

Auto Spatula, an Automatic Spatula with Mechanical Coil Concept, for Helping Seniors to do Cooking Activity: A Stage-gate Approach

Debrina Puspitarini, Radhianisa Iगतama, Fandi Ario Setiawan, and Akhmad Musthaza

Abstract-- Cooking activity is an essential part of living. However, for elderly this activity may come hard as they don't have much power and energy. A need of supporting apparatus to help the elders is risen. This also applies to they who don't have enough time to cook. By using a stage-gate approach, a research to develop a new tools that will help the elders to do cooking activity was conducted. The analysis conducted in the development process of Auto Spatula will not only includes the analysis of engineering aspect, but also includes the analysis of ergonomics. Next, financial analysis is also conducted to the product in order to see the feasibility of launching Auto Spatula to the market.

Keywords-- elder,ergonomics,spatula,stage-gate approach.

I. INTRODUCTION

ELDER people are people above 55 years old. In Indonesian population, elderly age group's number exceeds other age group and increases every year. In 2013, it is estimated that there are 31.807.700 elder people. Along with Indonesia's development, its people's life expectancy increases. It shows that Indonesia has huge marketing potency for products which elders are being the market.



Fig.1 Indonesia's citizen age group proportion

Human's organs and senses functions decline as in elder people.

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This age group is a non-productive age group in which people retired, thus spending much times in their house and doing activities like reading, gardening, cooking, cleaning the house, and watching TV. In Indonesia, 51% of elders are females, thus we focus on female elder's most common activity, which is cooking.

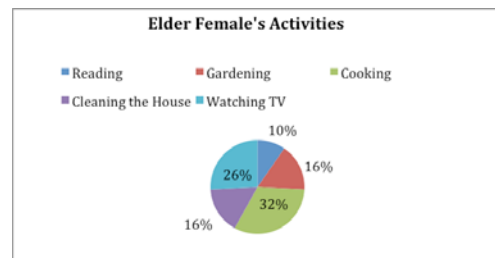


Fig. 2 Elder female's activities

Time spent on cooking is approximately two hours every day. There are some steps in cooking. The most dominant and time-consuming step is stirring. Most foods such as pudding, porridge, and cake / doughnut, Gulai, Bubur Kacang Ijo, Pasta Sauce, and Pasta need to be stirred simultaneously which is quite troublesome.

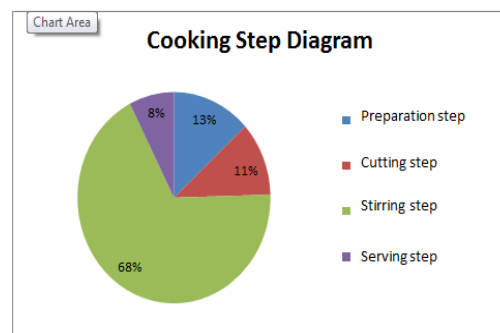


Fig. 3 Cooking step diagram

Can be seen in the diagram above that stirring manually is a tiresome activity for the elderly. In addition, from RULA calculation ergonomics to the activity, showed that the activity manually stirring the needed Necessary investigations and posture changes as soon as possible. Based on that, it means we need a new tool that can replace the manual stirring activity. This paper will discuss the development of Auto

Spatula products that can help seniors in cooking, the process of new product development stage gate method.

II. METHOD

New product development is a key factor to the successful product strategy and thus, one of the most important components of a firm's competitiveness [1]. The method and case studies presented in this paper will be useful to any industry that designs and produces consumer products. Product development is an interdisciplinary activity requiring contributions from nearly all the functions of management systems.

New Product Development (NPD) is the procedures and methods used to design the company's new product and bring it to the market [2]. In product innovation, there are several methods that can be used, the spiral model, the staged model, stage-gate model, and hybrid model. Spiral model is usually used to develop products that rapidly change, as well as services related to technology. By using this method, we can repeat / returning to a stage at any time when it is necessary. Hybrid model is a combination of staged models with spiral models. In contrast, when using a staged model we cannot easily go back to previous stage. We have to finish all the stages in the staged models, and if you want to repeat / returning to a phase, then you should really start again from the early stages of staged models and finish it to the end.

