Alternative Design for Salad Spinner-*Sallatë*

Suchada Rianmora, Dulyawat Padnoi, Tanapoom Rattanopas and Boonyanuch Yantabutr

School of Manufacturing Systems and Mechanical Engineering
Sirindhorn International Institute of Technology, Thammasat University
Pathumthani, Thailand
E-mail: suchada@siit.tu.ac.th, boss.dulyawat@gmail.com, tanapoomerz@gmail.com, yantabutr.b@gmail.com

Received: April 22, 2019 / Revised: June 11, 2019 / Accepted: June 26, 2019

***Abstract*—In order to develop and improve the salad spinner for everyday use with the least amount of time and skills required, and for a limited storage space, product design and development (PDD), rapid prototyping (RP) concepts have been applied for creating the guideline of the conceptual model, *Sallatë* salad spinner. Three alternative designs are suggested based on Kansei Engineer method with questionnaire. Dimensions and physical characteristics of the salad spinner have been created by applying the concept of ergonomics to fit the people who use it. Using this proposed design can help the users to minimize their time spent preparing ingredients with no skills required.**

***Index Terms*—Product design and development (PDD), Rapid prototyping (RP), Salad spinner, and Ergonomics Design.**

I. Introduction

Nowadays, an increasing amount of people is becoming aware of the importance of taking care of their body and eating healthy. As the newer generation are more concerned about their health and are attentive towards clean food and salads. With 25.5% [1] of the target customer, aging between eighteen to thirty-five years old, living in the metropolitan area, living space and time is limited. With no space and time, preparing their own meal can take a considerable amount of time according to individual skills.

Therefore, most people tend to buy meals, instead of preparing for their own. However, the price of salads for instance, is more expensive than most of the common recipe menus, and is more expensive comparing to the original cost of the ingredients. In addition, with chemicals and dirt on vegetables, improper cleaning method can cause illness. In response to this problem, the study will be proposing to investigate several options for making the meal preparation faster and require lesser skills with kitchen tools.

Before starting to design the salad spinner, a questionnaire was raised, with the area of interest being the metropolitan region. The questionnaire focused on how the target customer thinks towards a new kitchen gadget appliance that can shortens time preparing and cooking regarding limited storage spaces.

II. Research Background

Present in this section are the background of the research for identifying the customer's behavior, requirement and perceptions towards the salad spinner. These people will be accounted as the target group of the new salad spinner design. Four phases of *Product Design and Development* (PDD) have been described in the following subsection.

Before getting into phase 1, we reviewed some of the related researches and the existing salad spinner products in the market. After the questionnaires have been completed, a combination of both the base model and the questionnaire results will be taken into consideration towards the primary model. The number of respondents was 112 and all respondents live in the Bangkok metropolitan region and surrounding provinces. The questions were emphasized on the analysis of traditional kitchenware on new generation consumer behavior.

• *Customer Requirement*

Due to a hasty lifestyle in the city, people need proper equipment to keep up with their pace. With new generations trying to maintain a healthy lifestyle, an appliance that could prepare food and shortens time spent preparing food would be a solution.

• *Customer Perception*

Referring to the normal method, washing vegetables rinsed with water in a bucket is a common thing that every household does. However, with chemicals and dirt on vegetables, improper cleaning method can cause illness. Rinsing and washing with pure water helps reduce both normal and chemical residue around 25% [2]. For vinegar or baking soda mixed with water helps reduce left over residues approximately, 60% and 90% [2] respectively, compared to pure water. This infers that a new design should be able to withstand these chemicals.

• *Existing Products*

As being said, there are many existing appliances in the market already, but mostly all of them are basic gadgets or has only a few functions. Therefore, comparing the existing products in the market has been done to see its flaws and strengths, so it could be used as a reference for further use.

As there are many online market sources, the samples have been analyzed wholly and narrowed it down to four main sites, which are *Amazon*, *Alibaba*, *E-bay*, and *Lazada*.

After we explored the market, as shown in the four tables above, we compare all of the best models in the market together to find the most suitable reference model, as shown in Table V and from comparing the best seven models, the fifth model, "*Kitchen Master All-in-One Salad Maker*" is selected to be the primary model because of its versatility

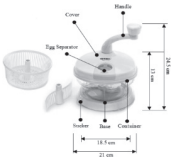
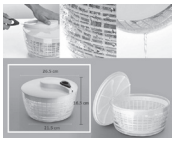
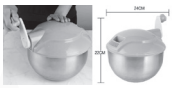
1. Products from Amazon

TABLE I
PRODUCTS FROM AMAZON

No.	Product and Components	Picture
1	**Salad Spinner LOVKITCHEN [3]** The dimension of the spinner is 25.4 × 25.4 × 15.24 cm. The material of this product is Hard Plastic. Retails at $18, around 592 THB [4].	
2	**Nopro Mini Salad Spinner [5]** The dimension of the spinner is 13 cm height × 20 cm diameter. Retails at $13, around 427 THB [4].	
3	**Prepworks by Progressive [6]** The dimension of the spinner is 20 × 20 × 8 cm. Retails at $21, around 691 THB [4].	

2. Products from Alibaba

TABLE II
PRODUCTS FROM ALIBABA

No.	Product and Components	Picture
1	**Hand-Powered Food Chopper Salad Spinner Vegetable Mixer [7]** The dimension of the spinner is 13 cm height × 21 cm diameter. The material of this product is plastic (PP+PS). Retails at $8.2 around 270 THB [4].	
2	**Vegetable Dehydrator [8]** The dimension of the spinner is 16.5 cm height × 26.5 cm diameter. The material of this product is plastic (PP+PS). Retails at $8, around 265 THB [4].	
3	**WT Stainless Steel Vegetable Salad Spinner [9]** The dimension of the spinner is 22 cm height × 24 cm diameter. The material of this product is stainless steel. Retails at $8, around 265 THB [4].	
4	**Green and White Manual Rotate Vegetable Salad Spinner [10]** The dimension of the spinner is 20.2 cm x 20.2 cm x 19 cm. The material of this product is plastic (PP+PS). Retails at $6.53, around 216 THB [4].	
5	**Eco-Friendly Salad Spinners with bowl [11]** The dimension of the spinner is 19.5 cm height x 26 cm diameter. The material of this product is plastic (PS+PP). Retails at $6.59, around 218 THB [4].	

