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Analysis of Components Selection of Oil Draining Machine for Spinner System Based Analytical Hierarchy Process

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ABSTRACT

The function of the oil draining machine is to effectively reduce the oil content in the food from frying. This study aims to analyse the spinner system's components for the oil draining machine using the Analytical Hierarchy Process (AHP) method. The AHP makes broad and unstructured problems into a flexible and easy-to-understand model. This research begins with a study of the initial design of the spinner system for the oil-draining machine components. Then, the characteristics and process parameters (spinner) of the oil-draining machine's parts were analysed using the AHP method. From the analysis results, the new designs were developed by eliminating or combining components that did not add value. The priority of consumer needs for function, performance, ergonomics, durability, serviceability and aesthetics were referenced to make a new design. Then, the new components of the spinner system oil draining machine were developed. Customers' needs for design priority include functionality to drain the cooking oil and crackers, capacity exceeding 3kg, ease of assembly, lightweight, easy to use, stainless steel material, easy to repair and dark colour selection.

KEYWORDS: *AHP, Oil drain machine, Spinner.*

1.0 INTRODUCTION

Along with technological developments, a cooking oil draining machine has been made to reduce the oil content in foods [1] effectively. The function of the oil draining machine is to reduce or eliminate the level of oil attached to the foods from frying. The traditional oil draining technique naturally places the oil content in the foods in a streaming wire container and then airs it out. Sub-sequence, drained snack foods require longer to dry. Therefore, the production period is extended.

Design an oil drainer using the centrifugal (spinner) method to increase the draining ability by increasing the engine rotation speed according to the principle of centrifugal force. The problem is that the higher the rotation, the more the engine vibration will increase. So, to reduce or eliminate this vibration, a sturdy axis is needed when given high rotation [2]. The design of a machine oil drainer with a draining machine tube component is practical when used; the machine is not noisy when operated, there is a rotation speed setting, and the machine is safe when running [3]. Machine oil drainer materials use stainless steel and aluminium due to their ease of cleaning, safety for food, corrosion resistance, and ease of fabrication [2-3].

A product with an efficient design can be reviewed by analyzing the number of components used to assemble the product and the manufacturing process parameters for each component made quickly and at a low cost [3]. The oil-draining machines on the market, such as the centrifugal type, have larger dimensions. Subsequently, the rotation affects the material damage when draining, whereas a more minor rotation can reduce product damage [4]. The system and components of the oil draining machine must be designed optimally. So, the manufacturing process becomes cheap and takes a short time.

In making product design decisions, one of the techniques that can be used is the Analytical Hierarchy Process (AHP). This AHP technique is a decision-support model developed by Thomas L. Saaty, where this decision-support technique describes a complex multicriteria problem in a hierarchical form [5-6]. Many researchers adopt the AHP decision-making method as a problem-solving method compared to other methods. The AHP method can make a hierarchical structure to the deepest sub-criteria as a consequence of the selected criteria. In the AHP method, the choices' validity is carried out as a tolerance limit for the inconsistency of various criteria and alternatives chosen by decision-makers [7]. This paper uses the AHP method to select the optimal components for re-designing oil-draining machine products. Therefore, it can produce new designs that are more efficient by taking into account the functional, performance, ergonomics, durability, serviceability and aesthetic factors.

2.0 FUNDAMENTAL THEORY

2.1 Oil Draining Machine

A draining machine is a type of machine that serves to drain cooking oil. The draining machine also removes the oil content by draining the container. The draining machine is made based on a centrifugal system, where the material to be drained is put into a container and then rotated at high speed. High spin will throw the oil contained in the food [8]. Therefore, the oil content in food can be drained to dry. It can help improve eating quality, as food will taste savoury, crunchy, delicious and last longer. Then, a drying machine can speed up and optimise the oil draining in fried foods.

The draining machine has two tubes mounted on one shaft; the first is a drain tube, and the second is a connecting tube [9]. The draining machine has a single transmission system: a pair of pulleys connected by a V-belt, and the driving source or player is an electric motor [10]. The working principle of an oil draining machine is almost the same as the working principle of a washing machine when in the drying process, which utilises the centrifugal force that arises due to rotation. The washing machine uses centrifugal force, and the drainer uses the same force to filter the oil [9].

