Development of Grip Comfort of Perfume Bottle by Applying the Concepts of Product Design and Development and Hybrid Optimization Technique

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Received: September 27, 2021 / Revised: October 28, 2021 / Accepted: November 1, 2021

***Abstract*—This study mostly relied on online customer reviews to reveal a problem with gripping comfort in perfume bottles, which was limiting customer willingness to purchase. The absence of ergonomic design owing to inappropriate dimensions in large-volume perfume bottles was the primary reason for of problems with comfortable gripping. As voted by local users in the preference survey, a rectangular-shaped bottle was used as the foundation of this study. Taguchi's experiment design was created according to the extraction of dimensions from a rectangular bottle. Based on the experimental design, bottle samples were fabricated by using the rapid prototyping (RP) process – a 3D Printer. Kansei words were applied to elicit customer feelings on bottle samples for grip comfort. For evaluating the responses and determining the proper dimension factors that resulted in the most comfortable grip and ergonomically designed perfume bottle, Grey relational analysis was used in this study.**

***Index Terms*— Content Analysis, Ergonomics Design, Grey Relational Analysis, Grip comfort perfume Bottle, Product Design and Development, Taguchi Method.**

I. Introduction

Perfume has now become an essential component of our daily lives. They are pleasant-smelling fluid-based items that many individuals utilize in their regular lifestyle. They are being worn all over the world by people of different genders, ages, and cultures. For years, they act as a symbol of personal style [1]. Perfume is becoming one of the most popular products among all fashionable labels. Because each brand has some distinct products, the emergence of brands has generated a scenario of confusion among consumers' purchase intentions. They may be in the form of the aesthetic appearance of perfume bottles or distinction in fragrance [2]. The global perfume market is growing at a compound annual growth rate of 3.9% from 2019 to 2025 [3]. In the context of Thailand, revenues generated from the perfume industry amount to US$266.9 million in 2021, and the market is expected to grow at a compound annual growth rate of 3.80% [4]. This demonstrates the need of studying many facets of perfume attributes. Many investigations have emphasized various elements, such as examining purchase intent based on factors related to the perfume bottle package design [5]-[9], any other researchers also studied odor perception [10], [11] and perfume bottle form [12]-[15]. Most of these studies are based on survey methods where the pre-determined product attributes are fixed. This study used content analysis of internet reviews, which allows for a more in-depth look at customers' genuine perceptions by considering the whole spectrum of criteria addressed [16]. Customer reviews have evolved into a space where customers may express their feelings about the products they have used, primarily through their level of satisfaction. These reviews also provide a unique set of information comprising positive and negative comments, as well as ratings, allowing market researchers to run various analyses and identify the features that are highly appealing, as well as those that are criticized and need to be improved [17]-[19]. Online retail platforms as well as some general discussion platforms, where customers share their feeling about various aspects of a particular product in the form of reviews have become a major source of the voice of the customer aiding to examine customers' needs and preferences as well as design requirements.

An in-depth investigation of these needs, preferences, and design criteria may lead to the identification of the product's features or the crucial element, which could lead to product innovation in the form of inventing a new product or revamping an

existing one [19]. This study looked at user reviews on *Fragrantica.com's* general discussion forum. *Fragrantica* is an online encyclopedia of perfume that also has a community of perfume lovers who offer their opinions on a variety of topics, including the scent, brand name, shape, size, material, and color of the perfume bottle, and nearly anything else about perfume [20]. As stated above, this study used *Fragrantica.com's* general discussion forum to examine reviews linked to various features of perfume bottles and identify difficulties people have with perfume bottles that have not yet been addressed by researchers or that need to be improved. After analyzing many opinions on the discussion form, it was discovered that buyers had difficulty gripping the perfume bottle comfortably due to the bottle's insufficient proportions. Difficulty in griping may also cause problems like carpel tunnel syndrome and trigger finger [21]. Following an examination of various articles (described in the research background section of this study), it was determined that several researchers appear to have employed multi-criteria decision-making techniques to improve the aesthetic of perfume bottles. No one, however, has investigated what proportion of perfume bottles is most pleasant in the customer's hands. In this study, we attempted to find online reviews where customers mentioned the issue of comfort grip, match it with local users via an online survey, optimize the bottle dimension via a multi-criteri decision-making method, and obtain customer feeling on grip comfort on the optimized bottle size via Kansei engineering. In order to access the depth of human emotions and understand customer needs, Kansei engineering translates human emotion to a quantifiable value where Grey relation analysis aids decision-making in uncertain contexts and circumstances involving several attributes by comparing each alternative to an ideal outcome.

II. Research Background

This section will be mentioned about the related works and backgrounds of perfume design and characteristics where the existing designs and physical characteristics of perfume bottles were studied via the perceptions and experiences of the customers who commented on some ideas and reviews through the online-block platform. The results were also presented in this section as the preliminary study before going to the design stage in the next section.

A. Studies on "Perfume Attributes"

Consumers value packaging and bottle design because they are the first quality that a product shares with them. It is the catalyst for a possible purchase [9]. The Influence of perfume packaging on Jordanian female customer purchasing behavior was investigated by Al Saed et al. [7], who found that all aspects of perfume packaging, except package material, have a substantial impact on consumer purchasing behavior. Chen et al. [22] researched customer's psychological impressions of perfume bottle form and concluded that aesthetically pleasing forms attract more customer preference. Sivagnanasundaram et al. [6] looked at the shape, material, and color of packaging in relation to gender. He found that there was a unisexual preference for the rectangular bottle, regardless of color or material. Similarly, men and women appear to like red-squared and blue-squared bottles equally, but males prefer black-squared bottles more. Lesot et al. used machine learning methodologies to investigate the forms of perfume bottles and the emotions associated with each shape, concluding that shapes influence consumers' emotions when they are introduced to packaging [15]. Wei et al. employed Kansei engineering and Type I quantification theory to perform a study on perfume bottle designs, demonstrating that the integrated model works well for recommending new product design and development using various parts of the bottle and visuals of the respective product. Tien-You *et al.* [1] investigated customer preferences for perfume bottle forms and found that circle shapes are the most appealing to buyers [22].

The *fuzzy analytic hierarchy process* was utilized by Chen et al. [12] to show that it can be used to generate alternative designs during the conceptual stage of design, providing perfume bottle designers an advantage. Lin et al. [13] created new perfume bottle designs based on client preferences using grey relational analysis, grey prediction, and the technique for "*order of preference*" by similarity to the ideal solution. Elango et al. [5] looked into the aspects that influence consumer purchasing decisions for local brand perfume packaging in Bangkok in 2020, and discovered that visual package design has an effect on consumer purchasing intents. According to the results of his consumer behavior survey, 71 % of respondents bought perfume in the 50-100 ml range per bottle. He also revealed that 72 % of those respondents wear perfume every day. As a result, another size to satisfy consumer behavior is 100 ml, which is a nice amount for customers who use perfume on a daily basis. They believe it is good to invest in and do not need to buy a new bottle of perfume on a regular basis. The customer's ease when holding the bottle to spray perfume is also influenced by the shape. They may decide not to buy the product if it does not fit their palm nicely.