3. Products from Lazada

TABLE III
PRODUCTS FROM LAZADA

No.	Product and Components	Picture
1	**Micronware Salad Spinner [12]** The dimension of the spinner is 20 cm height × 25 cm diameter. The material of this product is hard plastic. Retails at 255 THB.	
2	**GEFU Salad Spinner ROTARE [13]** The dimension of the spinner is 17 cm height × 25 cm diameter. The materials of this product are plastic (ABS/PS) and stainless steel. Retails at 1,790 THB.	
3	**ZTS Kitchen Cook Fruit Vegetable Salad Spinner Dryer Colander Strainer Sifter Tool [14]** The dimension of the spinner is (L) × (W) × (H) 19 × 16 × 16.5 cm. The material of this product is plastic (PS+PP). Retails at 666 THB.	
4	**Multifunction JUMBO 4.5 QUART [15]** The dimension of the spinner is 22 cm height × 24.5 cm width. The material of this product is plastic (PS+PP). Retails at 999 THB.	
5	**GEFU Salad Spinner SPEED WING [16]** The dimension of the spinner is 15 cm height × 27 cm width. The material of this product is stainless steel. Retails at 3490 THB.	

4. Products from E-Bay

TABLE IV
PRODUCTS FROM E-BAY

No.	Product and Components	Picture
1	**Kitchen Master All-in-One Salad Maker [17]** With a transparent glass, this salad spinner retails at $30, around 986 THB [4].	
2	**Press Salad Spinner [18]** The dimension of the spinner is 26 × 26 × 15 cm. Retails at $40, around 1315 THB [4].	

TABLE V
SALAD SPINNER – COMPARISONS

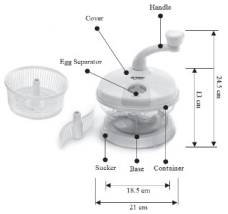
Product	Functions
 LovKitchen Large [3]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : Yes • Brake : N/A • Side Lock : Yes • Water Hole : N/A • Collapsible : N/A
 Nopro Mini Salad Spinner [5]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer: Yes • Brake : N/A • Side Lock : Yes • Water Hole : Yes • Collapsible : N/A
 Prepworks [6]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : Yes
 Hand-Powered Food Chopper Salad Spinner Vegetable Mixer [7]	• Cutter : Yes • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : Yes • Collapsible : N/A

TABLE V
SALAD SPINNER – COMPARISONS

Product	Functions
 Micronware Salad Spinner [12]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A
 Kitchen Master All-in-One Salad Maker [17]	• Cutter : Yes • Hand Pump : N/A • Hand Spin : Yes • Die Change : Yes • Drainer : N/A • Brake : Yes • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A
 Presse Salad Spinner [18]	• Cutter : N/A • Hand Pump : Yes • Hand Spin : N/A • Die Change : N/A • Drainer : Yes • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A

A. Phase 1: Customer's behavior towards clean food (salad spinner)

After collecting some ideas about customer's behaviors towards clean food (salad spinner), to construct the drafted design of the spinner, three main activities were established; *data collection process*, *data analysis*, *discussion results and conclusion.*

1. Data collection

In order to construct the salad spinner, market survey has been conducted by using data collection method. Questionnaire was selected as the method for data collection process. Questions were created and distributed in three parts, in order to determine the importance parameters such as how often do they cook, kitchenware storage size, most suitable space to be stored in the cupboard, how people response to a new gadget that can shorten the amount of food preparation time and most importantly the expected price that customer's are eager to pay for the salad spinner.

Illustrated in Fig. 1 is the sample questions of the self-administered questionnaires used for finding the customer's opinions and requirements on the existing kitchenware, some answers could be used for interpreting the words to be design directly and effectively.

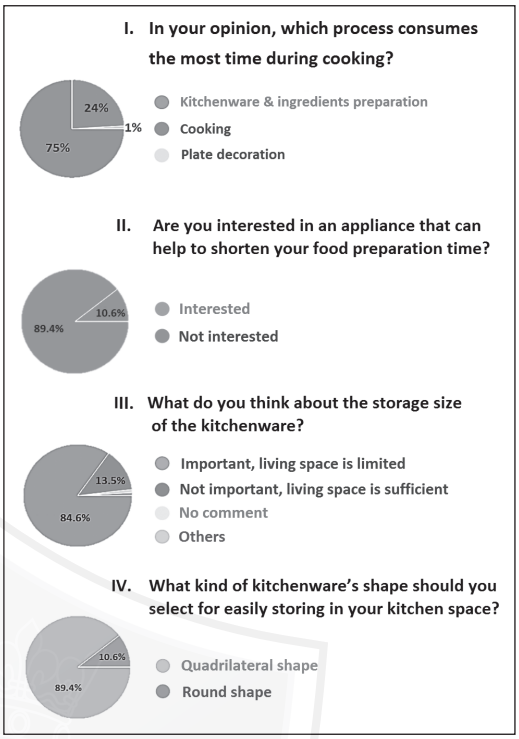


Fig. 1. The sample questions of the self-administered questionnaires raised for identifying the customer's requirements.

2. Data analysis

There were 112 questionnaire participants who took part answering via Google form. The first part of the questionnaire contains basic questions about the participant. From the questionnaire results 64 participants were female, 46 were male and two not specified. With 57.1% aging between 18 – 25 years old, 20.5% aging between 26 – 35 years old, and the rest is 36 years old and above. Most of the participants' answers live in a household with 3 – 5 family members, and their income per month, 33% being more than 35,000 THB (1100 USD), 22.3% ranging from 15,000 – 25,000 THB (470 – 780 USD) and so on. The second part of the questionnaire was base on "Problems you have encounter." Most participants, 37.5% spends around half an hour to an hour cooking, 27.7% spend less than half an hour, 16.1% spends more than an hour cooking, despite 18.8% does not have any spare time to cook. Along with 28.6% of participants cooking once or twice per month, 26.8% cook more than 4 times per month and 23.3% cook 3 – 4 times per month. With more than 76% of the participants saying they spend most of their time preparing kitchenware and ingredients, more than 84% thinks that space for storing kitchenware is important.