2.2 Product Development

Design is the process of translating an idea or market need into detailed information. The product can be made according to the type of design that is divided into three [11], namely:

- Original design is a new design that never existed before. The developer must think as broadly as possible about all possible solutions and choose one.
- Adaptive or experimental design is looking for a better change in the performance of the designed tool through improving the working principle. This type of design allows development in the material for which the tool is designed.
- Variant design is a design process where the dimension or detail scale of the designed tool is changed without any change in the function or working method of the tool.

Product design is the process of imagining a design and creating and improving it. That may include an extensive process called product development. Product design development as a new business development can be in production, distribution and marketing. Product development is part of innovation and cannot stand alone in the manufacturing industry. In terms of the manufacturing process of a product consisting of its components, it is directed to simplify the structure and components of the product. So, the assembly process is faster, has a shorter time, and becomes more straightforward, reducing assembly time and costs; product design to develop manufacturing must be done as optimally as possible. The optimal product development process can be achieved by reducing the row of materials, minimising the number of components, lowering assembly costs, and minimising production support costs [12-14].

In general, the objectives of product design include producing a product that is of high quality and has a high selling value. Produce products that suit consumer needs, especially products that are trending at the time. Product design can make the product as economical as possible but without compromising the product's selling value, quality, and benefits. To increase market share and obtain new market segments for the product. Innovation in product design in industry is crucial to implement. The activities in implementing product innovation are implementing new products, planning sales, production, distribution and marketing. Product innovation covers broader developments, such as implementing development plans and realising new products and product production processes [11].

2.3 Analytical Hierarchy Process (AHP)

The AHP is a decision support model that describes complex multi-factor or multi-criteria problems in a hierarchy. According to [15-17], the hierarchy is defined as a representation of a complex problem in a multi-position structure where the first position is the goal, followed by the position factors, criteria, and sub-criteria, down to the last position of the alternative. With this, a complex problem can be broken down into groups and arranged into forms. So, the problem will appear more structured and systematic. The AHP is often used as a problem-solving method compared to other methods for the following reasons:

- A hierarchical structure, as a consequence of the selected criteria, to the deepest sub-criteria.
- Considering the validity up to the tolerance limit for the inconsistency of various criteria and alternatives chosen by the decision-maker.
- Taking into account the durability of the sensitivity analysis of decision-making.

The AHP method has advantages and disadvantages in its analysis system. The advantages of this method are unity, complexity, interdependence, hierarchy structuring, dimension, conflation, trade-off, judgement and consensus, and process reiteration [15]. The weaknesses of the AHP method are as follows [18]: (a) the primary input is in the form of an expert's perception so that, in this case, it involves the subjectivity of the expert; (b) the AHP method is only a mathematical method without any statistical testing, which no confidence limit for the correctness of the model formed. However, the AHP is well-suited to multi-criteria decision-making, assisting in selecting the best machine configuration and components for a specific purpose machine from among the available options [19-20].

In the AHP method, the following steps are carried out [18]:

a. Define the problem and determine the desired solution.
   This stage determines the problem that needs to be solved clearly and quickly. From the existing problems, determine the solution that is suitable for the problem. There may be more than one solution to a problem.

b. Create a hierarchical structure.
   After compiling the main objective as the top position, a hierarchical position will be compiled below it, namely criteria that are suitable for considering or assessing the alternatives we provide and determining them. Each criterion has a different intensity. The hierarchy is continued by sub-criteria (if necessary). Create a pairwise comparison matrix that describes each element's relative contribution or influence to the goals.

c. The matrix used is simple

Have a strong position for the consistency framework, obtain other information that may be needed with all possible comparisons and be able to analyze the sensitivity of overall priorities for changes in consideration. Comparisons are made based on the decision maker's judgment by assessing the level of importance of an element compared to other elements.

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d. Doing define
Pairwise comparisons so that the total number of assessments is n x ((n- 1)/ 2) pieces, where n is the number of elements being compared.
The result of the comparison of each element is a number from 1 to 9, which shows the comparison of the level of importance of an element. If an element in the matrix is compared with itself, the comparison result is given a value of 1. A scale of 9 has proven acceptable and can distinguish the intensity between elements.
e. Calculate the eigenvalues and test their consistency. If it is not consistent, then the data collection is repeated.
Repeat steps for the entire hierarchy level. Calculations of the eigenvectors of each pairwise comparison matrix are the weight of each element for determining the priority of the elements at the lowest hierarchical level until reaching the goal. The calculation is done by adding up the values of each column of the matrix, dividing each value from the column by the corresponding column total to obtain a normalized matrix, and adding up the values from each row and dividing by the number of elements to get the average.
f. Check the consistency of the hierarchy. The measuring in the AHP is the consistency ratio by looking at the consistency indicator.

