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The conference covers, but not limited to, the following topics:

- Fracture Behaviors
- FEM in Forming Process
- Computational Mechanics
- Static and Dynamic Problems
- Noise and Vibration Control in Engineering
- The Atomic/Molecular Dynamics
- Analysis of Machine Element Design
- Computational Method in Chemical Engineering
- FEM Application in Geotechnical and Structural Engineering
- Numerical and Experimental Fracture Mechanics
- Numerical Analysis Tools for Web-Based Applications
- Computational Methods in Thermo and Fluid Mechanics
- Artificial Intelligence Application in Engineering, such as Expert System, Pattern Recognition, Neural Network Genetic Algorithm, etc.
- Metal and Polymeric Foams
- Experimental Solid and Fluid Mechanics

Table 7.1 Presentation Schedule in Technical Session (Day-1)

Day-1 (Friday, 15 May 2009)		
Technical Session		
TIME	ACTIVITIES	
	Senggigi Room (Regular Conference)	**Mataram Room (Regular Conference)**
13:40 - 15:30	Session A .1. 1: FRACTURE BEHAVIORS ; THE ATOMIC / MOLECULAR DYNAMICS ; FEM APLICATION Chairperson: Prof. Homma Hiromi	Session A. 2. 1: ARTIFICIAL INTELLIGENCE APLICATION IN ENGINEERING ; Chairperson: Prof. Ahmad Kamal Arifin
15:30 – 15:50	**COFFEE/TEA BREAK**	
15:50 - 17:40	Session A. 3. 1: FEM APPLICATION IN GEOTECHNICAL; Chairperson: Ir. Budi Santosa, MS., Ph.D.	Session A. 4. 1: COMPUTATIONAL METHODS IN THERMO AND FLUID MECHANICS Chairperson: Prof. Miyagi Kiyohiro
7:00 - 11:00	**BANQUET DINNER**	

Table 7.2 Presentation Schedule in Technical Session (Day-2)

Day-2 (Saturday, 16 May 2009)		
Technical Session		
TIME	ACTIVITIES	
	Senggigi Room (Regular Conference)	**Mataram Room (Regular Conference)**
8:30-10:20	Session A. 5. 2: COMPUTATIONAL METHODS IN ELECTRICAL AND ELECTRONIC APPLICATION Chairperson: Dr. Bambang Agus Kironoto	Session A. 6. 2: COMPUTATIONAL METHOD IN CHEMICAL ENGINEERING Chairperson: Dr. Syifaul Huzni, M.Sc.
10:20-10:40	COFFEE/TEA BREAK	
10:40-12:40	Session A. 7. 2: FEM APPLICATION; COMPUTATIONAL MECHANICS; Chairperson: Prof. Dr. Yasuhiro Kanto	Session A. 8. 2: ANALYSIS OF MACHINE ELEMENT DESIGN; NUMERICAL & EXPERIMENTAL FRACTURE MECHANICS; Chairperson: Prof. Ahmad Kamal Arifin
12:40-13:40 .	LUNCH BREAK	
13:40-15:30	Session A. 9. 2: ARTIFICIAL INTELLIGENCE APLICATION IN ENGINEERING; COMPUTATIONAL METHODE Chairperson: Dr. Amna Abdurrahman	Session B. 1. 2: COMPUTATIONAL METHODE Chairperson: Dr.Eng. Agus Setyo Muntohar Reviewer : 1. Prof. Dr. Kikuchi Masanori 2. Prof. Dr. Ahmad Kamal Arifin
3:30-3:50	**COFFEE/TEA BREAK**	
4:00-4:30	**CLOSING CEREMONY / GROUP PHOTO**	