Based on the studies mentioned above, there was clear that shape and size of perfume bottle that provide better grip comfort are one of the most influential factors for customer purchase intention apart from fragrance. Therefore, we looked for grip

comfort reviews on the internet. And the output is described in the next section.

B. Online Customer Reviews and Analysis

Reviews are no longer a choice for online users, but rather an expectation [24]-[26]. When a customer wants to find out more about a product or compare other product options, they have access to thousands of reviews that include both positive and negative feedback from other customers which serve as a guide for purchasing a new product [25]. The close evaluation of positive feedback will indicate the product's most popular feature, whilst the evaluation of negative feedback will reflects the feature that needs to be improved [18], [19]. Previous research has revealed that online reviews are often used for product innovation. Kim et al. [27] used online reviews as a resource to improve various aspects of a washing machines. Rianmora et al. [28], [29] customized gimbal stabilizer and salad spinner respectively based on data from online user assessments. Online reviews were used by Kim et al. [30] for the product innovation of MP3 players and mobile headsets. Similarly, fragrantica.com [20] was used in this study to investigate the ergonomics of the perfume bottle design. The reviews were gathered using the general discussion form [31]-[36], and the analysis was performed. The reviews are shown in Tables I and II.

Based on the reviewed results, the following data were obtained:

a. Mainly 100 ml. or more long volume bottles are harder to grip.
b. The majority of rectangular and square bottles are hard to grip.
c. People with carpal tunnel syndrome had high difficulty in holding long rectangular and squared bottles.
d. In addition, a variety of other and irregularly shaped enormous-sized bottles were difficult to hold.
e. The spray position also makes it hard to grip bottles.

According to the comments and findings from the target users, these can be made clear that the bottles lack a good ergonomic characteristics, and this would be better to design the bottle for fitting the user's palm during spraying or holding quickly.

TABLE I
PREFERRED SIZE REVIEW [31]-[36]

No.	Review
1	"30 ml and 50 ml work best for me, because I tend to rotate the scents and also I don't want to keep the bottles for too long in hot weather conditions. As for what bottles look prettiest. In my view this depends on the design of the bottles: some look best in 50 ml (the dainty stuff), some look best in 100 ml (the bold designs)."
2	"I prefer the nice BIG bottles, that way I do not fret about running out!"
3	"I usually prefer buying 30 ml and 50 ml bottles... unless it's a scent from my top 5, of which I would definitely buy 100 ml."

TABLE II
ONLINE PRODUCT REVIEW [31]-[36]

Product	Review
	"I recently got Da Man (Amber) and I love it, especially. The dry down. Just one annoyance, though. The bottle is really clumsy for spraying. My hands have to be completely dry and my index finger stretches too far to spray. Ergonomics must not be Da's strong point."
	"For the rectangular and square bottles, I have carpal tunnel in my hands and by far the worst for me would be the big square or rectangle-shaped bottles. I have a 100 ml bottle, it is very big to hold and spray."
	"100 ml bottle is like a heavy brick, impossible to hold and spray by one hand."

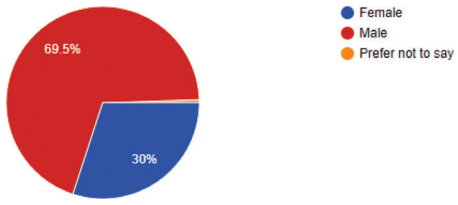
C. Role of Ergonomics in Package Design

Companies rapidly coming up with innovative products have significantly generated a scenario of fierce competition among each other. This rivalry among the companies has shortened the product's life cycle. Identifying a product's attribute which creates value for consumers is the key to innovation [37]. In this case, ergonomics appears to be the most important attribute that needs to be improved, which can also act as an innovation. Ergonomically designed items place a higher priority on comfort than aesthetics, making them simple and enjoyable to use [38]. Since corporations compete on the ease of use of their products, ergonomic features are recognized as critical [39], [40]. Researchers agree that, if the user experiences, such as safe usage and comfort, are not met, the affective and cognitive parts of the design are rendered ineffective [39], [41], [42]. Improper size in relation to shape may also make gripping more difficult, resulting in a decrease in consumer willingness to buy.

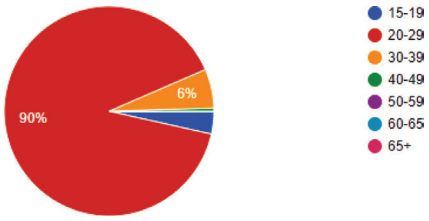
III. Customer Perception

Analyzing the customer's opinion shows the customer's actual feelings about the product [43]. Taking into account the problem of griping, an online survey was prepared to match the situation faced by the reviewers to the people of Thailand, This online survey was widely disseminated among students, product design researchers, and some members of the local community. The survey's findings revealed that the reviewer's and local people's problems were similar. The questionnaires with respective responses are listed below.

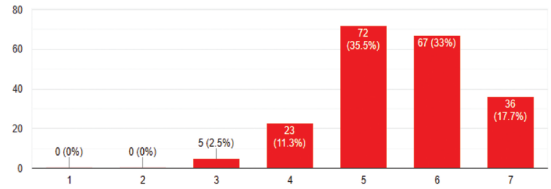
1. Gender



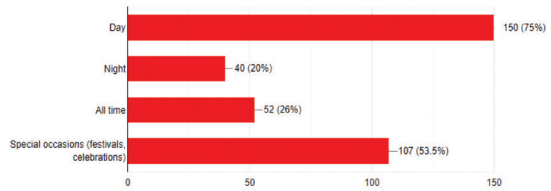
2. Age Group



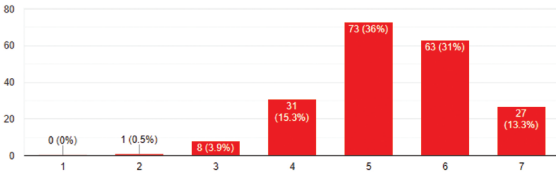
3. In your daily life, how important is perfume? (1=Not Important 7=Highly Important)



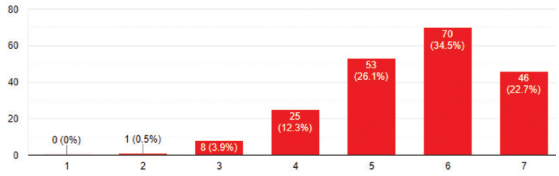
4. When do you like to put perfume on?