3.0 METHODOLOGY

3.1 Initial Design of Oil Draining Machine (Spinner)

The working principle of this spinner machine was that the tube rotated and threw the oil attached to the food out of the tube. The tube was driven by the primary mover of an electric motor with a power of 1 PK. An electric motor drives a small pulley with a diameter of 60 mm. The rotation of the small pulley was forwarded to the large pulley to get the rotation ratio with the belt transmission.

A large pulley with a diameter of 170 mm mounted on the end of the main shaft rotates. The rotation of the pulley caused the drain tube to rotate and throw the oil out of the food. The oil that came out of the tube was held by the cover of the food drain tube and flowed down. The oil flows down, collects at the bottom of the cover, and flows through the drain pipe so the oil can be used again.

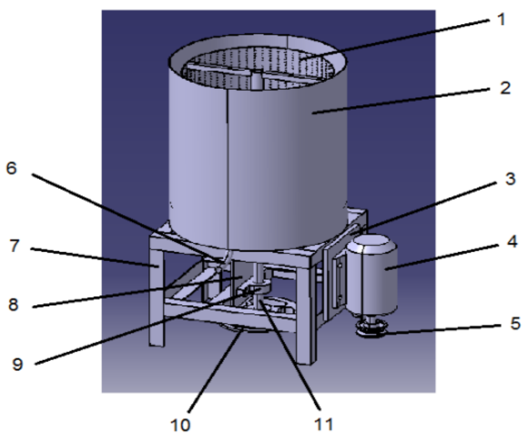

Figure 1: Initial design of the spinner [10]

The following is an explanation of Figure 1 of the initial design of the oil draining machine (spinner):

1. The food rotating tube serves as a place for oily food to be placed to rotate and remove the oil.
2. Cover the food rotating tube with the rotating machine parts so as not to harm the user and function as a barrier so that the oil does not spread.
3. The electric motor base serves as a holder where the electric motor is placed (bolted).
4. The electric motor, the primary power source of this slicing machine, rotates the feeding tube with a transmission in the form of a pulley and a belt.
5. Small pulley part of the engine transmission system, which is rotated directly by the electric motor
6. Residual oil drain pipe. The cover of the feeding tube cover collects the oil outlet.
7. The basic machine frame is the formation of the draining machine as a support and a place where machine components are installed.
8. The base pillow block serves as a seat where the pillow block is attached.
9. Pillow block is the main shaft rolling bearing of the food-drying machine.
10. Pulley is a large part of the transmission system, which rotates the main shaft to drive the food-draining tube directly and is indirectly rotated by an electric motor.
11. The main shaft is a shaft that rotates the draining tube directly, moving with a large pulley; the mechanism for connecting the shaft to the tube is to use the left thread so that when rotating, the connection is more robust.

3.2 Creation of Hierarchical Structures and Questionnaire Design

An initial questionnaire was created to obtain priority consumer needs. The questionnaire aims to determine what oil-draining machines (spinners) consumers need. Ten respondents worked as fried food traders. The distribution of questionnaires was carried out in the city of Pekanbaru. This initial questionnaire was created based on eight aspects, namely:

a. Flexible aspect: easy to carry, store, and use.
b. Design aspects (user comfort): The inner diameter of the tool corresponds to the number of fryers, the inner diameter of the tool is quite large, and the height of the tool can be adjusted.
c. Material aspect: made from light and strong materials, easy to clean, durable.
d. Security aspects: The safety-operated machine and the materials were neither dangerous nor toxic.
e. Usability spect: Easy to use, can be used with one hand, and can drain any remaining frying oil.
f. Functional aspects: the function of draining oil from frying fried foods, draining oil from frying chips, and draining oil from frying fritters and chips.
g. Dimensional aspects: The dimensions of the equipment were based on the frying needs of most Indonesian people, with equipment weight < 30 kg.
h. Aesthetic aspect: choice of bright colours, dark stem form, and decorations.

