PERANCANGAN WADAH PEMISAH KULIT ARI KEDELAI MENGGUNAKAN METODE *REVERSE ENGINEERING* GUNA MENGURANGI WAKTU SIKLUS

DESIGNING SOYBEAN PEEL SEPARATOR CONTAINER USING REVERSE ENGINEERING METHOD FOR DECREASING THE CYCLE TIME

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Abstrak

Ada tujuh tahap inti dalam proses pembuatan tempe yang dibagi menjadi 2 area; area basah dan area kering. Area basah adalah area produksi dengan menggunakan air dalam setiap proses dan itu membutuhkan banyak waktu siklus daripada area kering. Waktu siklus dari area basah adalah 115 menit dan menghabiskan 1085 liter air untuk menghasilkan 60 kg tempe. Salah satu proses dari area basah adalah pemisahan kulit kedelai menggunakan media air dengan waktu siklus adalah 45,59 menit. Objek penelitian ini adalah area basah pada produksi tempe di Rumah Tempe Indonesia, Bogor untuk mengurangi waktu siklus dengan merancang mesin pemisah kulit kacang kedelai. Penelitian ini dilakukan dengan menggunakan metode reverse engineering dengan melakukan analisis mendalam terhadap alat-alat yang digunakan dan mengembangkan alat pemisah kulit yang ada berdasarkan kebutuhan pengguna. Concept screening dan concept scoring dilakukan untuk memilih salah satu konsep terbaik dari 48 konsep yang mungkin di terapkan. Hasil dari konsep yang dipilih dari pemisah kulit kacang kedelai adalah kebutuhan akan motor penggerak sebagai sumber energi pengganti untuk kekuatan operator dan mekanisme untuk memisahkan kulit dan kedelai menggunakan kekuatan air dari bagian bawah wadah. Setelah itu, konsep akan dilakukan dengan membuat prototipe dan pengujian di Rumah Tempe Indonesia dengan hasil waktu siklus setelah menggunakan konsep usulan adalah 70,77 menit untuk semua proses di area basah, yang berarti waktu siklus menurun 39%.

Kata kunci : waktu siklus, tempe, pemisah kulit kacang kedelai, *reverse engineering*

Abstract

There are seven core stages in the process of making tempe which are divided by 2 area; wet area and dry area. Wet area is the production area by using water in each process and it's need much cycle time than dry area. The cycle time of wet area is 115 minutes and it spend 1085 liter of water to produce 60 kg of tempe. One of the process of wet area is separation of soybean's skin using water as its media, with the cycle time is 45.59 minutes. The object of this research is the wet area on tempe production in Rumah Tempe Indonesia, Bogor to reducing the cycle time by designing soybean peel separator machine. This research was conducted using reverse engineering method by performing in-depth analysis of the tools used and developing the existing peel separator equipments based on user needs. Concept screening and concept scoring are done to select one of the best concepts from 48 possible concepts. The result of the selected concept of the soybean peel separator is the need for a propulsion motor as a replacement energy source for the operator's power and the mechanisms for separating skin and soybeans using water force from bottom of the container. After that, the concept will be done by make a prototype and testing it in Rumah Tempe Indonesia with the result of cycle time is 70.77 minutes for all processes in wet area, which means the cycle time is decreasing 39%.

Keywords: cycle time, tempe, soybean peel separator, reverse engineering

1. Introduction

Tempeh is an Indonesian cultural heritage that is currently also popular in the world. Unlike other traditional soybean foods that usually come from China and Japan, the original tempe comes from Indonesia (Huang, 2000). Rumah Tempeh Indonesia (RTI) is a center of hygienic and environmentally friendly tempeh industry, as well as a tempe-based product development center to serve as a model for every tempe producer and the general public in Indonesia. RTI uses 12 standard stages for tempe production based on Forum Tempeh Indonesia (FTI) which is divided into 2 regions, wet and dry areas.

