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RESEARCH ARTICLE

Circular Intuitionistic Fuzzy TODIM Approach for Material Selection for Cryogenic Storage Tank for Liquid Nitrogen Transportation

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ABSTRACT In this paper, a circular intuitionistic fuzzy set is implicated, which is the extension of a fuzzy set and an intuitionistic fuzzy set. The circular intuitionistic fuzzy set includes a radius for both membership and non-membership. After this, we describe the TODIM method for decision making, which can handle both quantitative and qualitative criteria, as well as imprecise and uncertain information. TODIM takes into account the decision-maker's subjective preferences and attitudes towards the criteria while also considering the uncertainty and imprecision in the decision-making process. We define the algorithm of C-IF-TODIM approach for decisions making problem. The proposed method takes into account both the fuzziness and circularity of the decision-making problem, which come from the fact that the decision-maker's preferences are subjective and that the criteria depend on each other. A case study of choosing materials for a cryogenic storage tank is used to test the proposed method, and the results are compared to those from other ways of making decisions. The results show that the proposed method makes decisions that are more accurate and reliable and that it can handle the uncertainty and complexity of choosing materials for cryogenic storage tanks well. After reviewing this paper, we can help make liquid nitrogen transportation safer and more reliable, which will cut down on the chance of accidents and financial losses. The proposed method can be applied to decision-making in other domains where circular intuitionistic fuzzy information is common.

INDEX TERMS Fuzzy set, circular intuitionistic fuzzy set, TODIM approach, decision making.

I. INTRODUCTION

To achieve organizational goals, decision-making can be characterised as a sequence of actions for choosing the most beneficial option from a group of possibilities [1]. Today, tackling difficult choice problems with numerous aims or criteria has become the primary research focus for Multi-Criteria Decision Making (MCDM) [2]. Numerous MCDM techniques, including the Analytic Hierarchy Process (AHP) [3], on entropy [4], TOPSIS [5], VIKOR [6], and countless others, have been created to tackle decision-making problems involving numerous competing norms under unreliability. These traditional MCDM methods cannot manage ambiguity and imprecision in language judgements because they depend on precise numerical values. Numerous scholars have demonstrated that TODIM [7] has some benefits over the others among these techniques. MCDM approaches have been expanded to use intuitionistic fuzzy sets [8], spherical fuzzy sets [9], or neutrosophic sets [10] in addition to regular fuzzy sets to capture this ambiguity. MCDM has previously solved many problems, including drug selection [11], hydrogen modelling [12], medical diagnosis [13] and wind power plant [14]. Wang et al. [15] gives the concept of fuzzy TODIM method, after this Sun et al. [16] gives the new idea

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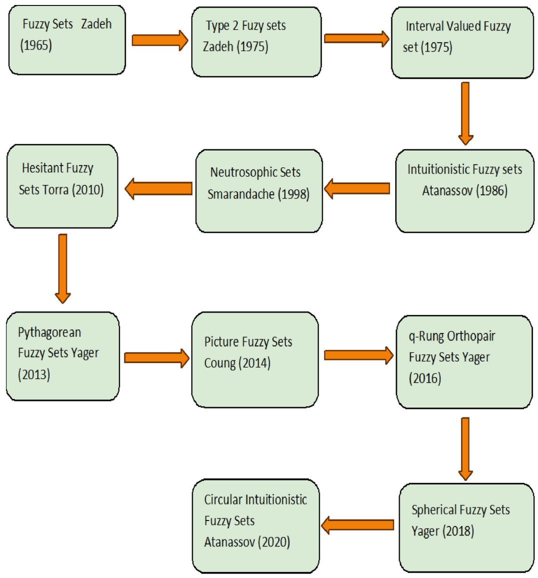

FIGURE 1. Developmentation in fuzzy set theory.

of TODIM method which can solve the exponent type problem. Hong et al. [7] gives the idea of selection of recycling the product by using extended TODIM approach.

Zadeh's theory [17] of fuzzy sets has led fuzzy logic, which began with Aristotle's logic, to its final conclusion. Standard fuzzy sets are defined by a membership degree and a degree of non-membership, which is the complement of the degree of membership, according to Zadeh. Many novel extensions that explain membership functions in more depth have been developed by various scholars to address the shortcomings of conventional fuzzy sets. In Figure 1 the new expansions of common fuzzy sets are historically depicted.