Table 7.3 Detailed of Presentation Schedule in Technical Session

AFTERNOON SESSION	DAY 1 – FRIDAY, 15 May 2009	
	VENUE A (Regular Conference): Senggigi Room (First Floor)	VENUE B (Regular Conference): Mataram Room (First Floor)
13.40-15.30	Session A .1. 1: **FRACTURE BEHAVIORS ; THE ATOMIC / MOLECULAR DYNAMICS ; FEM APLICATION** Chairperson: Prof. Dr. Homma Hiromi	Session A. 2. 1: **ARTIFICIAL INTELLIGENCE APLICATION IN ENGINEERING ;** Chairperson: Prof. Ahmad Kamal Arifin
Keynote Speaker	1. Fatigue Crack Growth Simulation In 3-D Field using S-FEM ***Masanori Kikuchi, Yoshitaka Wada and Yulong Li***	1. Tool Life Analysis by Partial Swarm Optimization ***M.M.Noor, K.Kadirgama, M.M.Rahman, M.S.M.Sani, M.R.M.Rejab, A.K.Ariffin***
	2. A Finite Element Investigation of the Residual Stress and Deformation in Sliding Contact between Cylinders. ***Rifky Ismail, M. Tauviqirrahman, Jamari, and D.J. Schipper*** 3. Finite Element Modeling of Tire-Road Contact ***M. Sabri, A. K. Ariffin & M. J. M. Nor*** 4. Static and Dynamic Load Calculation for Piping Stress Analysis on Electrical Power Generation ***Yusri Heni N. A.*** 5. Pore Water Pressure Change Of A Homogenous Slope During Rainfall Infiltration ***Agus Setyo Muntohar and Hung-Jiun Liao***	2. Sustainable Product Development for Car Lifting Equipment using Virtual Reality ***Willyanto Anggono, Ian Hardianto Siahaan, R.M. Moch. Trah Isworo Nugroho, Satria Arief Budi*** 3. Solving the Multiobjective Transportation Problem using Fuzzy Compromise Programming ***Parwadi Moengin*** 4. Optimum Method Solution for Determining Brake Distance Design ***Ian Hardianto Siahaan, Amelia Sugondo, and Willyanto Anggono*** 5. Surface Rougness Analysis in End Milling with Response Ant Colony Optimization ***K.Kadirgama, M.M.Noor, M.M.Rahman, M.S.M.Sani, A.K.Ariffin***

AFTERNOON SESSION	DAY 1 – FRIDAY, 15 May 2009	
	VENUE A (Regular Conference): Senggigi Room (First Floor)	VENUE B (Regular Conference): Mataram Room (First Floor)
15.50 – 17.40	Session A. 3.1: **FEM APPLICATION IN GEOTECHNICAL;** Chairperson: Ir. Budi Santosa, MS., Ph.D.	Session A. 4.1: **COMPUTATIONAL METHODS IN THERMO AND FLUID MECHANICS** Chairperson: Prof. Dr. Miyagi Kiyohiro
Keynote Speaker	1. Lateral Movement of the Tie-Back Wall in Alluvial Soil ***Agus Setyo Muntohar, Hung-Jiun, Liao***	1. Numerical Investigation of In-Cylinder Pressure Characteristic of Port Injection Compressed Natural Gas Engine Model **Rosli Abu Bakar and Semin**
	2. Numerical Analysis of Time Dependent Laterally Loaded Pile in Clay ***Jasim M Abbas, Zamri Hj Chik, Mohd Raihan Taha, Qassun S. M Shafiqu*** 3. Numerical Modelling on Shallow Water 2D Equations Applied on Flow Around a Cylinder ***Bambang Yulistianto*** 4. A Design Approach of Shallow Foundation Based on Rigid Plastic Analysis ***Husna Asmaul*** 5. Gravitational Pump Design Based on Runge-Kutta Method ***J. Aminuddin***	2. The k-ε Turbulence Model for Predicting Turbulence Characteristics in Rough Uniform Open Channel Flow ***Bambang Agus Kironoto*** 3. Sustainable Technology for Improving Autoclave Performance using Finite Element Application ***Willyanto Anggono, Ian Hardianto Siahaan, Andree Kadana Tirta, Satria Arief Budi*** 4. Verification of A VOF–Based Simulation for Thin Liquid Film Flow Applications **S. Balachandran, N.H. Shuaib,** **H. Hasini, M.Z. Yusoff** 5. Trends of Engine Speed On Engine Performance Of Four Cylinder Direct Injection Hydrogen Engine **M. M. Rahman, Mohammed K. Mohammed, Rosli A. Bakar, M.M. Noor and K. Kadirgama**

MORNING SESSION		DAY 2 – SATURDAY, 16 May 2009
	VENUE A (Regular Conference): SenggigiRoom (First Floor)	VENUE B (Regular Conference): Mataram Room (First Floor)
08.30-10.20	Session A. 5. 2: **COMPUTATIONAL METHODS IN ELECTRICAL AND ELECTRONIC APPLICATION** Chairperson: Dr. Bambang Agus Kironoto	Session A. 6. 2: **COMPUTATIONAL METHOD IN CHEMICAL ENGINEERING** Chairperson: Dr. Syifaul Huzni, M.Sc.
Keynote Speaker	1. Kernel Adatron for Multiclass Support Vector Machine ***Budi Santosa***	1. Evaluation of Drag Force Effect on Hold-Up in A Gas-Liquid Stirred Tank Reactor ***R. Zadghaffari***
	2. Numerical Method for Constructing Optimal Bids by Electricity Generators in Deregulated Electricity Market ***Vladimir Kazakov*** 3. Analysis Throughput Multi-code Multicarrier CDMA S-ALOHA To Support Various Data Rate ***Indri Neforawati and Hoga Saragih*** 4. Churn Prediction in Telecommunication using Kernel Adatron ***Budi Santosa*** 5. Local Short-Term Wind Speed Prediction in the Region Nganjuk (East-Java) using Neural Network ***Ali Musyafa, Binti Cholifah, Imam Robandi***	2. Cathodic Protection Simulation for Pipe-Lines Structure with Ribbon Sacrificial Anode ***Safuadi, Syarizal Fonna, M. Ridha, Israr, A. K. Ariffin and A. R. Daud*** 3. Prediction of Wax Deposition in Pipeline by CFD Techniques ***Hoda seyedinezhad, Farmarz Hormozi*** 4. Corrosion Analysis using BEM by Considering Polarization Curve of Steel ***Syarizal Fonna, Safuadi, Israr, M. Ridha, and A. K. Ariffin*** 5. Implementation of Parallel Computational tools for the Curing Simulation of Thermoset Composites Using the One Dimension Age Algorithm ***Amna Abdurrahman, Ahmad Kamal bin Zulkifle, Norma Alias, and Ishak Hashim***