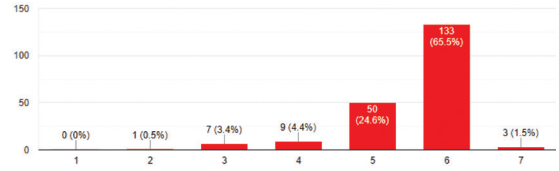
5. How likely are you impressed by perfume bottle design? (1=Very Unlikely 7=Very likely)



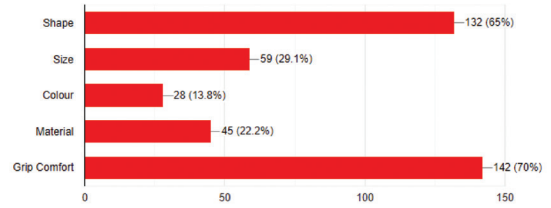
6. How vital is it to you that a design is user-friendly? (1=Not Vital , 7=Highly Vital)



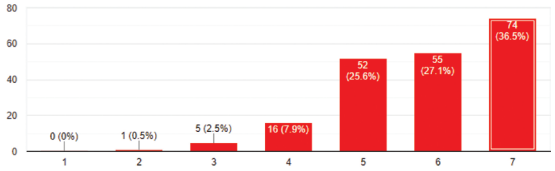
7. How much do you agree the design should be user-centered? (1=Not Agree 7=Highly Agree)



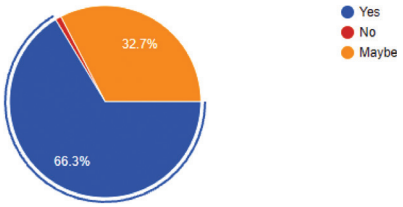
8. What aspects of the perfume container fascinate you the most in terms of ergonomics?



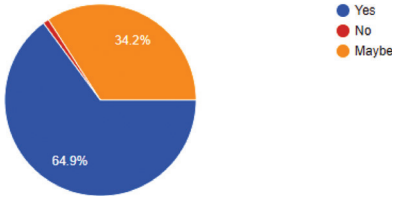
9. How crucial is it for you to be able to spray with ease?



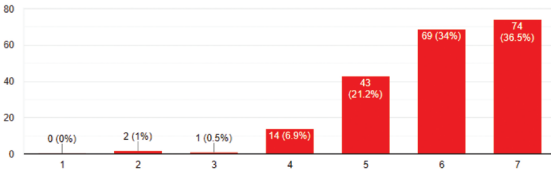
10. Have you ever had difficulty with gripping to spray in perfume bottles?



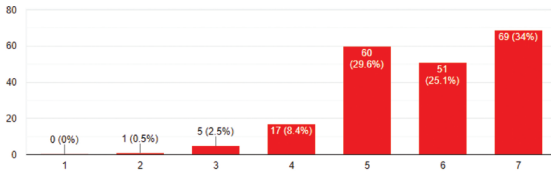
11. Do you believe that poor ergonomics in gripping to reach the spray caused by the incorrect form and size of the perfume bottle may create health problems in the finger or hand?



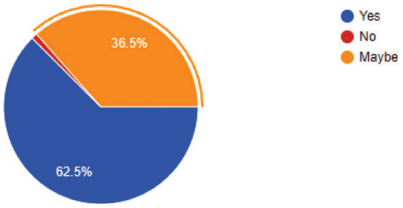
12. How significant is the sense of comfort you get when you hold the perfume bottle in your hands?



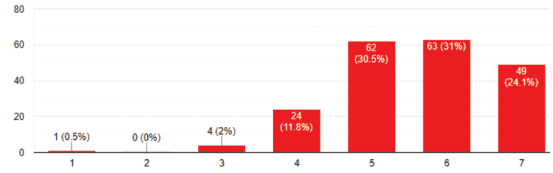
13. To you, how essential is safety in perfume bottle design (i.e., protection against injury caused by frequent gripping due to inappropriate dimension design)?



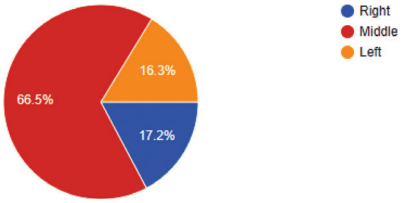
14. Do you believe that a perfume bottle with a longer breadth and length will be more difficult to handle and spray?



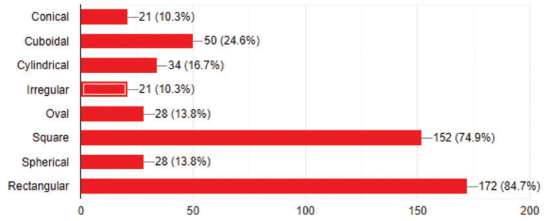
15. How much is the need of comfort of hand/wrist to you while griping bottle?



16. What location would you like the spray top to be?



17. What are your go-to perfume container shapes?



A total of 203 persons took part in the survey. According to the survey's findings, around 69.5% of men and 30% of women replied. 90% of the respondents were in the 20-29 year-old age bracket. Perfume appeared to play a significant role in the lives of the respondents. Respondents appeared to wear perfume primarily throughout the day, on special occasions, and at night. The design of the perfume bottle seems likely to have charmed a long number of users. The users seemed to place a high value on a user-friendly design. Almost 67% of respondents said the design should be centered on the user. Shape and grip comfort was discovered to be the most fascinating aspects of the perfume bottle in terms of ergonomics. Spraying convenience appears to be important to users. The difficulty of gripping has also been reported by respondents. Poor ergonomics in gripping to reach the spray caused by the inappropriate form and size of the perfume bottle, according to 65% of respondents, may cause health problems in the finger or hand, while 35% believe it may happen. The ability to grip the bottle comfortably while avoiding damage appears to be a highly desired feature among the respondents. It was also confirmed that a perfume bottle with a wider width and length is more difficult to grasp and spray. While gripping

the perfume bottle, hand-to-wrist comfort was also required. About 66.5% chose the middle position for the spray, while 17.3% chose Left and 16.3% opted Right. The respondent seems to prefer square and rectangular shapes. This selection could potentially be based on the respondents' ergonomic perceptions. Minitab 19 software was used for item analysis to ensure the internal consistency of the number of reviews received. The *Cronbach's alpha* can be calculated using the formula:

$$(\alpha) = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma_{Y_i}^2}{\sigma_X^2}\right) \quad (1)$$

K is the total number of factors.
$\sigma_{Y_i}^2$ is the variance for the current sample of respondents.
σ_X^2 is the variance for the sum of all respondents.

Cronbach's Alpha:

Alpha
0.8297

The Cronbach's Alpha value of 0.8297 indicates that the survey has strong internal consistency [44].

Methods Applied for Design Optimization

Gtilay Hasdoan et al. [45] attempted to throw some light on how user models might be used in product design and development to satisfy customers' expectations. The designer's assumption that various product attributes will be incorporated may not meet the requirements of the user. This happens when customers do not grasp how to use the product or when there are unforeseen accidents with the product in a certain context, causing a mismatch between the designer's prediction and the customer's actual use. Optimized the lat bar design for pull-down training stations using Taguchi design and a neural network for muscle responsiveness, proving that the method is appropriate for product optimization [46]. Lin et al. used grey relational analysis, grey prediction, and the Technique for Order of Preference by Similarity to Ideal Solution to produce new perfume bottle designs based on client preferences [13]. Sutono et al. employed a hybrid strategy that integrated Taguchi with grey connection analysis and principal component analysis to show that the hybrid method was capable of optimizing car design while meeting the multi-Kansei needs of the client [47]. Li et al. used fuzzy logic and Taguchi design to optimize the car body, with the results indicating an optimized product [48]. Based on customer feedback, the outcome revealed an upgraded and optimized product. Employed Kansei engineering to translate a customer request into a better design for eyeglasses [49]

Hybrid approaches are widely employed for product design optimizations, according to many researchers. In this study, the Taguchi method was used to create the experiment in this study, which was then combined with grey relational analysis and Kansei engineering. Chaiwat et al. discovered that this strategy is especially effective for shape parameter optimization of a wine bottle, using Kansei engineering and Taguchi-based Grey Relational analysis [50].