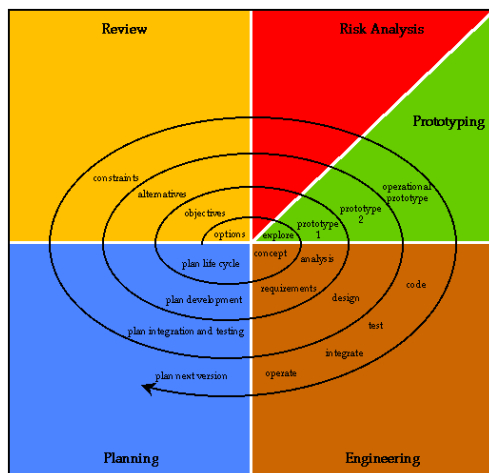


Fig.4 Spiral model

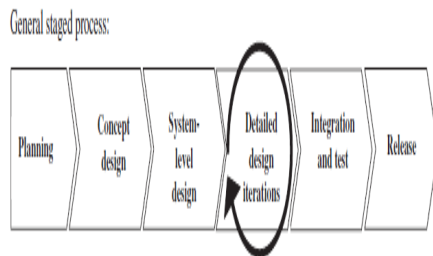


Fig. 5 General staged model

Stage-gate model consists of a stage or stages in the product development activities, and the gate (the gate), which acts as a quality control and checking of decision points [3]

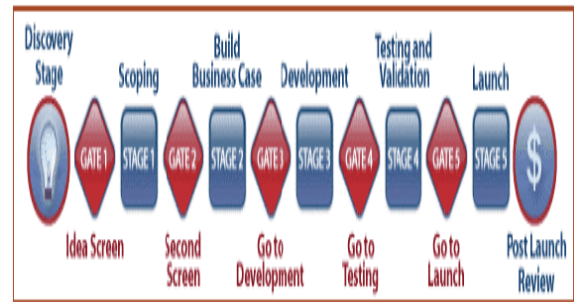


Fig.6 Stage gate model

In the stage-gate model, we can go back to the previous stage, but it is not as flexible as spiral models. There is a checkpoint gate that determines whether the product will be continued or discontinued. If terminated, the product development process is repeated again from the beginning (can not directly back to the desired stage). However, its benefit compared to the staged model is that we do not have to do all the stages until the end of the product development process and repeat from the earliest stage again if we want to go back to the previous stage.

Therefore, the authors use the stage-gate method because of its superiority over the staged models. Moreover, this method is suitable for product that has a long life cycle.

III. RESULT AND DISCUSSION

A. Discovery

Idea generation to identify the implicit needs of consumers and the areas of potential demand on a product, several analysis schemes have been developed. The analysis schemes include several means to apply human factor disciplines to generate new ideas.

In generating a variety of product innovation ideas, we use brainstorming method. Each author proposed at least one idea of product that will be develop.

Next we give ratings and weighted scores for each idea of product that will be developed initially. Rating and weighted score covering 5 aspects, including originality, market, technical, environmental, and product life cycle. Weighted score on originality aspect is 40%, 15% on market aspects, technical aspects is 15%, 15% on environmental aspects, and aspects of the product life cycle is 15%. The results showed that Auto Spatula is a product that has the highest total score. To sum up, we chose this product to be developed.

B. Scoping

To protect the copyright of product innovation idea, a copyright of product is needed. From patent analysis and patent design ,these innovations products has a high chance of market competition :

1. *Rotating Cooking Spatula*

By :Keith Harold Slinker.