DAY 2 – SATURDAY, 16 May 2009 (continue)		
	VENUE A (Regular Conference): Senggigi Room (First Floor)	VENUE B (Regular Conference): Mataram Room (First Floor)
10.40-12.40	Session A. 7. 2: **FEM APPLICATION; COMPUTATIONAL MECHANICS;** Chairperson: Prof. Dr. Yasuhiro Kanto	Session A. 8. 2: **ANALYSIS OF MACHINE ELEMENT DESIGN;** Chairperson: Prof. Ahmad Kamal Arifin
Keynote Speaker	1. On the Edge-effect of Stress Concentration Factor in Thin Plate with Two Holes ***Satryo Soemantri***	1. Shock and Elastic Waves on Dynamic Compaction Process of Two Layered Powder Media in the Dies **Kiyohiro Miyagi, Yukio Sano, Takuo Hayashi, Toshiyasu Sueyoshi**
	2. 3D Visualization of Wire Radiation Pattern using NEC2++ Antenna Radiation Generator ***Ridwan Montezari, Ignatius Dwi Mandaris, Lisandro Damian N Perez Meyer, Soemarni Mardjoeki, R. Harry Harjadi, Harry Ramza*** 3. Sound Profile Measurement for Brackish Water ***Sunardi, Anton Yudhana, Jafri Din, Saberi Mawi*** 4. Simulation for Predicting Thermal Effect in the Eye's Tissues Following A theraphy using Laser Retinal Photocoagulator ***AMT Nasution, NAP Ningtyas*** 5. Numerical Analysis of Harmonic Propagation and Distortion Caused by a Nonlinear Load in Balance Distribution Network ***Sabar Nababan***	2. Stress Distribution Analysis of Stress Corrosion Cracking Specimen using Ansys ***Syifaul Huzni, M. Ikhsan, M. Ridha & A. Kamal Ariffin*** 3. Crack Initiation and Propagation in Nylon 6 Sphere under Various Impact Velocities ***Sutikno and H. Homma*** 4. Optimization of the simple plate using high cycle multiaxial fatigue criteria ***A.E Ismail[1], A.K Ariffin, S. Abdullah*** 5. Influence of Magnetic Field on Noise Reduction: Experimental Study on Automotive Noise Silencer ***Ikhwansyah Isranuri, Eka Sunitra***

DAY 2 – SATURDAY, 16 May 2009 (continue)		
	VENUE A (Regular Conference): Senggigi Room (First Floor)	VENUE B (Student Conference): Mataram Room (First Floor)
13.40 – 15.30	Session A. 9. 2: **ARTIFICIAL INTELLIGENCE APLICATION IN ENGINEERING; COMPUTATIONAL METHODE** Chairperson: Dr. Amna Abdurrahman	Session B. 1. 2: **COMPUTATIONAL METHODE** Chairperson: Dr.Eng. Agus Setyo Muntohar, M.Eng.Sc. Reviewers : 1. Prof. Dr. Kikuchi Masanori 2. Prof. Dr. Ahmad Kamal Arifin
Keynote Speaker	1. Application of Fuzzy Multiple Attribute Group Dicision Making Method in Stretcher Concept Selection ***The Jaya Suteja***	1. Genetic Algorithms Approach for Multiobjective Stock Portfolio Optimization Problem ***Hoklie and Lavi Rizki Zuhal***
	2. Application Augmented Lagrange Multiplier Method In the Collaborative Optimization of Engineering Product Design ***Yuwono B. Pratiknyo*** 3. Analysis of Tapered Velocity and Tapered Coupling Couplers ***Ary Syahriar*** 4. Impact Response of Traffic Cones with Different Lower Base Structures ***Bustami Syam, Weriono, Rahmawati, Samsul Rizal, Basuki Wirjosentono***	2. Symmetrical and Unsymmetrical Flow Separation in Supersonic Ideal Contour Nozzles ***Bagus H. Jihad, Dedi Priadi, Tresna P. Soemardi, Eddy S. Siradj*** 3. Comparison Eigenvalue of Planar Waveguide Characteristic Equation using Analytical Approach and Method of Line ***Wibi Noviardi*** 4. Switch Characteristic in Silica Directional Couplers ***Disra Agifral, Syifa'ul Barir, and Ary Syahriar*** 5. Design and Analysis of Supersonic Axysimmetric Minimum Length Nozzle (MLN) As Rocket Nozzle ***Bagus H. Jihad, Dedi Priadi, Tresna P. Soemardi, Eddy S. Siradj*** 6. Stress Distribution Simulation in Non-Standardized Motor Cycle Helmet Subjected impact Loading ***Izwar Lubis, Bustami Syam, Samsul Rizal, Tugiman***