In reaction to criticism of fuzzy sets, Interval-Valued Fuzzy Sets (IVFS) [18] were created. As an extension of interval-valued fuzzy sets, Atanassov [19] created Intuitionistic Fuzzy Sets (IFSs), which are made up of a membership degree and a degree of non-membership, whose total is not always equal to 1. Their goal is to take into account the hesitation of specialists. A set of probable membership values for a component in a fuzzy set was utilised to handle hesitant fuzzy sets (HFSs), which Torra introduced [20]. Following Atanassov [21] invention of Intuitionistic Type-2 Fuzzy Sets (IFS-2), Yager [22] referred to them as Pythagorean Fuzzy Sets (PFSs), which were depicted with a bigger region for membership and non-membership degrees. After this the idea of Picture Fuzzy Set is introduced [23]. Subsequently, Yager [24] introduced Q-Rung Orthopair Fuzzy Sets (q-ROFSs) as a broad class of IFSs and PFSs. Some of them used this set for clean energy adoption [25]. Smarandache has created neutrosophic sets with varying degrees of truth, indeterminacy, and falsehood for each component in the multiverse [26]. These three distinct degrees can only be added up to a maximum of three. As a natural extension of IFSs, Coung and Kreinovich [27] and Ashraf et al. [28] proposed picture fuzzy sets and spherical fuzzy sets (SFS), which are defined by the membership, non-membership, and hesitation for each component in a set.

Circular intuitionistic fuzzy sets (C-IFSs), developed by [29] is an addition to all types of fuzzy sets that allow for more flexible and intuitive modelling of uncertainty and ambiguity in decision-making problems. C-IFSs are especially useful in situations where the boundaries between different categories or values are not well defined or when there is a need to represent uncertainty in a more nuanced way than a traditional fuzzy set.

Here are some potential benefits and applications of C-IFSs:

- Representing Uncertainty: C-IFSs can be used to represent uncertainty in a more flexible and intuitive way than traditional fuzzy sets. They can be especially useful when dealing with problems that have complex or ambiguous boundaries between different categories or values.
- Decision-Making: C-IFSs can be used to model decision-making (DM) problems, especially in situations where the decision-making criteria are not well-defined or when there are multiple conflicting criteria to consider. They can help decision-makers better understand and manage uncertainty and risk.
- Pattern Recognition: C-IFSs can be used in pattern recognition applications, where the boundaries between different classes of data are not well-defined or when there is a need to capture more nuanced information about the data.
- Optimization: C-IFSs can be used in optimization problems, where there is a need to balance conflicting objectives or find solutions that are robust to uncertainty and ambiguity.

Overall, C-IFS are a powerful tool for reducing mould uncertainty and ambiguity in DM problems. They can be used in a wide range of applications, from decision-making and pattern recognition to optimization and control.

We implicate C-IFSs in this paper due to the presence of circular radius, which are not present in IFS. In contrast to IFSs, a C-IFS represents each component by a circle with the center $(\mu_W(x), \nu_W(x))$, and radius r. These sets are those in which each component of the universe has a membership degree and a level of non-membership, and a circle about them has a radius r such that the total of the membership levels and non-membership inside this circle is at most equal to 1. In order to take into account the properties they have highlighted, C-IFSs can be employed in MCDM approaches. In this paper, we implicate the TODIM method [30] in the C-IF MCDM problem. The creation of the C-IF-TODIM and its use in solving the material selection problem give this work its novelty. Furthermore, if we want to check the radius of a circle in IFS, we are unable to find it. As a result, authors are thrilled to be able to meet this need. As a result, we must employ C-IFS to deal with this sort of issue. This is a transition to all predicting algorithms capable of handling any form of membership, and non-membership includes circular radius. They are useful when we need to calculate the radius of IFS. The question arises: why do we calculate the radius of any set? The answer is that after finding the radius, we know to check where the values of oversetting lie in this radius, which is helpful in observing our results.

There could be several motivations behind selecting ''Material selection for cryogenic tank for liquid nitrogen transportation'' as a research paper topic, including:

Importance: Cryogenic tanks play a crucial role in the transportation of liquid nitrogen, which is a widely used cryogen in several industries, including medical, food processing, and scientific research. The selection of the right material for these tanks is critical for ensuring safe and efficient transportation.

Technical complexity: Selecting the right material for cryogenic tanks is a technically complex process that involves several factors, such as temperature range, pressure, mechanical properties, and environmental factors. A research paper on this topic can help explore the technical complexities involved and provide insights into the selection process.

