

Design and Selection of The Face Shield Materials as a Self-Protective Tool in Preventing COVID-19 using The Analytical Hierarchy Process Method

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ABSTRACT

The world has been shocked by the emergence of COVID-19 since December 2019 which is an acute respiratory disease caused by a corona virus called severe acute respiratory syndrome coronavirus 2 or abbreviated as SARSCoV-2 (Gorbalenya et al., 2020). As of June 17, 2020, the World Health Organization (WHO) noted that there were 8,061,550 people infected with COVID-19 and 440,290 people died (WHO, 2020a). Even though the Case Fatality Rate (CFR) of COVID-19 is only around 5.46%, this disease is very dangerous because of its spread so fast it has infected 216 countries (Worldometer, 2020). To prevent uncontrolled spread, WHO declared COVID-19 a pandemic on March 11, 2020 (WHO, 2020b) to increase awareness of this disease. The status of this pandemic is a concern for the world to make various efforts to prevent the spread of COVID-19. One way to protect yourself from spreading COVID-19 is to use Personal Protective Equipment. Face shield is a personal protective device that functions to protect the face from exposure to dangerous substances in the case of the spread of the Covid-19 virus. A good face shield is a face shield that has a high level of durability, has high material quality, has a sufficient level of elasticity, and the costs incurred are not too expensive. In choosing the best alternative in making a decision, the right method is needed so that the best alternative is obtained from various predetermined criteria. Then the Analytical Hierarchy Process (AHP) method is used to select the best alternative material to be used in making the Face Shield.

Based on the results of the research conducted, it can be seen that each alternative has the advantage of the criteria felt by the respondent. However, of the four criteria for

selecting the face shield material, the most superior or chosen as the choice is mica. Judging from the percentage of mica against the Durability criteria is 31.7%, the percentage of mica against the quality criteria is 43.1%.

Keywords: Face Shield, APD, COVID-19, Analytical Hierarchy Process.

1. INTRODUCTION

Since December 2019, the world has been shocked by the emergence of COVID-19 which is an acute respiratory disease caused by a corona virus called severe acute respiratory syndrome coronavirus 2 or abbreviated as SARSCoV-2 (Gorbalenya et al., 2020). As of June 17, 2020, the World Health Organization (WHO) noted that there were 8,061,550 people infected with COVID-19 and 440,290 people died (WHO, 2020a). Even though the Case Fatality Rate (CFR) for COVID-19 is only around 5.46%, this disease is very dangerous because of its rapid spread that has infected 216 countries (Worldometer, 2020). To prevent uncontrolled spread, WHO declared COVID-19 a pandemic on March 11, 2020 (WHO, 2020b) to increase awareness of this disease. The status of this pandemic is a concern for the world to make various efforts to prevent the spread of COVID-19.

One way to protect yourself from spreading COVID-19 is to use Personal Protective Equipment. Some types of PPE that are required or recommended to prevent the transmission of COVID-19 are masks, face shields and gloves. The PPE aims to prevent exposure to the virus in the body or transmit the virus to other people.

Face shield is a personal protective device that functions to protect the face from exposure to harmful substances in the case of the spread of

the Covid-19 virus. Face shield is used to protect the face from droplets or saliva splashes. The face shield that is currently circulating in the market has various shapes and colors as well as the materials used, so the question arises how to choose a good face shield.

A good face shield is a face shield that has a high level of durability, has a high quality material, has a sufficient level of elasticity, and the costs incurred are not too expensive. It's just that face shields circulating in the market are often made not according to overall standards or criteria, and are made with a variety of different materials and of course, with different

materials having different levels of durability, quality, elasticity and price. Different too. So based on this explanation, the authors chose to choose the best material to use in face shield construction.

In choosing the best alternative in making a decision, the right method is needed so that the best alternative is obtained from various predetermined criteria. And in this case the previous criteria are used as indicators to determine the best alternative. Then the Analytical Hierarchy Process (AHP) method is used to select the best alternative material to be used in making the Face Shield.