APPLICATION OF FUZZY MULTIPLE ATTRIBUTE GROUP DECISION MAKING METHOD IN STRETCHER CONCEPT SELECTION

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Abstract

One of crucial phases in product design and development is concept selection phase. The best concept resulted in this phase will be developed and embodied to fulfill the customer need. In most cases, the importance weight of each criterion used in concept selection and the performance rate of each concept alternative with respect to each criterion are determined based on the competence and intuition of some decision makers. Therefore, they are subjective, imprecise, and vague.

In this paper, the best concept selection of stretcher is determined by applying Fuzzy Multiple Attribute Decision Making as the aggregation method of performance ratings with respect to all criteria for each alternative and Technique for Order Preference by Similarity to Ideal Solution as the ranking method of alternatives according to the overall aggregated performance ratings. Three stretcher concept alternatives are evaluated to select the best stretcher concept alternative. The criteria used in the stretcher concept selection are lightness, compactness, tight bond, strong join, reasonable price, easiness to use, easiness to identify blood, and easiness to hold. In addition, the decision makers who give opinion related to the importance weight and performance rate are designer, manufacturer, and lead user.

By applying the fuzzy multiple attribute group decision making, the concept selection process is more effective and objective.

Keywords: fuzzy multiple attribute group decision, stretcher, concept selection

1. Introduction

One of crucial phases in product design and development is concept selection phase. The best concept resulted in this phase will be developed and embodied to fulfill the customer need. In the concept selection phase, two important steps must be conducted carefully to obtain a good result. The first step is determination of selection criteria and the importance weight of each criterion. The second step is determination of performance rate for each concept alternative with respect to each criterion.

In most cases, the importance weight of each criterion used in the concept selection is expressed in linguistic terms and determined based on the competence and intuition of some decision makers. The decision makers usually consist of lead user, designer, and manufacturer. Because the importance weight is determined based on the intuition, the importance weight of each criterion is subjective, imprecise, and vague. The subjectivity, imprecision, and vagueness are mostly caused by three sources such as unquantifiable, incomplete, and non-obtainable information [1].

Furthermore, the performance rate of each alternative concept with respect to each criterion is also expressed in linguistic terms and determined based on the competence and intuition of the decision makers. As a result, the performance rate of each concept alternative also involves subjectivity, imprecision, and vagueness.

By using the traditional methodology, an unsatisfactory solution may be generated in selecting the best concept. For that reason, it is required to implement a methodology that accommodate the subjectivity, imprecision, and vagueness in determining the importance weight of all selection criteria and performance rating of all concept alternatives.

2. Literature Study

To select the best alternative form a finite number of alternatives characterized by multiple attributes, Multiple Attribute Decision Making (MADM) can be applied as the selection methods. Because the classical MADM cannot effectively handle multiple attribute group decision making problems with subjective, imprecise and vague information, then Fuzzy Multiple Attribute Decision Making (FMADM) is implemented to solve the problem with subjective, imprecise, and vague information.

Some researches have been conducted in applying FMADM to select the best alternative from a finite set of alternatives. Liang and Wang implemented FMADM in robot selection [2]. Chen applied FMADM for handling multiple attribute fuzzy decision making problems in tool steel materials selection [3]. Olcer and Odabasi develop a new FMADM and apply it to propulsion/maneuvering system selection [4]. Chuu also applies FMADM to evaluate Advance Manufacturing Technology [5].

Based on the literature review performed by Olcer and Odabasi, FMADM methods consist of two phases, which are aggregation of the performance ratings with respect to all attributes for each alternative and determination the ranking order of alternatives according to the overall aggregated performance ratings [4]. For the first phase, Olcer and Odabasi classify the methods to simple additive weighting based FMDAM approaches, Analytic Hierarchy Process (AHP) based FMDAM approaches, outranking relation based FMDAM approaches, implied conjunction methods, fuzzy linguistic approaches, and miscellaneous FMADM methods [4]. For the second phase, Ates, N. Y., et. al. describe two multiple attribute evaluation methods for fuzzy ranking, which are Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Fuzzy AHP [6]. Fuzzy TOPSIS is developed from the classical TOPSIS, which was introduced by Hwang and Yoon [7]. Ates, N. Y., et. al. compare the existing Fuzzy TOPSIS methods based on their type of attribute weight, type of fuzzy number, ranking method, and normalization method [6].

