories of the universe [4].

The paneling technique is a design method that unfolds graphics with independent closed shapes on a plane in a continuous, repetitive and non-overlapping manner without leaving any gaps. This study uses parametric design tools as the main axis of product creation, and Islamic patterns as the design basis. It follows the paneling technique to apply these patterns to the decoration of the product surface. Finally, it combines the currently popular 3D printing technology to quickly materialize the created product prototype, hoping to show a new and different look for this Islamic culture. This will not only expand the paneling technique from the plane to the application of the three-dimensional space surface, but also continue and promote the ideals of Islamic cultural creativity.

II. ISLAMIC GRAPHIC STYLE FEATURES

Geometric patterns appear in large numbers in Islamic culture. They exist on different materials such as tiles, wood, brass, paper, plaster, glass, etc., and they are particularly prominent on the surface of buildings. Leaving aside the patterns on felt, floral motifs and stylized floral designs, Islamic motifs appear in three specific geometric features. One of the most easily recognizable is the rectangular Kufic letter pattern. They used simple rectangles and squares to create calligraphic designs in a stylized form of Arabic letters. This pattern is most commonly used on building surfaces to add majesty and solemnity. The second special Islamic pattern form is the arabesque, which consists of curved elements that resemble leaves and flowers. In this pattern, the spiral shape continuously winds, undulates and connects, and the sense of periodicity and rhythm is very prominent in this pattern.

The largest category of Islamic patterns uses complex polygonal and, less commonly, circular arcs to enclose areas, with designs in a basic grid repeated over and over again to completely fill an enclosed area. The most striking feature of this type of pattern is the symmetrical form of the "stars" and "constellations". Some Islamic designs do not include stars, but they are quite rare and not very elaborate or complex. Stars with six, eight, ten, twelve and sixteen rays occur most frequently, but stars with other numbers of rays (especially multiples of eight, up to ninety-six) may also be seen. The star shape is not just decorative, but has important psychological and historical reasons.

The fusion of straight and curved elements and Arabic calligraphy shows the most obvious characteristics of Islamic architectural decoration. For Muslims, the poetry of the Quran represents the visible reality of God's word, and its calligraphy enhances its sacredness and inspiration. No other civilization has placed such a high value on pattern and symmetry, and no other civilization has so deeply respected the sanctity of words, that it can be said that "calligraphy is the jewel in the crown of Islamic art."

The other two characteristics are related to "fluidity" and "infinity", which may not be obvious from isolated patterns, but as in the Islamic patterns mentioned above, the geometric basis used is the replication of the grid, and the pattern can be repeated infinitely to fill the space as much as possible. A concomitant property is that the viewer's eye has no natural focal point. When people look at an unfolded pattern, their eyes will "flow" continuously along the lines, and they will see many complex structures and relationships. This feature is not evident in the geometric designs of other cultures.

III. PANELING TECHNOLOGY APPLIED TO THE CORRELATION ANALYSIS OF ISLAMIC PATTERN FORMS

Paneling means "to unfold a pattern with an independent closed shape on a plane in a continuous, repetitive manner without overlapping or leaving any gaps." In his 1958 paper, Dutch printmaker Maurits Cornelius Escher called tessellation or tiling a plane "a regular division of the plane," and explained it as "a plane or Poincare disk, which should be thought of as having infinite edges and can be filled or divided into countless similar geometric figures, leaving no empty space."

In general, paneling techniques can include concepts such as theme elements, translation units and mathematical skeletons.

(1) Thematic elements: In paneling patterns, simple geometric patterns or patterns of insects, ants, birds and animals can all be thematic elements, and mathematicians call them "tiles".
(2) Translation unit: A pattern that can cover the entire plane in a repeated arrangement is a translation unit.
(3) Mathematical skeleton: A polygon that contains exactly one translation unit and can be spread over the entire plane in a repeated arrangement is called a mathematical skeleton.

Therefore, when developing or constructing such a pattern, you can follow the following steps.

(1) Identify whether there is rotational symmetry

about certain points. If so, calculate the minimum angle that the pattern can be rotated to overlap with itself.

(2) Identify whether there is a mirror axis.

(3) Identify if there is more than one mirroring axis.

(4) Identify whether there is a sliding mirror axis in any direction? Do you confirm whether the sliding mirror axis coincides with the mirror axis? Is the center of rotation on the mirror axis?

IV. PARAMETRIC PANELING TECHNIQUE MODELING STEPS

The paneling technique is to unfold figures with independent closed shapes on a plane in a continuous, repetitive and non-overlapping manner without leaving any gaps; while the parametric concept is that the number of continuous figures can be adjusted arbitrarily under certain specifications, so there must be adjustable parameter values. The following are the steps for modeling the parametric paneling technique in this study:

Step 1: Construct the original plain finished product and panel pattern as shown in Figure 1.

