Design of Maternity Pillow by Using Kansei and Taguchi Methods

Fety Ilma Rahmillah\textsuperscript{1)}, Rachmah Nanda kartika\textsuperscript{2)}

\textsuperscript{1,2)} Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia, Jl. Kaliurang Km 14.5 Yogyakarta, Indonesia

fety.rahmillah@ui.ac.id\textsuperscript{1)}, rachmahnanda@gmail.com\textsuperscript{2)}

Abstract

One of the customers’ considerations for purchasing a product is it can satisfy their feeling and emotion. It because of such product can enhance sleep quality of pregnant women. However, most of the existing product such as maternity pillows are still designed based on companies’ perspective. This study aims to capture the desire of pregnant women toward maternity pillow desired product by using kansei words and analyze the optimal design with Taguchi method. Eight collected kansei words were durable, aesthetic, comfort, portable, simple, multifunction, attractive motive, and easy to maintain. While L16 orthogonal array is used because there are three variables with two levels and four variables with four levels. It can be concluded that the best maternity pillow that can satisfy the customers can be designed by combining D1-E2-F2-G2-C1-B2-A2 means the model is U shape, flowery motive, medium color, Bag model B, cotton pillow cover, filled with silicon, and use double zipper. However, it is also possible to create combination of D1-E2-F2-G2-C1-B1-A1 by using consideration of cost which means that the zipper is switched to single as well as filled with dacron. In addition, the total percentage of contribution by using ANOVA reaches 95%.

Keywords: Maternity Pillow, Taguchi, Kansei, Design

1. Introduction

Process trimester pregnancies from I, II, and III require changes in the anatomy of the body, such as the digestive system, cardiovascular, urinary, and musculoskeletal in pregnant women depends on the pregnancy. Some of the complaints often experienced by women in the third trimester of pregnancy are lower back pain, shortness of breath, varicose veins, haemorrhoid, sleep disorders, diastasis recti, pelvic pain and others [1]. Musculoskeletal discomfort most
frequently complained of pregnant women in the third trimester in India is 64.6% suffered calf muscle cramps, 37.1% reported leg pain, and 33.7% experienced back pain [2]. Whereas in the second trimester, a general musculoskeletal dysfunction experienced by pregnant women are sick calves (47.8%), back pain (42%), and pelvic girdle pain (37%).

Musculoskeletal disorders can be influenced by a variety of physical activity, culture, and environment. Most pregnant women do not seek medical help until the discomfort really began to interfere the activity. The majority of the discomfort associated with the physical changes that occur during pregnancy and the resultant effect on the biomechanical functional movement [2]. Musculoskeletal disorders may be affected by the quality of sleep. Sleep disorders cause depression and stress affects the fetus. Mild stress causes an increase in heart rate of the fetus, but severe stress and old will make the fetus become hyperactive. Further consequence of sleep disorders are depression and babies born have a little time to sleep soundly [3]. Insomnia in pregnant women mostly caused by the anxiety and panic associated with changes in responsibilities as parents. Sleep disorders during pregnancy occurs during the first trimester (13%-80%) and third trimester (66%-97%) [4].

One way to improve the quality of sleep is by using more pillows [4][5] because healthy pregnant women usually require more pillows than non-pregnant cardiac patients, and due to the difficulties in finding a comfortable sleep position in late pregnancy. The primary function of the pillow is to support cervical spine to be aligned with the other parts of the vertebral column in the body [6]. Maternity pillows on the market varies greatly. Sometimes, it confusing to select which one is appropriate. However, there has been no specific studies that examine pregnant pillow products.

