JURNAL SAINS DAN TEKNOLOGI
KEILMUAN DAN APLIKASI TEKNOLOGI INDUSTRI
E-ISSN : 2615-2827 P-ISSN : 1412-5455
Volume 24, Nomor1 Tahun 2024
https://ejurnalsttind.id/index.php/SainsdanTeknologi

Fuzzy AHP Approach in Handling Returns Product of Bottle Glass Mineral Water at PT Marina

Sesar Husen Santosa[1)*], Agung Prayudha Hidayat[2)], Ridwan Siskandar[3)], Annisa Rizkiriani[4)], Khoirul Aziz Husyairi[5)]

[1,2] Industrial Management Study Program, IPB University, Indonesia
[3] Computer Engineering Technology Study Program, IPB University, Indonesia
[4] Management Food Service and Nutrition Study Program, IPB University, Indonesia
[5]Agribusiness Management Study Program, IPB University, Indonesia

sesarhusensantosa@apps.ipb.ac.id[1]*; agungprayudha@apps.ipb.ac.id[2]; ridwansiskandar@apps.ipb.ac.id[3]; annisarizkiriani@apps.ipb.ac.id[4]; khoirulaziz@apps.ipb.ac.id[5]

ABSTRAK

PT Marina merupakan perusahaan yang bergerak di bidang produksi air minum dalam kemasan, dengan salah satu produknya menggunakan kemasan botol kaca. Fluktuasi permintaan terhadap produk air minum dalam kemasan botol kaca menuntut perusahaan untuk merencanakan produksi secara optimal. Berdasarkan hasil pemindaian menggunakan aplikasi SCAPSA, tercatat total pengembalian produk sebanyak 2.193 botol pada bulan Desember 2024. Melalui identifikasi menggunakan metode diagram Pareto, ditemukan bahwa penyebab pengembalian produk tertinggi dari konsumen adalah kebocoran akibat lubang kecil (needle leaks), yakni sebanyak 895 botol. Hasil identifikasi ini menentukan prioritas perbaikan yang akan dilakukan dengan menggunakan metode Fuzzy AHP dengan bilangan fuzzy segitiga (triangular fuzzy numbers). Pada tingkat aktor, nilai normalisasi tertinggi diperoleh oleh bagian produksi dengan nilai defuzzifikasi sebesar 0,78. Pada tingkat faktor, nilai normalisasi tertinggi diperoleh pada aspek kualitas kemasan botol kaca dengan nilai defuzzifikasi sebesar 0,49. Dengan demikian, pengaturan suhu tegangan (tension temperature) yang optimal pada mesin pengisi (filling machine) menjadi alternatif perbaikan untuk mengatasi masalah kebocoran tersebut, dengan nilai defuzzifikasi sebesar 0,55 dan indeks konsistensi sebesar 0,03. Berdasarkan hasil perbaikan ini, perusahaan mampu menekan angka pengembalian produk sebesar 85,70%, sehingga jumlah produk yang dikembalikan berkurang menjadi 128 botol.

Kata kunci: Pareto, Fuzzy AHP, Normalisasi, Defuzzifikasi, Produk Retur

ABSTRACT

PT Marina is a company engaged in bottled mineral water production, where one of its products is glass packaging. The fluctuating demand for glass bottled drinking water products causes companies to plan optimal production. Based on the results of image scanning using the SCAPSA application, it was found that the total return was 2193 glasses in December 2024. Based on the identification results using the Pareto diagram method, it was found that the highest product return from consumers was needle leaks, namely 895 glasses. The identification results indicate priority improvements that will be carried out using the Fuzzy AHP method with triangular fuzzy numbers. At the actor level, the highest normalization result was obtained for the production section with a defuzzification value of 0.78. At the factor level, the highest normalization was obtained for the quality of the glass packaging with a defuzzification value of 0.49. Hence, the optimal tension temperature setting on the felling machine was an alternative improvement for returning leaking needles with a defuzzification value of 0.55 and a consistency index of 0.03. Based on the results of the improvements, it was found that the company could reduce returns on products by 85.70% to 128 glasses.

Keyword: Pareto, Fuzzy AHP, Normalization, Deffuyfication, Return Product

Copyright (c) 2024 Sesar Husen Santosa, Agung Prayudha Hidayat, Ridwan Siskandar, Annisa Rizkiriani, Khoirul Aziz Husyairi
DOI: https://doi.org/10.36275/vvp9qe67

INTRODUCTION

The development of the bottled water industry currently has a high level of business competition, where business people must be able to provide competitive products to compete in the market. The current problem faced by mineral water industry players in packaging is related to high product returns, which give rise to problems related to stock buildup conditions and decreasing levels of consumer satisfaction. The high stock is caused by the company having to repackage due to returns, causing overstock.

Return stock can cause stock buildup in the warehouse and cause product damage (Malladi et al., 2020). Optimal inventory planning can be done by identifying problems related to product returns (Katsios et al., 2018). Managing product returns requires identifying alternative improvements related to problems in a structured manner to obtain optimal solutions (Bieniek, 2021; Hasani et al., 2018).

The stock return problem at PT Marina caused the company to experience an increase in stock, and the company could not identify the problem in a structured manner. Mistakes in product returns can be caused by non-optimal production processes and material handling activities during the distribution process (Ericsson et al., 2021). The company's material handling process is one of the factors in maintaining product quality before being sent to consumers. Delivery distance and the means of transportation used are factors in the success of product distribution (Ojha et al., 2019) (Santosa et al., 2023)

PT Marina's glass packaging products have the biggest return problems where six types of returns occur: Needle Leak Cup, Titled Cup, Split Cup, Dented Cup, Cup Lips not Flat and Lidcup Broken Coin. These six types of returns have different ways of handling them, so companies need to identify optimal alternative repair options. The quality handling process requires a check sheet to record the number of problems that occur so that you can determine the main priority of problems to be corrected using the Pareto diagram (Erdil, 2019; Ginting et al., 2020)

The quality of the glass can cause the problem of returning drinking water products in glass packaging in terms of the thickness and weight of the plastic cup used not being suitable for the product's condition (Malesa & Rajkiewicz, 2021). The production quality control process can determine whether the quality of the product produced can be maintained until the consumer (Ginel & Alvarez-Arenas, 2019; Liu et al., 2022). There are types of return products from customer at PT Marina consisting of tilted cup, needle leak lidcup, broken coin lidcup, split cup, cup lips are not flat, and dented cup.