The results obtained from the questionnaire indicate that participants are interested in an appliance that can help shorten food preparation time, and they preferred to have a quadrilateral shape for the appliance and most response expecting the product to cost around 400 – 700 THB (12–22 USD).

3. Discussion of questionnaire results and conclusion

After obtaining the results from the questionnaire, our group will continue the design with a quadrilateral shape. The majority of the response said they want the salad spinner to be push by hand. However, our group discussed that we will continue with the salad spinner using rotating mechanism by hand, due to the standard ergonomic height of the kitchen countertop [19] is 36 inches, roughly 91 cm above floor, because of that, hand spin mechanism is used due to less effort used for operating. In addition to the questionnaire results, our group decided to add some functions to the primary model to create a new design that will be more convenient to the user.

B. Phase 2: Translating requirements to be the design

In order to translate the requirements of the target customers to be the salad spinner design, factors affecting the salad spinner are considered and classified into three groups; *the dimension of appliance, mechanism, and material for each part.*

• *Dimension of Appliance*

According to the research objective, where storage space of the appliance is to be reduced. The design of the kitchenware appliance has to be compact, in the mean time providing sufficient amount of serves that customers desired, while being able to conveniently fitting in the corners of the customer's cupboards as well.

• *Mechanism*

To shorten meal preparation time, the movement of kitchenware appliance must lessen the user's effort and is easier to operate than common appliances.

• *Material for each part*

This research applies that knowledge about materials for selecting the suitable material for individual part, with lowest cost possible.

III. The Salad Spinner, SALLATË

After translating the customer's behaviors and requirements from the self-administered questionnaires, the drafted design was constructed. The key theme of this developed design was raised by seeking a gap in the market where there is no salad spinner as functional just yet, with the metropolitan area's life style and this generation's devotion towards clean and healthy foods, customers will be able to prepare food/ingredients for themselves, despite individual cooking skills within a short amount of time. These have led to our research for creating an alternative design for salad spinner, which is called *Sallatë*, and the overall phases required for accomplishing this new design, 5 phases are expressed as shown in Fig. 2.

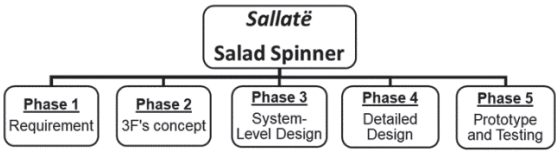


Fig. 2. Five phases for creating new design of salad spinner.

A. Phase 1: Expected design and Requirement from the questionnaires and the reference models.

From the questionnaire results combined with the reference model, a new prototype design that is more innovative than the existing products could be developed. Compare and adapt the good things from the existing product, with additional functions that could be added to the primary model, with a proper engineering point of view.

As the dimension of these products are roughly 20 × 20 × 20 cm, the expected design can be inferred that it should be roughly around this size as well. Since material used for these product references are all plastic, the expected design would likely use food-grade plastic. The expected design would likely be kept flat when left idle, and is able to fit into the corners inside cupboards. Additional functions will be included for a multipurpose used. The product characteristics, customer emotional requirements, and their definitions are presented in Table VI and VII.

TABLE VI
Product Characteristics and Their Definitions

Product Characteristics	Definitions
Quadrilateral	Salad spinner has a quadrilateral shape.
Round	Salad spinner has a round shape.
Rotating *(Spin)*	Applying force in circular motions to the handle.
Pushing	Applying force vertically downwards to the cap/topmost area of the equipment.
Multifunctional	Salad spinner can perform numerous operations.
Simple	Salad spinner can perform only specific operations.
Normal *(Plastic)*	The quality of the material is ordinary.
Excellent *(Steel)*	The quality of the material is exemplary.

TABLE VII
CUSTOMER EMOTIONAL REQUIREMENTS AND THEIR DEFINITIONS

Customer Emotional Requirements	Definitions
Affordable (Cheap)	Salad spinner should be sold with low price.
Unaffordable (Expensive)	Salad spinner should be sold with high price.
Modern	Salad spinner has a new, up-to-date appearance.
Classic	Salad spinner has a typical appearance.
Light	Salad spinner contains light weight
Heavy	Salad spinner contains high weight
Luxurious	An upscale design engages customer to buy the product
Average	A common design engages customer to buy the product

B. Adjective words with 7-points semantic differential scale

The answer of the 46 participants were analyzed from SPSS program. Three main factors are concerned as the following.

• *Kaiser-Meyer-Olkin Measure of Sampling Adequacy*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy uses to check the data validity for *Factor Analysis*. The value should be more than 0.5 for the reliability of the data obtained and make sure that the data is suitable for *Factor Analysis*. The result obtained from this step is presented in Fig. 3.

• *Barlett's Test of Sphericity*

The result is applied to deal with the hypothesis test. For this test the hypothesis is shown as:

H_0: Correlation Matrix = 1

H_1: Correlation Matrix ≠ 1

When the significance value is less than 0.05, H_0 is rejected. This can be concluded that the Correlation Matrix ≠ 1. The result of this test obtained is shown in Fig. 3.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.523
Bartlett's Test of Sphericity	Approx. Chi-Square	53.533
	df	28
	Sig.	.003

Fig. 3. Kaiser-Meyer-Olkin Measure of Sampling Adequacy result.

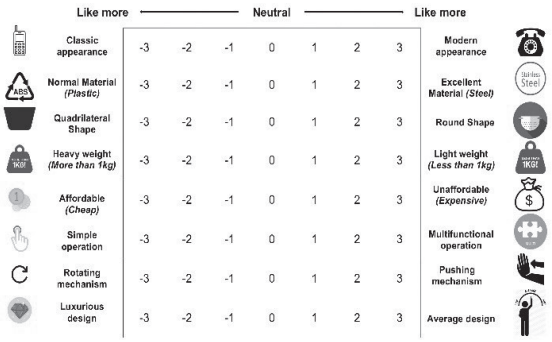


Fig. 4. Adjective words with 7-points semantic differential scale.

• *Rotated Component Matrix*

Rotated Component Matrix is used for identifying which factor should be arranged in which group. This can be considered by factor loading of each factor. Which factor loading is the greatest one, it is considered to be in that group. The scree plot shows the *Eigenvalue* on y-axis and the *component number* is on x-axis (Fig. 5). When the *Eigenvalue* is more than 1, the consideration of component number was emphasized and recorded.