Innovation: There is always room for innovation in the selection of materials for cryogenic tanks. A research paper on this topic can help explore new materials that could be used for cryogenic tanks and their potential benefits, including improved durability, safety, and efficiency.

Practical applications: This research paper can have practical applications in several industries, including aerospace, medical, and food processing. The findings of the research can help companies select the right material for their cryogenic tanks, resulting in safer and more efficient transportation.

The remainder of the article is structured as follows:

1) It is claimed that C-IFS and fuzzy sets are used to link the other parts of the content.
2) In the following section, we defined how to use my proposed method, as well as the circular intuitionistic membership, non-membership, and radius values, to calculate the score value.
3) Study of TODIM under a circular intuitionistic set was provided.
4) To evaluate the outcomes, we applied this approach to the illustrative example.
5) In this section, we provide an example for the purpose of comparative analysis.
6) A portion of the discussion will be presented here.
7) We concluded the article by presenting it.

II. PRELIMINARIES

In section II, we first review a few fundamental ideas, such as IFSs and C-IFSs, as well as their fundamental operations and distance units, before introducing the traditional TODIM technique, which will be applied in the next parts.

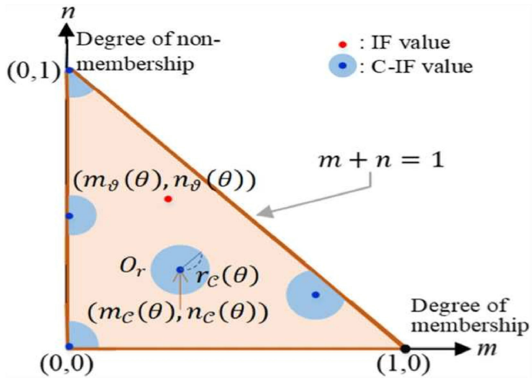

FIGURE 2. Geometrical representation.

A. CONCEPT OF IFSs AND C-IFSs AND ITS DISTANCE

The concept of IFSs is explained since it is useful in understanding the C-IFS. Additionally, the distance formula is illustrated to assist in determining the distance of the C-IFS.

Definition 1: If Υ is a group of objects represented comprehensively by q then fuzzy set A in Υ is:

$$A = \{(q, \mu_A(q) | q \in \Upsilon)$$

$\mu_A(q)$ is known as membership function which maps Υ to the space of membership. All non-negative real numbers fall within its scope, and supremum is a finite number which is that one.

Definition 2: [31] Let Υ is a nonempty set. An intuitionistic fuzzy set ξ in Υ is an object having the form $\xi = \{\langle q, \mu_\xi(q), \nu_\xi(q)\rangle; q \in \Upsilon\}$ where the function, $\mu_\xi(q), \nu_\xi(q) :\rightarrow [0, 1]$ define the presence of membership and non-membership respectively and for every component $q \in \Upsilon, 0 \leq \mu_\xi(q) + \nu_\xi(q) \leq 1$.

Definition 3: [32] A C-IFS O_r is distinguish by the presence of membership $m_\vartheta \in [0, 1]$, a presence of non-membership $n_\vartheta \in [0, 1]$ and a radius $r_\vartheta \in [0, 1]$ with $m_\vartheta + n_\vartheta \leq 1$ and denoted by:

$$O_r = ((m_\vartheta, n_\vartheta); r_\vartheta) \tag{1}$$

Each component in C-IFSs is depicted by a circle with a center $(m_\vartheta, n_\vartheta)$ and radius r, as opposed to the normal IFSs where each component is depicted by a point in the intuitionistic fuzzy analysis triplet. Figure 2 shows the geometrical representation of C-IFSs.

Definition 4: [33] The operations of C-IFS are defined as follows. For every $\Re, \aleph \in$ C-IFS (X),

1) $\Re \subseteq \aleph$ *iff* $\varsigma \in X, (\mu_\Re(\varsigma) \leq \mu_\aleph(\varsigma)$ *and* $\nu_\Re(\varsigma) \geq \nu_\aleph(\varsigma))$;
2) $\Re = \aleph$ *iff* $\Re \subseteq \aleph$ *and* $\aleph \subseteq \Re$;
3) $\Re^c = \{(\varsigma, \nu_\Re(\varsigma), \mu_\Re(\varsigma))\}$;
4) $d(\Re, \aleph) =$

$$\frac{1}{2}\left(\frac{r_\Re - r_\aleph}{\sqrt{2}} + \sqrt{\frac{1}{2k}\sum_{j=1}^{k}(\mu_\Re(\varsigma_j) - \mu_\aleph(\varsigma_j))^2 + (\nu_\Re(\varsigma_j) - \nu_\aleph(\varsigma_j))^2}\right) \tag{2}$$

$d(\Re, \aleph)$ is the normalised shortest distance between $\Re$ and $\aleph$; it is suggested to use this to determine how different two things are from one another.