According to the Olcer and Odabasi classification, the possible fuzzy linguistic FMADM method for crisp and fuzzy type of performance rating and fuzzy type of attribute weight is the method proposed by Chen, C. T. [4]. Olcer and Odabasi suggest TOPSIS method in ranking phase because it is quite effective in identifying the best alternative quickly and gives general and broad acceptability in many problem domains.

Chen, C. T., proposes that the rating of each alternative and the weight of each criterion, which are described by linguistic terms, are expressed in triangular fuzzy numbers [8]. Then a vertex method for TOPSIS is proposed to calculate the distance between two triangle fuzzy numbers. In his research, it is assumed that the fuzzy positive (FPIS) and negative ideal solutions (FNIS) as (1, 1, 1) and (0, 0, 0) respectively.

Referring to Chen, et. al., $A = \{A_1, A_2, ..., A_m\}$ is a set of alternatives for the problem of fuzzy hybrid multiple attribute decision making and $C = \{C_1, C_2, ..., C_n\}$ is a set of criteria with which all the alternatives are rated. The performance rating of alternative A_i to criteria C_j is denoted as x_{ij} ($i = 1, 2, ..., m$ and $j = 1, 2, …, n$)) The value of x_{ij} is not merely crisp but also fuzzy. All values of x_{ij} are formed a decision making matrix, it denoted as $D = (x_{ij})_{m\times n}$ or

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \dots & \dots & \tilde{x}_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix}$$

Furthermore, $\tilde{w}_j = [\tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n]$ is the weight of criterion, where $\tilde{w}_j$ satisfies

$$0 \le w_j \le 1, \ \sum_{j=1}^{n} w_j = 1$$

Because the decision makers consist of more than one person, the performance rating of alternative x_{ij} with respect to each criterion and importance weight of the criteria w_j can be calculated as

$$\tilde{x}_{ij} = \tfrac{1}{K}[\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + ... + \tilde{x}_{ij}^K] \quad (1)$$

$$\tilde{w}_j = \tfrac{1}{K}[\tilde{w}_j^1 + \tilde{w}_j^2 + ... + \tilde{w}_j^K] \quad (2)$$

where $\tilde{x}_{ij}^K$ and $\tilde{w}_j^K$ are the performance rating and the importance weight of the K^{th} decision maker respectively.

In this research, $\tilde{x}_{ij}$ and $\tilde{w}_j$ are linguistic variable and can be described by triangular fuzzy number (a_{ij}, b_{ij}, c_{ij}) and (w_{j1}, w_{j2}, w_{j3}) respectively.

To obtain the normalized fuzzy decision matrix, the linear scale transformation is used. $\tilde{R}$, which denotes the normalized fuzzy decision matrix, is calculated as

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn} \quad (3)$$

where

$$\tilde{r}_{ij} = (\tfrac{a_{ij}}{c_j*}, \tfrac{b_{ij}}{c_j*}, \tfrac{c_{ij}}{c_j*})$$

$cj* = \max_i c_{ij}$ for benefit criteria and

$$\tilde{r}_{ij} = (\tfrac{a_j^-}{c_{ij}}, \tfrac{a_j^-}{b_{ij}}, \tfrac{a_j^-}{a_{ij}})$$

$aj^- = \min_i a_{ij}$ for cost criteria

Furthermore, because of the different importance of each criterion, the weighted normalized fuzzy decision matrix can be constructed as

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn} \quad (4)$$

for i = 1, 2, …, m and j = 1, 2, …, n where $\tilde{v}_{ij} = \tilde{r}_{ij}(.)\tilde{w}_j$.

Then, we can define the FPIS (A*) and FNIS (A^-) as $A* = (\tilde{v}_1^*, \tilde{v}_2^*, ..., \tilde{v}_n^*)$ and $A^- = (\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-)$ where $\tilde{v}_j^* = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$ for j = 1, 2, …, n.

The distance of each alternative from A* and A^- are calculated as

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*) = \sqrt{\tfrac{1}{3}[(\tilde{v}_{ij}-1)^2 + (\tilde{v}_{ij}-1)^2 + ... + (\tilde{v}_{ij}-1)^2]} \quad (5)$$

for i = 1, 2, …, m and

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-) = \sqrt{\tfrac{1}{3}[(\tilde{v}_{ij}-0)^2 + (\tilde{v}_{ij}-0)^2 + ... + (\tilde{v}_{ij}-0)^2]} \quad (6)$$

for i = 1, 2, …, m

A closeness coefficient is defined to determine the ranking order of all alternatives. The closeness coefficient of each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \quad (7)$$

for i = 1, 2, …, m. According to the closeness coefficient, we can determine the ranking order of all alternatives and determine the alternative, which has the highest closeness coefficient as the best alternative.