IV. Research Concept

After the survey confirmed the griping problem, the recommended design was chosen for further investigation. The favored shape dimensions were gathered from the market, and the Taguchi method was utilized to create the experiment. The 3D perfume model was built using a 3D printer, and the Grey-Relation analysis was integrated with Kansei engineering to determine the user's grip comfort based on their feeling. The diagram (Fig. 1) depicts the flowchart of this research.

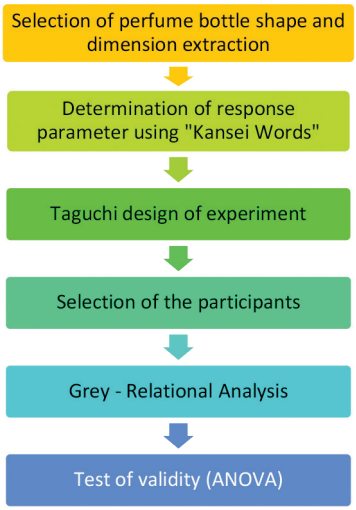


Fig. 1. Methodology

A. Selection of Perfume Bottle Shape and Dimension Extraction

The rectangular shape of 100 ml was chosen for this investigation since it received the highest rating on the survey questionnaire. The potential dimensions of the perfume bottles were extracted, and a range was determined for use in the experiment design. Dimensions were gathered from numerous sources on the internet like [51] as well as from store-bought bottles show in Fig. 2(a) and 2(b).

(a) The average dimensions of perfume bottle with 3 different sizes; 100 ml, 50 ml, and 30 ml [51]

(b) Measuring the real bottles from different brans at the cosmetic stores

Fig. 2. Dimension extraction of perfume bottle

Many concepts have been applied in this study for obtaining clean and clear results where the designs of the perfume bottle can be introduced to support users in different categories [51]-[58]. Total Height is obtained from the sum of height from bottom to neck and height from neck to top. Table III shows the extracted dimension for carrying out the design the of experiment. Fig. 3 depicts the parameters for the perfume bottle study.

TABLE III
THE EXTRACTED DIMENSIONS

Length (A)	Width (B)	Height bottom to Neck (C)	Neck to top Height (D)	Position of Spray (E)
55	30	90	30	Left
65	33	96	35	Middle
70	36	105	39	Right

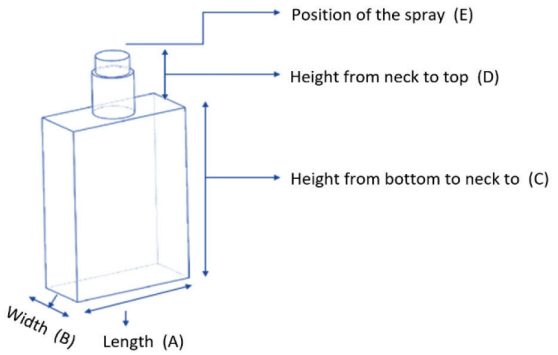


Fig. 3. The main components of perfume bottle

B. Determination of Response Parameter Using Kansei Words

Kansei is a Japanese word that refers to a customer's feelings and emotions. Kansei engineering blends human emotions and feelings to design fields in order to build a product that reflects consumer feelings and maximizes customer delight. Kansei words shown in Table IV are primarily chosen to elicit a customer's emotion to the product. To apply Kansei to the realm of design, qualitative data must be quantified [52]. The user's feelings toward product characteristics were quantified using a semantics scale of 1-7.

TABLE IV
SELECTION OF KANSEI WORDS

Product Characteristics	Descriptions
Hand/ Wrist Comfort	Wrist and hand motion are both relaxing while using the product
Overall Comfort	While utilizing the product, comfort is felt in the palm, finger joints, and virtually everything else in the human hand.
Safety	Condition of Protection from injury
User-friendly	Easy to use operate and understand

C. Design of Experiment

The Taguchi method is mostly used to build the experimental design for this project. Taguchi Design is a statistical method for planning and assessing trials aimed at improving product quality [50], [53]. To examine the process, the original data is converted to a signal-to-noise (S/N) ratio, which is the ratio of the mean to the standard deviation. Lower-the-better, higher-the-better, and nominal-the-better [50], [54] are the three types of S/N ratios.

For, this study higher the better (S/N) is preferred, and the following equation was used for Higher-the-better (S/N):

$$\frac{s}{N}\text{ ratio} = -10\log\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Z_{ij}^2}\right) \quad (2)$$

Where,

n = number of replicates

Z_{ij} = response observed value at i_{th} replication of j_{th} response

i = 1,2, .., n

j = 1,2, .., k

D. Fabricating Perfume Prototype

Once the experiment was developed, the perfume bottles were printed according to their run. The perfume bottle was created utilizing ABS (Acrylonitrile Butadiene Styrene) material and XYZ 3D Printer with different views as shown below (Fig. 4) to get responses from the users. Illustrated in Fig. 5 are the perfume bottle samples that were fabricated by using rapid prototyping (RP) - 3D Printing process where the physical parameters were obtained from the above experimental design. Three classic styles of the nozzle-head pressing set are introduced; the left RP model presents the pressing set on the left-hand side of the bottle, the middle RP model shows the middle area of pressing activity, and the right RP model provides the nozzle-head set at the right-hand side of the bottle.

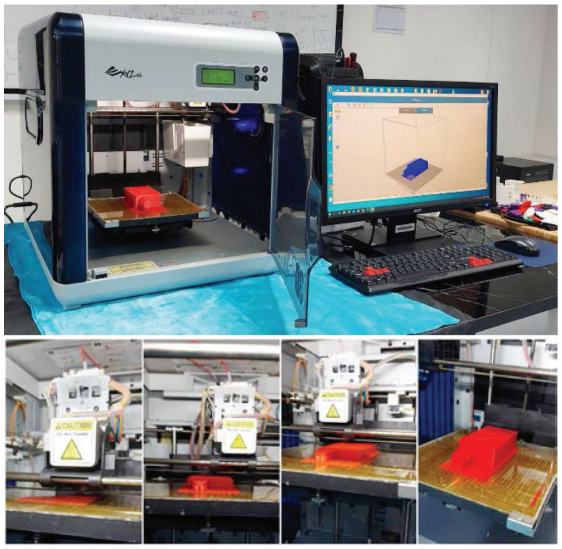


Fig. 4. 3D printing machine with different views during fabricating sample models of the perfume bottles