2. METHODS

2.1 Decision Making Theory

Decision making is the act of selecting the best alternative through various selections, based on various alternatives and predetermined criteria in order to obtain the best alternative that can be used as needed. Management theory pioneers such as Fayol and Urwick discussed decision making regarding its influence on delegation and authority, while the father of management - Frederick W. Taylor only alluding to the scientific method as an approach to decision making can be traced to Chester Bernard in The function of exec. Bernard provides a comprehensive analysis of decision making and states "The decision process is a technique for narrowing choices".

The theory used in decision-making theory is as follows:

1. Simple additive weighting (SAW)

The Simple additive weighting (SAW) method is often also known as the weighted addition method.

2. Weighted product (WP)

The weighted product method is the solution method using multiplication to relate the attribute rating, where the rating must be raised first with the attribute weight in question.

3. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. This decision support

model will describe a complex multi-factor or multi-criteria problem into a hierarchy.

2.2 Definition of AHP (Analytical Hierarchy Process)

AHP is a decision support model developed by Thomas L. Saaty. This decision support model will describe a complex multi-factor or multi-criteria problem into a hierarchy (Sylvia Hartati Saragih; 2015), a hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the factor level, criteria, sub criteria, and so on down to the last level of alternatives.

2.3 Analytical Hierarchy Process Stages

In the AHP method, the following steps are carried out:

a. Defining the problem and determining the desired solution.

In this stage we are trying to determine the problem we are going to solve in a clear, detailed and easy to understand manner.

b. Create a hierarchical structure that begins with the main objective

After compiling the main objectives as the top level, a hierarchical level will be arranged below, namely the suitable criteria for considering or assessing the alternatives we provide and determining these alternatives.

assess the alternatives that we provide and determine these alternatives.

c. Create a pairwise comparison matrix that describes the relative contribution or

influence of each element to the goal or criteria level above it.

The matrix used is simple, has a strong standing for a consistency framework, obtains any other information that may be needed with all possible comparisons and is able to analyze the overall sensitivity of priorities for changing considerations.

d. Defining pairwise comparisons so that the total number of assessments is n x [(n-1) / 2], where n is the number of elements being compared.

The result of the comparison of each element will be a number from 1 to 9 which indicates the comparison is assigned a value of 1.

e. Computes eigenvalues and tests for consistency.

If it is not consistent, then data retrieval needs to be done again, until consistent data is obtained.

f. Repeats steps 3,4, and 5 for the entire hierarchy

g. Calculate the eigenvector for each pairwise comparison matrix.

Which is the weight of each element for prioritizing the elements at the lowest hierarchical level until they reach the goal.

h. Check hierarchy consistency.

What is measured in AHP is the consistency ratio by looking at the consistency index. The expected consistency is near perfect in order to produce a decision that is close to valid. The formula for determining the Consistency Ratio
The consistency index of matrices of order n can be obtained by the formula :

$$CI = \frac{\lambda_{max} - n}{n(n-1)} \dots\dots\dots (1)$$

Where :

CI = Consistency Index

λ_{max} Maximum = the largest eigenvalue of the n order matrix.

λ The maximum is obtained by adding the product of the multiplication of the number of columns with the main vector eigenvalues.

If CI = 0, it means that the matrix is consistent. The limit of inconsistency is set when measured using a consistency ratio (CR), which is a comparison of the consistency index with the random generator value (RI). RI value depends on the matrix order n.

$$C = \frac{C}{R} \dots\dots\dots (2)$$

2.4 AHP Basic Principles and Axioms

1. Basic Principles

AHP is based on 3 basic principles, namely:

a. Decomposition

With this principle the structure of a complex problem is divided into parts in a hierarchical manner. Goals are defined from general to specific. In the simplest form the structure will be compared with the objectives, the criteria and alternative levels may be further divided into more detailed levels, covering more other criteria.

b. Comparison of judgments / considerations (comparative judgments).

With this principle, a pairwise comparison of all existing elements will be built in order to produce the relative importance scale of the elements.

c. Priority Synthesis

Priority synthesis is done by multiplying the local priority by the priority of the relevant criteria at the top level and adding it to each element in the level affected by the criteria.