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The assessment was carried out to get the highest percentage from each aspect. Scoring used a rating scale to get questionnaire results.

a = Very favourable (value 4)
b = Liked (value 3)
c = Less favourable (value 2)
d = Disliked (value 1)

Total score = total score on the assessment scale 1 to 4
Ideal score = highest score x number of respondents
Percentage = number of ideal scores x 100%.

Making a hierarchical structure of the oil draining machine (spinner) based on product quality, which consists of 6 indicators, namely:

- Functional
  The functional value of a product is related to the function of the product's intended use. The usefulness of a product can be immediately seen clearly from its appearance. An example is the presence of a handle on a product, indicating that the product is easy to carry.
- Performance
  Performance value or performance related to the main characteristics of a product. For example, in a developed model of an oil drainer (spinner), the central desired performance is draining cooking oil, and the dimensions of the oil draining machine (spinner) are the maximum or stable rotational force.
- Ergonomics
  The ergonomic value of a product requires an adjustment to human qualities. Technically, the Ergonomic function of a product can be implemented on a product by making the product easy to use, for example, in the proposed model of the oil draining machine (spinner), which can be adjusted in length. So, it can be adjusted to the height of a cook.
- Durability
  The durability value of a product is related to the durability of a product until it must be replaced. In this case, durability is also related to the material used to manufacture a product.
- Serviceability
  Serviceability value is related to the ease of service or repair if there is damage to the product. The developed model of an oil draining machine (spinner) can be disassembled or replaced. It can make it easier to repair.
- Aesthetics (beauty)
  The aesthetic value of a product is related to the appearance of a product. A product's ability to attract consumers' attention can be increased through size or colour.

The hierarchical structure of the oil draining machine (spinner) can be seen in Figure 2. Then, it was making a questionnaire based on the hierarchical structure that had been made previously. This questionnaire aims to obtain the level of importance in selecting designs by comparing interest 1 with other interests based on the comparison priority scale in Table 1. In distributing the questionnaire, three experts were selected to be the respondents. Respondents were selected based on fields related to the research topic: production and construction engineering. In this paper, the questionnaires were filled out by the Mechanical Engineering Lecturers at the University of Riau.

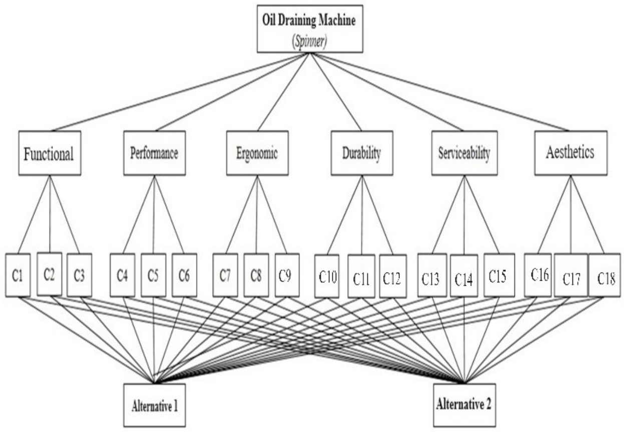

Figure 2: Hierarchical structure of oil draining machine (spinner)

Description:

C1: Draining cooking oil	C10: Aluminum
C2: Draining the cracker oil	C11: Mild steel
C3: Draining oil of cooking and crackers	C12: Stainless steel
	C13: Easy to disassemble
C4: Capacity > 3 kg	C14: Easy to clean
C5: Capacity < 3 kg	C15: Easy to repair
C6: Pulley > 60 mm	C16: Light colour
C7: Easy to disassemble	C17: Dark colour
C8: Light	C18: More than 1 color
C9: Easy to use	

Table 1: Level of interest [21]

Level of Importance Scale	Definition	Description
1	Equally important	Both elements have the same effect.
3	A little more important	Experience and judgment slightly favor one element.
5	More important	Experience and judgment slightly favor one element.
7	Very important	One element is very well liked and practically its dominance compared to its other one.
9	Absolute more important	One element is proven to be absolutely preferable to its partner.
2,4,6,8	Middle value	Given when there is doubt about the assessment.
opposite	Aij =1/Aij	If an activity i gets a number when compared to activity j, then j has the opposite value when compared to i.

4.0 RESULT AND DISCUSSION

4.1 Results of Consumer Needs

The questionnaire form was filled out by ten consumers. The results percentages of consumer needs recapitulation can be seen in Table 2.