A scree plot always displays a downward curve. The point where the slope of the curve is clearly leveling off indicates the number of factors that should be generated by the analysis. Both criteria sometimes yield an unreasonably high number of factors. And the scree plot suggests either three or five factors due to the way the slope levels off twice.

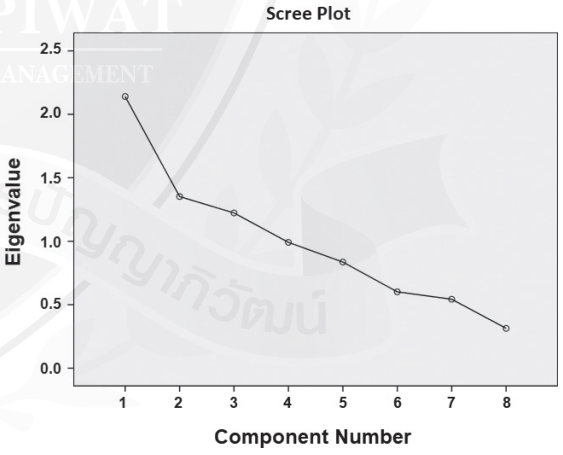


Fig. 5. The Scree Plot.

For running a factor analysis is to reduce a large number of variables that describe a complex concept such as economic status to a few interpretable latent factors. In other words, we would like to find a smaller number of interpretable factors that explain the maximum amount of variability in the data. The design of salad spinner (Sallatë) can be separated into 3 groups (Fig. 6).

Rotated Component Matrix[a]

Kansei words		Component		
Positive	**Negative**	**1**	**2**	**3**
Modern	Classic	0.825		
Plastic	Stainless Steel	0.692	0.441	-0.289
Quadrilateral	Round	-0.535	-0.428	-0.375
Light	Heavy		0.742	
Affordable	Unaffordable		0.707	
Multifunctional	Simple		-0.212	0.718
Spin	Push			0.651
Luxurious	Average	-0.5		0.547

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Fig. 6. Rotated Component Matrix.

Presented in Table VIII are the adjective words recommended for creating new design of salad spinner where the conceptual ideas were grouped according to the results from "*Rotated Component Matrix*" (Table IX).

TABLE VIII
THE ADJECTIVE WORDS RECOMMENDED FOR CREATING THE NEW DESIGN OF SALAD SPINNER

Customer's Requirement	Product Specification
1. *Price:* Expensive/Cheap 2. *Appearance:* Modern/Standard 3. *Weight:* Light/Heavy 4. *Design:* Simple/Luxurious 5. *Size:* Compact/Big	1. *Mechanism:* Push/Spin 2. *Material:* Plastic/Steel 3. *Function:* Multi-functional/ Simple 4. *Shape:* Quadrilateral/Round

TABLE IX
THE CONCEPTUAL IDEAS OBTAINED FOR THE NEW DESIGN

Model No.	Idea of salad spinner	Customer's Requirement	Product Specification
1		"Modern"	"Plastic" "Round"
2		"Light" "Affordable"	"Plastic"
3		"Luxurious"	"Multi-functional" "Spinning"

The researchers started to sketch the spinning design with various platforms and functions to fit the customer's requirements and product specifications listed in the previous phase (Table IX). The water draining part and the spinning system were the key components of this approach. Illustrated in Fig. 6 to 8 are the drafted designs (freehand drawings) of the salad spinning bowl.

For *model A*, the lid was designed as round-shaped cover with push-to-spin function. The drainer, extra die/cutter socket, and brake system were provided on the lid area around the cylinder-shaped spinner. Bowl and basket were created in the same direction with the tapered cylinder design. The draining sockets were formed in pattern with uniform layout.

For *design B*, the overall functions of this model were quite similar to the first one; however, the topmost and bottommost areas were changed. The round-shaped design (i.e., tapered cylinder bowl with round lid) provided the waste spaces; when it was located on the table or cooking area, since it could not be fitted easily to the other corner-designed cookware/kitchen products (e.g., microwave).

During spinning activity, the user might lose control since there were no references or handles to help the user to fix the bowl in place. Redesigning the salad spinner as a four-sided shape with every angle around ninety degrees and anti-slip buttons underneath the bowl could help to reduce the accidents. However, to remove the basket in and out easily, a taper design is required for creating bowl. The proper sketch of this model is shown in Fig. 8.

Sudden, extreme fatigue occurs for a variety of reasons, one of those is applying force on the push button (spinning mechanism) several times (i.e., up and down directions). Doing this may cause the fatigue around the fingers and hand, in order to reduce muscle strain and pain, the alternative spinning mechanism should be introduced. Normally, using the push-to-spin function presents the disadvantage during spinning attempt; pushing stroke is quite short. It may need a speed-increaser gear to increase the rotating stroke; however, the speed-increaser gear reduces the output torque which may result in insufficient spinning torque for certain vegetable.

For *model C*, the cone-shaped spinning handle was created to connect with the gear for turning the basket in 360 degrees. Comparing to the previous design, the way to drain the water out of the basket was quite easy and less human labour required. However, the shape of the lid and basket presented in this design (Fig. 9) were not recommended. The corner/edge design was required.

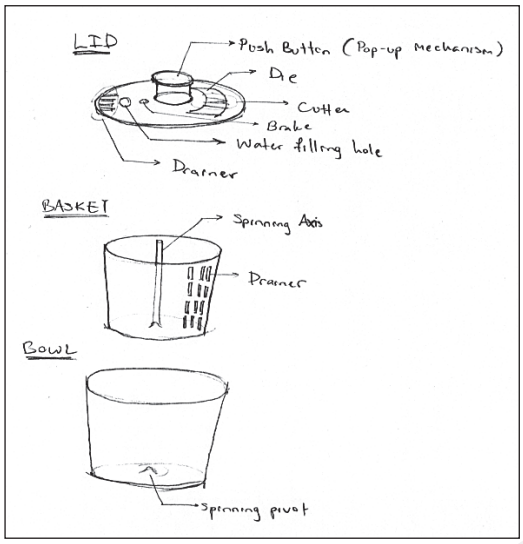


Fig. 7. Drafted model A: Push-to-spin design with round lid.

