Multi Criteria Decision Making Using Linguistic Fermatean Neutrosophic Number

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Abstract

The article aims to introduce the Linguistic Fermatean Neutrosophic set (LFNS) which is an important mathematical tool that helps to solve decision-making problems. LFNS is a generalization of the Linguistic Fermatean Fuzzy set (LFFS), by adding the truth, falsity and indeterminacy membership degrees to denote the uncertain information. Score and Accuracy functions are introduced to distinguish any two or more linguistic Pythagorean Neutrosophic Numbers. Weighted averaging and geometric aggregation operators with respect to linguistic Pythagorean neutrosophic weighted average and geometric, ordered weighted average are proposed. OEE (Overall Equipment Effectiveness) is the industry standard for measuring manufacturing productivity. It defines the percentage of manufacturing time that is productive. A 100% OEE score means that you are creating only high-quality products as soon as possible, with no downtime. By measuring OEE and the underlying losses, you will gain critical insights on how to systematically optimize your manufacturing process. OEE is the single most effective measure for detecting losses, assessing progress, and improving manufacturing equipment productivity (i.e., reducing waste). To adopt OEE practices in manufacturing industries, we must first understand, measure, and enhance OEE. The purpose of this research is to better understand OEE practices and their crucial aspects. The Human Arena, Engineering, Management, and Social elements are assessed, with sub-factors aggregated by similarity and analyzed using a LFNN. This method helps to comprehend the impact of each factor and ranks the group based on their influence in implementing the OEE practices effectively in an organization. The Engineering aspects and the Management aspects contribute a major role in the success of OEE. In this study, the assessment of numerous components and sub-factors involving determining the influence factor leading to OEE is translated into a Multi-Attribute Group Decision Making (MAGDM) problem and illustrated in the last section utilizing LFNN.

Keywords: Fermatean Neutrosophic Set; Multi-Attribute Group Decision Making; Overall Equipment Effectiveness

1. Introduction

In literature, data relating with uncertainty and vagueness can be dealt through fuzzy set (FS) [1,2,3], Intuitionistic fuzzy set (IFS) [4] in which membership and non- membership values are used to solve decision making problems. Qualitative and Quantitative fuzzy sets are two classifications in which qualities fuzzy sets are represented by the linguistic variables [5,6,7].

A FS K is $\{\langle z, \mu_A(z)\rangle \mid z \in K\}$ in which each element $x \in X$ gets a membership degree $\mu_K(z)$such that $0 \leq \mu_K(z) \leq 1$. An IFS K is $\{\langle z, \mu_K(z), \nu_K(z)\rangle \mid z \in \Phi\}$ which assigns to each element z$\in \Phi$ a membership degree (MSD) $\mu_K(z)$ and a non-membership degree (NMSD) $\nu_K(z)$ under the condition $0 \leq \mu_K(z) + \nu_K(z) \leq 1$.

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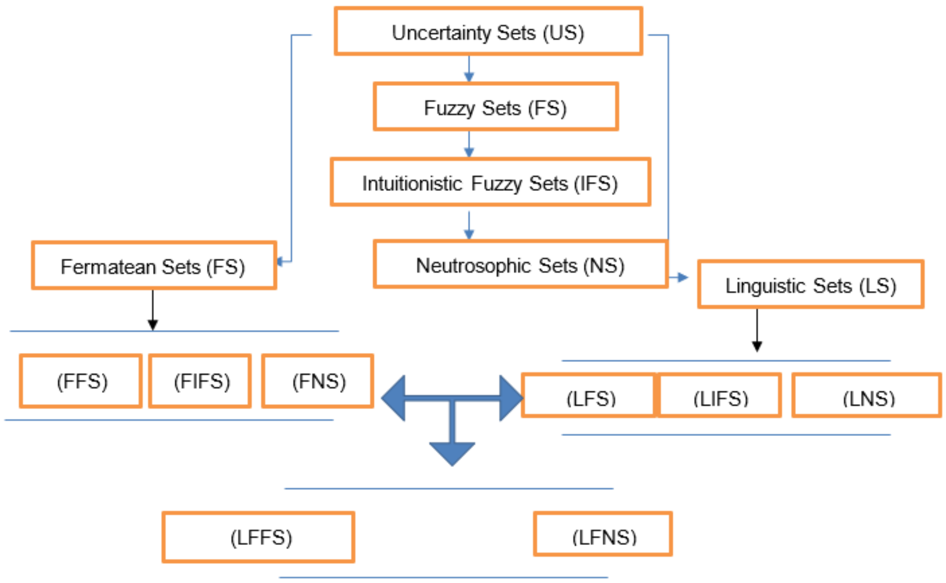

Consider a finite linguistic term set, $W = \{w_\delta \mid \delta = 0, 1, \ldots, j\}$ odd cardinality (5, 7, 9, etc.), each w_δ represents a possible linguistic term for a linguistic variable. For example, consider a set of 5 linguistic terms S explained as follows:

$$S = \{w_0 = VLC\ (VeryLowContribution), w_1 = LC(LowContribution), w_2 = M(Medium),\ w_3 = HC(HighContribution),$$

$$w_4 = VHC\ (VeryHighContribution)\}.$$

The linguistic term set satisfies the following conditions:

(1) Ordered Set: $w_i > w_j$, if and only if $i > j$.

(2) Negation operator: $Neg(w_i) = w_j$ such that $j = t - i$.

(3) Max operator: $max(w_i, w_j) = w_i$, if and only if $i \geq j$.

(4) Min operator: $min(w_i, w_j) = w_i$, if and only if $i \leq j$

Xu [31] converted the discrete term set to a continuous linguistic term set $W = \{w_\delta | w_0 < w_\delta \leq w_j, \delta \in [0, j]\}$, where, if $w_\delta \in W$, w_δ is called the original linguistic term.

The representation of uncertainty information through qualitative aspects plays a vital importance in the present decision-making problems. Xu [5,6] proposed a method to describe the continuous linguistic term set. Changing Numeric number by linguistic number may be useful for solving decision-making problems. Zhang [7] defined the Linguistic Intuitionistic Fuzzy Set (LIFS), which is a combination of the different concepts, linguistic approach and IFS. Here, membership (MS) and non-membership (NMS) degrees are represented by using linguistic terms.

Let $\mathfrak{U}$ be a finite universal set and $W = \{w_\delta | w_0 < w_\delta \leq w_j, \delta \in [0, j]\}$ a continuous linguistic term set. A LIFS K in Φ is given as $K = \{(z, w_\theta\ (z), w_\sigma\ (z))\ | z \in \Phi\}$, where $w_\theta(z), w_\sigma(z) \in W$ represents the linguistic MS and NMS of the element x to A, respectively.