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Table 2: Results of consumer needs questionnaire recapitulation

No	Aspect																							
	Flexible			Design			Material			Safety			Utility			Function			Dimension			Aesthetic		
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3	F1	F2	F3	G1	G2	G3	H1	H2	H3
1	4	4	3	4	4	4	4	4	3	3	4	3	4	4	4	3	2	3	4	3	2	4	2	3
2	4	4	3	4	3	4	4	4	4	4	3	4	4	4	4	3	3	4	4	4	2	1	3	4
3	4	4	4	4	3	4	4	4	4	4	4	4	3	4	4	3	4	4	3	4	1	1	4	4
4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	3	4	4	3	4	1	1	4	4
5	3	4	3	3	3	4	4	3	3	4	3	4	3	4	4	3	4	4	3	3	2	2	4	4
6	4	3	4	3	3	3	3	4	3	4	4	4	4	4	4	3	3	4	3	3	2	3	3	4
7	3	3	4	3	3	4	3	4	3	4	4	3	4	2	3	2	2	4	4	3	2	3	2	4
8	3	4	3	2	3	4	4	3	4	3	3	3	4	2	4	3	3	4	3	4	1	3	3	4
9	4	4	3	4	4	4	3	3	3	4	4	4	3	4	4	3	4	3	4	4	1	2	4	3
10	4	4	4	2	4	3	3	4	4	4	3	4	3	4	4	2	3	3	3	4	3	2	3	3
Amount	37	38	35	33	34	38	36	37	35	37	36	37	36	36	39	28	32	37	34	36	17	22	32	37
Percentage	93%	95%	88%	83%	85%	95%	90%	93%	88%	93%	90%	93%	90%	90%	98%	70%	80%	93%	85%	90%	43%	55%	80%	93%

From the calculations on the first aspect, the highest statement results were obtained, namely in the second question, A2, with a weighted value of 95%. So, the top priority result of consumer needs was the aspect of flexibility, which is easy to store with a weighted value of 95%. From the results of the overall calculation, the priority of consumer needs for each aspect can be seen in Table 3.

Table 3: Priority of consumer needs

No	Aspects	Priority	Weight (%)
1	Flexible	Easy to store.	95
2	Design	Tool height can be adjusted.	95
3	Material	It is made of lightweight and robust material.	95
4	Security	Materials are not dangerous or toxic.	90
5	Utility	Easy to use (no special tricks in its use).	90
6	Function	It has the function of draining frying oil.	90
7	Dimension	The tool's dimensions are based on the frying needs of Indonesian people.	90
8	Aesthetics	Dark colour choice.	91.67

It can be seen in Table 3 that the priority scale consumers were more interested in using a spinner machine that was easy to store, made of lightweight and robust materials, and materials that were not dangerous or toxic. This selection was based on the scale of consumer needs as spinner oil-draining machine users expect a minimalist design and easy storage, as well as the selection of lightweight and robust materials with maximum performance.

The design of the new spinner model based on the results of a questionnaire on consumer needs was a machine made of lightweight and robust materials. From the priority weights of each aspect in Table 3, a new model was obtained for the material section and the placement of the motor position. A new machine model was designed with the motor placement at the bottom of the drain. The driving mechanism used a motor that was connected using a belting to drive the shaft of the oil drain.

From the aspect of function, the priority of consumer needs was to drain fried frying oil. Based on the priority of consumer needs, the new design model of the oil draining machine (spinner) revealed two alternatives. Alternative 1 was designed in a circular shape on the engine with the motor under the oil drain with a sturdy and robust frame design shape. The design is sturdier on the stand so that the oil-draining machine can work more optimally. An alternative design can be seen in Figure 3.

Alternative 2 was designed in a circular shape on the engine with the motor below the draining oil tube. The bearing was used as the support of the shaft. The shaft was a component that functions as a successor to the motor's rotation. The clutch was used to transfer power from the shaft to the transmission. Use a frame design that has better vibration-dampening power. The oil drain machine is designed with a more robust shape so that the engine can operate more optimally. Alternative design two can be seen in Figure 4. The old design has a carrying capacity of 3kg, and the new alternatives 1 and 2 were designed to have a carrying capacity of >3kg. The two alternative new designs used a frame design with better vibration-dampening power. From the calculation of the weight of each criterion of the oil draining machine (spinner), the weight value was obtained as shown in Table 3.