Definition 5: [34] Let $\varpi_1 = ((\mu_{\varpi_1}(q), \nu_{\varpi_1}(q)); r_{\varpi_1})$ and $\varpi_2 = ((\mu_{\varpi_2}(q), \nu_{\varpi_2}(q)); r_{\varpi_2})$ be two C-IFS sets that go around in circles. As they bring the least and most volatility, respectively, the operations are based on the lowest and largest radius. A smaller radius indicates less ambiguity in C-IFS pairings, whereas a bigger radius indicates more vagueness. The way they operate is as follows:

1) $\varpi_1 \cap_{\min} \varpi_2 = \{(q, \min(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)), \max(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)); \min(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$
2) $\varpi_1 \cap_{\min} \varpi_2 = \{(q, \min(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)), \max(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)); \max(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$
3) $\varpi_1 \cup_{\min} \varpi_2 = \{(q, \max(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)), \min(\mu_{\varpi}1(q), \nu_{\varpi_1}(q)); \min(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$
4) $\varpi_1 \cup_{\max} \varpi_2 = \{(q, \max(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)), \min(\mu_{\varpi_1}(q), \nu_{\varpi_2}(q)); \max(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$
5) $\varpi_1 \oplus_{\min} \varpi_2 = \{q, \mu_{\varpi_1}(q) + \mu_{\varpi_2}(q) - \mu_{\varpi_1}(q) \times \mu_{\varpi_2}(q), \nu_{\varpi_1}(q) \times \nu_{\varpi_2}(q); \min(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$
6) $\varpi_1 \oplus_{\max} \varpi_2 = \{q, \mu_{\varpi_1}(q) + \mu_{\varpi_2}(q) - \mu_{\varpi_1}(q) \times \mu_{\varpi_2}(q), \nu_{\varpi_1}(q) \times \nu_{\varpi_2}(q); \max(r_{\varpi_1}, r_{\varpi_2})|q \in \Upsilon\}$

Definition 6: Let intuitionistic fuzzy pairs in an IFS ξ_i, have the following form: $\{\langle s_{i,1}, f_{i,1}\rangle\langle s_{i,2}, f_{i,2}\rangle, \ldots\}$, etc., where i is the amount of IFS ξ_i, and among ϑ_i. First, the intuitionistic fuzzy couples' numerical average is determined as follows:

$$\langle \mu_{(\xi_i)}, \nu_{(\xi_i)}\rangle = \langle \frac{\Sigma_{j=1}^{\vartheta_i} s_{i,j}}{\vartheta_i}, \frac{\Sigma_{j=1}^{\vartheta_i} f_{i,j}}{\vartheta_i}\rangle \tag{3}$$

where ϑ_i is the amount of intuitionistic fuzzy pairs ξ_i.

Radius of the $\langle \mu_{(\xi_i)}, \nu_{(\xi_i)}\rangle$ is the highest of the Euclidian distances.

$$r_i = \max_{1 \le j \le \vartheta_i} \sqrt{(\mu_{(\xi_i)} - s_{i,j})^2 + (\nu_{(\xi_i)} - f_{i,j})^2} \tag{4}$$

Definition 7: [35] Suppose $\xi = ((\mu_\xi, \nu_\xi); r))$ is a circular intuitionistic fuzzy value (C-IFV), then a score function § of the C-IFV is defined as follows: where p is any arbitrary value, $p \in [0, 1]$.

$$\S(\xi) = \frac{1}{3}((\mu_\xi - \nu_\xi) + \sqrt{2}r(2p - 1)) \quad where\ \ Score(\xi) \in [-1, 1] \tag{5}$$

B. SUMMARY OF THE TODIM APPROACH

Using a prospect theory-based multi-criteria value function, the TODIM technique measures the degree to which each choice dominates the others [36]. The alternative's rating can be established based on the attained dominance degrees. The TODIM method's primary benefit is its capacity to observe decision making behaviour. It is important to note that the TODIM can only be used to solve MCDM situations if the criterion values are presented as sharp integers. The TODIM technique would adhere to the procedures listed below [37] in algorithmic form:

To keep things simple, Let $\Upsilon = \{1, 2, 3, \ldots\ldots, m\}$ and $R = \{1, 2, 3, \ldots\ldots, n\}$.