Let Φ be a universal set and $W = \{w_\delta \mid w_0 \leq w_\delta \leq w_j, \delta \in [0, j]\}$ be a continuous linguistic term set. A LPFS K of Φ is $K = \{(z, w_\theta(z), w_\sigma(z)) \mid z \in \Phi\}$ where $w_\theta(z), w_\sigma(z) \in W$ stand for the linguistic membership and non-membership degree of the element $z$to Φ .

Muhammad et al. [8] introduced a novel concept of Fermatean fuzzy sets with linguistic term sets, termed as the linguistic Fermatean fuzzy set. These sets can be helped to deal with decision-making problems, which involve qualitative information. They also discussed several fundamental operations of these sets.

A NS [9] A on ϕ is defined by its truth $\mu_K(z)$, indeterminacy $\eta_K(z)$ and falsity membership function ν_K such that $0^- \leq \mu_K(z) + \nu_K(z) + \eta_K(z) \leq 3^+$ for all z$\in \phi$, whose all the subset of $]0^-, 1^+[$. A $SVNSA$ on ϕ is of the form as : A_{SVNS}= $\{\langle z, \mu_K(z), \nu_K(z), \eta_K(z)\rangle | \ z \in \phi\}$,where $\mu_K(z): \phi \rightarrow [0,1]$ indicates the degree of membership, $\nu_K(z): \phi \rightarrow [0,1]$

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indicates the indeterminacy-membership degree and $\eta_K(x): \phi \rightarrow [0,1]$ indicates the non-membership degree of the element $z \in \phi$ to the set A, respectively, with the constraints : $0 \leq \mu_K(z) + \nu_K(z) + \eta_K(z) \leq 3$.

Decision makers may be felt difficult to represent the judgments or preferences using numerical values. They may prefer linguistic terms to express in terms of qualitative attributes. Zadeh introduced Linguistic Fuzzy Number (LFNs), Chen et. al. defined Linguistic Intuitionistic Fuzzy Numbers (LIFNs) and Zebo Fang introduced Linguistic Neutrosophic Number (LNN).

Decision makers want to represent the MS values in terms of linguistic numbers in most of the complex real time situations. We introduce LFNN like LFN; can be used to choose the best factors and cofactors in a Multi- Criteria Decision – Making (MCDM) problems.

2. Linguistic Fermatean Neutrosophic Set (LFNS)

In this section, we introduce LFNS. The study of the score and accuracy functions with respect to LFNS are defined. Also, the properties of LFNS are discussed.

Definition 2.1

$L = \{w_\delta : w_0 \leq w_\delta \leq w_j : \delta \in [0,j]\} = \{w_0, w_1, \ldots, w_j\}$ is a continuous linguistic term set with cardinality $j + 1$. If $q = < w_a, w_b, w_c >$ is defined for $w_a, w_b, w_c \in L$ and $a \leq b \leq c$; $a, b, c \in [0,j]$, where w_a, w_b, and w_c represent the degree MS values of truth, indeterminacy and falsity degree by linguistic terms, respectively, then q is called the LFNN such that $0 \leq \sqrt{a^3 + b^3 + c^3} \leq j$.

The following two aggregate functions (score and accuracy) are used to compare two different LFNNs.

$SC(q) = w_{\sqrt{\frac{j^3+a^3-b^3-c^3}{2}}}$ & $AC(q) = w_{\sqrt{a^3+b^3+c^3}}$

Definition 2.2

Two LFNNs A and B and based on these scores and accuracy functions,

Comparison laws to rank these numbers:

if $SC(A) > SC(B)$ then $A \succ B$ where "$\succ$" means "choose to";

if $SC(A) = SC(B)$ and

- $AC(A) = AC(B)$, then $A = B$
- $AC(A) > AC(B)$, then $A \succ B$
- $AC(A) < AC(B)$, then $A \prec B$

Example 2.3 If $W_1 = (w_2, w_3, w_3), W_2 = (w_1, w_2, w_3), W_3 = (w_4, w_2, w_2)$ and $W_4 = (w_2, w_2, w_3)$ are four LFNNs from $W = \{w_\delta \mid w_0 < w_\delta \leq w_4, \delta \in [0,4]\}$. Then

We have

$$SC(W_1) = w_{\sqrt{\frac{4^3+2^3-3^3-3^3}{2}}} = w_{\sqrt{9}} \; ; SC(W_2) = w_{\sqrt{\frac{4^3+1^3-3^3-2^3}{2}}} = w_{\sqrt{15}} \; ;$$

$$SC(W_3) = w_{\sqrt{\frac{4^3+4^3-2^3-2^3}{2}}} = w_{\sqrt{56}} \; ; SC(W_4) = w_{\sqrt{\frac{4^3+2^3-2^3-3^3}{2}}} = w_{\sqrt{18.5}}$$

Therefore $W_3 \succ W_4 \succ W_2 \succ W_1$.

Let $\eta_{[o,j]}$ be the set of all LFNNs based on $W_{[o,j]}$. Consider $W_1 = (w_{a_1}, w_{b_1}, w_{c_1}), W_2 = (w_{a_2}, w_{b_2}, w_{c_2})$ be three LFNNs and belong to $\eta_{[o,j]}$ and $\rho > 0$.

2.3.1 Union, Intersection and Complement Operation For LPNNS

- ➢ $(w_{a_1}, w_{b_1}, w_{c_1}) \cup (w_{a_2}, w_{b_2}, w_{c_2}) = (\max(w_{a_1}, w_{a_2}), \min(w_{b_1}, w_{b_2}), \min(w_{c_1}, w_{c_2}))$
- ➢ $(w_{a_1}, w_{b_1}, w_{c_1}) \cap (w_{a_2}, w_{b_2}, w_{c_2}) = (\min(w_{a_1}, w_{a_2}), \max(w_{b_1}, w_{b_2}), \max(w_{c_1}, w_{c_2}))$

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- $(w_{a_1}, w_{b_1}, w_{c_1})^c = (w_{b_1}, w_{c_1}, w_{a_1})$
- $W_1 < W_2$ if $w_{a_1} < w_{a_2}$ and $w_{b_1} > w_{b_2}$, $w_{c_1} > w_{c_2}$
- $w_1 \oplus w_2 = \left(w_{j\sqrt{\frac{a_1^3}{j^3} + \frac{a_2^3}{j^3} - \frac{a_1^3 a_2^3}{j^9}}}, w_{j\left(\frac{b_1 b_2}{j^3}\right)}, w_{j\left(\frac{c_1 c_2}{j^3}\right)} \right)$
- $w_1 \otimes w_2 = \left(w_{j\left(\frac{a_1 a_2}{j^3}\right)}, w_{j\sqrt{\frac{b_1^3}{j^3} + \frac{b_2^3}{j^3} - \frac{b_1^3 b_2^3}{j^9}}}, w_{j\sqrt{\frac{c_1^3}{j^3} + \frac{c_2^3}{j^3} - \frac{c_1^3 c_2^3}{j^9}}} \right)$
- $\rho w = \rho(w_a, w_b, w_c) = \left(w_{j\sqrt{1-\left(1-\frac{a_1^3}{j^3}\right)^\rho}}, w_{j\left(\frac{b_1}{j}\right)^\rho}, w_{j\left(\frac{c_1}{j}\right)^\rho} \right)$
- $w^\rho = (w_a, w_b, w_c)^\rho = \left(w_{j\left(\frac{a_1}{j}\right)^\rho}, w_{j\sqrt{1-\left(1-\frac{b_1^3}{j^3}\right)^\rho}}, w_{j\sqrt{1-\left(1-\frac{c_1^3}{j^3}\right)^\rho}} \right)$

