Development of a Water-Droplet-Shaped Bra Mold Cup Design

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Abstract

Objectives: Mold cups with built-in wires are effective to maintain the shape of the breast but stimulate mammary region resulting in uncomfortableness while wearing. This study aims to develop no-wire mold cups in order to commercialize bras that make the breast appear beautiful by keeping the shape without wire supporting them. Methods/Statistical Analysis: Bras used in this study are based on 75B full cup design that is suitable for the standard size in twenties. Mold bras in this study are manufactured by making a mold out of a gypsum model based on body surface shell and cutting it through mold-cutting process. In the developed mold cup, breast volume appears to gather toward the center in the form of a water droplet and soar toward the upper-cup edge. The mold cup does not seem to spread sideways. This allows small breasts to appear larger and big breasts to appear reduced. Moreover, the shape of the mold cup is intended to fit different kinds of breasts comfortably by introducing embossing while initially developed for research, the mold is also made available commercially in a range of sizes. Seven items of sensory test are statistically analyzed to examine the wearing effects of the new mold. For statistical analysis, F-test and Duncan-test are performed by SPSS 18.0. Findings: We registered the design of the mold cup with the Korean Intellectual Property Office (Registration number: 30071595400). From the sensory test of wearing the research bra and bras on the market, we find that there is statistically significant relationship between the all sensory categories. Improvements/Applications: The method used to yield the shape of the mold can be applied to the development of various types of bras produced by mold cup manufacturers. Our mold cup will be helpful for bra manufacturers that want a new product to meet the needs of customers and improve the fit of their garments.

Keywords: Breast Volume, Gypsum Model, No-Wire Mold Cups, Surface Shell, Sensory Test

1. Introduction

A bra determines the external shape and appearance of the clothed breast; thus, consumers will select a product that can create what they perceive as the ideal breast silhouette. A bra cup is the main tool used for breast molding; in terms of materials, bra cups can be divided into fabric cups and mold cups. Although no-wire bras are common on the market today, since they improve fit and minimize inconvenience, consumers are nevertheless unsatisfied with them. no-wire bras give greater comfort because of the lack of a wire. However, they are not in a breast shape and have insufficient functionality for many consumers in terms of increasing the breast volume or lifting the breast. Furthermore, compared to a fabric bra cup, the shape of a mold cup often does not fit the shape of the breast or produces an exaggerated silhouette, leading wearers to feel a psychological burden. Many studies have been conducted about bras and mold cups. However, it is difficult to find research that suggests no-wire molded bra cups. Thus, there is a clear demand for a no-wire mold cup in the shape of a water droplet that takes adequate consideration of the size of the wearer's body and the breast volume.

This study aims to develop a mold cup that considers breast shape by remedying the shortcomings of existing molded bra cups. The characteristics of the mold cup being developed are as follows: 1) the breast shape appears to be gathered into a sphere in comparison to a no-wire bra: 2) small breasts appear to be gathered up and...
big breasts appear to be reduced; and 3) the bra is comfortable to wear.

2. Investigation of Commercial Bra Cups

2.1 Classification by Cup Height
The moldcup can be classified by the height of the cup into a “full cup” that covers the entire breast, a “three-quarter cup,” and a “half-cup.” The characteristics of these cups are shown by type in Table 1.

2.2 Classification of Mold Cups by Function and Correction
Mold cups can basically be divided into wired and no-wire cups. Regarding the latter, the bottom and sides of the cup can be classified into circular, triangular, and rectangular shapes, as follows. 1) The circular cup makes the breast into a relatively round shape and is effective in gathering together the breast when it has no wire; thus, the breast shape appears elongated sideways and the breasts stay apart. 2) As the triangular mold cup is parallel to the line of the under-breast, it functions to support the lower breast. However, the side portion of the breast tends to be squashed diagonally, and the shoulder straps tilt toward the center. Accordingly, it is used by itself or in a side-stretch bra. 3) As for the rectangular mold, the lower side of the breast takes on a rectangular shape, while the upper side has a tail section for the shoulder strap that is in line with the shoulder angle. Although it covers a wide part of the bottom and side of the breast, it does not follow the breast shape. In addition, the breast tends not to adhere to the cup but to float in the angled part where the under-breast and side breast meet. The types and characteristics of mold cup by function are shown in Table 2.