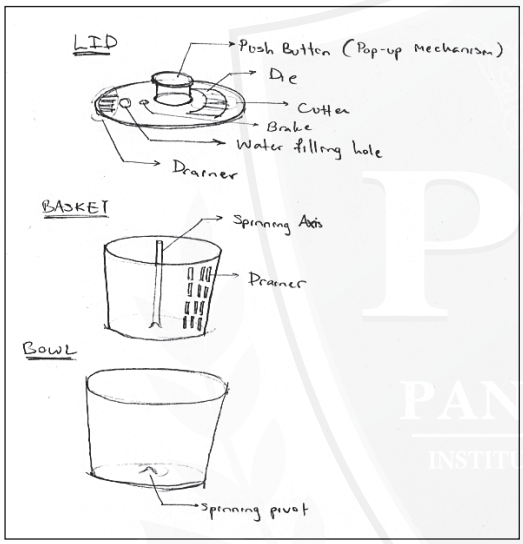


Fig. 8. Drafted model B: Push-to-spin design with square lid.

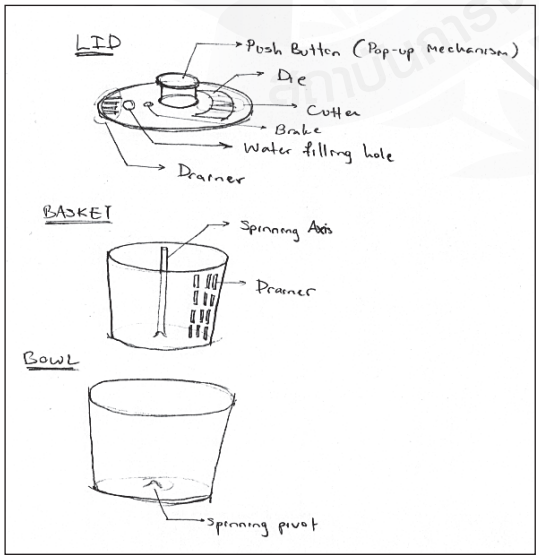


Fig. 9. Drafted model C: Spinner (Handle) with round bowl.

The advantages of the existing products which are available in the market (as presented in the related works), and the sketched models (A, B, and C) were applied as the guidelines for creating the alternative salad spinner.

The following issues were used as the key components:

- spinner with cone-shaped handle
- a four-sided shape (i.e., corner/edge lid and bowl)
- tapered cylinder basket
- anti-slip buttons underneath the bowl
- organized draining sockets around the basket and the lid
- brake system
- extra die/cutter on the lid

C. Phase 2: Concept of "3F's approach" for the salad spinner

The research of interest for this salad spinner prototype is the functional use of the salad spinner. As the aforementioned of the ideas for salad spinner, the "*Affordable*" issue was the critical point for the new design to be survived in the competitive market. To emphasize its functional use, the three main components details and functions will be mentioned in this chapter. The salad spinner embodies the 3F approach, form, fit and function as shown below.

I. Form

As mentioned earlier, the salad spinner dimension will be roughly 20 × 20 × 20 centimeters, respectively. The design of the salad spinner will be in a quadrilateral shape. This is so that the salad spinner can fit neatly in the corners of the storage cupboard (Fig. 10: a comparison between quadrilateral and rounded shape kitchenware), according to limited kitchen space in the metropolitan area.

Fig. 10. Quadrilateral and round shaped kitchenware [20].

II. Fit

The salad spinner consists of three main parts, which are *lid, basket*, and *bowl*, the drafted configurations of this proposed model are shown in Fig. 11. The details of each component will be presented in the sub-section below.

Fig. 11. Drafted configurations of the proposed model.

1) Lid

For the lid component contains the gearbox, die, and the spinner. Shown in Fig. 12, is the lid of the expected design, the brake, water filler and drainer has been added for draining and washing conveniently. The die slot contains blade chip storage whereas the blade is kept and the blade chip slot is where the user will be able to change depending on the die the user chose, chopping die, slicing die, for instance.

The blade chip contains a knife, like a mandolin slicer, whereas the user can slice vegetables or fruits along the die slot according to the blade type die the user chose, an example is shown below in Fig. 13. To attach the lid neatly with the bowl, rubber stripes will be attached on the side.

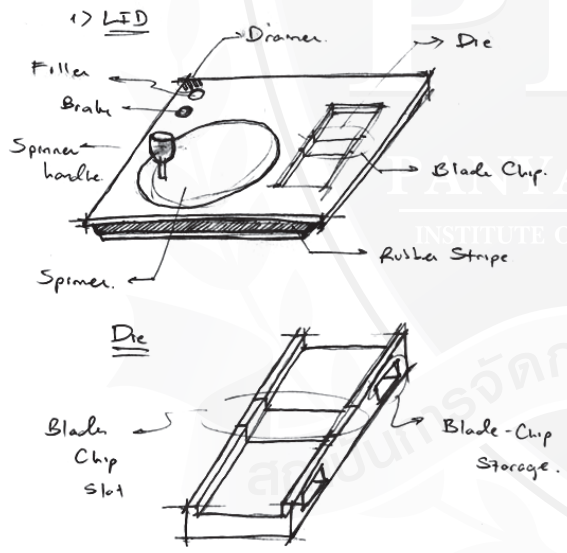


Fig. 12. Conceptual model of *Lid* and *Die slot*.

Fig. 13. Example of the die slicer (Mandolin Slicer) [21].

2) Basket

Presented in Fig. 14 is the basket of the expected design, the main component of the basket is the cover and basket. The cover is inserted with gear set and is locked with the basket.

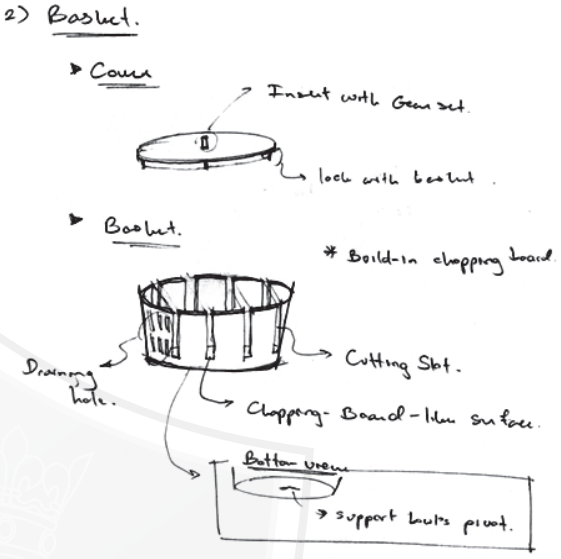


Fig. 14. Conceptual model of Basket.