Step I: [38] Recognized the decision matrix $V = (v_{ij})_{i\times j}$ and normalize the decision matrix $V = (v_{ij})_{i\times j}$ into $U = (u_{ij})_{i\times j}$, where, $i \in Y, j \in R$.

Step II: Determine the relative weight o_{jr} of the reference criteria $\hbar_r$ to the criterion $\hbar_j$ using the following expression:

$$o_{jr} = o_j/o_r, r, j \in R. \tag{6}$$

where o_j is the weight value of the requirement $\hbar_j$ and $o_r = \max\{o_j|j \in R\}$.

Step III: Use the following phrase to determine each alternative Υ_i dominance over each alternate Υ_k:

$$\emptyset(\Upsilon_i, \Upsilon_k) = \sum_{j=1}^{n} \Theta_j(\Upsilon_i, \Upsilon_k), \qquad \forall(i, k) \tag{7}$$

where $\Theta_j(\Upsilon_i, \Upsilon_k)$

$$= \begin{cases} \sqrt{o_{jk}(u_{ij} - u_{kj})/\Sigma_{j=1}^{n} o_{jk}} & , \text{ if } u_{ij} - u_{kj} > 0 \\ 0 & , \text{ if } u_{ij} - u_{kj} = 0 \\ \frac{-1}{\theta}\sqrt{(\Sigma_{j=1}^{n} o_{jk})(u_{kj} - u_{ij})/o_{jk}} & , \text{ if } u_{ij} - u_{kj} < 0 \end{cases} \tag{8}$$

The term $\Theta_j(\Upsilon_i, \Upsilon_k)$ reflects the contribution of the requirement $\hbar_j$ to the function $\emptyset(\Upsilon_i, \Upsilon_k)$ when comparing the alternative Υ_i with the alternative Υ_k. Parameter θ reflects the depletion factor of the losses, which can be adjusted based on the issue at hand. In equation (8) three cases can occur: First, if $u_{ij} - u_{kj} > 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represent a beneficial; Second, if $u_{ij} - u_{kj} = 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represent a nil; Third, if $u_{ij} - u_{kj} < 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represents a non-beneficial.

Step IV: Compute the option Υ_i total potential value using the following formula:

$$\varrho(\Upsilon_i) = \frac{\Sigma_{k=1}^{m}\emptyset(\Upsilon_i, \Upsilon_k) - \min_i\{\Sigma_{k=1}^{m}\emptyset(\Upsilon_i, \Upsilon_k)\}}{\max_i\{\Sigma_{k=1}^{m}\emptyset(\Upsilon_i, \Upsilon_k)\} - \min_i\{\Sigma_{k=1}^{m}\emptyset(\Upsilon_i, \Upsilon_k)\}}, \quad i \in Y. \tag{9}$$

Step V: Rank the possibilities according to the total worth of their prospects $\varrho(\Upsilon_i)(i \in Y)$.

III. STUDY OF TODIM UNDER CIRCULAR INTUITIONISTIC FUZZY ENVIRONMENT

In section III, we are solving the above-mentioned MCDM problem, the first thing we need to do is normalize the initial decision matrix by utilising citation [41]. This is virtually indistinguishable in any way from the steps involved in the TODIM approach. After that, we move on to the next step, which is constructing the prospect value function based on prospect theory in order to determine the degree to which one possibility is more dominant than the others [36]. In order to accomplish this, we must first select a criterion to serve as a reference and then determine how much weight each criterion should be given in comparison to the reference criterion. In most cases, the criterion that has the greatest weight can be considered the reference criterion, and then the proportional weight of the criterion $\hbar_j$ to the reference criterion $\hbar_r$ can be found by using the equation (6). Afterwards, based on the score functions $\S(u)$ we are able to make a comparison based on the magnitude of the ranking that each possibility received with respect to each criterion, which is indicated by C-IFSs. In addition, in a manner that is comparable to that of (8), we are able to determine the beneficial and non-beneficial associated with the alternative Υ_i in comparison to the alternative Υ_k in terms of the criterion $\hbar_j$ by utilising the given formula: C-IFSs will be used to describe the evaluations of potential alternatives based on the criteria $u_{ij}(i \in Y, j \in R)$.