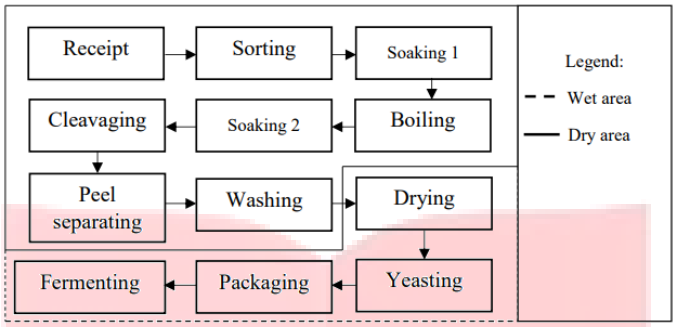

Figure 1 Flow Chart of tempe production
(Source : Rumah Tempe Indonesia)

Based on the production process, the production floor in RTI is divided into 2 areas: dry and wetland areas which can be seen in Figure 1. The wet area consists of sorting, boiling, soaking, division, skin separation, soaking (hot water) and washing. While dry areas consist of drying, fermenting, packaging, and fermentation process. There is a significant difference between dry and wet areas; Wet areas require many processes for each work area, and dry areas are areas that do not require air support. Based on the results of interviews with stakeholders from Rumah Tempe Indonesia, it is necessary to broaden the areas affected by waste on the use of cycle times, air use, and the cost of electricity use. Wet area is an area that involves air to conduct any production activity

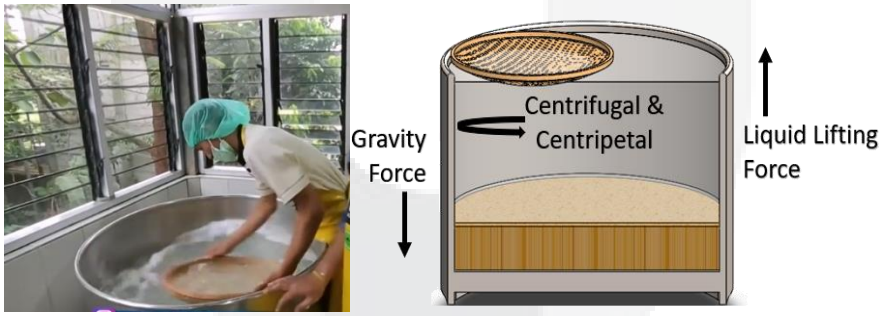

Figure 2 Peel separating process

Skin separation area is an area that aims to separate the skin with soybeans. In this area, the operator separates the soybean peel by placing soybeans and water in a tube and then the water is rotated at a speed of 60 rpm using a sieve. After that, the skin will rise to the surface of the water, then the operator will direct the screen to capture the skin that is on the surface of the water and collect it on the sieve.

Table 1-1 Cycle time in wet area

No	Workstation	Cycle time (minute)	Percentage	Cummulative
1	Peel separating	45.59	39%	45.59
2	Shoots separating	21.23	18%	66.81
3	Washing	43.62	38%	110.43
4	Rest	5.34	5%	115.77
	Total	115.77		

Cycle time is the main factor in increasing the productivity of tempe production, because the time required in the wet area is very long ie 115.7 minutes. After calculation of cycle time in wet area with 3 working area, that is skin separation area, shoot separation area, and stirring area, it is found that skin separation area is work area which has the biggest cycle time that is 45.59 minutes for one batch of production. While the shoot separation area has a cycle time of 21.23 minutes and the stirring area has a cycle time of 43.62 minutes. The impact of long cycle time is the amount of water required and the cost of electricity for tempe production is 1,836.9 liters and Rp 47.659, - / month.

Based on the cycle time description, it can be concluded that it takes the development of production equipment to reduce cycle time in the wet area to reduce cycle.

2. Literature Review

2.1 Reverse Engineering and Redesign Methodology

A deep understanding of the products to be developed is necessary in the development of a product. The basic understanding required in product development is the function, sub-function, or element of the product. Yau et al (1993) defines RE, as "a process of taking new geometries from the manufacturing side by digitizing and modifying existing CAD models".

The reverse engineering and redesign methodology first discovered by Otto and Wood (1998) has three phases. Stages in reverse engineering and redesign methods can be seen in the figure 4.