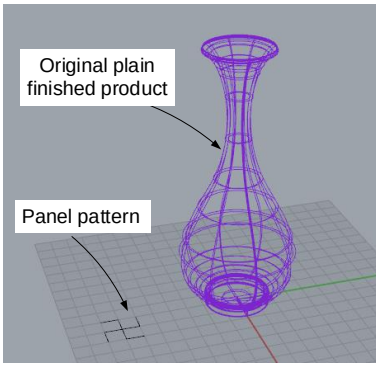

Figure 1 Original finished product and panel pattern

Step 2: Construct the UV surface of the finished product, that is, the seed point of the UV surface, as shown in Figure 2.

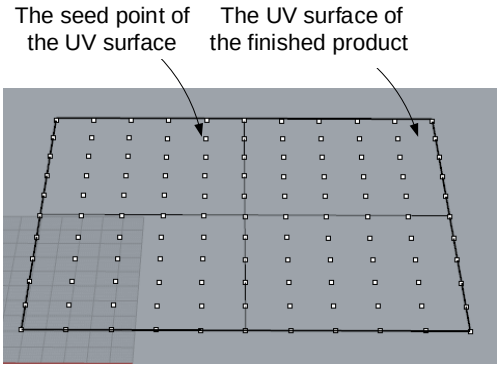

Figure 2 UV surface and seed points of the original plain finished product

Step 3: The repeated continuous pattern is calculated, as shown in Figure 3.

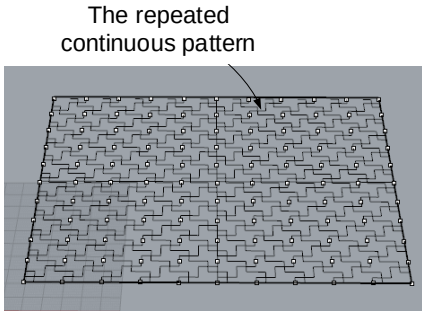

Figure 3 The repeated continuous pattern

Step 4: Determine the pipe diameter and calculate the repeated continuous polysurface, as shown in Figure 4.

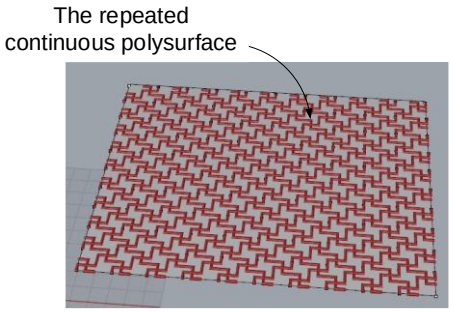

Figure 4 Repeated continuous polysurface

Step 5: According to the UV reference point, attach the repeated continuous polysurface to the original finished surface, as shown in Figure 5.

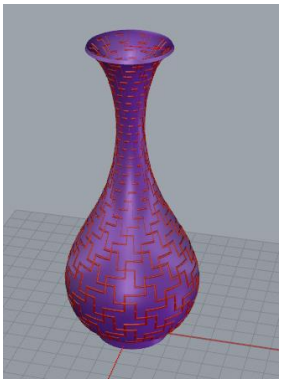

Figure 5 Finished product

V. RESULTS AND DISCUSSION

Islamic patterns appear in three specific geometric features. One of the most easily recognizable is the rectangular Kufic letter pattern. They used simple rectangles and squares to create calligraphic designs in a stylized form of Arabic letters. This pattern is most commonly used on building surfaces to add majesty and solemnity. The second special Islamic pattern form is the arabesque, which consists of curved elements that resemble leaves and flowers. In this pattern, spiral shapes continuously wind, undulate and mesh. The sense of period and rhythm is very evident in this pattern. The largest category of Islamic pattern forms uses complex polygons and, less commonly, circles to enclose areas, with designs in a basic grid repeated over and over again to completely fill an

enclosed area. The most striking feature of this type of pattern is the symmetrical form of the "stars" and "constellations". In this article, the three most representative "vases" in the history of the development of Chinese ceramic aesthetics, namely the Yuhuchun vase, Mei-ping vase and Shang-ping vase, are used as the main body of this study on Islamic decorative patterns to highlight the coordination and integration of Chinese and Western cultures.

(a) Yuhuchun vase + Islamic pattern polygonal and circle pattern

The shape of the jade Yuhuchun vase is a typical form of Chinese porcelain, see Figure 6[b). Therefore, the bottle shape is used as the base for the largest category of Islamic patterns - "complex and repetitive polygonal and circular" patterns, as shown in Figure 6(a), to highlight its universality. The result of integrating the two is shown in Figure 6 (c), and Figure 7 is a 3D printed product with this feature.