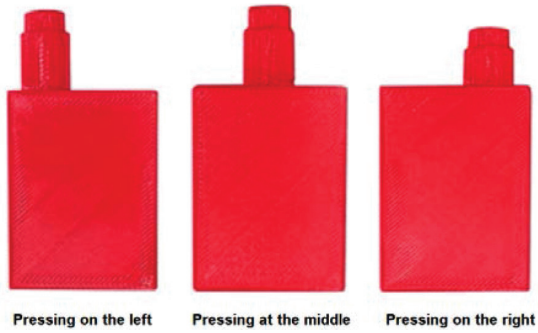


Fig. 5. Three styles of printed perfume bottle samples

E. Selection of Participants

The study included thirty participants (15 men and 15 women) with an average age of 22.6 years and a standard deviation of 3.2 years. A university dormitory population was used to choose all of the participants. They were all right-handed and in good health, with no musculoskeletal issues in their wrists. Individuals with a variety of hand lengths, including short, medium, and long-handed, were enlisted. Every participant signed a consent form and was compensated for their time. The experimental protocol was approved by the local institutional review board. Short (177.5 mm, 30th % ile), medium (177.6-180.3 mm, 45th-55th % ile), and long (120.3 mm, 70th and greater % ile) were the three categories for men's hand length. Short (165.7 mm, 30th% ile), medium (167.6-170.5 mm, 45th–55th% ile), and long (190.5 mm, 70th% ile and greater) were the three categories for female hand length. Previous research has revealed a similar measurement [57]. Participants were requested to offer their response by gripping the bottle in their hand and expressing the relevant semantic number with reference to Kansei words.

F. Grey Relational Analysis

Grey Relational analysis is a useful method for supporting decision-making in ambiguous circumstances and situations with varying quality by evaluating the similarity of variables in each alternative to the best choice [55]. Taguchi mainly fails for optimizing the multi- objective problems thus grey relational analysis was selected which has ability for multi-objective optimization mainly by exploring the relationship between the variables and the responses [50], [56]. The steps involved in Grey Relation Analysis are given below as:

Step 1. Normalization of signal to noise ratio as Pij (0<P<1) given by Eq. (3)
For "Higher-the-better"

$$Pij = \frac{Q_{ij}-(Q_{ij})min}{(Q_{ij})max-(Q_{ij})min} \quad (3)$$

Where,

P_{ij} = the noramalized value
$Q_{ij}\ min$ refers to the minimum value max
$Q_{ij}\ max$ refers to the maximum value at i th replicate of j th response
i = 1,2,..,n
j = 1,2,..,k

Step 2. Calculation of the deviation sequence Eq. (4).

$$\Delta_{ij} = |Q_0 - Q_{ij}| \quad (4)$$

Q_{oj} = optimum performance value of the j th response

Step 3. Calculation of Grey relational coefficient from the deviation sequence from the given equation:

$$GRC_{ij} = \frac{\Delta_{min}+\delta\Delta_{max}}{\Delta_{ij}+\delta\Delta_{max}} \quad (5)$$

Where,

GRC_{ij} the grey relational coefficient for the i th replicate of j the response
Δ_{ij} = the deviation sequence
Δ_{min} = minimum value of delta
Δ_{max} = maximum value of delta
δ distinguishing coefficient which is defined in the range $0 \leq \delta \leq 1$

Step 4. Using the average of the grey relational coefficient, the grey relational grade is calculated by the given equation as:

$$G_i = \frac{1}{k}\sum_{j=1}^{k} GC_{ij} \quad (6)$$

Where,

G_i = grey relational grad for the i th replicate
k = the number of responses

G. Analysis of Variance

The hypothesis that the means of two or more populations are equal is tested using analysis of variance (ANOVA). ANOVA compares the response variable means at different factor levels to determine the importance of one or more factors [58].

V. Result and Discussion

A. Taguchi Experimental Design and Result

The Taguchi design was mostly used in this study. For five factors and three levels, the L 27 orthogonal array was employed. The users' semantic replies for Kansei words were collected and averaged. The higher the better the S/N ratio was employed. Minitab 19 was used for the experiment design and signal-to-noise ratio analyses. Table V depicts the experimental design.

TABLE V
Taguchi Design of Experiment

No. of Iteration	Bottle Design parameters				
	Length (A)	Width (B)	Height from Bottom to Neck (C)	Neck to top Height (D)	Position of Spray (E)
1	55	30	90	30	Left
2	55	30	90	30	Middle
3	55	30	90	30	Right
4	55	33	96	35	Left
5	55	33	96	35	Middle
6	55	33	96	35	Right
7	55	36	105	39	Left
8	55	36	105	39	Middle
9	55	36	105	39	Right
10	65	30	96	39	Left
11	65	30	96	39	Middle
12	65	30	96	39	Right
13	65	33	105	30	Left
14	65	33	105	30	Middle
15	65	33	105	30	Right
16	65	36	90	35	Left
17	65	36	90	35	Middle
18	65	36	90	35	Right
19	70	30	105	35	Left
20	70	30	105	35	Middle
21	70	30	105	35	Right
22	70	33	90	39	Left
23	70	33	90	39	Middle
24	70	33	90	39	Right
25	70	36	96	30	Left
26	70	36	96	30	Middle
27	70	36	96	30	Right

In practice, the ways to identify the size of the hands (for both left and right ones) are quite subjective and difficult, therefore, in this research, the customer perceptions and experiences were very

useful and crucial for classifying dimensions of hands into three categories: short, medium, and long hands. The responses of participants with short, medium, and long-size hands are converted to signal to noise ratio.

The "Higher- the better" S/N ratios for each of the participant feelings were determined using Eq. (2). Table VI to VIII show the S/N ratio of participants with three sizes of hands: short, medium, and long, respectively.

TABLE VI
S/N RATIO FOR SHORT-SIZE HANDS

No. of Iteration	S/N Hand to Wrist Comfort	S/N Overall Comfort	S/N Safety	S/N User Friendliness
1	13.1515	13.1318	13.1115	13.0908
2	13.6166	13.6082	13.5995	13.5493
3	13.4504	13.4799	13.4682	13.4142
4	13.4922	13.5225	13.4701	13.4161
5	13.6166	13.6082	13.5582	13.5898
6	13.6985	13.7328	13.7271	13.7618
7	13.4083	13.3949	13.3387	13.2809
8	13.2380	13.1772	13.2013	13.2689
9	13.6985	13.6920	13.6445	13.5955
10	13.6985	13.7328	13.7676	13.7628
11	13.0643	13.0862	13.1085	13.1747
12	12.9316	12.9952	13.0597	13.1252
13	14.2131	14.1799	14.2228	14.2283
14	13.9001	13.8583	13.8955	13.8536
15	14.2131	14.2184	14.1852	14.2283
16	14.1359	14.1394	14.2202	14.3020
17	13.9398	13.8992	13.8574	13.8546
18	13.2380	13.2204	13.2454	13.2280
19	14.2515	14.2192	14.1861	14.1522
20	13.8601	13.8574	13.8946	13.9720
21	12.9761	12.9962	13.0607	13.0825
22	13.1949	13.1762	13.1570	13.0938
23	13.4504	13.5216	13.5938	13.6261
24	13.6985	13.7733	13.7685	13.8041
25	13.7797	13.8155	13.8918	13.9296
26	13.4922	13.4808	13.5109	13.5416
27	13.1949	13.1328	13.1125	13.1788