Patent Number :US4095832 A

Date of Publication :June,20,1978

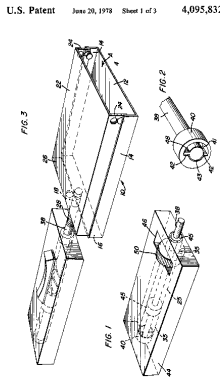


Fig. 7 Rotating cooking spatula

2. *Food Flipping and Turning Spatula*

By :Wong Don M

Patent Number :US8303166 B2

Date of Publication :May,30,2012

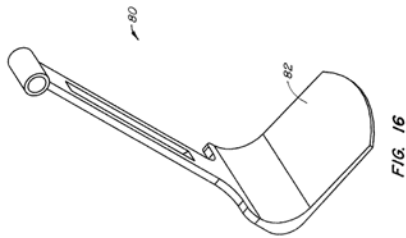


Fig. 8 Food flipping and turning spatula.

3. *Rotatable Spatula*

By :Hilderbrandth Kenneth D.

Patent Number :WO 053727 A1

Date of Publication :May,30,2012

(Picture is not provided.)

With no same feature and design of Auto Spatula design with previous patents,Auto Spatula is not violating patent copyright and can be patented for protection of idea and innovation copyright.

Description of patent that will be submitted:

1. Adjustable Strecher Hook and Holder
The holder for cooking container of Auto Spatula can be adjusted for any size of cooking container.
2. Design of Spatula
The special design of spatula to mix the cooking effectively.

The process of identifying consumer needs is an integral part of the larger product development process and most closely related to the conceptual design, design selection, competitive benchmark- ing and the establishment of product specifications.

Needs are largely independent of any particular product while the concept of specification is heavily dependent upon the product itself. Because of this characteristic, although manufacturers argue that they fully recognize the impor- tance of consumer needs, systematically including a process that incorporates user's viewpoint and implicit needs on a product has been difficult to realize.

From the interview and questionnaire, we got the elderly women's needs. Some difficulties faced during food stirring are Long stirring time, Fatigue caused in feet and wrist, Frequent food spilling during stirring, Forgetting to stir continuously, Hot steam burn due to prolonged stirring time.

Auto spatula presents to overcome the difficulties faced by seniors. Auto Spatula is composed of three major parts, the stirrer, holder, and spring spiral rotator. Materials used is safe for food and will not affect its taste, thus there is no need to worry about this product's safety for their food. Material used for the hook to pans is isolator in nature so the users don't have to worry in using it.

TABLE I
PRODUCT SPECIFICATION

No	Specification	Description
1	Available diametre of holder	160mm - 320 mm
2	Available depth of mixer	120 mm - 400 mm
3	Spring	flat spiral spring
4	material of spring	Stainless steel EN 10270-3-1.4310
5	Rate, Nmm per degree of torque	0.43
6	Number of coils	8
7	Thickness of spring	0.6 mm
8	Width of spring	6 mm
9	Diametre of spring	50 mm
10	Strain energy stored in the spring	562m

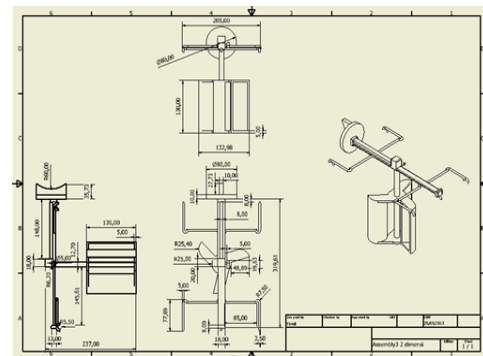


Fig.9 Sketch of Auto spatula

C. *Business Case & Plan: Flowchart Process*

At this stage, authors conducted financial analysis to see whether Auto Spatula is feasible to be marketed or not.

In terms of financials, there are four parameters that we use to assess the project's feasibility of auto spatula, such as NPV, IRR, B/C Ratio and Payback Period. If $IRR > MARR$ and $NPV > 0$, then a business is said to be financially viable. Calculations and financial analysis we have done is the 5-year time horizon. From the table above it can be seen that the IRR of this project is 46%, while NPV is equal to Rp287,085,445. Having done the calculations and financial analysis with a time horizon of 5 years, it was found that the payback period of the project is in the 3rd year. The B/C ratio of this project is 1.65 which is higher than 1. It means that this project has greater benefits than its cost. From the assessment of the project using the 4 parameters above, it was concluded that the project is financially feasible.