Handling returned products requires an inspection process related to product quality from production to consumer delivery (Ren et al., 2023). The company conducts the inspection process during production by looking at the condition of the packaging and testing the strength of the product packaging. Still, this condition cannot reduce returns for glass bottled mineral water products.

Managing machines' production speed is one factor that must be considered to maintain accurate quantity and quality of production (Polotski et al., 2019; Santosa & Hidayat, 2019). Based on the identification results, several levels are related to various variables that influence product returns management at PT Marina. This creates complexity in the decission making analysis to improve product returns.

The model for determining alternative solutions to a problem can use a hierarchy that shows the relationship between levels to obtain an optimal solution (Butdee & Phuangsalee, 2019; Prayudha Hidayat et al., 2023). By paying attention to the relationship between variables at each level, analytical decision-making can be done using the Analytical Hierarchy Process.

The hierarchical structure of glass product return problems in companies can be described based on literature studies and field observations in companies. There is ambiguity in determining the importance value of experts, which results in vague results, so a fuzzy logic approach is needed in describing the natural expression of the assessment carried out (Shaygan & Testik, 2019; Venkatesh et al., 2019).

Determining alternative options for optimally resolving return problems at PT Marina uses the fuzzy AHP approach to conduct the fuzzification process of natural expressions with vague values from expert assessments' results. The normalization process in Fuzzy AHP is obtained from the impact factor value resulting from the expression of expert assessment, which is processed into a fuzzy value for the defuzzification process of alternative options selected for decision making (Ogundoyin & Kamil, 2020).

Based on the problem of product returns at PT Marina, the researcher will focus on selecting optimal alternatives to reduce returns on glass bottled mineral water products using the Fuzzy AHP approach. The novelty of this research is developing a fuzzy AHP model related to handling returns of mineral water products in glass packaging using a defuzzification model to determine alternative improvement priorities integrated with the Pareto diagram at PT Marina.

RESEARCH METHOD

Handling product returns at PT Marina uses the Fuzzy AHP approach to identify those related to the highest returns uses the product return scanning application, namely Stock Control and Production Schedule Application (SCAPSA). Identify the highest return using the Pareto diagram. The following are the stages of research on handling returns of glass bottled drinking water products at PT Marina:

1. Pareto Diagram

The Pareto diagram illustrates the problem of the number of product returns based on the type of return generated in the company. The Pareto diagram is a tool in quality control to identify the number of product rejects (Memon et al., 2019) (Ginting & Fattah, 2020)

2. Natural Representation

Natural representation is used to describe the actual conditions of return problems in companies based on expert assessments. Natural representation describes the variables involved in solving expert value-based problems (Zhu et al., 2020). The scale used for natural representation is the SAATY scale and can be seen in Table 1. (Satty, 1994)

Table 1. Saaty Scale Value

No	Saaty Scale	Normalization Value	Fuzzy Set Number
1	1	Equally Important	(1,1,3)
3	3	Little More Important	(1,3,5)
5	5	Obviously More Important	(3,5,7)
7	7	Cleary More Important	(5,7,9)
9	9	Absolutely More Important	(7,9,9)

Consistency Index (CI) determines expert consistency in conducting assessments. Consistency in filling out the questionnaire is obtained if the CI value is <10% (Cinar & Cebi, 2020; Singh & Sarkar, 2019). The CI formulation is as follows (Al Khoiry et al., 2022)

Ve = xabj/ $\sum_{j=1}^{i}$ xab, ∀ a,b, $x$ab ∈ x

Vp = $\sum_{b=1}^{a}$ xab/n

λ_{max} = $\sum_{b=1}^{a}$ λ/n

CI = (λ_{max} -n)/(n-1)

3. Fuzzyfikasi

Fuzzyfication describes the expert's vagueness value for each variable in the AHP hierarchy (Büyüközkan et al., 2020). The fuzzyfication value uses a fuzzy membership set model with the triangular type. The fuzzyfication values used can be seen in Table 2.

4. Fuzzy Computation

Fuzzy computing is used to determine impact factors and normalize expert assessment results. The impact factor uses the geomean for three levels, namely Lower (L), Medium (M), and Upper (U). The Impact Factor Assessment Model is as follows (Al Khoiry et al., 2022; Tooranloo et al., 2018)

Si = [$\sum_{j=1}^{i}$ Mgi ⊗ [$\sum_{i=1}^{a}$ $\sum_{j=1}^{b}$ Mgi]$^{-1}$

The Impact Factor in the fuzzy number calculation process in the AHP matrix is as follows.

$$\sum_{i=1}^{J} Mgi = \sum_{j=1}^{a} \text{Lij}, \sum_{j=1}^{b} \text{Mij}, \sum_{j=1}^{c} \text{Uij}$$

5. Normalize Fuzzy Number

Normalization is carried out to determine the fuzzy value of each variable based on the Lower (L), Medium (M) and Upper (U) levels. The normalization model used for the defuzzification process is as follows (Tooranloo et al., 2018) (Al Khoiry et al., 2022)

$$[\sum_{i=1}^{a} \sum_{j=1}^{b} \text{Mgi}]^{-1} = \frac{1}{\left[\sum_{i=1}^{a} \sum_{j=1}^{b} \text{Uij}\right]}, \frac{1}{\left[\sum_{i=1}^{a} \sum_{j=1}^{b} \text{Mij}\right]}, \frac{1}{\left[\sum_{i=1}^{a} \sum_{j=1}^{b} \text{Lij}\right]}$$

6. Defuzzification

The defuzzification process in Fuzzy AHP is used to determine the weight of each variable at the AHP level. The defuzzification model used is as follows (Al Khoiry et al., 2022; Büyüközkan et al., 2020)

$$F = (1/2)\ (\alpha U + M + (1-\alpha)\ L$$

7. Determining Alternative Solutions

Alternative solutions are determined using the highest weight assessment of the alternatives used to solve PT Marina's product return problems. The choice is determined using the weight values resulting from the defuzzification process from each level in the AHP fuzzy hierarchy being developed (Prayudha et al., 2021) (Wardah & Baidawi, 2020)

RESULT AND DISCUSSION

The return of mineral water products in glass packaging at PT Marina is a problem that causes production planning conditions to be not optimal. This problem has an impact on high stock returns, which causes the amount of stock in the warehouse to become overstocked. This product return condition requires optimal handling, where alternative improvements to return conditions become critical in managing product returns.