TABLE VII
S/N RATIO FOR MEDIUM-SIZE HANDS

No. of Iteration	S/N Hand to Wrist Comfort	S/N Overall Comfort	S/N Safety	S/N User Friendliness
1	13.2236	12.3958	13.0643	13.3801
2	13.2236	13.0643	12.9019	11.8583
3	13.6849	12.7364	12.9019	13.9794
4	13.6849	13.2236	12.7364	13.0643
5	13.0643	12.7364	14.5400	13.2236
6	12.5678	13.6849	12.7364	13.0643
7	12.0412	12.5678	13.6849	13.0643
8	12.0412	13.0643	12.7364	11.8583
9	13.6849	13.6849	13.8334	13.2236
10	13.3801	13.8334	12.3958	12.9019
11	12.5678	13.2236	12.9019	12.9019
12	13.9794	13.3801	13.0643	13.3801
13	13.5339	12.7364	12.9019	13.3801
14	13.8334	13.2236	13.3801	13.3801
15	13.6849	13.3801	12.7364	13.2236
16	14.8073	13.9794	14.1230	14.1230
17	14.4032	14.8073	14.2642	14.8073
18	13.9794	13.6849	13.5339	13.0643
19	13.9794	12.9019	13.0643	12.3958
20	12.9019	12.9019	12.0412	11.6715
21	13.0643	13.5339	13.5339	11.0857
22	12.3958	11.4806	12.0412	12.3958
23	13.0643	13.0643	13.2236	11.4806
24	13.3801	13.5339	12.5678	11.8583
25	13.2236	13.3801	12.3958	12.7364
26	12.7364	13.2236	12.7364	11.8583
27	12.0412	13.6849	12.0412	12.0412

TABLE VIII
S/N RATIO FOR LONG-SIZE HANDS

No. of Iteration	S/N Hand to Wrist Comfort	S/N Overall Comfort	S/N Safety	S/N User Friendliness
1	12.2203	12.4273	12.2203	12.7364
2	12.3958	12.6141	12.9019	12.5678
3	11.2854	12.6141	13.5339	13.8334
4	11.2854	13.8200	13.3801	13.8334
5	12.7364	13.4922	13.2236	13.3801
6	13.0643	12.7970	12.7364	13.0643
7	12.2203	12.7970	12.7364	12.7364
8	13.2236	13.4922	12.0412	12.2203
9	11.8583	12.9761	13.2236	13.2236
10	12.9019	13.6577	11.8583	12.0412
11	12.5678	12.4273	13.3801	12.7364
12	12.9019	12.9761	13.8334	14.1230
13	12.0412	13.3235	13.2236	13.3801
14	12.2203	13.3235	13.6849	13.9794
15	12.9019	13.6577	11.6715	12.5678
16	12.9019	14.1359	13.5339	13.0643
17	13.6849	14.8787	12.9019	13.2236
18	12.7364	13.4922	13.5339	12.3958
19	12.3958	12.9761	13.0643	12.9019
20	12.5678	14.1359	11.6715	13.2236
21	12.3958	14.2896	13.2236	12.5678
22	12.2203	13.4922	12.9019	13.8334
23	11.8583	12.7970	12.5678	12.7364
24	11.2854	12.6141	12.2203	13.2236
25	12.3958	13.3235	13.5339	14.1230
26	12.5678	12.9761	13.3801	13.6849
27	12.3958	13.1515	11.6715	13.5339

B. Grey Relation Analysis Result

This section will discuss how to identify the proper conditions and physical characteristics of a perfume design where Eq. (3) was used to normalize the "Higher-the-better" S/N ratio, and Eq. (4) was used to compute the deviation sequence value utilizing the normalized value. The deviation sequence value was used to calculate the grey relational coefficient by using Eq. (5), and the grey relational coefficient was then used to calculate the grey relational grade by using Eq. (6).

Finally, using their grade values, the grey relational average grade for each level of parameters for the respective hand was calculated to obtain the ideal perfume bottle model. Tables IX to XI shows the grey relation coefficient and grade for short-size hands, medium-sized hands, and long-size hands.

TABLE IX
GREY RELATIONAL COEFFICIENT AND GRADE (SHORT-SIZE HANDS)

No. of Iteration	Grey Relational Coefficient (Short-size Hands)				Grade	Rank
	Hand to Wrist Comfort	Overall Comfort	Safety	User Friendliness	-	-
1	0.3750	0.3601	0.3435	0.3348	0.3534	24
2	0.5097	0.5004	0.4827	0.4475	0.4851	13
3	0.4517	0.4529	0.4352	0.4071	0.4367	18
4	0.4650	0.4676	0.4359	0.4077	0.4440	17
5	0.5097	0.5004	0.4667	0.4612	0.4845	14
6	0.5441	0.5571	0.5398	0.5302	0.5428	11
7	0.4390	0.4261	0.3968	0.3739	0.4089	19
8	0.3944	0.3700	0.3628	0.3712	0.3746	21
9	0.5441	0.5372	0.5014	0.4633	0.5115	12
10	0.5441	0.5571	0.5609	0.5307	0.5482	10
11	0.3573	0.3507	0.3429	0.3510	0.3505	25
12	0.3333	0.3333	0.3333	0.3413	0.3353	27
13	0.9451	0.9396	1.0000	0.8922	0.9442	1
14	0.6525	0.6291	0.6399	0.5762	0.6244	7
15	0.9451	0.9986	0.9393	0.8922	0.9438	2
16	0.8510	0.8847	0.9955	1.0000	0.9328	4
17	0.6792	0.6566	0.6141	0.5768	0.6317	6
18	0.3944	0.3799	0.3730	0.3621	0.3774	20
19	1.0000	1.0000	0.9406	0.8027	0.9358	3
20	0.6277	0.6285	0.6392	0.6489	0.6361	5
21	0.3410	0.3335	0.3335	0.3333	0.3353	26
22	0.3845	0.3698	0.3530	0.3354	0.3607	22
23	0.4517	0.4673	0.4804	0.4743	0.4684	15
24	0.5441	0.5785	0.5614	0.5505	0.5586	9
25	0.5831	0.6025	0.6373	0.6208	0.6109	8
26	0.4650	0.4532	0.4496	0.4450	0.4532	16
27	0.3845	0.3603	0.3437	0.3519	0.3601	23

TABLE X
GREY RELATIONAL COEFFICIENT AND GRADE (MEDIUM-SIZE HANDS)