In the selection of a product, consumers will influenced by emotions and feelings. The expression of emotions and feelings will cause a nuance, impression, sense of love, and feel of comfort when consumers decide to choose a product [7]. Therefore, it is necessary to know emotions and feelings of maternity pillow that want to be developed. One method that can quantify emotion of the customer in product development is Kansei Engineering [8]. It has been implemented in designing baby bag [9][10], office chair [11], and washing machine [12]. While in designing the products, there are some products’ elements need to be evaluated. It is necessary to create several designs as well as combine and test the designs. Taguchi is a method that can be used to find the best combination of elements of maternity pillow that will satisfy the customers by considering the minimum number of experiments. Therefore, this study aims to capture the desire of pregnant women toward maternity pillow desired product by using kansei words and analyze the optimal design with Taguchi method.

2. Research Method
Research was conducted by using literature review, interview and questionnaire. There were some steps to do in this research. First, survey to maternity pillows via world wide web was done to collect kansei words as well as identify basic specification of the product such as the function of each part of the pillow which could be separated as head, neck, back, belly, pelvic, center, and legs support. In addition, direct interview involving eight women were also done to collect kansei words which aimed to explore ideal maternity pillow that fit with their desires. The number of subjects who were interviewed usually around 15±10. This process is the technique of free association that is commonly used in qualitative research to psychoanalysis [13]. Twelve kansei words were collected from this first stage.

Then, first questionnaire consists of various sample of maternity pillows and collected kansei words were shown to fifteen pregnant woman to be selected. The selected Kansei
words are chosen by more than 90% of total respondents. Nine kansei words (affordable, durable, aesthetic, comfort, portable, simple, multifunction, attractive motive, and easy to maintain) were picked. Then, second questionnaire was distributed to thirty five respondents to gain data on respondents’ opinion of product’s importance towards kansei words, identify the initial preferences on model, cloth of pillow case, as well as motive. Each respondent was asked to assess the statements by scaling the importance level which score 1 (very disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (very agree). However, kansei word relates to price “affordable” is excluded due to its validity. According to validity test using corrected item-total correlation score, kansei words which has score above 0.4 were valid [14]. While the reliability score is more than 0.8 for all kansei words means that reliable [15]. It is performed by using IBM SPSS version 24. Table 1 shows the validity and reliability score of the kansei words.

| Kansei Words     | Description                                                                 | Validity Score | Reliability Score |
|------------------|-----------------------------------------------------------------------------|----------------|-------------------|
| Affordable       | Reasonably price                                                            | 0.000*         | 0.880             |
| Durable          | Has strong zipper and durable fabric                                        | 0.594          | 0.852             |
| Aesthetic        | Gives aesthetic design                                                       | 0.675          | 0.845             |
| Comfort          | The pillow case comfy for the skin, fluffy pillow, total body support as well as comfort for breastfeeding | 0.672          | 0.844             |
| Portable         | Able to be easily carried or moved                                            | 0.779          | 0.836             |
| Simple           | Modest design                                                               | 0.467          | 0.877             |
| Multifunction    | Support more than one part of the body, can be used for various sleeping positions as well as other activities | 0.666          | 0.845             |
| Attractive motive| Chic appearance                                                             | 0.694          | 0.842             |
| Easy to maintain | Easy to clean, insert, and remove the cover                                  | 0.779          | 0.836             |

The next step is designing the experiment by using Taguchi method. It is to find the best combination of elements of pillow that will satisfy the customers. The elements in designing maternity pillows are generated from expert designers. By grouping items and categories, obtained 7-core elements with 22 categories with predetermined specification (control factors) while the noise is users who are breastfeeding and pregnant women. Generally, the categories chosen are come from material that is easy to find and available as the main component to make maternity pillow. The elements (factors) and levels determined in this study are shown in Table 2. This study did not consider another attribute since the seven-mentioned attribute representing the dominant factors in manufacturing maternity pillow.