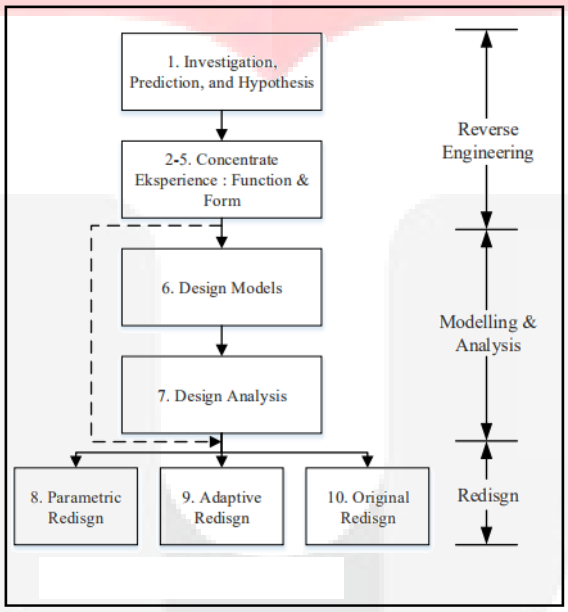

Figure 4 Framework of reverse engineering and redesign methodology
(Source : Otto & Wood Kristin, 1998)

2.1.1 Investigation, Prediction and Hypothesis

The product is treated as a black box, analyzed by operating parameters, and studied based on customer requirements and making hypothesized estimates or functions, product components, and physical principles. (Otto & Wood Kristin, 1998). In this study investigation of existing products by calculating cycle time and movement studies.

2.1.2 Product Decomposition

This phase includes full product disassembly, design for manufacturing analysis, further functional analysis, and final design specifications (Otto & Wood Kristin, 1998). Based on the explanation is disassembly from existing product to be analyzed to existing model and existing specification.

2.1.3 Functional Analysis

After decomposition of the existing product then the next is to perform a functional analysis on the process of soybean skin separation. Decomposition and investigation of the previous process will assist in determining the function to be made. The functions analyzed in this process will assist in the physical design of soybean separator machines.

2.1.4 Constraint Propagation

At this stage an analysis of the relationship of components or elements that exist in the product to estimate the design changes of the products developed.

1. Morphological analysis
2. Product compability

2.1.5 Model Design

This stage is the stage where the target of product development compared with the results of the selected concept. The target obtained is an improvement to the existing soybean queue separator which can ultimately conclude that the chosen model or concept will meet the objectives of the research. The targets of product development are tailored to the technical specifications obtained in the previous process.

2.1.6 Concept Prototyping and Testing

At this stage the process of analysis is done by testing using a prototype made. The prototype test is done directly to get valid cycle time after the repair.

3. Conceptual Model

The conceptual model is a picture of the mindset in solving the problem. Conceptual model of this design of soybean separator machine can be seen in figure 5.