The company's step in making improvements in identifying six types of product returns using the SCAPSA (Stock Capacity and Production Schedule Application) Scanning application. The results of scanning returns will be used to analyze the highest number of returns using the Pareto diagram.

1. Pareto Diagram

Six types of product returns occur in companies that can be identified using the SCAPSA application: Needle Leak Cup, Titled Cup, Split Cup, Dented Cup, Cup Lips not Flat and Lidcup Broken Coin. Based on the scanning results in December 2024, the number of returns for each type can be seen in Figure 1.

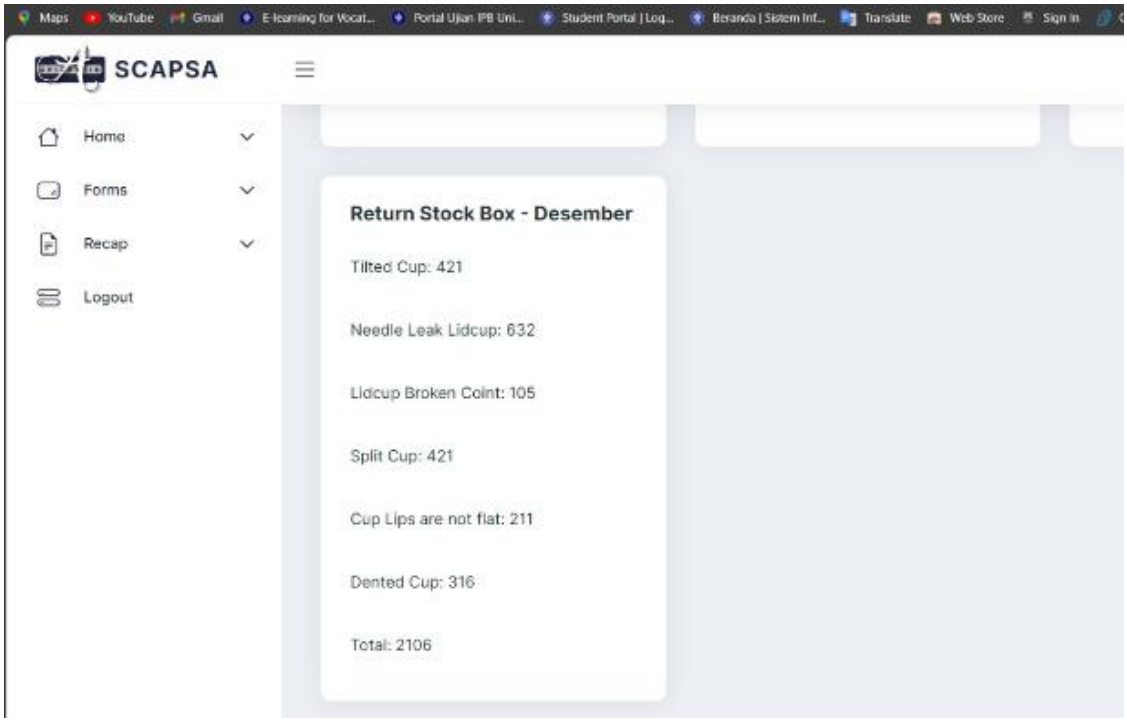


Figure 1 The number of returns Product in December 2023

Based on the results of SCAPSA scanning, the number of product returns from each type is obtained, where this number of returns will be converted back into stock in the warehouse when the packaging process has been carried out again for the remaining undamaged products in the box. The scanning process using the SCAPSA application is carried out continuously to provide information regarding the condition of product returns per day. The results of the Pareto diagram for the number of product returns can be seen in Figure 2.

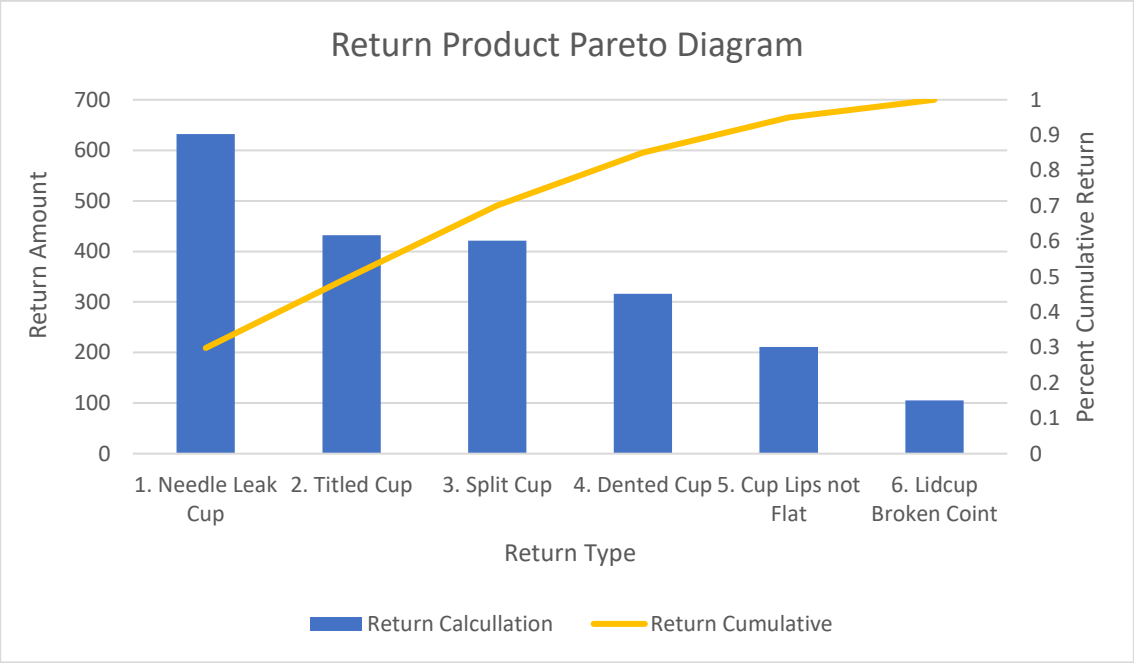


Figure 2 Return Product Pareto Diagram

Based on the results of identifying the number of returns, it was found that the highest product return was the needle leak cup type, with a total of 632 cups. Product returns of this type will be analyzed using the Fuzzy AHP approach to determine alternative improvement solutions so that the number of returns can decrease to maintain product stock conditions.