D. Development

DFMA is used for three main activities: [4]

1. As the basis for concurrent engineering studies to provide guidance to the design team in simplifying the product structure, to reduce manufacturing and assembly costs, and to quantify the improvements.
2. As a benchmarking tool to study competitors' products and quantify manufacturing and assembly difficulties.
3. As a should-cost tool to help negotiate suppliers contracts

In this section, authors started to develop product from engineering aspect and ergonomic aspect. It is now necessary for designer to use DFMA (Desain for Manual Assembly) for reducing production cost.

Moreover, by using DFMA method, designer will be easier to develop and optimize the used materials. For the design or manufacture of a product based on DFMA, so the first timewere are doing is to record the state of the components we produce. The components that we need to know are Depressions, Uniform Wall, Uniform Cross Section, Axis of Rotation, Regular cross Section, Captured Cavity, Enclosed Cavity, No Draft. Next, based on which we will form part of manufacturing, we can adjust the existing manufacturing processes in accordance with the conditions of the part that we want:

Part Component	Dep	Uni	Uni Sec	Axs Rot	Reg Cros Sec	Capt Cav	En Cav	No Dra
stirrer	V	V	V	V	X	V	V	X
holder	V	V	X	V	X	V	V	X
hook	V	V	X	V	X	V	V	X
knob	V	V	X	V	X	V	V	X

Fig.10 Expectations of product

Part Component	Sand Casting Investment Casting	Die Casting Injection Moulding	Structural Foam Moulding	Blow Moulding (extr)	Blow Moulding (inj)	Rotational Moulding	Impact Extrusion	Cold Chasing Forging	Hot Forging	Powder Metal Processing	Hot Extrusion	Rotary Swaging	Machining	E-DM	EDM	Wire EDM	Sheet Metal	Thermoforming	Metal Spinning
Stirrer	V	V	V	X	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Holder	V	V	V	V	X	X	V	V	V	V	V	V	V	V	V	V	V	V	V
Hook	V	V	V	V	X	X	V	V	V	V	V	V	V	V	V	V	V	V	V
Knob	V	V	V	V	X	X	V	V	V	V	V	V	V	V	V	V	V	V	V

Fig. 11 Machine selection

Ref. No.	Description	Part Name	Thickness Size	Material	Primary Process	Secondary Process	Tertiary Process	Part Size (mm)	Tolerances	Surface Finish	Shapers Compatibility	Process Limitation	Typical Application	Notes	Comments
1		Stirrer	1.34 41 3.60 0	Stainless Steel	Die casting	Drilling tapping	machining	Min wal 0.05 Min hole dia 0.1 Max Weight 20	±0.003 (in.) ±0.006 (in.) Add 0.004 across parting line or moving core	32-85 µin	Similar to injection moulding	Trimming operation required for flash and over flow removal. Porosity can be present. Die life limited to approximately 200k shots in AL	Similar to injection moulding in part geometry, but particularly suited where higher mechanical properties or the absence of creep are required	5.6.2.3	Produce thin set wall of all casting process production rate approximately 150 parts per h. Tooling cost and lead time similar to that for injection moulding but timing an surface treatment can make process less economic

Fig. 12 Design for manufacturing stirrer

Ref. No.	Description	Part Name	Thickness Size	Material	Primary Process	Secondary Process	Tertiary Process	Part Size (mm)	Tolerances	Surface Finish	Shapers Compatibility	Process Limitation	Typical Application	Notes	Comments
2		hook	305 360 360	Stainless Steel	Injection molding	Cutting, tapping	Injection molding	Envelope 0.01 in. 3-6000 Wall 0.03-0.250 in	General: ±0.003 (in.) 3-25 pin. ±0.008 (in.) Hole dia: ±0.001 (in.) Flatness: ±0.002 in. in increase to 1/4 for each additional inch cavity increase tolerance: ±0.004 for dimensions across parting line	8-25 µin	Small-to-medium sized parts with intricate detail and good surface finish	Tooling is costly and requires greater lead time than most alternative processes. Poor design can result in high levels of moldable stress, resulting in warpage or failure	10.11	Typical cycle time 20-40 s. Details such as living hinges, insert molding and many features allow significant opportunity for part consolidation. Injection molding of thermoplastic materials also possible. Longer cycle time, no repricing of waste, generally harder, more brittle, but more stable material which can be used at higher service temperatures	