2.3.2 Aggregation operators in LFNNs

In this section, we define the following average operators of LFNN

1. LFN weighted average and geometric operators (LFNWA, LFNWG)
2. LFN order weighted average and geometric operator (LFNOWA, LFNOWG)

Consider $w_k = (w_{a_k}, w_{b_k}, w_{c_k})$, $(j = 1, 2, \ldots, n)$ is a collection of LFNNs in W. The Linguistic Fermatean Neutrosophic Weighted Averaging (LFNWA) operator which map $\eta_{[0,j]}^n \rightarrow \eta_{[0,j]}$ such that $LfNWA(w_1, w_2, \ldots, w_n) = \gamma_1 w_1 + \gamma_2 w_2 + \cdots + \gamma_n w_n$, where $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the weight vector of $w_k (k = 1, 2 \ldots, n)$, satisfying that $0 \leq \gamma_k \leq 1$, $\sum_{k=1}^n \gamma_k = 1$.

$$LfNWA(w_1, w_2, \ldots, w_n) = \sum_{k=1}^n \gamma_k w_k = \left(w_{j\sqrt{\left(1-\prod_{k=1}^n \left(1-\frac{a_k^3}{j^3}\right)^{\gamma_k}\right)}}, w_{j\prod_{j=1}^n \left(\frac{b_k}{j}\right)^{\gamma_k}}, w_{j\prod_{k=1}^n \left(\frac{c_k}{j}\right)^{\gamma_k}} \right)$$

where $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the weight vector of $w_k (k = 1, 2 \ldots, n)$, satisfying that $0 < \gamma_k \leq 1$, $\sum_{k=1}^n \gamma_k = 1$.

$$LPNWG(w_1, w_2, \ldots, w_n) = \sum_{k=1}^n w_k^{\gamma_k} = \left(w_{j\prod_{k=1}^n \left(\frac{a_k}{j^2}\right)^{\gamma_j}}, w_{j\sqrt{\left(1-\prod_{k=1}^n \left(1-\frac{b_k^3}{j^3}\right)^{\gamma_k}\right)}}, w_{j\sqrt{\left(1-\prod_{k=1}^n \left(1-\frac{c_k^3}{j^3}\right)^{\gamma_k}\right)}} \right)$$

where $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the weight vector of $w_k (k = 1, 2 \ldots, n)$, satisfying that $0 < \gamma_k \leq 1$, $\sum_{k=1}^n \gamma_k = 1$.

Consider $w_1, w_2, \ldots, w_n \in \eta[0, j]$. The Linguistic Fermatean Neutrosophic Ordered Weighted Averaging (LFNOWA) operator is defined as

$$LFNOWA(w_1, w_2, \ldots, w_n) = \gamma_1 w_{\eta(1)} + \gamma_2 w_{\eta(2)} + \cdots + \gamma_n w_{\eta(n)}$$

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where $(\eta(1), \eta(2), \ldots, \eta(n))$is a permutation of $(i = 1,2,\ldots,n)$, such that $w_{\eta(i-1)} \geq w_{\eta(i)}$ for each i, $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the weight vector of $w_j (j = 1,2\ldots,n)$, satisfying that $0 < \gamma_j \leq 1$, $\sum_{j=1}^{n} \gamma_j = 1$.

Consider $w_j = \left(w_{a_j}, w_{b_j}, w_{c_j}\right)$, $(j = 1,2,\ldots,n)$ is a collection of LPNNs in W. From the above definition, we can define the following aggregation formulae:

$$LFNOWA(w_1, w_2, \ldots, w_n) = \sum_{k=1}^{n} \gamma_k w_k = \left(w_{j\sqrt{1-\prod_{k=1}^{1}\left(1-\left(\frac{a_k^3}{j^3}\right)\right)^{\gamma_j}}}, w_{j\prod_{j=1}^{n}\left(\frac{b_k}{j}\right)^{\gamma_k}}, w_{j\prod_{k=1}^{n}\left(\frac{c_k}{j}\right)^{\gamma_k}} \right)$$

where $w_k = \left(w_{a_k}, w_{b_k}, w_{c_k}\right)$ is the k^{th} largest of all w_k's and $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the is the associated weight vector of $w_k (k = 1,2,\ldots,n)$ satisfying that $0 < \gamma_k \leq 1$, $\sum_{k=1}^{n} \gamma_k = 1$.

$$LPNOWG(w_1, w_2, \ldots, w_n) = \sum_{j=1}^{n} w_j^{\gamma_j} = \left(w_{j\prod_{j=1}^{n}\left(\frac{a_k}{j}\right)^{\gamma_k}}, w_{j\sqrt{1-\prod_{k=1}^{1}\left(1-\left(\frac{b_k^3}{j^3}\right)\right)^{\gamma_j}}}, w_{j\sqrt{1-\prod_{k=1}^{1}\left(1-\left(\frac{c_k^3}{j^3}\right)\right)^{\gamma_j}}} \right)$$

where $w_k = \left(w_{a_k}, w_{b_k}, w_{c_k}\right)$ is the k^{th} largest of all w_k's and $\gamma = (\gamma_1, \gamma_2, \ldots, \gamma_n)^T$ is the weight vector of $w_k (k = 1,2\ldots,n)$, satisfying that $0 \leq \gamma_k \leq 1$, $\sum_{k=1}^{n} \gamma_k = 1$.

3. Critical Factors Influencing OEE (Overall Equipment Effectiveness)

In order to verify the level of impact of various factors on the overall equipment effectiveness, the factors which are assumed to have an impact on OEE are identified from the literature and the experts, and they are presented below [10 - 20].

- Human factors
- Technical factors
- Maintenance factors
- Production factors
- Environmental factors
- Economic factors
- Managerial factors
- Organizational factors

The various elements in each influencing factor are described in the following sections.