No. of Iteration	Grey Relational Coefficient (Med.-size Hands)				Grade	Rank
	Hand to Wrist Comfort	Overall Comfort	Safety	User Friendliness	-	-
1	0.4662	0.4082	0.4585	0.5659	0.4747	15
2	0.4662	0.4883	0.4327	0.3869	0.4435	22
3	0.5520	0.4454	0.4327	0.6921	0.5306	8
4	0.5520	0.5123	0.4092	0.5163	0.4975	10
5	0.4424	0.4454	1.0000	0.5402	0.6070	3
6	0.3818	0.5971	0.4092	0.5163	0.4761	14
7	0.3333	0.4262	0.5937	0.5163	0.4674	17
8	0.3333	0.4883	0.4092	0.3869	0.4044	25
9	0.5520	0.5971	0.6388	0.5402	0.5820	4
10	0.4922	0.6307	0.3682	0.4941	0.4963	12
11	0.3818	0.5123	0.4327	0.4941	0.4552	20
12	0.6256	0.5382	0.4585	0.5659	0.5470	6
13	0.5206	0.4454	0.4327	0.5659	0.4912	13
14	0.5868	0.5123	0.5186	0.5659	0.5459	7
15	0.5520	0.5382	0.4092	0.5402	0.5099	9
16	1.0000	0.6677	0.7498	0.7311	0.7871	2
17	0.7739	1.0000	0.8192	1.0000	0.8983	1
18	0.6256	0.5971	0.5539	0.5163	0.5732	5
19	0.6256	0.4661	0.4585	0.4355	0.4964	11
20	0.4206	0.4661	0.3333	0.3724	0.3981	26
21	0.4424	0.5664	0.5539	0.3333	0.4740	16
22	0.3645	0.3333	0.3333	0.4355	0.3667	27
23	0.4424	0.4883	0.4870	0.3587	0.4441	21
24	0.4922	0.5664	0.3878	0.3869	0.4583	19
25	0.4662	0.5382	0.3682	0.4733	0.4615	18
26	0.4004	0.5123	0.4092	0.3869	0.4272	23
27	0.3333	0.5971	0.3333	0.4022	0.4165	24

TABLE XI
GREY RELATIONAL COEFFICIENT AND GRADE

No. of Iteration	Grey Relational Coefficient (Long-size Hands)				Grade	Rank
	Hand to Wrist Comfort	Overall Comfort	Safety	User Friendliness	-	-
1	0.4503	0.3333	0.4012	0.4288	0.4034	27
2	0.4820	0.3512	0.5371	0.4009	0.4428	23
3	0.3333	0.3512	0.7830	0.7824	0.5625	9
4	0.3333	0.5366	0.7046	0.7824	0.5892	6
5	0.5585	0.4692	0.6393	0.5835	0.5626	8
6	0.6590	0.3706	0.4963	0.4958	0.5054	14
7	0.4503	0.3706	0.4963	0.4288	0.4365	24
8	0.7223	0.4692	0.3762	0.3536	0.4803	18
9	0.3964	0.3918	0.6393	0.5365	0.4910	17
10	0.6051	0.5009	0.3537	0.3333	0.4483	22
11	0.5178	0.3333	0.7046	0.4288	0.4961	16
12	0.6051	0.3918	1.0000	1.0000	0.7492	2
13	0.4219	0.4408	0.6393	0.5835	0.5214	13
14	0.4503	0.4408	0.8792	0.8788	0.6623	4
15	0.6051	0.5009	0.3333	0.4009	0.4601	21
16	0.6051	0.6226	0.7830	0.4958	0.6266	5
17	1.0000	1.0000	0.5371	0.5365	0.7684	1
18	0.5585	0.4692	0.7830	0.3760	0.5467	12
19	0.4820	0.3918	0.5843	0.4602	0.4796	19
20	0.5178	0.6226	0.3333	0.5365	0.5026	15
21	0.4820	0.6754	0.6393	0.4009	0.5494	11
22	0.4503	0.4692	0.5371	0.7824	0.5597	10
23	0.3964	0.3706	0.4606	0.4288	0.4141	25
24	0.3333	0.3512	0.4012	0.5365	0.4056	26
25	0.4820	0.4408	0.7830	1.0000	0.6765	3
26	0.5178	0.3918	0.7046	0.7038	0.5795	7
27	0.4820	0.4151	0.3333	0.6386	0.4673	20

The optimal model of the perfume bottle that could contain values of participants' emotions and feelings was determined and listed into Table XII to XIV.

For the "short-size hands", the suggestions were shown as: the length (65 mm) at level 2, width (33 mm) at level 2, height bottom to neck (90 mm) at level 1, height from neck to top (35 mm) at level 2, and position of spray at left at level 1, as listed in Table XII

TABLE XII
GREY RELATIONAL AVERAGE GRADE FOR EACH LEVEL OF PARAMETERS (SHORT-SIZE HANDS)

Level	Length (A)	Width (B)	Height bottom to Neck (C)	Neck to top Height (D)	Position of Spray (E)
1	0.4491	0.4907	0.5116	0.5791	0.5313
2	0.6320	0.5968	0.4014	0.5912	0.5009
3	0.5244	0.5179	0.4014	0.4352	0.4352
Delta	0.1830	0.1061	0.1103	0.1560	0.0961
Rank	1	4	3	2	5

The optimum design of perfume bottles for short-hand users is depicted in the figure below (Fig. 6) as;

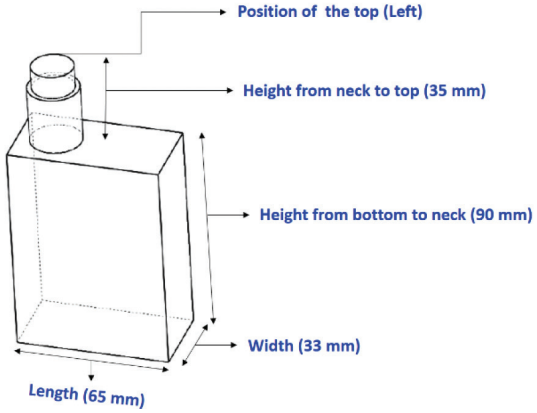


Fig. 6. Optimum perfume bottle design for "short-size hand" users

For the "medium-size hands", the suggestions were shown as the length (65 mm) at level 2, width (36 mm) at level 3, the height bottom to neck (90 mm) at level 1, the height from neck to top (35 mm) at level 2 and the position of spray in middle at level 2 as presented in Table XIII and Fig. 7.

TABLE XIII
GREY RELATIONAL AVERAGE GRADE FOR EACH LEVEL OF PARAMETERS (MEDIUM-SIZE HANDS)

Level	Length (A)	Width (B)	Height bottom to Neck (C)	Neck to top Height (D)	Position of Spray (E)
1	0.4982	0.4698	0.5530	0.4779	0.5043
2	0.5894	0.4886	0.4871	0.5786	0.5130
3	0.4381	0.5575	0.4855	0.4691	0.5075
Delta	0.1513	0.0877	0.0675	0.1096	0.0087
Rank	1	3	4	2	5

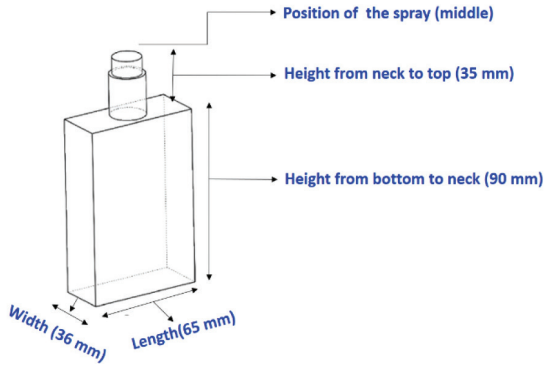


Fig. 7. Optimum perfume bottle design for "medium-size hand" users

For the "long-size hands", the suggestions were shown as the length (65 mm) at level 2, width (33 mm) at level 2, the height bottom to the neck (96 mm) at level 2, the height from neck to top (35 mm) at level 2 and the position of spray in middle at level 2 as presented in Table XIV and Fig. 8.