The basket has a build-in chopping board like surface, with the basket designed to have cutting slot so that the user can cut vegetables externally by inserting a knife through the cutting slot for precise cutting, basket has small draining holes for the water to be drained out, and underneath the basket there will be a pivot hole to support the bowl's pivot.

3) Bowl

Referring to Fig. 15 is the bowl of the expected design, with a pivot point for the spinning axis and an anti-slip surface to hold the bowl while spinning in place.

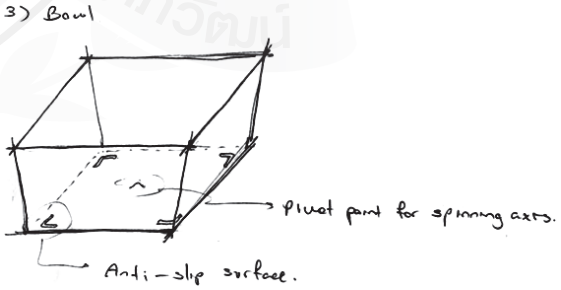


Fig. 15. Conceptual model of Bowl.

III. Function

The function of the salad spinner is to minimize time preparing ingredients, clearly cut vegetables and fruits precisely, and drain/wash water out leaving vegetables/fruits/food nice and clean.

For cutting vegetables and fruits precisely, there will be blade chip slots that allow the user to choose what type of cut they would like to mince their food. The die slot contains blade chip storage where the blades are kept and the blade chip slot is where the user will be able to change the type of knife, depending on the die the user chosen, the user will be able to cut the vegetables, fruits, etc, precisely by sliding back and forth. As for the basket, the user will also be able to cut vegetables externally via the cutting slot by inserting a knife through the gaps of the basket.

D. Phase 3: System-level design

In order to identify the physical characteristics of the salad spinner, all components are classified and operational stage conditions. These data can help the designer to minimize some mistakes that might be occurred during the design stage. Fig. 16 illustrates the main frame of the developed prototype.

For the lid mechanism, six items are required: *blade clip, handle, gear set, die/die slot, brake and spinner.* These six items build up the lid, and the mechanism to chop, spin and wash vegetables/fruits/food inside. At the bottom of the bowl, we will attach the anti-slip pad on the corners to hold the bowl while spinning in place.

Lastly, the basket set, two items are required which are *basket cover and the basket.* The basket cover is attached to the bottom of the lid and the basket has a pivot hole underneath which will be put on top of the bowl.

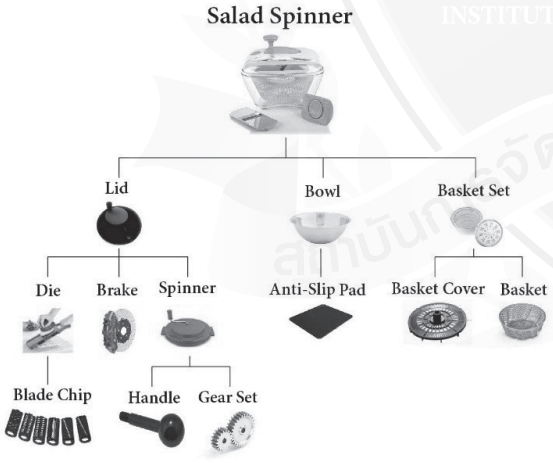


Fig. 16. The mainframe of the salad spinner.

E. Material considerations

From the mainframe diagram, different parts of the salad spinner will use different materials. For the salad spinner to be set at the lowest price possible, two plastic materials will be used to make the salad spinner, *Polypropylene (PP) and Acrylonitrile Butadiene Styrene (ABS).*

1) Polypropylene (PP)

The main property of PP [22] is that it is semi-rigid, translucent, has good chemical resistance, and good heat resistance [23]. The properties of PP are shown below in Table X.

TABLE X
PROPERTIES OF PROPYLENE

Physical Properties:	Value:
Tensile Strength:	0.95-1.30 N/mm^2
Notched Impact Strength:	3.0-30.0 Kj/m^2
Thermal Coefficient of Expansion:	100-150 $\times 10^{-6}$
Max. Continued Use Temperature:	80°C (176°F)
Melting Point:	160°C (320°F)
Glass Transition Temp. (Atactic):	-20°C (-4°F)
Glass Transition Temp. (Isotactic):	100°C (212°F)
Density:	0.905 g/cm^3

2) Acrylonitrile Butadiene Styrene (ABS)

ABS is an ideal material of choice for various structural applications. Some advantages of ABS [24] is that it has a good impact resistance, even at low temperatures, is a good insulating properties and is mechanically strong and stable over time. The properties of ABS is shown below in Table VI.

TABLE XI
PROPERTIES OF ABS

Physical Properties:	Value:
Elongation at Break	10-50%
Elongation at Yield	1.7-6%
Flexibility (Flexural Modulus)	1.6-2.4 GPa
Hardness Shore D	100
Stiffness (Flexural Modulus)	1.6-2.4 GPa
Strength at Break (Tensile)	29.8-43 MPa
Strength at Yield (Tensile)	29.6-48 MPa
Toughness (Notched Izod Impact at Room Temperature)	200-215 J/m

Therefore, PP and ABS will be use for the following parts, shown below in Table XII. The part that is in contact with food will use Polypropylene and for parts that are not in contact with food will use ABS to minimize the price as possible.

TABLE XII
MATERIALS USED FOR EACH PART

Function Part:	Material Used:
Spinner	ABS
Spinner Handle	ABS
Spinner Brake	ABS
Lid	Polypropylene
Bowl	Polypropylene
Die Slot	Polypropylene
Basket	Polypropylene
Spinner	ABS

F. Phase 4: Detailed Design

In order to create and develop the new design of the salad spinner, the characteristics of the key components which are *handle attached on the lid* (applying the concepts of ergonomic and detachable), *blade die located on the lid*, *basket* (cutting board inspired), and *quadrilateral shape of the basket and bowl* (storage utilization) are taken into considerations. Illustrated in Figs. 17-20 are the 3D CAD models of the lid, basket, and bowl designs.