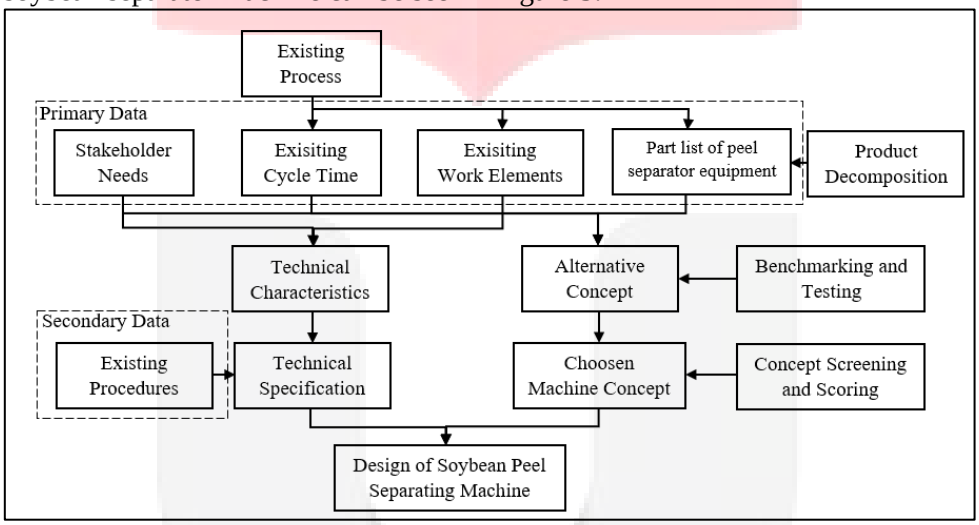

Figure 5 Conceptual model

Technical characteristics are determined by analyzing the work elements and user needs which will then be determined attributes and relationships between attributes and technical characteristics. From the attribute of the product obtained will be an analysis of the relationship of values between attributes. For the physical design of the product, an alternative concept search is obtained by disassembling or decomposing existing products to analyze the function of each element and then perform benchmarking to look for similar components to add or combine its functions based on user needs.

4. Discussion

4.1 Prediction and Investigation

4.1.1 Use of the Past Product

The process of soybean peel separation is a process found in the wet area. This process uses an operator working 45.59 minutes or 115 minutes for cycle time in the wet area for each batch of production (60 kg). This process consists of 2 pieces of components, namely a container to accommodate soybeans and sieves to catch the skin and turn the water. The container capacity in this process is 60 kg and is done by one operator. If production exceeds 100 kg in one day, then 3 pieces of skin separator will be used and require 3 workers only for this process.

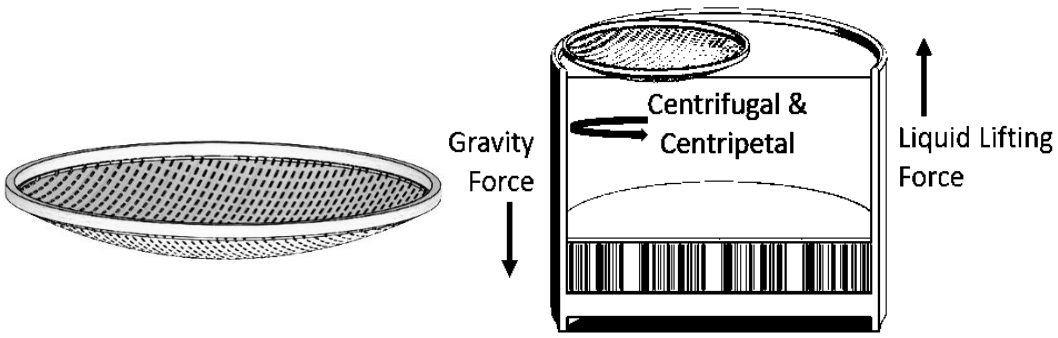

Figure 6 (1) sieve and (2) skin separation mechanism
(Source : Rumah Tempe Indonesia)

The process of soybean peel separation is done by using the operator's power. The operator stirred the soybeans by grabbing the deepest peanut shells by using a sieve and pulling them up. After that, the operator rotates the soybeans by placing a sieve on the surface of the water and rotating it in a horizontal direction that makes the soybean skin rise to the surface. After the soybean peel rises to the surface, the operator will capture the skin on the surface by directing the sieve and moving the sieve following the movement of water at the same time.

The study of movement is an analysis performed on several movements of the worker's body parts in completing his work (sutalaksana, 2006). The object of motion study conducted in this study is the area of work on the process of soybean peel separation. According to the table 4.1.1. there are 4 basic movements used in soybean skin separation process.

Table 4.1.1. Working element of soybean skin separation process

No	Therblig name	Therblig symbol	
1	Reach	RE	
2	Use	U	U
3	Position	P	
4	Release load	RL	

4.1.2 User Needs Identification

User needs is the basis of the purpose of the development of soy bean separator machine. The data obtained is the result of the interview process performed on the user from the soybean peeler. User in this research is Endang as engineer for machine and equipment, and Muhammad Ridha as marketing director. The following is a list of user needs of the soybean peel separation process at Rumah Tempe Indonesia:

1. Soybeans can be mixed without operator assistance.
2. water and soybeans can spin without operator assistance.
3. soybean peanuts and soybean seeds can be separated by the lifting force of the liquid.
4. Soya bean skin can be wasted to landfill with special disposal flow.