Four model of maternity pillows were used for the basic design experiment of Taguchi because they had been represented various products in the market. These are the advantages and disadvantages of the selected pillows. Advantages of U model are convenient to change position at night, total body support (head support, neck support, back support, belly support, leg support), naturally conform to the curves of the body, adjustable reading position, and can be used to breast feeding baby. While the negatives are bulky or consume more spaces, more
heavy, and more expensive. Pillow B can support total body (head support, neck support, back support, belly support, leg support), but inconvenient to change direction during the night. It is also ideal for nursing while lying in the bed because easier to move than using U model. However, B pillow also consume more spaces and heavy like U pillow. E pillow can support several parts of the body such as head, bump or back, leg, and central, but if the sleep position is changing, the back is less support. The other advantage is removable central part to easier nursing and portable. Pillow J is more practical or portable, less consume spaces, less heavy, but need more pillow for head and neck support. It is also inconvenient to change position during night sleep.

Table 2. Classification Elements of Maternity Pillow (Control Factors)

| Elements | Level | Category |
|----------|-------|----------|
| A Zipper | 1     | Single   |
|          | 2     | Double   |
| B Filling| 1     | Dacron   |
|          | 2     | Silicon  |
| C Cloth  | 1     | Cotton   |
| cover    |       |          |
|          | 2     | Waterproof Cotton |
| D Model  | 1     | U        |
|          | 2     | B        |
|          | 3     | E        |
|          | 4     | J        |
| E Motive | 1     | Plain    |

Respondents asked to evaluate each virtual design with five semantic differential scales. Subjects were thirty-four women who were familiar with maternity pillow such as pregnant women and breastfeeding mothers. The fractional factorial design used is a standard L16 orthogonal array for control factors. It was chosen due to the minimum number of experiment. Each row of the matrix described one design as shown in Table 3. The response is customers’ satisfaction which can be assessed through averaging the score of eight kansei words chosen from the previous questionnaire (durable, aesthetic, comfort, portable, simple, multifunction, attractive motive, and easy to maintain) with five semantic differential scale.

Table 3. L16 Orthogonal Array to Design Maternity Pillow

| Design | Zipper | Filling | Cloth Cover | Model | Motive | Color | Bag Model |
|--------|--------|---------|-------------|-------|--------|-------|-----------|
| 1      | Single | Dacron  | Cotton      | U     | Plain  | Light | A         |
| 2      | Single | Silicon | Waterproof  | U     | Flowery| Medium| B         |
### Design Control Factors (Elements)

| Design | A Zipper | B Filling | C Cloth Cover | D Model | E Motive | F Color | G Bag Model |
|--------|----------|-----------|---------------|---------|----------|---------|-------------|
| 3      | Double   | Dacron    | Waterproof Cotton | U Polka-dot | Dark | C |
| 4      | Double   | Silicon   | Cotton         | U Combination | Gradation | D |
| 5      | Double   | Silicon   | Cotton         | B Plain | Medium | A |
| 6      | Double   | Dacron    | Waterproof Cotton | B Flowery | Light | B |
| 7      | Single   | Silicon   | Waterproof Cotton | B Polka-dot | Gradation | D |
| 8      | Single   | Dacron    | Cotton         | B Combination | Dark | C |
| 9      | Single   | Silicon   | Waterproof Cotton | E Plain | Dark | D |
| 10     | Single   | Dacron    | Cotton         | E Flowery | Gradation | C |
| 11     | Double   | Silicon   | Cotton         | E Polka-dot | Light | B |
| 12     | Double   | Dacron    | Waterproof Cotton | E Combination | Medium | A |
| 13     | Double   | Dacron    | Waterproof Cotton | J Plain | Light | B |
| 14     | Double   | Silicon   | Cotton         | J Flowery | Medium | A |
| 15     | Single   | Dacron    | Cotton         | J Polka-dot | Dark | D |
| 16     | Single   | Silicon   | Waterproof Cotton | J Combination | Gradation | C |

**Signal Noise Ratio (SNR)**

The response is customer satisfaction which uses Larger the Better (LTB). Equation (1) can be used to calculate SNR.

where:

\[
SNR_{STB} = -10 \log \left[ \frac{1}{n} \sum_{i=n}^{n} y_i^2 \right] \tag{1}
\]