The flow of work, which is followed in this research, is summarized as follows:

First Stage

- Step 1: Form a committee of decision makers
- Step 2: Identify the selection criteria with types of them
- Step 3: List all possible alternatives
- Step 4: Determine an appropriate linguistic variables for the importance weight of criteria
- Step 5: Determine an appropriate linguistic variables for the performance rating of alternatives with respect to selection criteria
- Step 6: Collect decision makers' opinion for the importance weight of each criterion
- Step 7: Collect decision makers' opinion for the performance rating of each alternative

Second stage

- Step 8: Aggregate the importance weight of each criterion to obtain the aggregate fuzzy weight of criterion
- Step 9: Aggregate the performance rating of each alternative with respect to selection criteria
- Step 10: Construct a fuzzy decision matrix

Third Stage

- Step 11: Normalize the fuzzy decision matrix
- Step 12: Construct a weighted normalized fuzzy decision matrix
- Step 13: Define the Fuzzy Positive Ideal Solution and Fuzzy Negative Ideal Solution
- Step 14: Calculate the distance of each alternative from FPIS and FNIS
- Step 15: Calculate the closeness coefficient of each alternative
- Step 16: Determine the ranking order of all alternatives and choose the best alternative

3. Case Study

In this paper, a concept selection of a new stretcher is taken as a case study. There are some characteristics in the new stretcher concept selection. First, the new stretcher concept selection involves more that one criterion in selecting concept. The criteria used in the stretcher concept selection are lightness (C1), compactness (C2), tightness of bond (C3), strongness of join (C4), reasonable price (C5), easiness to use (C6), easiness to identify blood (C7), and easiness to hold (C8). According to the type of attribute, all criteria above are included as benefit type of attribute. Each of criteria has its importance weight determined based on the decision makers opinion. According to the type of variable, all performance rating of criteria in the concept selection are linguistic variable. Meanwhile, the type of all importance weight is only linguistic variable.

In the new stretcher concept selection, more than one individual with his or her own competence and intuition are required to give his or her opinion with regard to the importance weight of all criteria and the performance rating of all alternatives. The decision makers are lead user (D1), designer (D2), and manufacturer (D3).

From generation concept phase, five concept alternatives of stretcher are generated. Through concept screening, these five concept alternatives are screened to three concept alternatives. Then, three concept alternatives (A1 – A3) are evaluated to obtain the best concept by performing concept selection.

The first concept alternative (A1) uses one strap with six holes and implements a button to join two holders of the stretcher. For the second concept alternative (A2), one strap with a buckle is used. In addition, it has fourteen holes in it. To join two holders of the stretcher, the small holder is inserted to the larger holder and both of them are hold firmly with the aid of a pin. The last concept alternative (A3) is similar to the first concept selection. Instead of using a button, the small holder of this concept alternative is inserted to the larger holder and both of them are hold firmly with the aid of a pin.

At the first stage, each of decision makers gives their performance rating of all alternatives with the respect to each attribute. The purpose of this stage is to convert the performance ratings from the decision makers, which are mostly in expressed in linguistic term into standardized positive triangular fuzzy numbers. The linguistic terms and their corresponding fuzzy number may vary. However, a conversion scale with 5 labels as listed in table 1 is used.

Table 1. Linguistic Variables for the Ratings

Linguistic Terms	Fuzzy Number
Very Poor (VP)	(0, 0, 1)
Poor (P)	(0, 1, 3)
Fair (F)	(3, 5, 7)
Good (G)	(7, 9, 10)
Very Good (VG)	(9, 10, 10)

The importance weights of all criteria are also converted from linguistic term into standardized positive triangular fuzzy numbers. The conversion scale for the importance weight can be seen in table 2.

Table 2. Linguistic Terms for the Importance Weight

Linguistic Terms	Fuzzy Number
Very Low (VL)	(0.0, 0.0, 0.1)
Low (L)	(0.0, 0.1, 0.3)
Medium (M)	(0.3, 0.5, 0.7)
High (H)	(0.7, 0.9, 1.0)
Very High (VH)	(0.9, 1.0, 1.0)

The decision makers' opinion for the importance weight of each criterion is shown in table 3. Meanwhile, the decision makers' opinion for the performance rating for each alternative can be seen in table 4.

At the second stage, the importance weights of all criteria based on three decision makers are aggregated to obtain the aggregate fuzzy weight of criteria. Then, all performance ratings of each alternative with respect to all criteria based on three decision makers are aggregated to construct a fuzzy decision matrix. The fuzzy decision matrix and fuzzy weight of three alternatives can be seen in table 5.

At the last stage, the fuzzy decision matrix is normalized. The normalized fuzzy decision matrix is constructed by using TOPSIS with linear scale transformation as seen in figure 6. Then, considering the different importance of each criterion, the fuzzy weighted normalized decision matrix is constructed as shown in table 7.