2. Axioms

AHP is based on 3 main axioms, namely:

a. Respirokal's Axiom

This axiom states that if PC (EA, EB) is a pairwise comparison between element A and element B, taking into account C as the parent element, indicating several times as many properties as element A over B, then PC (EB, EA) = 1/ PC (EA, EB). For example if A is 5 times bigger than B, then B = 1/5 A.

b. The Axiom of Homogeneity

This axiom states that the elements being compared do not differ too greatly. If the difference is too large, the result will contain a high error value. When hierarchies are built, we should try to arrange elements so that they don't produce results with low accuracy and high inconsistency.

c. The Axiom of Dependence

This dependent axiom states that the priority of an element in the hierarchy does not depend on the level element below

it.This axiom makes us apply the principle

of hierarchical composition.

3. RESULTS AND DISCUSSION

Respondents for this data collection were students of Pattimura University, Faculty of Engineering, Department of Industrial

Engineering, Manufacturing Interest, class of 2017 with 26 students.Respondents can be seen in table 1.

Table 1. Questionnaire Respondents

No.	Respondent
1	Glori Uniwaly
2	Faridah Nurhayati
3	Falensia kaihena
4	Lia Tan
5	Abdul Halim Panigfat
6	M. Rifqi
7	Gloria Talaba
8	Alberth Z Sahertian
9	Delviero Nanlohy
10	Johanis Sobalely
11	Vicky Refualu
12	Erza Latumeten
13	Mega C. Umasugi
14	Syahril Soulisa
15	Muhammad Syahril
16	Malik Ismanto
17	Dwi Sasongko
18	Eric Laipeny
19	Julio Hahury
20	Farah R. Upate
21	Rizaldi Dwi Suryo
22	Malfriando Sinai
23	Dolly M. Romer
24	Christian Alessandro
25	Musa Rumwokas
26	Briand W. Lattan

3.2 AHP Method

1. Hierarchy Arrangement

In the AHP method, the criteria are usually arranged in a hierarchical form.The criteria and sub-criteria in this study are the criteria and sub-criteria used in the selection of the face shield material obtained from the preliminary interview results.The problem

of choosing face shield material is arranged in three hierarchical levels which can be seen in Figure 1. Level 0 is the goal, namely choosing the best face shield, level 1 is the criterion for selecting the face shield, which level 2 material should be chosen. The hierarchical structure can be seen in Figure 1.

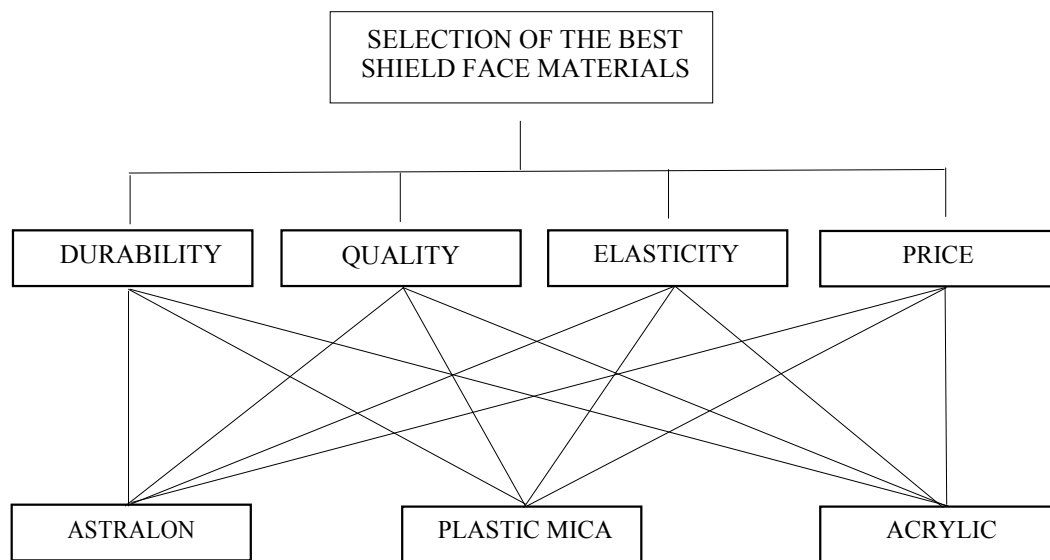


Figure 1. Face Shield Material Selection

2. Pairwise Comparison Matrix for Face Shield Material Selection

Retrieval and data collection used in AHP using a questionnaire distributed to respondents. The scale used in the questionnaire is a scale of 1-9 and it is

provided that the respondents choose the level of importance of each of the criteria and alternatives. The following is the data made in pairwise comparisons according to 26 respondents and the average is taken.