The problem of returning products from consumers can be caused by the thickness of the glass packaging being 2.25 grams which still has a very large chance of tearing. Apart from that, the temperature of the packaging closing press machine is often not optimal, which causes the packaging to be damaged during distribution and storage to consumers. The quality control process for glass packaging is not carried out optimally and is only carried out by one Quality Control person using the sense of sight. This is a cause that can influence the amount of product returns based on the type of return obtained in the company

An alternative analysis of product return improvements with the needle leak cup type uses a fuzzy approach, which determines natural representations from experts to describe comparisons between variables. The Fuzzy AHP hierarchy in solving this problem can be seen in Figure 7.

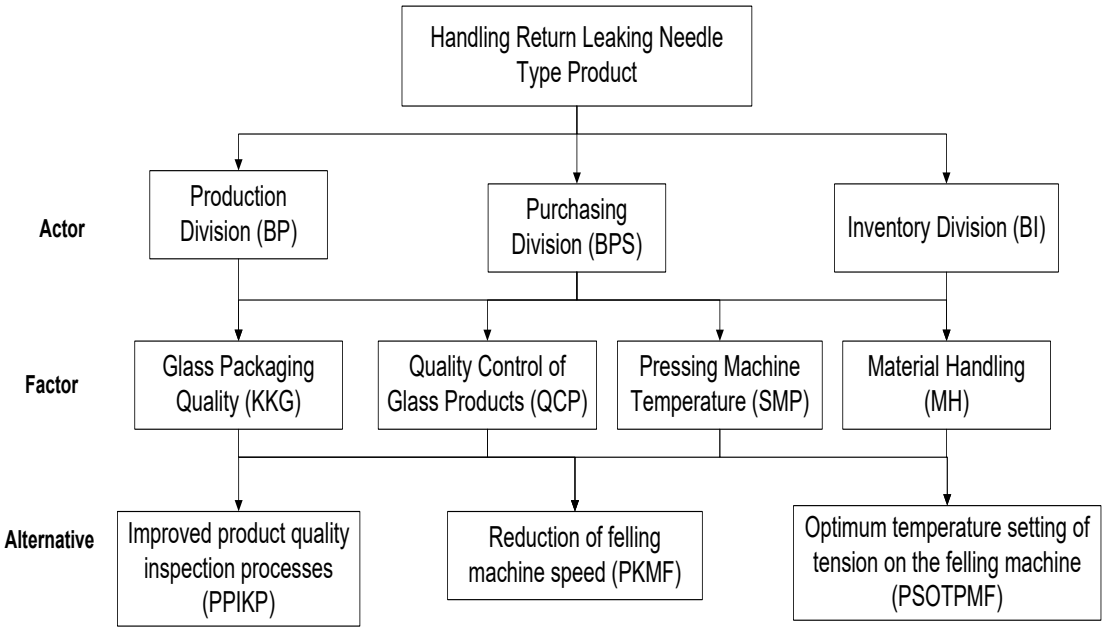


Figure 3 AHP Structure Return Product

Based on the results of identifying the fuzzy AHP structure, the steps in decision making using fuzzy AHP are then identified as follows:

2. Natural representation

Natural representation is used to see the results of expert assessments related to the problem of returning glass packaging products resulting from expert assessments to determine the Consistency Index (CI) value. The results of determining the expert value in the AHP model. The factors for achieving the goal, namely Handling return leaking needle product (Goal), can be seen in Table 3.

Table 1 Goal Level Consistency Index (CI) Analysis

Goal	Natural Representation			VE	VP	VA	CR	CI
	BP	BPS	BI					
Produktion Division (BP)	1	Obviously More Important	Cleary More Important	3,27	0,73	2,24	0,03	0,06
Purchasing Division (BPS)		1	Little More Important	0,84	0,19	0,58		
Inventory Division (BI)			1	0,36	0,08	0,25		

The results of expert identification regarding factors influencing product returns consist of related variables, namely production, purchasing and inventory. The results of determining the Consistency index value to be used as the expert's level of consistency in the natural representation of acts can be seen in Table 4.

Table 2 Production Division Factor Level Consistency Index (CI) Analysis

Production Division	Natural Representation				VE	VP	VA	CR	CI
	KKG	QCP	SMP	MH					
Glass Packaging Quality (KKG)	1	Little More Important	Obviously More Important	Cleary More Important	3,20	0,56	2,33	4,12	0,04
Quality Control of Glass Products (QCP)		1	Little More Important	Obviously More Important	1,50	0,26	1,08		
Pressing Machine Temperature (SMP)			1	Little More Important	0,67	0,12	0,48		
Material Handling (MH)				1	0,31	0,06	0,23		

Based on the CI value of the production division, the CI value related to factors in the purchasing division is then determined. The results of expert filling showed that the CI value was below 0.1, so in the purchasing division, the consistency of expert filling was acceptable for use in determining natural fuzzy representatives. The results of CI calculations in the purchasing division for factors can be seen in Table 5.

Table 3 Purchasing Division Factor Level Consistency Index (CI) Analysis

Purchasing Division	Natural Representation				VE	VP	VA	CR	CI
	KKG	QCP	SMP	MH					
Glass Packaging Quality (KKG)	1	Little More Important	Little More Important	Obviously More Important	2,59	0,49	2,14	4,23	0,08
Quality Control of Glass Products (QCP)		1	Little More Important	Cleary More Important	1,63	0,31	1,32		
Pressing Machine Temperature (SMP)			1	Little More Important	0,76	0,14	0,59		
Material Handling (MH)				1	0,31	0,06	0,25		

Based on the results of CI calculations in the inventory division for factors observed by mechanical experts, it was found that the CI value was below 0.10. This condition shows that the questionnaire is filled out consistently by experts. The results of the CI consistency test in the inventory division on factors can be seen in Table 6

Table 4 Inventory Division Factor Level Consistency Index (CI) Analysis

Natural Representation					VE	VP	VA	CR	CI
Inventory Division	KKG	QCP	SMP	MH					
Glass Packaging Quality (KKG)	1			Little More Important	0,67	0,13	0,54	0,07	0,07
Quality Control of Glass Products (QCP)	Obviously More Important	1	Little More Important	Obviously More Important	2,94	0,55	2,29		
Pressing Machine Temperature (SMP)	Little More Important		1	Little More Important	1,32	0,25	1,03		
Material Handling (MH)				1	0,39	0,07	0,31		

3. Fuzzyfication Process

The Fuzzyfication process changes natural numbers into fuzzy numbers based on triangular membership sets. This fuzzy number determination is carried out to obtain importance factor and normalization values for the computing process. The results of the fuzzification goal calculation are handling the return leaking needle for each influencing factor by determining the impact factor and normalizing Lower (L), Medium (M) and Upper (U) to get the defuzzification value for each actor. The results of the goal fuzzification of actors who influence the AHP hierarchy can be seen in Table 7.