$$\Theta_j(\Upsilon_i, \Upsilon_k) = \begin{cases} \sqrt{o_{jk} d(u_{ij} - u_{kj}) / \Sigma_{j=1}^{n} o_{jk}} & , \text{if} \S(u_{ij}) - \S(u_{kj}) > 0 \\ 0 & , \text{ if } \S(u_{ij}) - \S(u_{kj}) = 0 \\ \frac{-1}{\theta} \sqrt{(\Sigma_{j=1}^{n} o_{jk}) d(u_{kj} - u_{ij}) / o_{jk}} & , \text{if } \S(u_{ij}) - \S(u_{kj}) < 0 \end{cases} \tag{10}$$

where the framework constant θ represents the depletion factor of the non-beneficial, $d(u_{ij} - u_{kj})$ denote the distance between the C-IFSs u_{ij} and u_{kj} using (2). Clearly, there are three different cases in (10): First, if $\S(u_{ij}) - \S(u_{kj}) > 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represent a beneficial; Second, if $\S(u_{ij}) - \S(u_{kj}) = 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represent a nil; Third, if $\S(u_{ij}) - \S(u_{kj}) < 0$ then $\Theta_j(\Upsilon_i, \Upsilon_k)$ represents a non-beneficial.

By acquiring $\Theta_j(\Upsilon_i, \Upsilon_k)$ with every criterion $\hbar_j$, the dominance of the alternative Υ_i over the alternative Υ_k can be collected as follows:

$$\emptyset(\Upsilon_i, \Upsilon_k) = \sum_{j=1}^{n} \Theta_j(\Upsilon_i, \Upsilon_k), \qquad \forall(i, k) \tag{11}$$

At last, we arrive at the following formulation in order to compute the global forecast value of the alternative form Υ_i.

$$\varrho(\Upsilon_i) = \frac{\Sigma_{k=1}^{m} \emptyset(\Upsilon_i, \Upsilon_k) - \min_i\{\Sigma_{k=1}^{m} \emptyset(\Upsilon_i, \Upsilon_k)\}}{\max_i\{\Sigma_{k=1}^{m} \emptyset(\Upsilon_i, \Upsilon_k)\} - \min_i\{\Sigma_{k=1}^{m} \emptyset(\Upsilon_i, \Upsilon_k)\}}, \; i \in Y. \tag{12}$$

Obviously, $0 \leq \varrho(\Upsilon_i) \leq 1$, and the larger $\varrho(\Upsilon_i)$ is, the stronger the alternative Υ_i will be. Because of this, we are capable of identifying the ordering order of all alternatives $\Upsilon_i(i \in Y)$ according to the ascending order of the overall potential value of the alternative $\Upsilon_i(i \in Y)$, and then choosing the preferable alternative from the collection of alternatives $\hbar$.

On the basis of the models and analysis given above, the following is a presentation of an algorithm for the C-IF-TODIM strategy: A flowchart of the C-IFS TODIM approach is shown in Figure 3.

Step I: [41] Recognized the decision matrix $V = (v_{ij})_{i \times j}$ and normalize the decision matrix $V = (v_{ij})_{i \times j}$ into $U = (u_{ij})_{i \times j}$. After this convert the IFs into C-IFSs by calculating the radius with the usage of equations (3) and (4).

Step II: Equation (6) can be used to find the reference criterion $\hbar_r$ and compute the relative weight o_{jr} of the criterion $\hbar_j$ to the reference criterion $\hbar_r$.

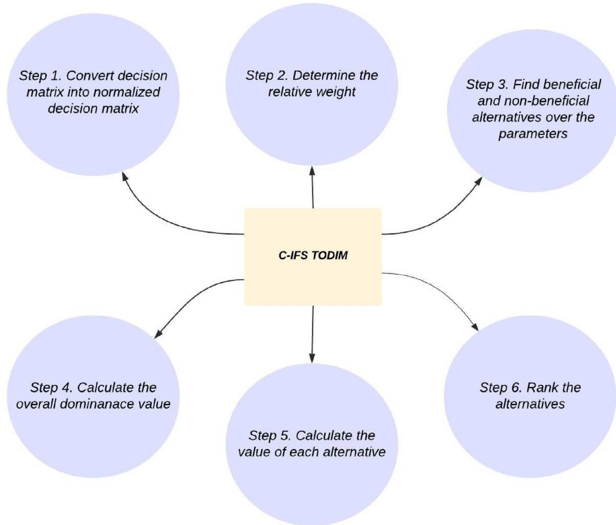

FIGURE 3. Flowchart of the proposed method.