Table 2. Pairwise Comparisons in Each Criteria

Criteria	Durability	Quality	Elasticity	Price
Durability	1	1	1.25	1,25
Quality	1	1	2.5	2
Elasticity	0.8	0.4	1	1.25
Price	0.8	0.5	1.25	1
Total	3.6	2.9	6	4.25

3. Calculating the Weight Value

Weight calculation is done to determine the weight of each criterion and alternative. The weight value is obtained from the eigen value divided by the total eigen value.

• Calculating the Weight Value of the Criteria

The following are the weight values of each criterion:

Table 3. Weight Values of each Criterion

Criteria	Durability	Quality	Elasticity	Price	Eigen Value	Priority Weights
Durability	1	1	1.25	1,25	1.25	0.175
Quality	1	1	2.5	2	5	0.699
Elasticity	0.8	0.4	1	1.25	0.4	0.056
Price	0.8	0.5	1.25	1	0.5	0.070
Total	3.6	2.9	6	4.25	7.15	1

From the table above the maximum λ value is obtained from the eigen value divided by the priority

weight of the face shield material selection criteria as follows.

Alternatif	Eigen Value	Bobot Prioritas	λ Maks
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Table 4. The λ Max Criteria

Criteria	Eigen Value	Priority Weights	λ max
Durability	1.25	0.175	7.15
Quality	5	0.699	7.15
Elasticity	0.4	0.056	7.15
Price	0.5	0.07	7.15
Total	7.15	1	29

The average of λ max = 0.0715
 The calculation is continued by calculating the consistency index (CI). Because it has 4 orders, the CI value is:

$$CI = \frac{0,075}{3} = 0,025$$

For n = 4 and R = 0.90 (Random Consistency index table), then:

$$CR = \frac{CI}{R} = \frac{0,025}{0,90} = 0,027$$

The calculation result is acceptable because CR < 10% = 0.027 < 0.1 is consistent.

4. Calculating the Weight Value of the Price Criteria

Table 5. Weight Value of Price

Alternatif	Astralon	Mica	Acrylic	Eigen Value	Priority Weights
Astralon	1	0.4	1.67	0.7	0.111731844
Mica	3	1	2	5.0	0.837988827
Acrylic	0.6	0.50	1	0.3	0.05027933
Total	4	2	5	6	1

From the table above the maximum λ value is obtained from the eigen value divided by

the priority criteria for selecting face shield material as follows:

Table 6. Weight Value of Price Criteria

Astralon	0,7	0.111731844	5.967
Mika	5,0	0.837988827	5.967
Akrilik	0,3	0.05027933	5.967
Jumlah	6	1	18

Average λ max = 0.05967 The calculation is continued by calculating the consistency index (CI). Because it has 3 orders, the CI value is:

$$C = \frac{0,05967}{2} = 0,029835$$

For n = 3 and RI = 0.58 (Consistency Random Index table), then:

$$C = \frac{C}{R} = \frac{0,05967}{0,58} = 0,102879$$

The calculation result is accepted because CR < 10% = 0.0102879 < 0.1 is consistent.

5. Calculations using Expert Choice Software

Processing of the number of comparisons was carried out with the help of expert choice software, both the Face Shield Material Selection criteria and the

processing of the comparison of the Durability, Quality, Elasticity, and Price criteria against alternative face shield materials.