I. Lid

As the lid is designed to be multifunctional, there are several functions that will be included, these functions are as follows.

1) Hand Spinner

The hand spinner will be designed to be able to fold/remove during storage and able to pull up/re attach during in use.

2) Brake

The brake will allow the user to stop the spinning basket without forcing at the handle to extend the product's life span.

3) Filling hole

The filling hole is designed to allow the user to fill up the water without taking the lid off to reduce time loss in meal preparation.

4) Drainer

The drainer is designed to allow the user to drain water without taking the lid off to reduce time loss in meal preparation.

5) Die slot

The die slot is designed for the user to be able to insert their desired type of cut by inserting a cutting die of their choice. The die slot is also designed to be able to stack up to obtain maximum utilization of space. The die for inserting the die slot will be designed based on basic cuts.

6) Die cover

The die cover will be the cover part of die section, to keep the die clean and make the appliance surface flat to optimize storage space.

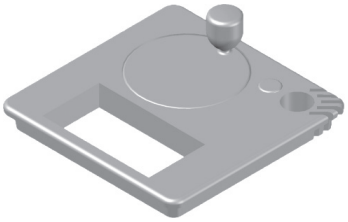


Fig. 17. CAD model of conceptual lid design.

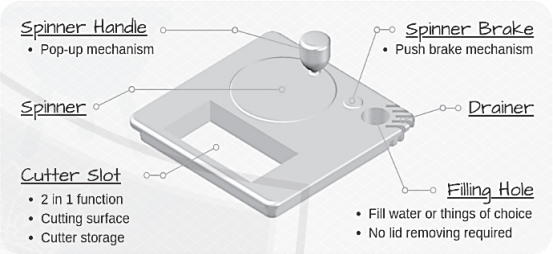


Fig. 18. Functions of the conceptual lid design.

II. Basket

The basket is designed to be able to cut the food on its base, with the blade slot designed to guide the blade while cutting. The drainage slot will be designed to have angle outwards, to provide the optimal drainage of the water after food washing.

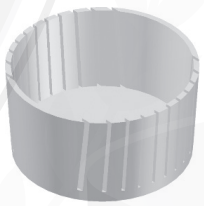


Fig. 19. CAD model of conceptual basket design.

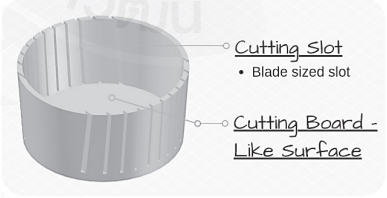


Fig. 20. Functions of the conceptual basket design.

III. Bowl

The bowl is designed to be microwavable and dishwasher safe, an anti-slip will be attached underneath to keep the bowl in place. Moreover, the bowl can be separated from the lid and basket to be used as a salad bowl itself. The dimension of the bowl will be compatible with the living space our target customer has.

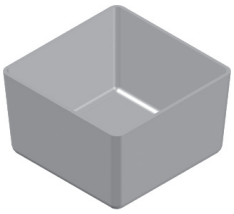


Fig. 21. CAD model of conceptual bowl design.

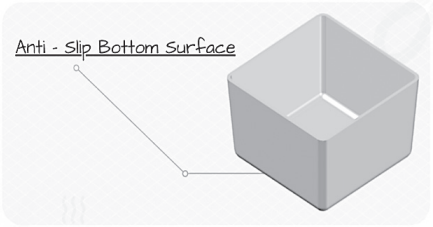


Fig. 22. Functions of the conceptual bowl design.

After combining all components, the 3D virtual model was established (Fig. 20) and this model was ready for fabricating in rapid prototyping (RP) process explained in the next section.

Presented in Fig. 24 is the overall details of the "*Sallatë*" salad spinner where the dimension and brief description of each component will be mentioned and expressed.

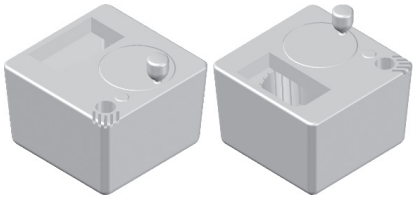


Fig. 23. 3D virtual model of the "Sallatë" salad spinner.

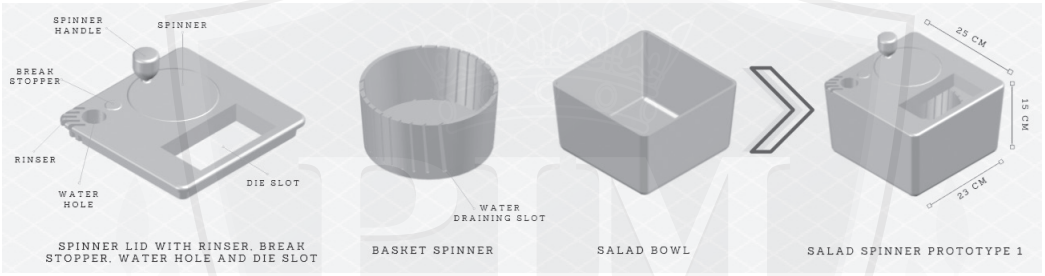


Fig. 24. The overall details of the proposed salad spinner model.

G. Phase 5: Testing and Refinement

After 3D model has been made by using SolidWorks, Rapid prototyping (RP) method has been used to create a prototype by using 3D printer. *XYZ da vinci 1.0A 3D printer* operated by using fused filament fabrication (FFF) technique. The material used is ABS plastic, which gives high strength and durability, as mentioned earlier in Table VII the material can be formed into different layer of the workpiece. The 3D printing is used for the salad spinner prototype model, the 3D printer layers the ABS plastic layer by layers into a salad spinner geometry shape. Fig. 25 is the prototype of the salad spinner printed by the 3D printer using ABS plastic.

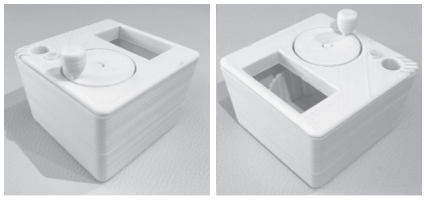


Fig. 25. Real picture of RP (Scale 1:3).