Table 5 Fuzzyfication Results of Handling Return Leaking Needle Type Product

Fuzzy Computation									
Handling Return Leaking Needle	BP	BPS	B	Importance Factor			Normalization		
				L	M	U	L	M	U
Production Division (BP)	(1,1,1)	(3,5,7)	(5,7,9)	2,466	3,271	3,979	0,429	0,731	1,218
Purchasing Division (BPS)	(0,14; 0,20; 0,33)	(1,1,1)	(1,3,5)	0,519	0,843	1,182	0,090	0,189	0,362
Inventory Division (BI)	(0,11; 0,14; 0,20)	(0,20; 0,33; 1)	(1,1,1)	0,280	0,359	0,585	0,049	0,080	0,179

The results of fuzzy computing calculations are carried out at each level, including the actor and factor levels in the AHP structure. The results of determining normalization at the factor level for actors, namely the production division, are identified by determining the impact factor and normalizing Lower (L), Medium (M) and Upper (U) to determine the defuzzification results for each level in the AHP hierarchy. The results of fuzzy computing on factors can be seen in Table 8.

Table 6 Production Division Fuzzification Results at Factor Level

Production Division	KKG	QCP	SMP	MH	Importance Factor			Normalization		
					L	M	U	L	M	U
Glass Packaging Quality (KKG)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)	1,968	3,201	4,213	0,238	0,547	1,206
Quality Control of Glass Products (QCP)	(0,20; 0,33; 1)	(1,1,1)	(1,3,5)	(3,5,7)	0,880	1,492	2,432	0,106	0,255	0,696
Pressing Machine Temperature (SMP)	(0,14; 0,20; 0,33)	(0,20; 0,33; 1)	(1,1,1)	(1,3,5)	0,409	0,667	1,133	0,049	0,114	0,324
Material Handling (MH)	(0,11; 0,14; 0,20)	(0,14; 0,20; 0,33)	(0,20; 0,33; 1)	(1,1,1)	0,236	0,488	0,507	0,028	0,083	0,145

The results of determining the impact factor value and normalization of the purchasing division for each factor are determined based on expert assessment. The results of determining normalization at the factor level for actors, namely the purchasing division, were identified by determining the impact factor and normalizing Lower (L), Medium (M) and Upper (U) to determine the defuzzification results for each level in the AHP hierarchy. The results of the fuzzification of expert assessments on factor assessments for the purchasing section can be seen in Table 9.

Table 7 Purchasing Division Fuzzification Results at Factor Level

Purchasing Division	KKG	QCP	SMP	MH	Importance Factor			Normalization		
					L	M	U	L	M	U
Glass Packaging Quality (KKG)	(1,1,1)	(1,3,5)	(1,3,5)	(3,5,7)	1,316	2,590	4,787	0,140	0,491	1,596
Quality Control of Glass Products (QCP)	(0,20; 0,33; 1)	(1,1,1)	(1,3,5)	(5,7,9)	1,000	1,622	2,590	0,107	0,307	0,864
Pressing Machine Temperature (SMP)	(0,20; 0,33; 1)	(0,20; 0,33; 1)	(1,1,1)	(1,3,5)	0,447	0,756	1,495	0,048	0,143	0,499
Material Handling (MH)	(0,14; 0,20; 0,33)	(0,11; 0,14; 0,20)	(0,20; 0,33; 1)	(1,1,1)	0,236	0,310	0,507	0,025	0,059	0,169

The impact factor values and normalization results in the inventory division are used to determine the defuzzification results of each factor variable. The results of determining normalization at the factor level for actors, namely the inventory division, are identified by determining defuzzification values at the Lower (L), Medium (M) and Upper (U) levels in the AHP hierarchy. The results of the fuzzification of the expert assessment on the factor assessment of the inventory section can be seen in Table 10.

Table 8 Inventory Division Fuzzification Results at Factor Level

Inventory Division	KKG	QCP	SMP	MH	Importance Factor			Normalization		
					L	M	U	L	M	U
Glass Packaging Quality (KKG)	(1,1,1)	(0,14; 0,20; 0,33)	(0,20; 0,33; 1)	(1,3,5)	0,40	0,66	1,13	0,05	0,12	0,36
Quality Control of Glass Products (QCP)	(3,5,7)	(1,1,1)	(1,3,5)	(3,5,7)	1,73	2,94	3,95	0,21	0,55	1,28
Pressing Machine Temperature (SMP)	(1,3,5)	(0,20; 0,33; 1)	(1,1,1)	(1,3,5)	0,66	1,31	2,23	0,08	0,24	0,72
Material Handling (MH)	(0,20; 0,33; 1)	(0,14; 0,20; 0,33)	(0,20; 0,33; 1)	(1,1,1)	0,27	0,38	0,75	0,03	0,07	0,24

4. Fuzzy Computation

The results of determining the impact factor value and normalizing glass packaging quality factors were identified by determining the impact factor and normalizing it with Lower (L), Medium (M) and Upper (U) levels to determine the defuzzification results for each level in the AHP hierarchy. The expert assessment fuzzification process results on the Glass Packaging Quality factors can be seen in Table 11.

Table 9 Glasses Packaging Quality Computing Fuzzy Results

Glass Packaging Quality	PPIKP	PKMF	PSOTPMF	Importance Factor			Normalization		
				L	M	U	L	M	U
Improved product quality inspection processes (PPIKP)	(1,1,1)	(0,33; 1; 1)	(0,11; 0,14; 0,2)	0,33	0,51	0,58	0,06	0,11	0,19
Reduction of feeling machine speed (PKMF)	(1,1,3)	(1,1,1)	(0,14; 0,20; 0,33)	0,24	0,58	0,99	0,04	0,13	0,32
Optimum temperature setting of tension on the felling machine (PSOTPMF)	(5,7,9)	(3,5,7)	(1,1,1)	2,46	3,27	3,97	0,44	0,74	1,31

The results of determining the impact factor value and normalizing the Quality Control of Glass Product factors were identified by determining the impact factor and normalizing it with the Lower (L), Medium (M) and Upper (U) levels to determine the defuzzification results for each level in the AHP hierarchy. The results of the expert assessment fuzzification process on the assessment of the Quality Control of Glass Product factors can be seen in **Table 11**