- Calculation of the number of Criteria comparisons

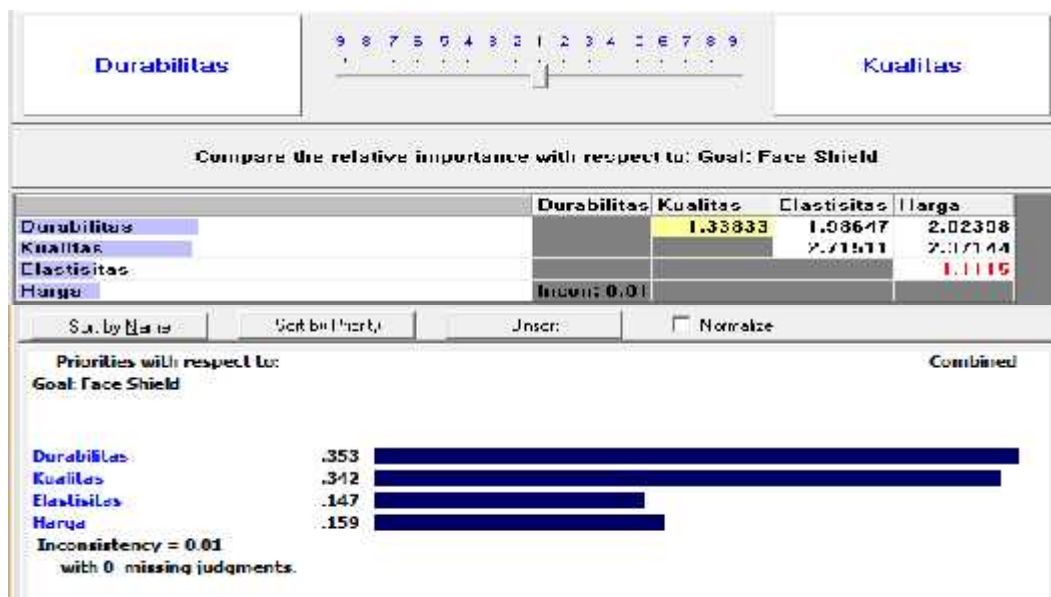


Figure 2. Comparison of face material criteria shield

The result of comparison of criteria with manual calculation is different from processing using Expert Choice, CR from processing criteria comparison with manual calculation is 0.027 while using expert choice is 0.01, but the two data do not exceed 10% or are consistent.

6. Result of Decision Making

From the results of manual calculations and data processing through expert choice software, carried out on respondents who use the Astralon, Mica, and Acrylic

alternatives, it can be seen that the hierarchy of decisions for selecting face shield material is as follows. From table 7 it can be understood that each alternative has the advantage of the criteria felt by the respondent. However, from the four criteria for selecting the face shield material that is the most superior or chosen as the choice is Mika, seen from the percentage of mica against the Durability criteria is 31.7%, the percentage of mica against the Quality criteria is 43.1%.

Table 7. Selection of the Best Alternative

Criteria	Alternative	Weight Value		Percentage (%)
		Calculation Manual	Expert calculation Choice	
Durability	Astralon	0,04	0,265	26,5%
	Mica	0,6	0,317	31,7%
	Acrylic	1,25	0,418	41,8%
Quality	Astralon	0,75	0,320	32%
	Mica	1,33	0,431	43,1%
	Acrylic	1	0,249	24,9%
Elasticity	Astralon	0,19	0,326	32,6%
	Mica	0,47	0,514	51,4%
	Acrylic	0,32	0,16	16%
Price	Astralon	0,11	0,247	24,7%
	Mica	0,83	0,639	63,9%
	Acrylic	0,05	0,115	11,5%

Mica against the elasticity criteria is 51.4% and the price criteria is 63.9%. So that it can be ascertained that Mica is the best material that can be used by Students of the Faculty

4. CONCLUSION

The conclusions obtained are as follows: From the results of calculations that have been done using the Analytical Hierarchy Process (AHP) method, it can be concluded that, the best material used in the

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of Engineering, Pattimura University, Interested in Manufacturing Systems, Class of 2017 in making Face Shield.

manufacture of face shields is mica material where the mica material is 51.4% of the elasticity criteria and the price criteria is 63.9%. This can be seen from the percentage of mica weight value which is the highest compared to other materials.

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