Fig. 13 Design for manufacturing hook

Ref. No.	Description	Part Name	Thickness Size	Material	Primary Process	Secondary Process	Tertiary Process	Part Size (mm)	Tolerances	Surface Finish	Shapers Compatibility	Process Limitation	Typical Application	Notes	Comments
3		knob	10 300 300	Stainless Steel	Injection molding	Cutting, tapping	Injection molding	Envelope 0.01 in. 3-6000 Wall 0.03-0.250 in	General: ±0.003 (in.) 3-25 pin. ±0.008 (in.) Hole dia: ±0.001 (in.) Flatness: ±0.002 in. in increase to 1/4 for each additional inch cavity increase tolerance: ±0.004 for dimensions across parting line	8-25 µin	Small-to-medium sized parts with intricate detail and good surface finish	Tooling is costly and requires greater lead time than most alternative processes. Poor design can result in high levels of moldable stress, resulting in warpage or failure	10.11	Typical cycle time 20-40 s. Details such as living hinges, insert molding and many features allow significant opportunity for part consolidation. Injection molding of thermoplastic materials also possible. Longer cycle time, no repricing of waste, generally harder, more brittle, but more stable material which can be used at higher service temperatures	

Fig. 14 Design for manufacturing knob

In developing new product, engineering aspect is not the only thing that needs to be considered. Thus, the authors also consider about ergonomics aspect of the product. More innovation done in the world cause more products sold to the people.

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well being and overall system performance [5].

Ergonomics problem space contains all elements of the total human-environment system, comprising people’s interactions with hardware; software, firmware (including space), and other people both individually and as social groups.

According to ergonomics science, product design work can make users at ease if it has practicality through effective motion according to motion economy principle. Motion study analysis is a method we use in our product design work. Its analysis purpose is to eliminate ineffective motion and give specific movement design.

First, we try to evaluate the ergonomics point when seniors use traditional spatula. We use motion study and RULA evaluation for ergonomics analysis. We describe the movements of the seniors when cooking using traditional spatula among is: Seniors must stand in quite a long time, and then holding the traditional spatula and stir it across the pan. After some time doing so, senior will stop stirring in order to take a rest because this activity is quite tiring. From the description, it can be noted that there are two ineffective movements according to the Therblig, which are “hold” and “rest to overcome fatigue”.Figure 15 showing us all of the effective Therbligs [5] in Auto Spatula motion.We calculated the RULA score for manually stirring activity and we got the result as shown in the table II .

TABLE II
RULA SCORE

Action Level	
1,2	Acceptable
3,4	Investigate Further
5,6	Investigate and Change Soon
7	Immediate Action

From the final score of RULA analysis it can be concluded that it is needed *necessary investigations and posture changes as soon as possible*.

Therefore, we try to develop the tools to help cooking for seniors, namely auto spatula. We also conduct analysis of ergonomic to the seniors when using auto spatula. We got RULA final score of 2 which means that the observed posture is acceptable if not performed continuously on long term. Therefore, we conclude that using auto spatula can reduce the risk of MSD.

Another consideration in designing product is anthropometry. Body dimensional data is very important for user easiness. Anthropometry data we used is human’s hand dimensional data. We use anthropometry analysis in determining some sizes in our product such as:

1. The Spring Constant for “Auto Spatula” Hook

Above 55 years olds, human’s muscle strength will be 35-45% lower than in the prime youth, even though its decline varies according to muscle group and gender. Hand grips strength needs combination of action from several hand and forearm muscle, and this action is very important for many daily activities. From data collected, elders’ hand grips strength ranges from 13,57 to 30 (in N). The value becomes the basic of spring constant we used in the product so changing the diameter will not be difficult for the users of “Auto Spatula”. Therefore, we design Auto Spatula using spring constant of 16.67 N/m.