2.3 Types of Mold Cup Material
The materials used in the mold cup generally include urethane sponge, woven fabric, and punctured sponge. To bond fabric to sponge, various functional materials are used.
The urethane sponge mold has excellent shape stability, can be formed in a wide range of thicknesses and shapes, and is not costly; therefore, it is often used. However, it has poor breathability and can cling to the skin and be uncomfortable. To compensate, the woven bra cup is often used in summer due to its good breathability. However, its thickness is fixed and cannot be adjusted, and thus, it has low shape stability. Alternatively, the punctured mold cup has good breathability and is flexible, due to the small holes in the sponge. However, has weaker shape stability than the sponge mold cup and the range of thicknesses is limited due to the punctures. To address these disadvantages, our mold cup was developed to reduce the discomfort of the sponge clinging to the skin and to enhance breathability by using embossing embedded mold. Mold cup materials were investigated, and their pros and cons are summarized in Table 3.

### 3. Research Methods

#### 3.1 Research on Bra-Mold Cup Design Method

As shown in Figure 1, design lines were established based on a bust shape sample collected directly from an inner...
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Figure 1. Definition of design line by collecting bust shell and refinement of the design line based on data collected during thermo forming of bra mold cup (left: design lines from an innerwear-only mannequin body, right: design lines mimicking wearing brassiere).

3.2 Bra Mold Cup Fabrication Process

The bra mold, which manufacturers can adopt immediately to enable high volume production without additional refinement, was fabricated as follows. In order to create the mold, all directional elastic fabric was bonded to the urethane sponge to enhance extrusion during molding. The physical properties of the fabric and sponge samples used in producing the mold cup are shown in Table 4.

A plaster was made to mold the mold cup in the same manner as collecting the bust shell from the mannequin. In order to produce the embossing embedded mold, a cone-shaped hole was carved deeply into the mold. A 15T sponge was added to the mold piece made for thermoforming, and thermoforming was also successfully conducted. The thermoforming condition such as temperature and duration were the same condition as those used in high volume manufacturing. Then, the mold was cut using a molding cutter. The bra mold cup fabrication process is as follows: 1) plaster molding; 2) making a mold; 3) making a hole in the mold; 4) making a top mold casting piece; 5) making a bottom mold casting piece; 6) sponge fabric bonding; 7) thermoforming the bra mold; 8) completion of mold; 9) using a custom-made cutter; and 10) mold cutting. This procedure is described in Figure 2.

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The bra mold, which manufacturers can adopt immediately to enable high volume production without additional refinement, was fabricated as follows. In order to create

| Weight (g/m²) | Thickness (mm) | Density (piece/5cm) | Tensile strength (N) | Tensile elongation strain (%) | Restoration (%) | Fiber mixture rate (%) |
|---------------|----------------|---------------------|----------------------|-----------------------------|----------------|-----------------------|
| 125.0         | 0.33 wale       | 145.6               | 242.9                | 240                         | 95.6           | nylon 87.5            |
|               | course          | 240.6               | 261.1                | 180                         | 95.6           | polyurethane 12.5     |
| 9 g/PCS       | 15             | -                   | -                    | -                           | -              | polyurethane 100%     |
the mold, all directional elastic fabric was bonded to the urethane sponge to enhance extrusion during molding.

### 3.4 Sensory Test

Table 5 show the categories from the sensory test of wearing the bras made of the developed mold cup and mold cup A/B on the market.

The sensory test of the completed researched bra was conducted in seven categories. Each item in the survey asked respondents to rate stated attributes on a five-point scale from 5 = ‘very good (very appropriate)’ to 1 = ‘very bad (inappropriate)’.