Table 10 Fuzzy Quality Control of Glass Product Computation Results

Quality Control of Glass Product	PPIKP	PKMF	PSOTPMF	Importance Factor			Normalization		
				L	M	U	L	M	U
Improved product quality inspection processes (PPIKP)	(1,1,1)	(0,14; 0,20; 0,33)	(0,33; 1; 1)	0,359	0,585	0,691	0,063	0,144	0,090
Reduction of felling machine speed (PKMF)	(3,5,7)	(1,1,1)	(1,3,5)	1,442	2,466	3,271	0,254	0,609	0,426
Optimum temperature setting of tension on the felling machine (PSOTPMF)	(1,3,5)	(0,20; 0,33; 1)	(1,1,1)	5,877	0,997	1,710	1,036	0,246	0,223

The results of determining the impact factor value and normalizing the Pressing Machine temperature factor were identified by determining the impact factor and normalizing it with the Lower (L), Medium (M) and Upper (U) levels to determine the defuzzification results for each level in the AHP hierarchy. The expert assessment process results on the Pressing Machine temperature factor assessment can be seen in Table 13.

Table 11 Fuzzy Pressing Machine Temperature Computation Results

Pressing Machine Temprature	PPIKP	PKMF	PSOTPMF	Importance Factor			Normalization		
				L	M	U	L	M	U
Improved product quality inspection processes (PPIKP)	(1,1,1)	(0,20; 0,33; 1)	(0,14; 0,20; 0,33)	0,304	0,404	0,691	0,085	0,180	0,491
Reduction of felling machine speed (PKMF)	(1,3,5)	(1,1,1)	(0,20; 0,33; 1)	0,585	0,997	1,710	0,163	0,444	1,215
Optimum temperature setting of tension on the felling machine (PSOTPMF)	(3,5,7)	(1,3,5)	(1,1,1)	0,519	0,843	1,182	0,145	0,376	0,839

The results of determining the impact factor value and normalization of Material Handling factors were identified by determining the impact factor and normalization with the Lower (L), Medium (M) and Upper (U) levels to determine the defuzzification results for each level in the AHP hierarchy. The expert assessment process results on the Material Handling factor assessment can be seen in Table 14.

Table 12 Fuzzy Material Handling Computation Results

Material Handling	PPIKP	PKMF	PSOTPMF	Importance Factor			Normalization		
				L	M	U	L	M	U
Improved product quality inspection processes (PPIKP)	(1,1,1)	(3,5,7)	(5,7,9)	2,466	3,271	3,979	0,429	0,731	1,218
Reduction of feeling machine speed (PKMF)	(0,14; 0,20; 0,33)	(1,1,1)	(1,3,5)	0,519	0,843	1,182	0,090	0,189	0,362
Optimum temperature setting of tension on the felling machine (PSOTPMF)	(0,11; 0,14; 0,20)	(0,20; 0,33; 1)	(1,1,1)	0,280	0,359	0,585	0,049	0,080	0,179

5. Defuzzification

The defuzzification process determines the weight of each variable used in Fuzzy AHP. The results of the defuzzification process to determine the importance weight of each level in the AHP hierarchy for handling product returns can be seen in the following Table 15.

Table 13 Defuzzification Results at Each Level of the Fuzzy AHP Hierarchy

Variable	BP	BPS	BI	KKG	QCP	SHM	MH	PPIKP	PKMF	PSOTPMF
Goal	0,72	0,19	0,09							
Production Division (BP)				0,63	0,33	0,15	0,09			
Purchasing Division (BPS)				0,68	0,40	0,21	0,08			
Inventory Division (BI)				0,17	0,65	0,33	0,11			
Glass Packaging Quality (KKG)								0,122	0,160	0,812
Quality Control of Glass Products (QCP)								0,111	0,475	0,438
Pressing Machine Temperature (SMP)								0,234	0,567	0,434
Matrial Handling (MH)								0,778	0,207	0,097

3. Alternative Solution

Based on the results of the defuzzification process using a triangular membership set with parameters, an alternative selection process can be carried out regarding the problem of product returns at PT Marina. The results of determining the factor level defuzzification value in the

Fuzzy AHP hierarchy for selecting the best alternative improvement related to the return problem of glass packaging products can be seen in Table 16.

Table 14 Defuzzification of factor levels in the Fuzzy AHP hierarchy

Criteria	Alternative			Attribute Value
	Production Division	Purchasing Division	Inventory Division	
Glass Packaging Quality	**0,53**	**0,50**	**0,13**	**0,49**
Quality Control of Glass Products	0,27	0,29	0,52	0,30
Pressing Machine Temperature	0,13	0,15	0,26	0,14
Material Handling	0,07	0,06	0,08	0,07
Weight	0,72	0,19	0,09	

Based on the results of the defuzzification process using a triangular membership set with parameters using the Saaty scale, a defuzzification process can be carried out to select alternative priorities related to product return problems at PT Marina. The results of prioritization at the alternative level in the Fuzzy AHP hierarchy show that the best alternative improvement is related to the problem of returning *product can be seen at* Table 17.

Table 15 Priority Alternative Value

Criteria	Alternative				Attribute Value
	Glass Packaging Quality	Quality Control of Glass Products	Pressing Machine Temperature	Material Handling	
Improved product quality inspection processes	0,11	0,11	0,19	0,72	0,16
Reduction of filling machine speed	0,15	0,46	0,46	0,19	0,29
Optimum temperature setting of tension on the filling machine	**0,74**	**0,43**	**0,35**	**0,09**	**0,55**
Weight	0,49	0,30	0,14	0,07	

Based on the analysis using the fuzzy AHP method, it was found that the greatest alternative value for handling product returns was related to felling machine management. This felling machine is a machine for uniting plastic lids with glass packaging. Based on the fuzzy AHP analysis results, improvements must be made: the company must carry out an Optimum temperature setting of tension on the felling machine with a weight value of the defuzzification results of 0.55. This is a priority repair so that the plastic parts of the lid and glass can stick together perfectly. The results of the improvements have been tested in the production period in January 2024 and a return reduction of 79.75% was obtained which can be seen in Figure 4.