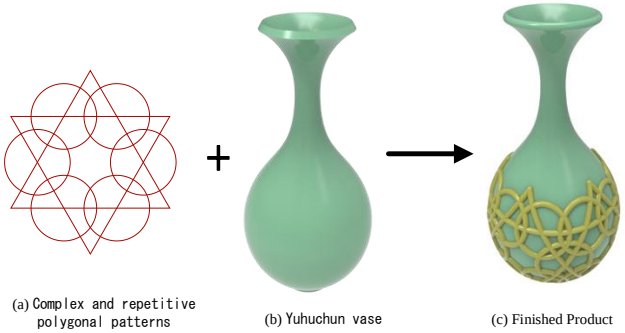

Figure 6 Yuhuchun vase and Islamic polygonal pattern

Figure 7 Islamic polygonal patterns decorated on the surface of the Yuhuchun vase 3D printed product

(b) Mei-ping vase + Rectangular Kufa letter pattern

The Mei-ping vase is a famous traditional porcelain of the Han nationality. It is a vase with a small mouth, short neck, plump shoulders, thin bottom and ring foot. It is named because its small mouth can only hold plum branches, as shown in Figure 8(b). Therefore, its appearance is used as the base of the “Rectangular Kufic letter pattern” in the Islamic pattern form, as shown in Figure 8(a), to highlight its stability. The result of integrating the two is shown in Figure 8(c), and Figure 9 is a 3D printed product with this feature.

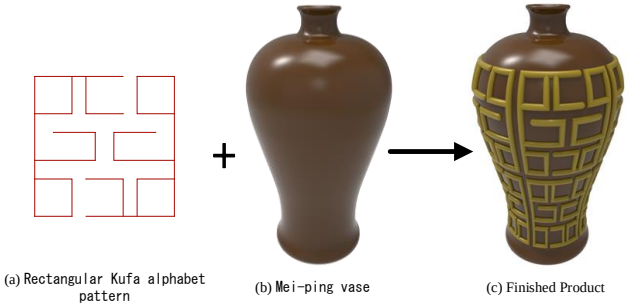

Figure 8 Mei-ping vase and Islamic Rectangular Kufic letter pattern

Figure 9 Islamic Rectangular Kufic letter patterns decorated on the surface of the plum vase 3D printed product

(c) Shang-ping vase + vine pattern

The Shang-ping vase is a treasure of Chinese ceramic art, see Figure 10(b). Because it was often given as a reward or admonition by the emperor, it was used as the base of the “arabesque” pattern in Islamic patterns, as shown in Figure 10(a). And match it with blue color. "Qing" stands for "clear" and "Lian" stands for "honest". When "Qing" and "Lian" are put together, we hope that the current politics will be "clean and honest". It is used to echo the ancient emperors' intention of rewarding and admonishing their subjects. The result of integrating the two is shown in Figure 10 (c), and Figure 11 is a 3D printed product with this feature.

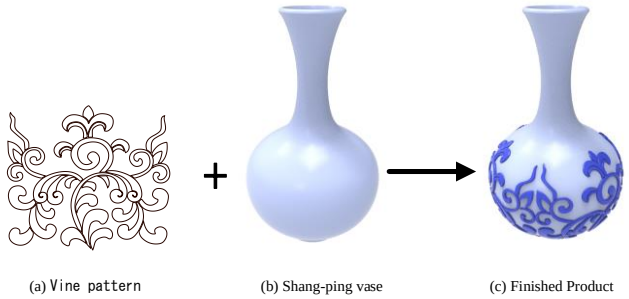

Figure 10 Shang-ping vase with Islamic vine patterns

Fig.11 The 3D printed product with Islamic vine patterns on the surface of the Shang-ping vase

VI. CONCLUSION

Decorative patterns are an artistic expression that originated very early in human history. Under the influence of different regions and cultures, each place has developed its own cultural style. The decorative style of Islamic patterns has been influenced by Islamic religious ideas since its inception. Its main feature is the beauty of abstract patterns. Although it is complex and varied, it gives people a unified and harmonious visual effect. This study uses parametric design tools as the main axis of product creation and Islamic patterns as the design basis. It uses paneling techniques to apply Islamic patterns to the surface decoration of the " The three most representative vases", which are the most representative in the history of the development of Chinese ceramic aesthetics. Finally, by combining the currently popular 3D printing technology, the product prototype was quickly materialized, hoping to show a new look for Islamic culture that is different from the past. This will not only expand the paneling technique from a flat surface to a 3D surface, but also highlight the coordination and integration of Chinese and Western cultures, thereby achieving the ideal of continuing and promoting Islamic cultural creativity.

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