Because the FPIS (A*) and FNIS (A^-) are defined according to Chen, C. T., as [(1, 1, 1), (1, 1, 1), (1, 1, 1), (1, 1, 1), (1, 1, 1), (1, 1, 1), (1, 1, 1), (1, 1, 1)] and [(0, 0, 0), (0, 0, 0), (0, 0, 0), (0, 0, 0), (0, 0, 0), (0, 0, 0), (0, 0, 0), (0, 0, 0),] respectively, the distance of each alternative from FPIS and FNIS can be calculated as listed in table 8.

Table 3. The Importance Weight of Each Criterion

	D1	D2	D3
C1	(0.9, 1.0, 1.0)	(0.9, 1.0, 1.0)	(0.9, 1.0, 1.0)
C2	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
C3	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
C4	(0.7, 0.9, 1.0)	(0.9, 1.0, 1.0)	(0.7, 0.9, 1.0)
C5	(0.3, 0.5, 0.7)	(0.9, 1.0, 1.0)	(0.7, 0.9, 1.0)
C6	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)
C7	(0.3, 0.5, 0.7)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)
C8	(0.9, 1.0, 1.0)	(0.0, 0.1, 0.3)	(0.7, 0.9, 1.0)

Table 4. The Performance Rating of all Alternatives with Respect to All Criteria

		D1	D2	D3
C1	A1	(0, 1, 3)	(0, 1, 3)	(0, 1, 3)
	A2	(7, 9, 10)	(7, 9, 10)	(7, 9, 10)
	A3	(7. 9. 10)	(7, 9, 10)	(7, 9, 10)
C2	A1	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
	A2	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
	A3	(3, 5, 7)	(3, 5 ,7)	(3, 5, 7)
C3	A1	(3, 5 , 7)	(0, 1, 3)	(3, 5, 7)
	A2	(9, 10, 10)	(7, 9, 10)	(7, 9, 10)
	A3	(3, 5 ,7)	(0, 1, 3)	(3, 5, 7)
C4	A1	(7, 9, 10)	(3, 5, 7)	(7, 9, 10)
	A2	(9, 10, 10)	(9, 10, 10)	(9, 10, 10)
	A3	(9, 10, 10)	(9, 10, 10)	(9, 10, 10)
C5	A1	(0, 0, 1)	(0, 1, 3)	(0, 1, 3)
	A2	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
	A3	(7, 9 ,10)	(3, 5, 7)	(3, 5, 7)
C6	A1	(9, 10, 10)	(7, 9, 10)	(7, 9, 10)
	A2	(3, 5, 7)	(7, 9, 10)	(3, 5, 7)
	A3	(7, 9, 10)	(7, 9, 10)	(7, 9, 10)
C7	A1	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
	A2	(7, 9, 10)	(7, 9, 10)	(7, 9, 10)
	A3	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
C8	A1	(3, 5, 7)	(3, 5 ,7)	(3, 5, 7)
	A2	(7, 9, 10)	(7, 9, 10)	(7, 9, 10)
	A3	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)

Table 5. The Fuzzy Decision Matrix and Fuzzy Weight of Three Alternatives

	C1	C2	C3
A1	(0.0, 1.0, 3.0)	(3.0, 5.0, 7.0)	(2.0, 3.7, 5.7)
A2	(7.0, 9.0, 10)	(3.0, 5.0, 7.0)	(7.7, 9.3, 10)
A3	(7.0, 9.0, 10)	(3.0, 5.0, 7.0)	(2.0, 3.7, 5.7)
Weight	(0.9, 1.0, 1.0)	(0.3, 0.5, 0.7)	(0.4, 0.6, 0.8)

Table 5. The Fuzzy Decision Matrix and Fuzzy Weight of Three Alternatives (cont.)

	C4	C5	C6
A1	(5.7, 7.7, 9.0)	(0.0, 0.7, 2.3)	(7.7, 9.3, 10)
A2	(9.0, 10, 10)	(3.0, 5.0, 7.0)	(4.3, 6.3, 8.0)
A3	(9.0, 10, 10)	(4.3, 6.3, 8.0)	(7.0, 9.0, 10)
Weight	(0.8, 0.9, 1.0)	(0.6, 0.8, 0.9)	(0.7, 0.9, 1.0)

Table 5. The Fuzzy Decision Matrix and Fuzzy Weight of Three Alternatives (cont.)

	C7	C8
A1	(3.0, 5.0, 7.0)	(3.0, 5.0, 7.0)
A2	(7.0, 9.0, 10)	(7.0, 9.0, 10)
A3	(3.0, 5.0, 7.0)	(3.0, 5.0, 7.0)
Weight	(0.1, 0.2, 0.4)	(0.5, 0.7, 0.8)

Table 6. The Fuzzy Normalized Decision Matrix

	C1	C2	C3
A1	(0.0, 0.1, 0.3)	(0.4, 0.7, 1.0)	(0.2, 0.4, 0.6)
A2	(0.7, 0.9, 1.0)	(0.4, 0.7, 1.0)	(0.8, 0.9, 1.0)
A3	(0.7, 0.9, 1.0)	(0.4, 0.7, 1.0)	(0.2, 0.4, 0.6)

Table 6. The Fuzzy Normalized Decision Matrix (cont.)