After getting the user needs list from the development of soybean peeler machine then the next process is to divide the list of user. This concept is used to separate all possible solutions into different classes that will facilitate comparison and pruning (Ulrich & Eppinger, 1994).

4.1.3 Functional Prediction

After determining the need statement function of the development process of soybean peeler machine, then made solution from design in the form of functional prediction.

Product types:

1. Soybeans can be stirred without operator assistance.
2. water and soybeans can spin without operator assistance.
3. soybean peanuts and soybean seeds can be separated by the lifting force of the liquid.
4. Soybean skin can be wasted to landfill with special disposal flow.

Product criteria:

1. The machine has a motor rotator.
2. The machine is equipped with a stirrer that reaches the base of soybeans.

3. The machine comes with a blade that can rotate water and soybeans.
4. The engine is equipped with a thrust mechanism from the bottom of the container surface.
5. The machine is equipped with a soybean peel disposal path.
6. The machine is equipped with brush.

4.2 Decomposition analysis

4.2.1 Decomposition of Structures

Structure decomposition analysis is done to know in detail each part that is in product to be developed. By performing an in-depth analysis on each part of the product the development of soybean separator machine can be more easily done. The existing soybean skin separator has 2 pieces of part. The first part is a sieve or sieve made of bamboo. The second part is a container made of stainless steel that serves to hold water and soybeans.

a. Sieve, are used by the operator to stir soya beans so that all soybeans can be separated from their skin. this tool also serves to rotate water so that soybean can rise to the. The sieve is rotated by the operator at a certain speed of rotation.
b. Soybean container, this section serves to accommodate soybeans and air used to separate soybean skin. The container holds soybeans before it is tried with the skin and the more soybeans that are already separated from the skin.

4.3 Technical Spesification

4.3.1 Determining the Targets to be Achieved for Technical Characteristics

This stage is done to know the characteristic so that the target specification of soybean separator machine can be known. The target of each technical characteristic can be seen in table 4.3.1. Target of technical characteristics is a result of combining the existing product with customer needs.

Table 4.3.1 Technical characteristics and targets

No	Technical characteristics	Target	Unit
1	Force needed	1	Hp
2	Rotation of water per minute	60	rpm
3	Blade diameter	16.5	cm
4	Blade length	58.5	cm
5	Water force needed	220	Watt
6	Cycle time	< 115	minute
7	Width of disposal path	5	cm
8	Height of disposal path	5	cm
9	Brush length	25	cm

4.4 Product Morphological Analysis

4.4.1 Product Morphological Chart

The product morophologycal chart is the way in which all product feature choices are made alternative by comparing alternative choices based on existing products. The choice of initial thinking of product development is then combined to create a systematic solution. The result of this morphological analysis is the result of concept selection based on the comparison of existing concepts.

Table 4.4.1 Morphological chart of soy bean separator machine

Function	Existing	Alternative		
		Option 1	Option 2	Option 3
Rotating water and soybean	Sieve	Electric motor	2 stroke motor	-
Mixing the soybean	Sieve	Horizontal flat blade	Vertikal flat blade	High speed blade
Thrust the water	-	Water pump	Compressor	-
Peel and water disposal line	-	Disposal path	Disposal hose	-
Separating the water and peel	Sieve	Nylon brush	Metal brush	-

It can be seen in Table 4.4.1 that the function of the development of soybean separator machine can produce various alternatives to realize it. There are two new functions that appear on the morphology map is the function of the mechanism of water impulse to the surface and the flow of soybean skin disposal. From the results of morphological maps can be concluded that the concept to be developed has the number of combinations that is 2x3x2x2x2 = 48 concepts that can be combined.

An analysis of 48 concepts will thoroughly lead to difficulties and ineffectiveness of the research process. In addition there are several alternatives that can not be realized when compared with the control parameters and quality adjustments that exist in the process of soybean skin separation. After that, the best option will be selected using concept screening and concept scoring..

4.4.2 Selection of Concepts

By using the value of the percentage of weights, the purpose of conceptual filtering can be determined by easier and systematic stages. Percentage of weight is obtained from the calculation of the level of trust obtained by filling the validation form (attachment). Stage concept scoring produces a chosen concept that has been compared with all the concepts being made alternative. Based on the concept scoring results obtained concept that has the highest scoring score is the concept of C, so the concept C will be developed to be the concept of soybean separator skin machine.