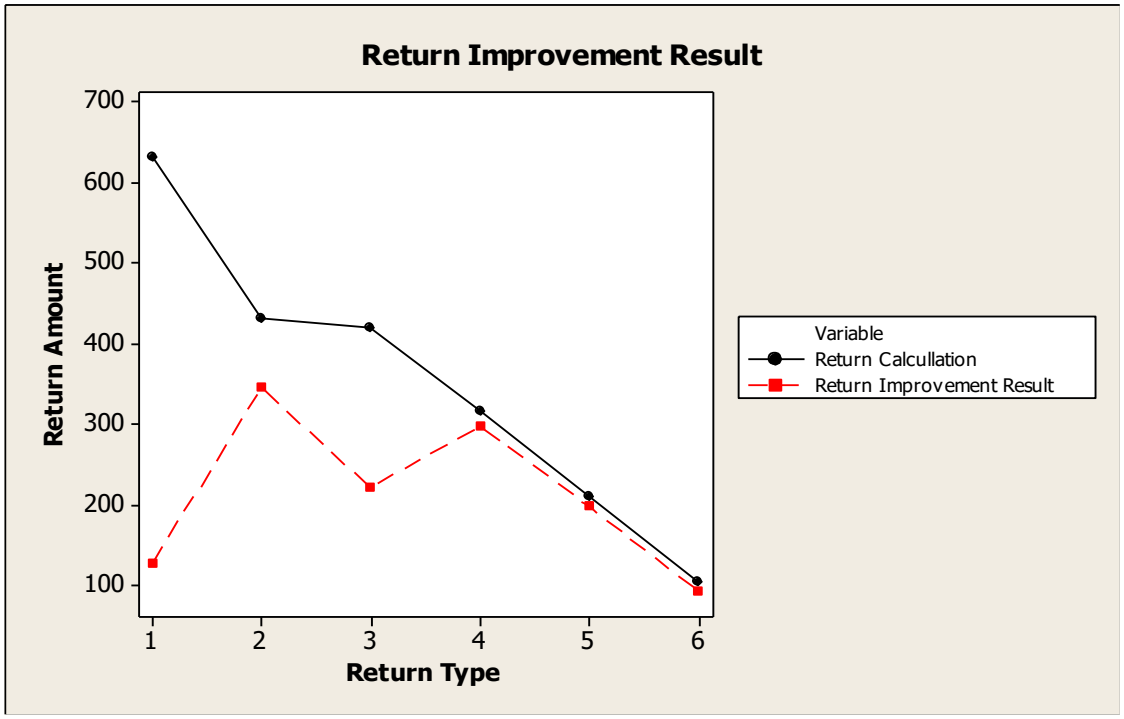


Figure 4 Comparison of the Return Product Improvement Results

CONCLUSION

The analysis of alternative improvements related to product returns at PT Marina using the fuzzy AHP method shows that the company must improve the tension temperature on the filling machine. This temperature setting can reduce product returns by 79.75% to 128 consumer returns. This condition shows that the company requires further research studies to optimize return conditions by analyzing product distribution channels to improve inbound and outbound logistics continuously.

REFERENCES

Al Khoiry, I., Gernowo, R., & Surarso, B. (2022). Fuzzy-ahp moora approach for vendor selection applications. *Register: Jurnal Ilmiah Teknologi Sistem Informasi*, *8*(1), 24–37. https://doi.org/10.26594/REGISTER.V8I1.2356

Bakır, M., & Atalık, Ö. (2021). Application of fuzzy AHP and fuzzy MARCOS approach for the evaluation of e-service quality in the airline industry. Decision Making: Applications in Management and Engineering, 4(1), 127-152.

Bieniek, M. (2021). Consumer returns in consignment contracts with inventory control and additive uncertainty. *Infor*, *59*(1), 169–189. https://doi.org/10.1080/03155986.2020.1796065

Butdee, S., & Phuangsalee, P. (2019). Uncertain risk assessment modelling for bus body manufacturing supply chain using AHP and fuzzy AHP. *Procedia Manufacturing*, *30*, 663–670. https://doi.org/10.1016/j.promfg.2019.02.094

Büyüközkan, G., Havle, C. A., & Feyzioğlu, O. (2020). A new digital service quality model and its strategic analysis in aviation industry using interval-valued intuitionistic fuzzy AHP. *Journal of Air Transport Management*, *86*(December 2019). https://doi.org/10.1016/j.jairtraman.2020.101817

Çalık, A. (2021). A novel Pythagorean fuzzy AHP and fuzzy TOPSIS methodology for green supplier selection in the Industry 4.0 era: A. Çalık. Soft computing, 25(3), 2253-2265.

Cinar, U., & Cebi, S. (2020). A hybrid risk assessment method for mining sector based on

QFD, fuzzy logic and AHP. In *Advances in Intelligent Systems and Computing* (Vol. 1029). Springer International Publishing. https://doi.org/10.1007/978-3-030-23756-1_141

Erdil, A. (2019). An Evaluation on Lifecycle of Products in Textile Industry of Turkey through Quality Function Deployment and Pareto Analysis. *Procedia Computer Science*, *158*, 735–744. https://doi.org/10.1016/j.procs.2019.09.109

Ericsson, M., Johansson, D., & Stjern, D. (2021). Ai-based quality control of wood surfaces with autonomous material handling. *Applied Sciences (Switzerland)*, *11*(21). https://doi.org/10.3390/app11219965

Ginel, A. M., & Alvarez-Arenas, T. G. (2019). Air-coupled Transducers for Quality Control in the Food Industry. *IEEE International Ultrasonics Symposium, IUS*, *2019-Octob*, 803–806. https://doi.org/10.1109/ULTSYM.2019.8925853

Ginting, R., & Fattah, M. G. (2020). Production quality control with new seven tools for defect minimization on PT. Dirgantara Indonesia. *IOP Conference Series: Earth and Environmental Science*, *452*(1). https://doi.org/10.1088/1755-1315/452/1/012082

Ginting, R., Wanli, & Fauzi Malik, A. (2020). Crude Palm Oil Product Quality Control Using Seven Tools (case study: XYZ Company). *IOP Conference Series: Materials Science and Engineering*, *851*(1). https://doi.org/10.1088/1757-899X/851/1/012046

Hasani, A., Eskandarpour, M., & Fattahi, M. (2018). A simulation-based optimisation approach for multi-objective inventory control of perishable products in closed-loop supply chains under uncertainty. *International Journal of Advanced Operations Management*, *10*(4), 324–344. https://doi.org/10.1504/IJAOM.2018.097268

Hossain, M. K., & Thakur, V. (2021). Benchmarking health-care supply chain by implementing Industry 4.0: a fuzzy-AHP-DEMATEL approach. Benchmarking: An International Journal, 28(2), 556-581.