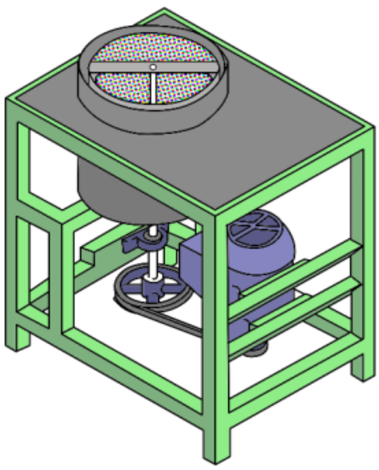

Figure 3: New model alternative 1

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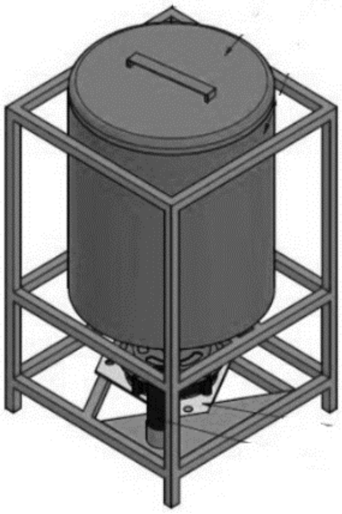

Figure 4: New model alternative 2

Table 4: Weight value of oil draining machine criteria rank

Criteria	Weight	Ranking
Functional	0.318	1
Performance	0.169	3
Ergonomics	0.176	2
Durability	0.151	4
Serviceability	0.151	5
Aesthetics	0.036	6

Table 4 shows the highest criterion weight value of the functional criteria, with a value of 0.318. It meant the Functional criteria became the most influential criterion on the optimal design of the oil draining machine. It was because of the Functional value of a product that was related to the function of the product shown. The lowest criterion was Aesthetics, with a value of 0.036. It was due to the Aesthetic value that was only related to the appearance of a product. The percentage of criteria that affect the optimal design is depicted in Table 5.

Table 5: Percentage of criteria affecting optimal design of oil draining machine

No	Criteria affecting the oil draining machine	Persentage
1	Functional	31.8 %
2	Performance	17.6 %
3	Ergonomics	16.9 %
4	Durability	15.1 %
5	Serviceability	15.1 %
6	Aesthetics	03.6 %

The results of distributing questionnaires and calculations that have been made revealed the customer needs and functions desired by the community to make the oil draining machine (spinner). The criteria obtained were the second alternative where the indicators that influence the selection of the new model of the spinner based on product quality from the highest to the lowest using the AHP method, namely: Functional 31.8% (draining cooking oil), Ergonomic 17.6% (Easy to use), Performance 16.9% (capacity exceeding 3kg), Durability 15.1%, Serviceability 15.1% (Stainless steel) and Aesthetics 3.6% (Dark colour). Therefore, after being modified, the result of the selected design can be seen in Figure 4.

5.0 CONCLUSION

Based on the initial design, it was an oil-draining machine (spinner) with a capacity of 3 kg and using a transmission in the form of a pulley and a belt. Then, the old model analysed component selection based on the Analytical Hierarchy Process (AHP) method. The new model revealed a capacity of more than 3kg. Based on the initial design evaluation, several customer needs for priority of design include functionality to drain the cooking oil and crackers, capacity exceeding 3kg, easy to assemble, lightweight, easy to use, stainless steel material, ease to repair and dark colour selection. Therefore, the selection of the developed model of oil draining machine (spinner system) based on the AHP method, from the highest to the lowest values, namely: functional criteria of 31.8%, ergonomic of 17.6%, the performance of 16.9% (capacity exceeding 3kg), the durability of 15.1%, serviceability of 15.1% and aesthetics 3.6% (dark colour).

REFERENCES

[1] Aisyah, S., Yulianti, E. & Fasya, A.G. (2010). Penurunan angka peroksida dan asam lemak bebas (FFA) pada proses bleaching minyak goreng bekas oleh karbon aktif polong buah kelor (Moringa Oliefera) dengan aktivasi NaCl, *Journal of Chemistry*, 2, 53-103.