- \( n \) = number of tests in the experiment (trial)
- \( y_i \) = response value for each respondents

### 3. Results and Discussion

First, normality test is used know whether the data set is well-modeled by a normal distribution. By using Anderson-Darling normality test, the data is considered normal since the significant value is 0.52 (>0.05). While the homogeneity test is used to find out the two or more of data distribution that has the same variation or not. It defines whether the X and Y data is homogen or not. In homogeneity test, if the value of \( \chi^2 \) calculation < \( \chi^2 \) table, then the data is homogeneous. The \( \chi^2 \) calculation is 459.16 and \( \chi^2 \) table is 598.32. Thus, \( \chi^2 \) calculation is less than \( \chi^2 \) table, which means the data is homogeneous.
Effect of Factors to Responses

The optimal customers’ satisfaction can be gained through combination design of maternity pillow D1-E2-F2-G2-C1-B2-A2 which is shown in Table 4. The calculation is using equation (1) for calculating LTB.

Table 4. Response Optimal Combination Table for S/N Ratio (LTB)

|   | A  | B   | C   | D   | E   | F   | G   |
|---|----|-----|-----|-----|-----|-----|-----|
| 1 | 0,301 | 0,2989 | 0,3059 | 0,4087 | 0,2697 | 0,3081 | 0,3074 |
| 2 | 0,3025 | 0,3045 | 0,2975 | 0,3248 | 0,3371 | 0,3258 | 0,3128 |
| 3 | 0,2774 | 0,3193 | 0,2836 | 0,2867 | 0,2893 | 0,2919 |
| 4 | 0,1959 | 0,2807 | 0,2893 | 0,2947 |

Differences: 0,0015, 0,0056, 0,0083, 0,2127, 0,0674, 0,0423, 0,0209

Rank: 7, 6, 5, 1, 2, 3, 4

Selected: A2, B2, C1, D1, E2, F2, G2

Analysis of Variance (ANOVA)

It is to explore which of the factors significantly affect the customer’s satisfaction. Table 5 shows the results of ANOVA’s response. Statistically, the F-test can be used to specify which factor has a significant effect towards customers’ satisfaction. It can be known by comparing the value of F. When F>4 means that the change of operating factors has a significant effect on the quality characteristics. It can be seen from Table 4 that all the factors significantly contributed toward customer satisfaction: Factor D (Model), motive (Factor E), Bag model (Factor G), Color (Factor F), filling (Factor B), Zipper (Factor A), and cloth cover (Factor C) as much as 78.34%, 9.80%, 3.37%, 2.99%, 0.36, 0.34, and 0.06 respectively. The total contribution is 95% while the other five percent is from unidentified factor.

Table 5. Response of ANOVA Test

| Source of Var | SS  | DB | MS  | F Stat | F table | SS' | % Contribution |
|---------------|-----|----|-----|--------|---------|-----|----------------|
| Factor A      | 0,19 | 1  | 0,19 | 39,99  | 3,86    | 0,18 | 0.34            |
| Factor B      | 0,20 | 1  | 0,2  | 41,99  | 3,86    | 0,19 | 0.36            |
| Factor C      | 0,04 | 1  | 0,04 | 7,47   | 3,86    | 0,03 | 0.06            |
| Factor D      | 42,27 | 3  | 14,1 | 2989,91 | 2,62 | 42,26 | 78,34           |
| Factor E      | 5,30 | 3  | 1,77 | 374,94 | 2,62 | 5,29 | 9,80            |
| Factor F      | 1,63 | 3  | 0,54 | 114,94 | 2,62 | 1,61 | 2,99            |
| Factor G      | 1,83 | 3  | 0,61 | 129,57 | 2,62 | 1,82 | 3,37            |
| Residual      | 2,49 | 528 | 0    |        |         |      |                 |
It can be seen from Table 4 and Table 5 that the effect of factor A, B, and C is relatively small, but it doesn’t meant that those factors are unimportant. There is no significant differentiation (only 0.0015 for Factor A and 0.0056 for Factor B), whether A1 or A2 and B1 or B2 that will be used will not have significant impact towards customer satisfaction. It is possible to select the products’ element by using other consideration such as single zipper (A1) is chosen due to practicality and cheaper cost while dacron (B1) is used because of its cheaper price.