3.1 The elements of Human factor

The cognitive factors differ with individuals with influences their performance and decision making of a process. The domains of the cognitive factors are perception, memory, learning, attention, decision-making, and language abilities. It enables the operator in the process of effective decision-making and hence influences performance rate. Operator age is important, since the operator is a person who operates equipment or a machine. The operator age is the period of human life of the operator, measured by years from birth. It plays a major role in encountering challenges and adapting to the manufacturing environment thereby influence performance rate. Operator capability is a measure of the ability of the operator to achieve his objectives, especially in relation to the overall mission. It motivates the operator to achieve the target thereby influence performance rate. Operator confidence is the state of mind characterized by the operator's reliance on himself and is referred to as operator confidence. It minimizes the chance of committing errors by the operator and hence influences quality rate. The cooperation between the operator depends upon the mutual agreement between the parties who interact promotes beneficial exchange and not competing with each other. Without any conflict. It reduces

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the occurrence of conflicts between the operators and hence influences availability rate. The operator efficiency increases the efficiency of the process by decreasing the input, with increases the output incorporating the time and energy without comprising of quality. It is very much required in the process of converting input to output in an efficient manner and hence influences performance rate. Operator fitness is the quality of being suitable to fulfil a particular role or task. It helps to possess the required physical stamina for carrying out the routine operations and hence influences availability rate. The innovation from the operator end paves a new path towards the transformation of resources in creativity of new opportunity and wealth. It facilitates determining innovative methods of manufacturing and utilizing the resources in an optimum manner and hence influences performance rate. Operator interest is the state of wanting to know or learn about something or someone. It empowers the operator to create a sense of belonging and ownership and hence influence quality rate. Operator involvement is the act of taking part in an activity, event, or situation. It transforms the operator to be more passionate in doing his job and hence influences quality rate. The operator punctuality is the inherent characteristic of the employee to accomplish the task in stipulated time. Punctuality always refers to time. It helps to minimize the downtime and increasing the availability of the equipment and influences availability rate. Physical factors are related to things involving bodily contact or activity. It provides the required physical strength in carrying out the routine task and hence influences performance rate. Psychological factors are the mental and emotional factors governing a situation or activity. It ensures that operators possess sufficient emotional stability while carrying out his task and influence performance rate. Sensory factors such as visual (sight), tactile (touch), olfactory (smell), gustatory (taste), auditory (hearing), temperature, hearing etc influence the performances of the operator precisely and hence influence quality rate.

3.2 Technical factor and its elements

Equipment ageis the age of the equipment from the manufacturing date to till date put into service/ production for a specific purpose without compromising on the availability rate, performance rate and quality rate. Equipment complexity is the degree of many new features incorporated in the system design and its internal structure, which is difficult to understand, and maintained in the initial stage. The more complex the equipment, the more time will be taken to rectify the fault, which occurred, and hence it influences the availability rate. **Equipment** is given by the state of health of the equipment. / A state of readiness or fitness of the equipment. If the equipment is maintained in good condition with periodic maintenance, the chance of the occurrence of breakdown is minimized and hence it influences availability rate. **Equipment type** refers to resembling or having the characteristics of a specified thing (Conventional, semi-automated, automated). The equipment type will decide the precision and accuracy and hence it influences quality rate. **Equipment versatility** means flexible and **capable** and executing in varying different the functions competently. The versatility enables us to do multiple operations and a reduction in setup and adjustment time, hence it influences availability rate. **Jigs and Fixtures** are considered one among the technical factors. Usage of jigs and fixture ensure accuracy and therefore it influences quality rate. **Job familiarization** means having a fair knowledge and acquaintance with the job. If the operator is more conversant and familiar with the job, the performance and quality of job is improved and hence it influences performance rate and quality rate. **Operator skill level / proficiency** refers to the ability, coming from one's knowledge, practice, aptitude, etc., to do something well. The skill of the operator is derived from practice and familiarity of the job and as practice improves the proficiency. If the operator is skilled and proficient with the operations, he can complete the operations in time with the required quality. Therefore, it influences the availability rate, performance rate and quality rate. **Operator training** will enhance the operator's ability, skills, knowledge as well as their attitude and behavior. Trained operators handle the equipment and carry out the operations as per the instructions and hence it influences availability rate, performance rate and quality rate. **Quality awareness** means having the knowledge of quality. Operators who have the awareness and quality consciousness produce quality jobs and hence it influences quality rate. **Quality of incoming raw material** is considered as one of the technical factors. If the input is of good quality, it leads to output of good quality. Therefore, it influences quality rate. **Quality target** means how the efforts are directed towards the objective or result. If the target to be achieved is set, then every operator will try to strive for it and hence this factor influences quality rate. **Tool change over time/ setting time** is the time required to modify a system or workstation, usually including both teardown time for the existing condition and setup time for the new condition. Increase in tool changeover time or setting time will lead to increase in equipment idle time and hence this factor influences availability rate. **Tool wear rate** means the deformation of shape during the processing of the tool in various operation results in the loss of tool material over a period of operating time. If the tool is worn out, frequently it needs to be changed or to be sharpened which increases the idle time and affects the performance and quality of product. Hence, this factor influences availability rate, performance rate and quality rate.

3.3 The elements considered under maintenance factor.

Frequency of maintenance is considered as important**.** Increase in frequency of maintenance increases the equipment idle time and hence this factor influences availability rate. **Level of maintenance effort** is the amount of work involved in performing the maintenance activity. If the quantum of maintenance work involved is more, it leads to increase in equipment down time and hence this factor influences availability rate. **Maintenance policy** and **Maintenance scheduling** increases the availability and hence reduces the down time. **Mean down Time, Mean Time between Failure**

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(MTBF) and Mean Time to Repair (MTTR) are the basic measures in maintenance**. Quality of maintenance** is the degree to which the maintenance function meets the specified requirements. If the quality of maintenance is good, the equipment will be running with good condition and produce products with good quality. Hence, this factor influences availability rate, performance rate and quality rate.

3.4 Production factor

The following are the elements considered under production factor.