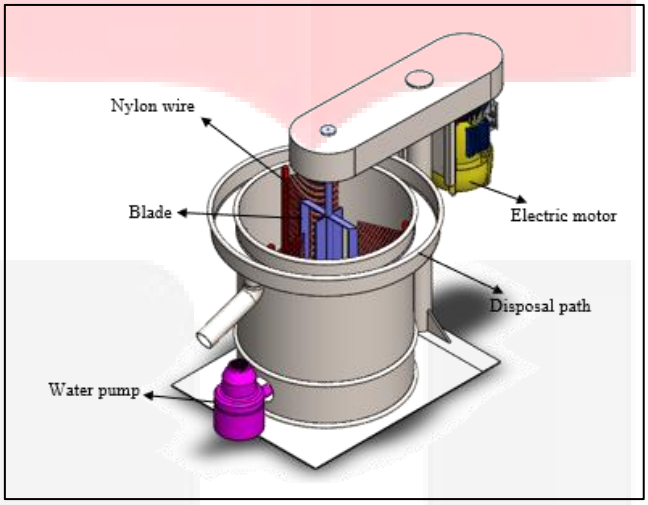

Figure 8 Selected concept

4.5 Prototyping and Testing

At this stage a prototype is made based on the selected design concept. The prototype is made by standardizing the use of existing tools at Rumah Tempe Indonesia. Based on field research conducted at Tempe Indonesia house on April 5, 2018. There are 4 processes calculated by the initial separation process as the longest time consuming process. Recap of time cycle data of proposal can be seen in Table 4.6.

Tabel 4.6 Cycle time after using developed machine

No	**Work elements**	**Cycle time (minute)**	**Percentage**
1	Initial separating	31.5	45%
2	Peel separating	20.14	28%
3	Shoots separating	9.55	13%
4	Hot water flushing	8.02	11%
5	Rest	1.55	2%
	Total	**70.76**	

The initial separation process is the process by which the soybeans that are still united with the skin are incorporated into the soybean skin separator machine that has been developed based on the

selected concept. From the time-consuming cycle of soybean separator area, there are 4 processes performed. In the initial separation process, activities carried out using the proposed tool have been developed. The result of the initial separation is done hygiene calculation by sampling method. Samples taken from the initial separation amounted to 106 soybeans with skin still tied to nuts as many as 63 pieces. The result of hygiene percentage calculation was found to increase the cleanliness percentage by 41%, so the initial separation using existing tools can help the process of skin separation, sprout separation, and washing.

5. Conclusion

The purpose of the development of soybean peeler machine is to get a new concept that can be a solution to the problems that exist in the process of soybean peel separation. The problem is obtained by identifying user needs which in this case consists of marketing director and Tempe Indonesia Home engineer. After that the addition of features on the soybean peel so that the role of operators in this process can be reduced that is the electric motor instead of energy operator. The addition of a thrust force mechanism feature from the bottom of the container serves to separate the soya bean skin assisted by the presence of nylon fibers so that the soya bean skin can be separated from the nut. In addition, the disposal path is added so that the skin can be discharged to the dump quickly.

Table 5.1 Comparation between existing and developed equipments

Chriteria	Unit	Existing	propose	Difference	Reduction
Cycle time	minute	115.77	70.77	45.00	39%
Use of water	liter	1836.90	1072.05	764.85	42%
Use of electricity cost	rupiah	Rp 47,659,-	Rp 31,298,-	Rp 16,361,-	34%

Prototyping and testing was done at Rumah Tempe Indonesia, Bogor. The results of the test show there is a reduction of cycle time by 39% so that the impact to the use of water and electricity usage. By using a proposed soybean separator machine, there was a decrease in the volume of water use and the cost of electricity usage by 42% and 34%. Water volume reduction is caused by a water pump that serves to recycle water to return to the initial separation process, so water is not wasted. While the decrease of electricity usage caused by shorter cycle time, so that the use of electrical component in tempe production process less. Recap of cycle time comparison, water usage, and electricity usage cost can be seen in table 5.1.

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