	C4	C5	C6
A1	(0.6, 0.8, 0.9)	(0.0, 0.1, 0.3)	(0.8, 0.9, 1.0)
A2	(0.9, 1.0, 1.0)	(0.4, 0.6, 0.9)	(0.4, 0.6, 0.8)
A3	(0.9, 1.0, 1.0)	(0.5, 0.8, 1.0)	(0.7, 0.9, 1.0)

Table 6. The Fuzzy Normalized Decision Matrix (cont.)

	C7	C8
A1	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
A2	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)
A3	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)

Table 7. The Fuzzy Weighted Normalized Decision Matrix

	C1	C2	C3
A1	(0.0, 0.1, 0.3)	(0.13, 0.36, 0.7)	(0.09, 0.23, 0.45)
A2	(0.63, 0.9, 1.0)	(0.13, 0.36, 0.7)	(0.33, 0.59, 0.80)
A3	(0.63, 0.9, 1.0)	(0.13, 0.36, 0.7)	(0.09, 0.23, 0.45)

Table 7. The Fuzzy Weighted Normalized Decision Matrix (cont.)

	C4	C5	C6
A1	(0.43, 0.72, 0.9)	(0.0, 0.07, 0.26)	(0.54, 0.84, 1.0)
A2	(0.69, 0.93, 1.0)	(0.24, 0.50, 0.79)	(0.30, 0.57, 0.80)
A3	(0.69, 0.93, 1.0)	(0.34, 0.63, 0.9)	(0.49, 0.81, 1.0)

Table 7. The Fuzzy Weighted Normalized Decision Matrix (cont.)

	C7	C8
A1	(0.03, 0.12, 0.3)	(0.16, 0.33, 0.54)
A2	(0.07, 0.21, 0.43)	(0.37, 0.6, 0.77)
A3	(0.03, 0.12, 0.30)	(0.16, 0.33, 0.54)

Table 8. The Distance Measurement

	d_i*	d_i^-
A1	5.36	3.19
A2	3.77	4.84
A3	4.10	4.53

Finally, according to closeness coefficient, the ranking order of the three alternatives can be sorted as seen in table 9. It is obvious that the second alternative is the best alternative because it has the highest closeness coefficient.

Table 9. The Closeness Coefficient

	CC	Ranking
A1	0.37	3
A2	0.56	1
A3	0.52	2

Conclusions

This paper present the use of FMADM as the aggregation method of the performance ratings with respect to all criteria for each alternative and TOPSIS as the ranking method of alternatives according to the overall aggregated performance ratings in a new stretcher concept selection. Based on the applied methods, the second concept alternative is selected as the best result.

By applying the fuzzy multiple attribute group decision making in the new stretcher concept selection, the concept selection process is more effective and objective.

References

[1] Chen, S. J., Hwang, C. L., *Fuzzy Multiple Attribute Decision-Making: Methods and Applications*, Springer, New York, 1992.

[2] Liang, G. S., Wang, M. J., A Fuzzy Multi-criteria Decision-making Approach for Robot Selection, *Robotics Computer Integrated Manufacturing*, Vol. 10, pp. 267–274, 1993.

[3] Chen, S.M., A New Method for Tool Steel Materials Selection under Fuzzy Environment, *Fuzzy Sets and Systems*, Vol. 92, pp. 265–274, 1997.

[4] Olcer, A.I., Odabasi, A.Y., A New Fuzzy Multiple Attributive Group Decision Making Methodology and Its Application to Propulsion/Maneuvering System Selection Problem, *European Journal of Operation Research*, Vol. 166, pp. 93–114, 2005

[5] Chuu, S. J., Group Decision-making Model Using Fuzzy Multiple attributes Analysis for the Evaluation of Advanced Manufacturing Technology, *Fuzzy Sets and Systems*, Vol. 160 (5), pp. 586–602, 2009

[6] Ateş, N.Y., Çevik, S., Kahraman, C., Gülbay, M., Erdoğan, S. ., Multi Attribute Performance Evaluation Using a Hierarchical Fuzzy TOPSIS Method, *Fuzzy Applications in Industrial Engineering*, Springer, Berlin Heidelberg, 2006

[7] Hwang, C. L., Yoon, K., *Multiple Attribute Decision Making Methods and Application*, Springer, Berlin Heidelberg, 1981

[8] Chen, C. T., Extensions of the TOPSIS for Group Decision-making under Fuzzy Environment, *Fuzzy Sets and Systems* Vol. 114 (1), pp. 1–9, 2000

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