**Table 5. A sensory test categories**

| No | contents |
|----|----------|
| Q1 | The overall size of the cup covers the breast appropriately. |
| Q2 | The cup line is natural. |
| Q3 | The upper and lower edges of the cup doesn’t push the breast. |
| Q4 | There is no gap in the side of the brassiere cup. |
| Q5 | There is no gap in the center front. |
| Q6 | The cup keeps the breast shape properly. |
| Q7 | There is no space in the B. P position by close adhesion of B. P point and cup. |

### 3.5 Data Processing and Analysis

The data of the current study were statistically processed using SPSS 18.0. To verify the effect of wearing the bra, an F test and Duncan’s multiple comparison method were used for the sensory test.

### 4. Development of Mold Cup and Sensory Test

#### 4.1 Development of Mold Cup

As mentioned above, the mold cup makes the breast appear to be gathered toward the center, with its volume pushed toward the uppercup edge, and the mold cup does not appear to spread sideways. In addition, sewing a bra using this cup is easy, as the edge is thin, and the mold cup matches the breast shape and does not give discomfort.

As shown in Figure 2, there are various-sized embossing son the inner edge of the cup. These embossing enable air circulation and prevent the discomfort that results from the breast clinging to the sponge for a long time; in other words, they enhance breathability, reducing odor and skin irritation by preventing the accumulation of sweat inside of the bra cup.

The actual object of the mold cup was registered with the Korean Intellectual Property Office (Registration number 3007159540000). Pictures of the object are shown in Figure 2, and specifications of the mold are shown in Table 6. The mold for research was developed with 75B as a basic size. By making an adjustment of 0.9cm for the upper-cup edge and an adjustment of 1.6cm for the circumference of the cup.

**Table 6. Standard of mold for research(unit: cm)**

| Circumference | Depth | Length | Diameter | Thickness |
|---------------|-------|--------|----------|-----------|
|               |       |        |          |           |
|               |       |        |          |           |
|               |       |        |          |           |
|               |       |        |          |           |

A: Upper-cup edge ±0.9cm  
B: Diameter of the cup ±1cm  
C: Circumference of the cup ±1.6cm

 Specification reference  
Grading measurement  
Mold cup size

Figure 3. Drawing of research mold cup; grading deviation.
and grading the model, four additional delineators were developed and made available Commercially. The final grading measurement and cup size of the developed mold are shown in Figure 3.

4.2 A Sensory Test

Table 7 and Figure 4 show the results from the sensory test of wearing the bras made of the developed mold cup and mold cup A/B on the market. It recognized that there is statistically significant relationship. The developed mold bra scored an average of 4.41, which is higher than market mold A & mold B scoring 3.09 and 2.97, respectively. It demonstrated that the developed mold designed to push breasts upward and outward and to eliminate gaps between breast and mold cup.

Q1 The suitability of bras for breast size is higher in the new mold cup than two other products. Q2 the naturalness of cup line is the highest in the new cup, and the product A and B follow in a descending order. Q3 The suitability of the upper and lower edges of the cup is the highest in the new cup, next in the product A, and then the lowest in the product B. Q4 The suitability of the side of the bra is the highest in the developed product with the product B and A following in a descending order. Q5 The suitability of the center front part is the highest in the new product, the second highest in the product B and the lowest in the product A. Q6 The suitability of the breast shape is the highest in the developed product, and that of the product A and B follow in a descending order. Q7 the volume up effect of the new cup is the highest and that of product B and A follow in the order.

5. Conclusion

This study developed a mold cup in a water droplet shape, which makes the breast shape appear beautiful and improves hygiene. From the sensory test of wearing the research bra and bras on the market, we find that there is statistically significant relationship between the seven sensory categories. Overall the research bra scored higher than bras on the market by wearers, and six out of seven items, the values are outstanding. In order to commercialize the no-wire embossing embedded mold, it was graded into four sizes and was made available on the market.
The findings of this research can be applied to the development of mold cups by manufacturers. Additionally, our mold cup can itself be helpful to bra manufacturers that want to develop a new product. As an outcome, the research bra will be manufactured using the developed mold as designed and will be commercialized for its market successfully. In future work, new brassieres will be developed using the no-wire embossing embedded mold cup from this study.

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