IV. Discussion and Conclusion

From the results above, the concept design of this product were occurred from the survey of customer's demand. Integrating between design and function is applied into the design of the product in order to satisfy demand of customer. The guidelines/criteria for creating the proper salad spinner are as follows.

- *Spinner:* cone-shaped handle, and 360-degree rotating system
- *Lid:* a four-sided shape with tapered design, organized layout for small draining sockets, brake system, and extra die/cutter
- *Basket:* tapered cylinder basket with organized draining sockets
- *Bowl:* a four-sided shape with anti-slip buttons underneath the bowl

After the core idea is acquired, mechanic and material parts are considered. From the results acquired earlier, 3D CAD model is constructed to show the design and rough function of the product. Next, material part is considered. Then, a prototype is created to show the appearances of the first phase

of product design. For further design, the mechanism part will involve the concept design with 3D CAD model to demonstrate how concept product will work. To produce and inject a new plastic mold, the mold costs 70,000 THB each. The price for polypropylene plastic is 79 THB [4] per kilogram, and for ABS plastic the price is 57 THB [4] per kilogram, for a minimum order of 1000 kilograms. To produce one complete product of the salad spinner, 'Sallatë', 0.165 kilograms (with a safety factor of 10%) of ABS plastic will be used for three parts; lid, gear, and cutting die. As for polypropylene plastic, 0.275 kilograms (with a safety factor of 10%) will be use for three parts; bowl, basket, and basket lid. To achieve this unit price, corresponding with the minimum order, the amount of ABS plastic required is 1000 kilograms in order to produce 6060 pieces, and 1665 kilograms of polypropylene is required in order to produce 6054 pieces for this unit cost price. The processing cost for the "*Sallatë"* includes 1,000,000 molding cycles with 160 THB for the price per cycle, amount to a cost of 350,000 THB for the price of mold (five molds are selected), which is 457 THB for processing cost per unit. For a total of 6000 units, 546 THB will be the cost of material and processing cost per unit, and plus a 30% profit 710 THB will be the selling price of the "*Sallatë"*. Nevertheless, in case of injecting a new plastic mold, the cost might be quite high for a university research project; our group has another alternative way to direct this know-how as well. We can also do a flow analysis of how the water flows in and out of the basket. Also, the prototype design refinement will take place in upcoming events as we rendered material 3D model and animate the salad spinner demonstration.

References

[1] Urban Population of Thailand, (2018, Oct.) The World Fact-book. [Online]. Available: https://bit.ly/1nk5eRW

[2] Maharusee Yamee (2015, May). Journal of Public Health Nursing. Insecticides Near Disaster. [Online]. 29(2). [Online]. Available: https://bit.ly/2CN442j

[3] Salad Spinner LOVKITCHEN. (2018, Oct.). [Online]. Available: https://amzn.to/2AdqjfC.

[4] Bank of Thailand, (2018, Oct.). Daily Foreign Exchange Rates. [Online]. Available: https://bit.ly/2OpnRv0

[5] Norpro Mini Salad Spinner. (2018, Oct.). [Online]. Available: https://amzn.to/2CQnseQ

[6] Prepworks by Progressive Collapsible Salad Spinner. (2018, Oct.). [Online]. Available: https://amzn.to/2EooeBr

[7] Hand-Powered Food Chopper Salad Spinner Vegetable Mixer. (2018, Oct.). [Online]. Available: https://bit.ly/2NKfLrF

[8] Vegetable Dehydrator. (2019, Feb.). [Online]. Available: https://bit.ly/2GuWxam

[9] WT Stainless Steel Vegetable Salad Spinner. (2019, Feb.) [Online]. Available: https://bit.ly/2trtmg0

[10] Green and White Manual Rotate Vegetable Salad Spinner. (2019, Feb.). [Online]. Available: https://bit.ly/2TOezrb

[11] Eco-Friendly Salad Spinner with bowl. (2019, Feb.). [Online]. Available: https://bit.ly/2GO28b5

[12] Micronware Salad Spinner. Available: https://bit.ly/2Cml0Mo (2018, Oct.). [Online].

[13] GEFU Salad Spinner ROTARE. (2019, Feb.). [Online]. Available: https://bit.ly/2S8UM45

[14] ZTS Kitchen Cook Fruit Vegetable Salad Spinner Dryer Colander Strainer Sifter Tool. (2019, Feb.). [Online]. Available: https://bit.ly/2EfLkbo

[15] Multifunction JUMBO 4.5 QUART. (2018, Oct.). [Online]. Available: https://bit.ly/2GKdlto

[16] GEFU Salad Spinner Speed Wing. (2018, Oct.). [Online]. Available: https://bit.ly/2EeD77c

[17] Kitchen Master All-in-One Salad Maker. (2018, Sep.). [Online]. Available: https://bit.ly/2PGaVxH

[18] Presses Salad Spinner. (2018, Oct.). [Online]. Available: https://ebay.to/2Ox3jRC

[19] Chris Adams (2018, July). Height Standards for Kitchen Countertops. ThoughtCo. [Online]. Available: https://bit.ly/2A1KtYb

[20] Quadrilateral and round shape kitchenware. (2019, Jan.). Available: https://bit.ly/2H54sur

[21] Mandolin Slicer. (2019, Jan.). [Online]. Available: https://bit.ly/2SJzjUu

[22] Properties of Polypropylene. (2018, Nov.). [Online]. Available: https://bit.ly/2z9P0aX

[23] Advantage of Polypropylene. (2018, Nov.). [Online]. Available: https://bit.ly/2PyIFjL

[24] Properties of ABS. (2018, Nov.). [Online]. Available: https://bit.ly/2Pp59U6

Suchada Rianmora is a lecturer in School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand.

She received her D.Eng from Asian Institute of Technology, Thailand. Her research interests are reverse engineering, rapid prototyping, design and development, and manufacturing processes.

Dulyawat Padnoi is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. His research interests are the product design and development, manufacturing process design, and rapid prototyping.

Tanapoom Rattanopas is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. His research interests are Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), reverse engineering, product design and development, and finite element analysis.

Boonyanuch Yantabutr is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. Her research interests are reverse engineering, instrument process control, and product design and development.