TABLE XIV
GREY RELATIONAL AVERAGE GRADE FOR EACH LEVEL OF PARAMETERS (LONG-SIZE HANDS)

Level	Length (A)	Width (B)	Height bottom to Neck (C)	Neck to top Height (D)	Position of Spray (E)
1	0.4971	0.5200	0.5255	0.5306	0.5268
2	0.5866	0.5636	0.5638	0.5701	0.5454
3	0.1521	0.5200	0.5092	0.4979	0.5263
Delta	0.4345	0.0436	0.0546	0.0722	0.0191
Rank	1	4	3	2	5

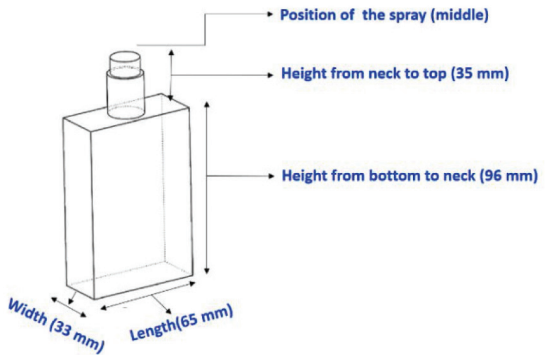


Fig. 8. Optimum perfume bottle design for "long-size hand" users

C. ANOVA for the Grey Relational Grade

The percentage contribution of each shape parameter in the response variable is attributed using ANOVA to determine which of the shape parameters are significant and influence the consumer emotions and experiences. Fig. 9 to Fig. 11 are the ANOVA results to support the perfume design of "short, medium, and long-size-hand" users.

• Analysis of Variance – (Short-Size Hands)

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution
Length	2	0.1522	0.0761	2.9	0.084	24%
Width	2	0.0547	0.0273	1.04	0.375	9%
Height from Bottom to Neck	2	0.147	0.0735	2.81	0.09	23%
Neck to top Height	2	0.1355	0.0678	2.59	0.106	22%
Position of Spray	2	0.0877	0.0438	1.67	0.219	14%
Error	16	0.4193	0.0262			8%
Total	26	0.9964				100%

Fig. 9. ANOVA results to support the perfume design of "short-size hand" users

None of the parameters appear to be significant in the ANOVA for "short-size hand users" based on this table. With contributions of 24%, 23%, and 22%, respectively, bottle length (A), height from bottom to the neck (C), and height from neck to top (D) supplied the most variability, while width (B) and spray position (E) (14%) contributed the least.

• Analysis of Variance – (Medium-Size Hands)

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution
Length	2	0.1044	0.0522	8.26	0.003	43%
Width	2	0.0328	0.0164	2.59	0.106	13%
Height from Bottom to Neck	2	0.0266	0.0133	2.11	0.154	11%
Neck to top Height	2	0.0667	0.0334	5.27	0.017	27%
Position of Spray	2	0.0004	0.0002	0.03	0.968	0%
Error	16	0.1012	0.0063			5%
Total	26	0.3322				100%

Fig. 10. ANOVA results to support the perfume design of "medium-size hand" users

Only the length (A) and neck-to-top height (D) were significant in influencing the grey relational grade values, accounting for 43% and 27% of total variability, respectively. As a result, the length (A) and neck-to-top height (D) were the most important factors influencing client sentiments and feelings. The remaining variables, such as height from bottom to the neck (C), width (B), and spray position (E), were found to be insignificant, and their effects were minimal.

- **Analysis of Variance – (Long-Size Hands)**

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution
Length	2	0.0404	0.0202	2.08	0.158	36%
Width	2	0.0129	0.0065	0.66	0.528	11%
Height from Bottom to Neck	2	0.0141	0.0071	0.73	0.499	13%
Neck to top Height	2	0.0235	0.0118	1.21	0.324	21%
Position of Spray	2	0.0021	0.0011	0.11	0.897	2%
Error	16	0.1554	0.0097			17%
Total	26	0.2485				100%

Fig. 11. ANOVA results to support the perfume design of "long-size hand" users

None of the parameters for long-hand users appear to be significant in the ANOVA based on this table. With 36%, 13%, and 21% contributions, respectively, bottle length (A), height from bottom to neck the (C), and height from neck to top (D) offered the most variability, whereas width (B) with 11% and spray position (E) with (14 %) gave the least.

VI. Conclusion

This study mostly relied on customer feedback to identify a gripping problem in a perfume bottle caused by inappropriate dimensions. This challenge was solved by using the Taguchi method to create an experimental design, using Kansei words to elicit user sentiment about grip comfort, and using grey relational analysis to find the best combination of perfume bottle dimensions. For users with short, medium, and long hands, three optimum parameters for bottle design were discovered. The length (65 mm), breadth (33 mm), height from bottom to neck (90 mm), height from neck to top (35 mm), and position of spray at left was the recommended design of perfume bottle for small hand users that could store values of participants' emotions and sentiments. The length (65 mm), width (36 mm), height from bottom to the neck (90 mm), height from neck to top (35 mm), and the position of spray in the middle at was the optimal design model of rectangular perfume bottles that could carry values of consumer emotions and feelings for medium hand users. The ideal design model of the rectangular perfume bottle that could hold values of customer emotions and sentiments for long-hand users was the length (65 mm), width (33 mm), height bottom to the neck (96 mm), height from neck to top (35 mm), and the position of spray in the middle. The length (65 mm), width range (33-36 mm), height from bottom to neck (90-96 mm), height from neck to top (35 mm), and position of spray in the middle could be considered the ideal design framework for rectangular perfume bottles for users of all sizes of hands that can store values of participants' emotions and sentiments. In the case of short long-hand users, none of the dimension factors were shown to be significant in rectangular perfume bottle design. In the case of medium-hand users, length and height from neck to top factors were determined to be significant in the dimensional design of perfume bottles. In all cases, length, height from the bottom to the neck, and height from the neck to the top contributed the most to the variation, while width and spray position contributed the least. This study aims to demonstrate the importance of gripping comfort, which appears to be overlooked in perfume bottle design. This research also addresses the issue of gripping comfort by determining the right dimensions of rectangular perfume bottles using a hybrid optimization technique based on the emotion of the customer. The analysis of customer emotions was primarily used to boost customer willingness to buy. Other perfume bottle shapes could be subjected to a similar investigation.

VII. Limitations of This Study

This research was carried out in Thailand. In this study, only right-handed university students were used as participants. The study was based on customer emotion and feelings in order to determine the appropriate size of the perfume bottle enhancing purchase willingness. This study did not include any musculoskeletal examination for grip comfort.

Acknowledgement

This research study is supported by School of Manufacturing Systems and Mechanical Engineering, Sirindhorn International Institute of Technology, Thammasat University, Thailand.

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