2. Stirrer’s Height

Suitability of its height to pans used for cooking is crucial as well. Pans available in Indonesia have maximum 30 cm and minimum 12 cm in height. It will minimize the risk of spills resulting from the process of incorrect stirring. Thus, we design the stirrer of Auto Spatula with 10 cm in height.

3. Turning Knob Size to Human’s Finger Size

Size determination design also pay attention to ease and security of users in turning the knob to use the “Auto Spatula”. Average Indonesian finger as a reference design is 6 cm. High compatible design with users is very important to reduce dangers and losses due to nonconformity of product and users. Therefore, we design the knob of Auto Spatula with 6 cm in diameter.

4. Market Testing & Validation

We do alpha testing for Auto Spatula by distributing questionnaires to senior citizens while showing the design

Effective Therbligs		
Therblig	Symbol	Description
Reach	RE	Motion of empty hand to or from object; usually preceded by Release and followed by Grasp
Move	M	Movement of loaded hand; time depends on distance, weight, and type of move; usually preceded by Grasp and followed by Release or Position
Grasp	G	Closing fingers around an object; begins as the fingers contact the object and ends when control has been gained; depends on type of grasp; usually preceded by Reach and followed by Move
Release	RL	Relinquishing control of object, typically the shortest of therbligs
Preposition	PP	Positioning object in predetermined location for later use; usually occurs in conjunction with Move, as in orienting a pen for writing
Use	U	Manipulating tool for intended use; easily detected, as it advances the progress of work
Assemble	A	Bringing two mating parts together; usually preceded by Position or Move; followed by Release
Disassemble	DA	Opposite of Assemble, separating mating parts; usually preceded by Grasp and followed by Move or Release

Fig. 15 Design for manufacturing knob

of auto spatula. The result of the questionnaire showed that more than 50% of seniors are interested in buying Auto Spatula. Next, we do the beta testing for our products through exhibitions at shopping malls in Yogyakarta. Approximately 70% of visitors who came to our booth are interested in our products and want to buy Auto Spatula.

5. *Product Launch*

A good marketing strategy is needed to launch a product. Besides, the “unique” quality of the product must be known by the customer, especially in product launch stage. The excellence feature of Auto Spatula is as an automatic stirrer in order to reduce fatigue on the body especially the wrists, arms, and legs during cooking. The excellence features of Auto Spatula can be viewed from Health, Comfort, and Safety perspectives.

6. *Health Perspective*

Based on surveys we've done, it is known that the elders have to stir cuisine in a fairly long period of time that can lead to fatigue on the wrist, arm, and also legs because seniors are required to remain standing while stirring the food. With the presence of our products, the seniors do not need to stir the food, so that cooking will not tire seniors anymore.

7. *Comfort*

Our stirrer that we design serves to improve the comfort and ease an elder to stir dishes, especially if cooking in a sizable amount. Ergonomics is the study of human factors. We realize that comfort factors become very important which certainly is considered by every seniors. For that, we design the Auto Spatula based on Woman Adult anthropometry. Additionally Auto Spatula can also be used in various types of pans because of its size can be changed according to the pan used.

8. *Safety*

In addition to attention to comfort and health, to design a good product should be able to pay attention to the safety factor of the product users. Our products are made of an insulating material so it will not cause the heat on hand when seniors use the tool to stir the food. In addition to the materials we use to make this product will not change the flavor and color of food.

IV. CONCLUSION

Auto spatula make a good support for elders to help them in cooking activity. All of auto spatula's feature is suited for ergonomics for seniors. With more than 50% of seniors are interested in buying and 70% of visitors who came to our booth in an exhibition are interested with auto spatula, it makes a good opportunity in the market competition. Auto spatula's high value is the ergonomics based on woman adult anthropometry, safety, time-efficient and suited for most size of pan.

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