[2] Harmen, H., Sofi'i, I. & Baharta, R. (2021). Modifikasi mesin peniris minyak sistem spinner. *Jurnal Ilmiah Teknik Pertanian - TekTan*, 12(3), 147-157.

[3] Adriana, M. & Syahyuniar, R. (2019). Rancang bangun alat peniris minyak pada keripik singkong, *Elemen: Jurnal Teknik Mesin*, 6(1), 20-27.

[4] Pranata, D. & Arief, D. (2021). Automatic task machine (atm) design for logistic package by method analytical hierarchy process (ahp) through approach the design for manufacturing (dfm). *Journal of Ocean, Mechanical and Aerospace -Science and Engineering-, 65*(1), 1-7.

[5] Pasman, H.J., Rogers, W.J. & Behie, S.W. (2022). Selecting a method/tool for risk-based decision making in complex situations. *Journal of Loss Prevention in the Process Industries*, 74, 104669.

[6] Motlagh, M.G., Amraei, B., & Halimi, M. (2020). Evaluating the hazardous potential of the dieback of the zagros oak forests using the multi-criteria decision-making methods. *Arabian Journal of Geosciences*, 13, 1-11.

[7] Reforiandi, A. & Arief, D. (2021). Design of the vertical roundness tester machine using the ahp method (analytical hierarchy process) through the dfm approach (design for manufacturing). *Journal of Ocean, Mechanical and Aerospace -Science and Engineering-, 65*(2), 68-76.

[8] Prasetio, P.J. & Ibik, M.K. (2015). Rancang bangun keripik mangga podang kapasitas 10 kg per proses

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(bagian: mesin peniris). *Jurnal Teknik Mesin*, 4, 1-25.
[9] Wasisto, S. (2016). *Perancangan Mesin Peniris Untuk Aneka Makanan Ringan Hasil Gorengan* (UAJY).
[10] Erlangga, D.A. (2018). Perancangan mesin peniris minyak (Spinner) untuk kebutuhan dapur rumah tangga dengan menggunakan metode TRIZ.
[11] Nugroho, A. (2008). Perancangan alat bantu untuk proses permesinan pada mesin chamfering dr99 di industri sepeda motor dengan metode dfma (*design* for manufacturing and assembly). Universitas Indonesia.
[12] Yunus, N. & Susilawati, A. (2020). Innovation of elbow fixture welding process based on design for manufacture and assembly (dfma). *Journal of Ocean, Mechanical and Aerospace -Science and Engineering-, 64*(1), 19-24.
[13] Jahan, A., Edwards, K.L. & Bahraminasab, M. (2016). *Multi-Criteria Decision Analysis for Supporting the Selection of Engineering Materials in Product Design*. Butterworth-Heinemann.
[14] Tyagi, S., Choudhary, A., Cai, X. & Yang, K. (2015). Value stream mapping to reduce the lead-time of a product development process. *International Journal of Production Economics,* 160, 202-212.
[15] Darko, A., Chan, A.P.C., Ameyaw, E.E., Owusu, E.K., Pärn, E. & Edwards, D.J. (2019). Review of application of analytic hierarchy process (AHP) in construction. *International Journal of Construction Management*, 19(5), 436-452.
[16] Veisi, H., Deihimfard, R., Shahmohammadi, A. & Hydarzadeh, Y. (2022). Application of the analytic hierarchy process (AHP) in a multi-criteria selection of agricultural irrigation systems. *Agricultural Water Management,* 267, 107619.
[17] Unver, S. & Ergenc, I. (2021). Safety risk identification and prioritize of forest logging activities using analytic hierarchy process (AHP). *Alexandria Engineering Journal*, 60(1), 1591-1599.
[18] Chamid, A.A. & Murti, A.C. (2017). Kombinasi metode ahp dan topsis pada sistem pendukung keputusan. *Prosiding SNATIF*, 115-119.
[19] Farhan, U.H., Tolouei-Rad, M. & Osseiran, A. (2016). Use of AHP in decision-making for machine tool configurations. *Journal of Manufacturing Technology Management,* 27(6), 874-888.
[20] Ic, Y.T., Yurdakul, M.N. & Eraslan, E. (2012). Development of a component-based machining centre selection model using AHP. *International Journal of Production Research,* 50(22), 6489-6498.
[21] Saaty, T.L. (1990). How to make a decision: the analytic hierarchy process. *European Journal of Operational Research*, 48(1), 9-26.