Delivery schedule refers to the mutually agreed time by the buyer and the seller to deliver the goods/service with required quantity. In addition, it is influenced by the availability, productivity and quality rate. **Duration of work** is the length of time that the work lasts or continues during each day of work for an operator. If the duration of work is extended beyond the normal duration due to any production issues, the operator is subjected to physical and mental stress, which affects the output. Hence, this factor influences availability rate, performance rate and quality rate. **Equipment scheduling** is the process of determining when an activity should start or end, depending on its duration, predecessor activity (or activities), predecessor relationships, resource availability, and target completion date of the project. One of the important considerations for equipment scheduling is the availability of equipment in running condition. Hence this factor influences availability rate. **Frequency of inspection** is to be considered as one among the production factors. Inspection is defined as a critical appraisal involving examination, measurement, testing, gauging, and comparison of materials or items. An inspection determines if the material or item is in proper quantity and condition, and if it conforms to the applicable or specified requirements. Frequency of inspection determines the rate at which inspection is carried out over a particular period. Frequency of inspection will be increased if there are any quality issues and hence this factor influences quality rate. **Low machining time per Job:** Machining time is the time when a machine is processing something. If the machining time is low compared to the setup and adjustment time, then there is an increase of unproductive time or idle time. Hence, this factor influences availability rate. **Method of Inspection** is a particular form of procedure for accomplishing the inspection. It is the process of inspecting something, especially a systematic way. Quality of inspection depends upon the method of inspection and hence this factor influences quality rate. **Nature of shift** (Day, Evening, and midnight) is the period during which the operator is at work. There may be a variation in supervision and inspection between the shifts and hence this factor influences performance rate and quality rate. **Process planning** is systematic procedure defined in selecting the manufacturing process, equipment, tooling and the sequences of operations to be performed in the effective transformation of raw material to the final product. An effective process plan ensures good quality products with optimum resources and hence this factor influences performance rate and quality rate. **Product complexity** is the degree to which a component or system has a design and/or internal structure that is difficult to understand, maintain and verify [14]. Complex product requires sophisticated tools and equipment, skilled labor and precision material to achieve the desired quality. Hence, this factor influences quality rate. **Product variety** is referred to the number of different types of products produced by a company. Higher the product variety more will be change in equipment settings and hence this factor influences the availability rate. **Production capacity** is defined as the volume of products that can be produced by an enterprise using available resources. If the production capacity is higher than the actual quantity produced, then the level of equipment utilization is low. Hence, this factor influences the availability rate. **Production volume** is defined as the volume of products that is actually produced by an enterprise using current resources. If the quantity produced is less than the targeted quantity then there may be maintenance, productivity or quality issues. Hence, this factor influences availability rate, performance rate, quality rate. **Production target** is defined as the volume of products that is targeted to produce by an enterprise using current resources. Production target can be achieved by producing the right quantity with right quality. Hence, this factor influences availability rate, performance rate, quality rate. **Uninterrupted power supply** is the standby power source usually put into function when the input power main fails. As power is directly related to the output, the uninterrupted power source affects the availability rate, production rate and performance rate.

3.5 Environmental factor and its elements

Equipment cleanliness is the condition of the equipment being clean and free of contaminants. Cleanliness will prevent malfunctioning of equipment and running with full efficiency. Hence, this factor influences availability rate, performance rate and quality rate. **Operating convenience** is the state of the operator being able to perform the operations with little effort or difficulty. It helps to achieve the desired performance and hence this factor influences performance rate. **Housekeeping** is the process of ensuring that the workplace is kept clean and tidy. Hence, this factor influences availability rate, performance rate and quality rate. **Lighting** refers to the use of an artificial source of light for adequate illumination. Adequate lighting is necessary for carrying out critical operations and if not adhered to it may cause quality issues. Hence, this factor influences the quality rate. **Noise level** is the amplitude level of the undesired background noise expressed in terms of decibels. Noise level beyond the permissible limit may affect operator performance and concentration and hence this factor influences performance rate and quality rate. **Room temperature and humidity** also need to be considered. Operators working in a hot and humid environment will be often subjected to fatigue, which affects their performance. Hence, this factor influences performance rate and quality rate. **Safety practices** are adopted to prevent workplace illnesses, accidents, injuries, and fatalities. Safety practices ensure the availability of equipment as

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well as operators and hence this factor influences availability rate. **Ventilation** is providing and enhancing the indoor air quality by replenishing the oxygen level, controlled room temperature, removing moisture, bad Oduor, smoke etc. It refers to the replacement of stale or noxious air with fresh air. A good, ventilated workspace increases the morale of the operator and hence this factor influences the performance rate and quality rate. **Workplace layout** should be defined as "the environment (as place, tools, social connections, physical well-being) enabling work to be done". A proper workplace layout ensures free movement of material and operators and hence this factor influences performance rate.

3.6 Economic factors

The cost of operator training is the amount paid or required in payment for acquiring a particular skill or type of behaviour to a person operates equipment or a machine. The amount spent training the operator influences the skill acquired by the operator which in turn increases his performance and hence this factor influences the performance rate. **Inventory policy** plays a major role in the economic factor, and it has to be well addressed in handling the entire stock of the business, which includes raw material, components, work in process and finished goods. A good inventory policy ensures uninterrupted availability of raw material, tools and consumables and hence this factor influences the availability rate. **Labor cost** is the cost to be paid to the employees as wages and extra benefits include the direct and indirectly during the accounting period. Adequate compensation to the operator motivates him to perform well and hence this factor influences performance rate and quality rate. **The maintenance budget** of the department is the quantum of funding required to address the maintenance activities, which includes the salary of the maintenance personnel involved, utilities, and equipment parts. Adequate maintenance budget helps to formulate maintenance planning and scheduling, which in turn ensures equipment availability and hence this factor influences availability rate. **Maintenance cost** is the cost incurred in maintaining the equipment and the facilities in operating condition by systematic procedures. Maintenance is not to be considered as an unproductive cost and improves the performance of the equipment. Hence, this factor influences the performance rate. **Spare parts inventory** is considered as one among the maintenance factors. Spare part is defined as a duplicate or replacement component for a machine or other equipment. Availability of spare parts eliminates the equipment downtime waiting for spares and hence this factor influences availability rate.

3.7 Managerial factor

Authority and Responsibility is considered as one of the managerial factors. **Authority** is the legitimate power to make decisions and direct the subordinates**.** Responsibility is the right to accomplish the goals prescribed by the position in the organization chart. Authority and Responsibility if defined clearly leads to effective supervision, which in turn increases the performance of operators. Hence, this factor influences the performance rate. **Leadership style** is the style followed by an organization to integrate the comprehensive objective of every department and to maximize the available resources within the internal and external environment for the attainment of organizational or societal goals. Leadership style affects the performance of operators in a positive or negative way and hence this factor influences the performance rate and quality rate. **Shop floor management commitment** is also considered as one of the factors. Shop floor is defined as the part of a factory housing the machines and men directly involved in production. The commitment of shop floor manager propels him to formulate effective strategies, which increase the shop floor output. Hence, this factor influences performance rate and quality rate. **Superior - Subordinate Relationship** is also considered as one of the managerial factors. A good superior – subordinate relationship will lead to a conducive manufacturing environment and hence this factor influences availability rate, performance rate and quality rate.