4. Conclusions

Based on the discussion above, it can be concluded that the best maternity pillow that can satisfy the customers can be designed by combining D1-E2-F2-G2-C1-B2-A2 means the model is U shape, flowery motive, medium color, Bag model B, cotton pillow cover, filled with silicon, and use double zipper. However, it is possible to create combination of D1-E2-F2-G2-C1-B1-A1 by using consideration of cost which means that the zipper is switched to single as well as filled with dacron. In addition, the total percentage of contribution reach 95%.

Recommendation

It is necessary to do further research such as in increasing the quality of the maternity pillow.

5. References

[1] Wahyuni, & Ni’mah, L. (2013). Manfaat Senam Hamil untuk Meningkatkan Durasi Tidur Ibu Hamil. Jurnal Kesehatan Masyarakat, 145-152.
[2] Ramachandra, P., Maiya, A. G., Kumar, P., & Kamath, A. (2015). Prevalence of Musculoskeletal Dysfunctions among Indian Pregnant Women. Journal of Pregnancy.
[3] Sharma, S. & Franco, R. (2004). Sleep and Its Disorders in Pregnancy. Wisconsin Medical Journal, 103(5), pp. 48-52.
[4] Jeon, M. Y., Jeong, H., Lee, S., Choi, W., Park, H., Tak, S. J., et al. (2014). Improving the quality of sleep with an optimal pillow: A randomized, Comparative study. Tohoku J. Exp. Med., 183-188.
[5] Farine, D. & Seaward, G. (2007). When It Comes to Pregnant Woman Sleeping, Is Left Right?. JOGC Octobre.
[6] Verhaert, V. (2011). Ergonomic Analysis of Integrated Bed Measurements: Towards Smart Sleep Systems. Dissertation. Arenberg Doctoral School of Science, Engineering & Technology Faculty of Engineering Department of Mechanical Engineering.
[7] Norman, D. (2004). Emotional Design: Why We Love (or Hate) Everyday Things. Prentice Hall, Singapore.
[8] Nagamachi, M. (1995). Kansei Engineering: A New Ergonomic Consumer-Oriented Technology For Product Development. International Journal of Industrial Ergonomics, 15(1), 3-11.
[9] Janari, D., Rakhmawati, A. (2016). Developing Baby Bag Design by Using Kansei Engineering Method. *Materials Science and Engineering* 105 doi:10.1088/1757-899X/105/1/012031

[10] A. H. Soewardi and B. M. I. Nasution. (2016). Design of Kansei Baby Bags by Using Fuzzy Linguistic Principles. *IEEE International Conference on Knowledge Engineering and Applications (ICKEA)*, Singapore, pp. 165-171, doi: 10.1109/ICKEA.2016.7803012

[11] Park J, Han SH. (2004). "A fuzzy rule-based approach to modeling affective user satisfaction towards office chair design". *International Journal of Industrial Ergonomics* 34. Pp. 31-47.

[12] Ishihara S, Ishihara K, Nakagawa R, Nagamachi M, Sako H, Fujiwara Y, Naito M. (2010). Development and improvement of a washer-dryer with kansei ergonomics. *Proceedings of The International MultiConference of Engineers and Computer Scientists.*

[13] Steinar., (2007) *Doing interviews*, London: SAGE Publications.

[14] Fayers PM, Machin D. (2000). Quality of Life: Assessment, Analysis and Interpretation. Chichester: John Wiley & Sons. pp. 72–79.

[15] Bland J, Altman D. (1997). Statistics notes: Cronbach's alpha. *BMJ.* 314:275.