Katsios, D., Xanthopoulos, A. S., Koulouriotis, D. E., & Kiatipis, A. (2018). A simulation optimisation tool and its production/inventory control application. *International Journal of Simulation Modelling*, *17*(2), 257–270. https://doi.org/10.2507/IJSIMM17(2)425

Liu, J., Ellies-oury, M. P., Stoyanchev, T., & Hocquette, J. F. (2022). Consumer Perception of Beef Quality and How to Control, Improve and Predict It? Focus on Eating Quality. *Foods*, *11*(12), 1–27. https://doi.org/10.3390/foods11121732

Malesa, M., & Rajkiewicz, P. (2021). Quality control of pet bottles caps with dedicated image calibration and deep neural networks. *Sensors (Switzerland)*, *21*(2), 1–16. https://doi.org/10.3390/s21020501

Malladi, S. S., Erera, A. L., & White, C. C. (2020). A dynamic mobile production capacity and inventory control problem. *IISE Transactions*, *52*(8), 926–943. https://doi.org/10.1080/24725854.2019.1693709

Memon, I. A., Rajput, U. A., Ali, A., Abro, S. A. K., Memon, M. A., & Memon, A. A. (2019). Controlling the Defects of Paint Shop using Seven Quality Control Tools in an Automotive Factory. *Engineering, Technology and Applied Science Research*, *9*(6), 5062–5065. https://doi.org/10.48084/etasr.3160

Nezhad, M. Z., Nazarian-Jashnabadi, J., Rezazadeh, J., Mehraeen, M., & Bagheri, R. (2023). Assessing dimensions influencing IoT implementation readiness in industries: A fuzzy DEMATEL and fuzzy AHP analysis. Journal of soft computing and decision analytics, 1(1), 102-123.

Ogundoyin, S. O., & Kamil, I. A. (2020). A Fuzzy-AHP based prioritization of trust criteria in fog computing services. *Applied Soft Computing Journal*, *97*, 106789. https://doi.org/10.1016/j.asoc.2020.106789

Ojha, V. K., Dixit, S., & Goyal, S. (2019). An AHP-based comparison between automated and manual material handling systems in FMS environment. *International Journal of*

Productivity and Quality Management, *28*(2), 256–277. https://doi.org/10.1504/IJPQM.2019.102927

Polotski, V., Kenné, J. P., & Gharbi, A. (2019). Production control of hybrid manufacturing–remanufacturing systems under demand and return variations. *International Journal of Production Research*, *57*(1), 100–123. https://doi.org/10.1080/00207543.2018.1461272

Prayudha, A., Husen, S., Siskandar, R., & Gilang, R. (2021). *Evaluation of Chicken Eggs Supply With Fuzzy AHP Approach Through Development of Safea Software*. *5*(2), 104–110.

Prayudha Hidayat, A., Wiyoto, W., Julio Pratama, A., Vibowo, H., Husen Santosa, S., & Siskandar, R. (2023). Fuzzy Analytical Hierarchy Process (AHP) Model for Chicken Egg Supply and Demand Management Strategies Through SAFCES Application Development. *E3S Web of Conferences*, *454*. https://doi.org/10.1051/e3sconf/202345403004

Ren, H., Chen, R., & Lin, Z. (2023). A Study of Electronic Product Supply Chain Decisions Considering Quality Control and Cross-Channel Returns. *Sustainability (Switzerland)*, *15*(16), 1–23. https://doi.org/10.3390/su151612304

Santosa, S. H., & Hidayat, A. P. (2019). Model Penentuan Jumlah Pesanan Pada Aktifitas Supply Chain Telur Ayam Menggunakan Fuzzy Logic. *Jurnal Ilmiah Teknik Industri*, *18*(2), 224–235. https://doi.org/10.23917/jiti.v18i2.8486

Santosa, S. H., Hidayat, A. P., Siskandar, R., & Husyairi, K. A. (2023). Smart Production Planning Model for T-Shirt Products at Raensa Convection. *Jurnal Ilmiah Teknik Industri*, *22*(1), 49–57. https://doi.org/10.23917/jiti.v22i1.21398

Satty, T. L. (1994). Theory and Methodology Highlights and critical points in the theory and application of the Analytic Hierarchy Process. *European Journal of Operational Research*, *74*(3), 426–447.

Shaygan, A., & Testik, Ö. M. (2019). A fuzzy AHP-based methodology for project prioritization and selection. *Soft Computing*, *23*(4), 1309–1319. https://doi.org/10.1007/s00500-017-2851-9

Singh, P. K., & Sarkar, P. (2019). A framework based on fuzzy AHP-TOPSIS for prioritizing solutions to overcome the barriers in the implementation of ecodesign practices in SMEs. *International Journal of Sustainable Development and World Ecology*, *26*(6), 506–521. https://doi.org/10.1080/13504509.2019.1605547

Tooranloo, H. S., Ayatollah, A. S., & Iranpour, A. (2018). A model for supplier evaluation and selection based on integrated interval-valued intuitionistic fuzzy AHP-TOPSIS approach. *International Journal of Mathematics in Operational Research*, *13*(3), 401–417. https://doi.org/10.1504/IJMOR.2018.094854

Venkatesh, V. G., Zhang, A., Deakins, E., Luthra, S., & Mangla, S. (2019). A fuzzy AHP-TOPSIS approach to supply partner selection in continuous aid humanitarian supply chains. *Annals of Operations Research*, *283*(1–2), 1517–1550. https://doi.org/10.1007/s10479-018-2981-1

Wardah, S., & Baidawi, T. (2020). Development of Fuzzy Analytic Hierarchy Process(F-AHP) for the Selection of Alternative New Product Development Ideas in Coconut Downstream Agroindustry. *Journal of Physics: Conference Series*, *1641*(1). https://doi.org/10.1088/1742-6596/1641/1/012024

Liu, Y., Eckert, C. M., & Earl, C. (2020). A review of fuzzy AHP methods for decision-making with subjective judgements. Expert systems with applications, 161, 113738.

Zhu, G. N., Hu, J., & Ren, H. (2020). A fuzzy rough number-based AHP-TOPSIS for design concept evaluation under uncertain environments. *Applied Soft Computing Journal*, *91*, 106228. https://doi.org/10.1016/j.asoc.2020.106228