3.8 Organizational factor

Job satisfaction has been defined as a pleasurable emotional state resulting from the appraisal of one's job. Job satisfaction leads to job accomplishment and aspiring to achieve more and hence this factor influences performance rate and quality rate. **Job security** is the probability that an individual will keep his or her job. Job security is dependent on the economy, prevailing business conditions, and the individual's personal skills. A secured person will work with more confidence and commit less mistakes and hence this factor influences performance rate and quality rate. **Operator experience** is defined as practical knowledge, skill, or practice derived from direct observation of or participation in events or in a particular activity. An experienced operator is expected to perform well and hence this factor influences performance rate and quality rate. **Operator loyalty** is faithfulness or a devotion to a person, country, group, or cause. A loyal operator will subordinate his personal interest to the interest of the organization and hence this factor influences performance rate and quality rate. **Operator turnover** is the rate at which an employer gains and loses operators. Simple ways to describe it are "how long operators tend to stay". Increase in operator turnover will affect the morale and motivation of the workforce and hence this factor influences performance rate and quality rate. **Personal allowances** are the time that is associated with workers' daily personal needs. Personal allowances help the operator to take care of his personal needs and to overcome fatigue, which in turn increases his performance. Hence, this factor influences performance rate and quality rate. **Vision and Mission** is considered as one among the organizational factors. A mission statement is a brief description of a company's fundamental purpose. A vision statement is sometimes called a picture of your company in the future. A vision statement may apply to an entire company or to a single division of that company. Vision and Mission statements helps the operator to focus over the goals and objectives and he will be motivated to achieve them. Hence, this factor

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influences performance rate and quality rate. **Welfare schemes** are those welfare facilities organizations provide to their employees to keep their motivation levels high. If the organization take care of the needs of the operators, then it will act as morale boosters for them, and they will be willing to be contribute more. Hence, this factor influences availability rate, performance rate and quality rate.

Uncertainty, ambiguity, and missing data are typical in MCDM problems, particularly those involving OEE. LFFS addresses linguistic variables and human judgement, whereas Neutrosophic Sets account for information's truth, indeterminacy, and falsehood. Their combination improves the ability to manage uncertainty more successfully.OEE assessment encompasses a number of aspects, including availability, performance, and quality, all of which may be interdependent and of varying value. The merging of LFFS and Neutrosophic Sets enables a more nuanced way to balancing these factors, resulting in more accurate and trustworthy ratings.

In a fuzzy setting, LFFS allows for a flexible representation of linguistic terms (e.g., "high", "medium", "low"), making it easier to model expert judgements. Neutrosophic Sets add an extra layer by including degrees of truth, indeterminacy, and falsity, resulting in a more complete picture of the information. Neutrosophic Sets are specifically designed to account for ambiguous and inconsistent information, making them effective in MCDM situations with incomplete or contradictory data. This increases the robustness of OEE evaluations.

Combining these strategies improves the accuracy of rating alternatives (such as machines or processes) using OEE criteria. The LFFS addresses the fuzziness of linguistic concepts, whereas the Neutrosophic Set's three-dimensional representation allows for a deeper investigation of the factors involved in OEE.

4. Procedure For Solving Decision Making Problem

We solve the problem that is mentioned in the first section by using LPNN operators to deal with decision makers (DM) opinions for selecting the best alternative among a group of k alternatives. The critical factors that significantly affect the OEE are grouped under Human Arena, Engineering Perspective, Management Perspective and Social aspects as alternatives to considered in these investigations with its symbolic representation are given below. As well as the factors associated with each alternative are also displayed in the table below. Grouping the factors associated with the alternatives helps the decision maker to characterize priorities and rank them based on the importance of current situation as to decide with respect to the present conditions to solve the decision-making problem rationally.

Table 1: Alternatives and the factors associated with its symbol

Sl.No	Alternatives	Symbol	Group of Attributes
1	Human Arena	$\boldsymbol{\Phi_1}$	**Human factor (ψ_1)**
2	Engineering Perspective	$\boldsymbol{\Phi_2}$	**Technical factor (ψ_2)** **Maintenance factor (ψ_3)** **Production factor (ψ_4)**
3	Management Perspective	$\boldsymbol{\Phi_3}$	**Managerial factor (ψ_7)** **Organizational factor (ψ_8)**
4	Social aspects	$\boldsymbol{\Phi_4}$	**Environmental factor (ψ_5)** **Economic factor (ψ_6)**

The weight vector of the attributes is ω = (0.088,0.076,0.08,0.082,0.08,0.09,0.088,0.085). In this study, we have collected a pilot study among two Supervisors (S_1, S_2) and two Operators(OP_1, OP_2) their preferences for each alternative on each attribute with the linguistic term set $w_0 = VLC(VeryLowContribution), w_1 = LC(LowContribution),$

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$w_2 = M(Medium)$,

$w_3 = HC(HighContribution) w_4 = VHC\ (VeryHighContribution$. They are the decision makers in this study. Let the weight vector of decision makers is $\chi_k = (0.25, 0.3, 0.2, 0.25)^T, k = 1,2,3,4$.

Step 1: Decision matrix, which contains LFNN values are given by the Supervisors and Machine Operators, are shown below. $R_k = \left(r_{ij}^k\right)_{m\times n}\ (k = 1, 2, 3)$ shown below tables:

Table 2: Decision matrix based on S_1

Criteria	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$	$\boldsymbol{\psi_3}$	$\boldsymbol{\psi_4}$	$\boldsymbol{\psi_5}$	$\boldsymbol{\psi_6}$	$\boldsymbol{\psi_7}$	$\boldsymbol{\psi_8}$
Φ_1	$< w_4, w_2, w_1 >$	$< w_3, w_2, w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_1, w_1 >$	$< w_2, w_1, w_1 >$	$< w_2, w_1, w_1 >$	$< w_3, w_2, w_1 >$	$< w_3, w_1, w_1 >$
Φ_2	$< w_4, w_2, w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_3, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_3, w_2, w_1 >$	$< w_2, w_3, w_4 >$
Φ_3	$< w_1, w_2, w_3 >$	$< w_4, w_2, w_1 >$	$< w_2, w_3, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_2, w_1 >$	$< w_4, w_2, w_1 >$	$< w_4, w_1, w_1 >$
Φ_4	$< w_2, w_3, w_4 >$	$< w_1, w_2, w_3 >$	$< w_1, w_2, w_2 >$	$< w_4, w_3, w_1 >$	$< w_4, w_2, w_1 >$	$< w_3, w_3, w_1 >$	$< w_3, w_2, w_3 >$	$< w_3, w_1, w_2 >$

Table 3: Decision matrix based on S_2

Criteria	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$	$\boldsymbol{\psi_3}$	$\boldsymbol{\psi_4}$	$\boldsymbol{\psi_5}$	$\boldsymbol{\psi_6}$	$\boldsymbol{\psi_7}$	$\boldsymbol{\psi_8}$
Φ_1	$< w_4, w_1, w_1 >$	$< w_4, w_2, w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_2, w_1 >$	$< w_3, w_1, w_1 >$	$< w_3, w_1, w_1 >$	$< w_4, w_3, w_1 >$	$< w_3, w_2, w_1 >$
Φ_2	$< w_4, w_3, w_1 >$	$< w_4, w_3, w_2 >$	$< w_4, w_4, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_3, w_1 >$	$< w_3, w_3, w_1 >$
Φ_3	$< w_1, w_1, w_2 >$	$< w_4, w_2, w_1 >$	$< w_3, w_3, w_1 >$	$< w_4, w_1, w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_2, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_1, w_1 >$
Φ_4	$< w_2, w_2, w_3 >$	$< w_1, w_1, w_2 >$	$< w_2, w_1, w_2 >$	$< w_4, w_4, w_1 >$	$< w_4, w_3, w_1 >$	$< w_4, w_4, w_1 >$	$< w_4, w_3, w_2 >$	$< w_3, w_1, w_3 >$

Table 4: Decision matrix based on OP_1

Criteria	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$	$\boldsymbol{\psi_3}$	$\boldsymbol{\psi_4}$	$\boldsymbol{\psi_5}$	$\boldsymbol{\psi_6}$	$\boldsymbol{\psi_7}$	$\boldsymbol{\psi_8}$
Φ_1	$< w_4, w_1, w_1 >$	$< w_4, w_1 w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_4, w_4 >$	$< w_1, w_3, w_2 >$	$< w_1, w_2, w_3 >$	$< w_1, w_1, w_1 >$	$< w_1, w_4, w_3 >$
Φ_2	$< w_4, w_4, w_4 >$	$< w_3, w_3, w_1 >$	$< w_3, w_4, w_1 >$	$< w_4, w_4, w_4 >$	$< w_3, w_2, w_1 >$	$< w_3, w_4, w_1 >$	$< w_1, w_3, w_2 >$	$< w_4, w_1, w_1 >$
Φ_3	$< w_3, w_2, w_1 >$	$< w_4, w_1, w_1 >$	$< w_4, w_3, w_1 >$	$< w_3, w_3, w_2 >$	$< w_3, w_4, w_2 >$	$< w_1, w_4, w_3 >$	$< w_1, w_3, w_4 >$	$< w_4, w_4, w_1 >$
Φ_4	$< w_3, w_3, w_2 >$	$< w_2, w_3, w_2 >$	$< w_3, w_2, w_1 >$	$< w_4, w_4, w_4 >$	$< w_4, w_4, w_3 >$	$< w_3, w_3, w_1 >$	$< w_4, w_3, w_2 >$	$< w_2, w_2, w_3 >$

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Table 5: Decision matrix based on OP_2

Criteria	ψ_1	ψ_2	ψ_3	ψ_4	ψ_5	ψ_6	ψ_7	ψ_8
Φ_1	$< w_3, w_1, w_1 >$	$< w_4, w_1, w_1 >$	$< w_3, w_1, w_2 >$	$< w_4, w_3, w_3 >$	$< w_1, w_2, w_2 >$	$< w_3, w_3, w_2 >$	$< w_1, w_1, w_1 >$	$< w_1, w_3, w_3 >$
Φ_2	$< w_4, w_4, w_4 >$	$< w_3, w_2, w_1 >$	$< w_4, w_3, w_1 >$	$< w_4, w_4, w_4 >$	$< w_4, w_3, w_1 >$	$< w_4, w_3, w_1 >$	$< w_2, w_2, w_1 >$	$< w_2, w_1, w_1 >$
Φ_3	$< w_3, w_3, w_2 >$	$< w_3, w_3, w_1 >$	$< w_3, w_2, w_1 >$	$< w_4, w_3, w_1 >$	$< w_4, w_3, w_1 >$	$< w_1, w_4, w_2 >$	$< w_2, w_4, w_3 >$	$< w_4, w_4, w_1 >$
Φ_4	$< w_4, w_3, w_1 >$	$< w_3, w_3, w_2 >$	$< w_2, w_3, w_3 >$	$< w_4, w_4, w_4 >$	$< w_4, w_4, w_1 >$	$< w_4, w_3, w_1 >$	$< w_4, w_4, w_2 >$	$< w_2, w_3, w_3 >$

Step 2: In [20], authors mentioned method based on the normal distribution, we consider the weight vector is determined as $\gamma = (0.25\ 0.3, 0.2, .25)^T$.

Table 6: LFNOWA operator based the aggregated decision matrix

Criteria	Φ_1	Φ_2	Φ_3	Φ_4
ψ_1	$< w_{3.7866}, w_{0.7846}, w_{0.6598} >$	$< w_{4.0000}, w_{2.6861}, w_{1.62}$ $>$	$< w_{2.1759}, w_{1.3625}, w_{1.2}$ $>$	$< w_{2.8696}, w_{2.1836}, w_{1.7}$ $>$
ψ_2	$< w_{3.7866}, w_{0.9659}, w_{0.6598} >$	$< w_{3.3468}, w_{2.0132}, w_{0.8}$ $>$	$< w_{3.7866}, w_{1.2712}, w_{0.6}$ $>$	$< w_{1.9221}, w_{1.6024}, w_{1.6}$ $>$
ψ_3	$< w_{3.0000}, w_{1.2746}, w_{0.7846} >$	$< w_{3.8308}, w_{3.0157}, w_{.65}$ $>$	$< w_{3.0496}, w_{2.2279}, w_{0.6}$ $>$	$< w_{2.0764}, w_{1.3625}, w_{1.1}$ $>$
ψ_4	$< w_{4.0000}, w_{1.8612}, w_{1.5118} >$	$< w_{4.0000}, w_{1.6245}, w_{1.6}$ $>$	$< w_{3.8308}, w_{1.3474}, w_{0.8}$ $>$	$< w_{4.0000}, w_{3.2406}, w_{2.0}$ $>$
ψ_5	$< w_{2.0612}, w_{1.2176}, w_{1.0353} >$	$< w_{3.8308}, w_{1.1457}, w_{0.6}$ $>$	$< w_{3.5523}, w_{1.8612}, w_{0.8}$ $>$	$< w_{4.0000}, w_{2.6861}, w_{1.0}$ $>$
ψ_6	$< w_{2.9247}, w_{1.5930}, w_{1.2176} >$	$< w_{3.83.08}, w_{2.1020}, w_{0.6}$ $>$	$< w_{3.1228}, w_{1.9319}, w_{1.2}$ $>$	$< w_{3.6011}, w_{2.4656}, w_{0.8}$ $>$
ψ_7	$< w_{2.3525}, w_{0.9659}, w_{0.6598} >$	$< w_{2.4986}, w_{2.0132}, w_{0.8}$ $>$	$< w_{3.2264}, w_{1.7219}, w_{1.5}$ $>$	$< w_{3.5026}, w_{1.7219}, w_{2.0}$ $>$
ψ_8	$< w_{2.8060}, w_{1.8612}, w_{1.3474} >$	$< w_{3.2147}, w_{1.0690}, w_{.93}$ $>$	$< w_{4.0000}, w_{1.6245}, w_{0.8}$ $>$	$< w_{3.0154}, w_{1.4105}, w_{2.2}$ $>$

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Table 7: LFNOWG operator based the aggregated decision matrix

Criteria	Φ_1	Φ_2	Φ_3	Φ_4
$\boldsymbol{\psi_1}$	$< w_{3.2406}, w_{1.3281}, w_{1.0}$ $>$	$< w_{3.4822}, w_{3.3362}, w_{2.8}$ $>$	$< w_{1.3474}, w_{2.1037}, w_{2.1}$ $>$	$< w_{2.1199}, w_{2.7469}, w_{2.8}$ $>$
$\boldsymbol{\psi_2}$	$< w_{3.2406}, w_{1.6334}, w_{1.0}$ $>$	$< w_{2.6879}, w_{2.5602}, w_{1.3}$ $>$	$< w_{3.2406}, w_{2.1715}, w_{1.0}$ $>$	$< w_{1.1457}, w_{2.3352}, w_{2.3}$ $>$
$\boldsymbol{\psi_3}$	$< w_{2.4656}, w_{1.8066}, w_{1.3}$ $>$	$< w_{3.1037}, w_{3.5523}, w_{1.0}$ $>$	$< w_{2.4997}, w_{2.7911}, w_{1.0}$ $>$	$< w_{1.4990}, w_{2.1037}, w_{1.8}$ $>$
$\boldsymbol{\psi_4}$	$< w_{3.4822}, w_{2.6767}, w_{2.5}$ $>$	$< w_{3.4822}, w_{2.8734}, w_{2.8}$ $>$	$< w_{3.4822}, w_{2.1759}, w_{1.2}$ $>$	$< w_{3.4822}, w_{3.7866}, w_{3.0}$ $>$
$\boldsymbol{\psi_5}$	$< w_{1.0909}, w_{1.8254}, w_{1.53}$ $>$	$< w_{3.1037}, w_{1.9221}, w_{1.0}$ $>$	$< w_{2.8471}, w_{2.6767}, w_{1.2}$ $>$	$< w_{3.4822}, w_{3.3362}, w_{1.6}$ $>$
$\boldsymbol{\psi_6}$	$< w_{1.5651}, w_{2.4702}, w_{1.8}$ $>$	$< w_{3.1037}, w_{2.9375}, w_{1.0}$ $>$	$< w_{1.4142}, w_{2.9887}, w_{1.8}$ $>$	$< w_{2.8883}, w_{3.0000}, w_{1.3}$ $>$
$\boldsymbol{\psi_7}$	$< w_{1.2073}, w_{1.6334}, w_{1.0}$ $>$	$< w_{1.4357}, w_{2.5602}, w_{1.2}$ $>$	$< w_{1.6818}, w_{2.7225}, w_{2.5}$ $>$	$< w_{2.9726}, w_{2.7225}, w_{2.8}$ $>$
$\boldsymbol{\psi_8}$	$< w_{1.3161}, w_{2.6767}, w_{2.1}$ $>$	$< w_{2.4623}, w_{1.9970}, w_{2.2}$ $>$	$< w_{3.4822}, w_{2.8734}, w_{1.3}$ $>$	$< w_{2.0651}, w_{2.1379}, w_{2.7}$ $>$

Step 3. The collective overall preference values r_i for each alternative ϕ_i (i = 1, 2, …, 4) based on the LFNWA or LFNWG operator with the weight vector w = (0.3, 0.1, 0.2, 0.4), as shown below:

Table 8: The collective overall preference values and the rankings of alternatives.

Alternatives	LFNOWA/ LFNWA	LFNOGA/ LFNGA
ϕ_1	$< w_{3.2365}, w_{1.3592}, w_{0.9241} >$	$< w_{2.0970}, w_{2.2557}, w_{1.7056} >$
ϕ_2	$< w_{3.5949}, w_{1.6193}, w_{0.9506} >$	$< w_{2.6752}, w_{2.6144}, w_{1.9338} >$
ϕ_3	$< w_{3.3925}, w_{1.5731}, w_{0.9402} >$	$< w_{2.2798}, w_{2.5535}, w_{1.6643} >$
ϕ_4	$< w_{3.1172}, w_{1.8384}, w_{1.5072} >$	$< w_{1.9647}, w_{2.6335}, w_{2.4214} >$
Ranking	$\phi_2 > \phi_3 > \phi_1 > \phi_4$	$\phi_2 > \phi_3 > \phi_1 > \phi_4$

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Step 4. By ranking ϕ_i (i = 1, 2, 3, 4) , listed in Table 6, it is obvious to see that the best alternative is ϕ_2 by considering both the methods. We conclude that the order preference for the alternatives are Engineering Perspective, Management Perspective, Human Arena and Social aspects.

5. Conclusion

Many of these businesses face challenges in maintaining all activities, processes, and synchronized use of equipment while minimizing time losses. As a result, proper utilization of available resources and equipment is a high priority in any industry's task list. Six Big Losses (SBL) are currently the primary emphasis for achieving excellent manufacturing standards in conjunction with strategic tools such as OEE (Overall Equipment Effectiveness). Availability, Performance, and Quality are the three elements that contribute to OEE. Overall Equipment Effectiveness (OEE) is a valuable technique for identifying loss causes in a plant and tracking the progress towards Lean Manufacturing. These time losses (dubbed the "Six Big Losses") have a collection of analyzing factors that influence overall performance. To understand the dynamics of the critical factors it must be rationalized and classified based on the significant effect on OEE, and then only the decisions will be predictable and match with the dynamic changing manufacturing scenario. The intricacy of keeping all activities, processes, and equipment use in sync with the minimization of all possible losses and flaws is the problem. Such losses are increasingly becoming the primary driver of investment in industrial unit maintenance. The various versions of established notions define 'Maintenance' as ‘repair of the equipment,' however this concept only applies to old and limited dimensions. As a result, this concept solely relates to maintenance techniques in terms of preventive, predictive, and corrective maintenance. At the most basic level of OEE adoption, the country's diverse process sectors are still uninformed of the potential benefits of this strategic tool. Time management and production loss analysis are being used to develop quality and performance-enhancing measures. In these investigations, the critical factors that significantly affect the OEE are grouped under Human Arena, Engineering Perspective, Management Perspective and Social aspects. The order preference is identified among the alternatives are Engineering Perspective, Management Perspective, Human Arena and Social aspects in successfully executing the OEE using Linguistic Fermatean Neutrosophic approach. It is very clear that effective implementation of OEE depends upon the engineering aspects such as technical, maintenance and production factors supported by the management implemented by the individual as human factors and delivered to society as social factors. The usage of Linguistic Fermatean Neutrosophic approach mathematical tool gave rise to clear the vagueness that presents in the effective utilization of OEE as well as ranks the order of alternatives as OEE has multiple criteria with multiple sub factors. The LFNS tool is an effective tool to solve multiple criteria decision making and it can be used in any domain to understand and to explore alternatives.

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