Step III: Apply equation (10) to determine the beneficial and non-beneficial of the alternative Υ_i over the alternative Υ_k for each parameter $\hbar_j$.

Step IV: Equation (11) can be used to determine the alternative Υ_i supremacy over the alternative Υ_k.

Step V: Utilizing equation (12), determine the total possibility value of the option $\Upsilon_i(i \in Y)$.

Step VI: The preferred option from the collection of alternatives, Υ, is selected by generating an ordering order for each alternative based on the ascending order of the alternative's total potential value, $\Upsilon_i(i \in Y)$.

IV. ILLUSTRATIVE EXAMPLE

In section IV, we'll look at a decision-making problem that involves using our suggested strategy and evaluating and ranking the best materials for cryogenic storage tanks used to transport liquid nitrogen.

A. DESCRIPTION

Cryogenic storage tanks are widely used in the transportation of liquefied gases such as liquid nitrogen, which is stored and transported at extremely low temperatures of $-196^0 C$. The selection of materials for cryogenic storage tanks is crucial as they need to withstand the low temperatures and pressure variations during transportation. In this case study, we will discuss the material selection for a cryogenic storage tank for the transportation of liquid nitrogen.

The material selection for the cryogenic storage tank involved a comprehensive evaluation of various materials based on their mechanical properties, thermal conductivity, and resistance to low-temperature embrittlement. After considering the pros and cons of several materials, including aluminum alloys, stainless steel, and carbon steels, the final material selected was 304 stainless steel. 304 stainless steel has excellent mechanical properties and resistance to low-temperature embrittlement, making it a suitable material for the cryogenic storage tank. It also has a high thermal conductivity, which facilitates heat transfer between the liquid nitrogen and the tank wall. Additionally, 304 stainless steel is corrosion-resistant, making it ideal for transporting liquid nitrogen, which is highly reactive with many materials.

After selecting the material, the design and fabrication of the cryogenic storage tank began. The tank was designed to ASME code standards and had a capacity of 20,000 liters. The tank had a double-walled construction, with an inner vessel made of 304 stainless steel and an outer vessel made of carbon steel.

So the company constructs a committee to explore the six major parameters, which are AL 2024-T6 ($\curlyvee_1$), SS 301 FH ($\curlyvee_2$), SS 310-3AH ($\curlyvee_3$), Ti-6Al-4V ($\curlyvee_4$), Inconel 718 ($\curlyvee_5$) and 70Cu-30Zn ($\curlyvee_6$) and five criteria are given based on the decision making. These five main criteria are: Toughness Index $\hbar_1$, Yield Strength $\hbar_2$, Young's Modulus $\hbar_3$, Density $\hbar_4$ and Thermal Expansion $\hbar_5$.

1) TOUGHNESS INDEX

The toughness index is an important factor to consider when designing and constructing cryogenic storage tanks for liquid nitrogen transportation. The toughness index is a measure of the material's ability to resist brittle fracture under low-temperature conditions, which is critical for ensuring the structural integrity of the tank during use. In cryogenic applications, the temperature of the stored liquid nitrogen can be as low as $-196^0C(-321^0F)$, which can cause materials to become brittle and more prone to cracking or fracturing. Therefore, materials used for cryogenic tanks must have high toughness index values to withstand the low temperatures and potential mechanical stresses that can occur during transportation and handling.

2) YIELD STRENGTH

The yield strength of the materials used in cryogenic storage tanks for liquid nitrogen transportation is an important factor to consider because it affects the structural integrity and safety of the tank. When a material is subjected to stress, it will deform. The amount of stress that a material can withstand before it starts to deform permanently is known as its yield strength. In cryogenic applications, the low temperatures can make the material more brittle, reducing its yield strength and making it more prone to cracking or failure. Therefore, when selecting materials for cryogenic storage tanks, it is important to choose materials with a high yield strength, even at low temperatures. Common materials used for cryogenic tanks include stainless steel, aluminum, and nickel alloys, which have good mechanical properties at cryogenic temperatures.

3) YOUNG'S MODULUS

Young's modulus is another important factor to consider when designing cryogenic storage tanks for liquid nitrogen transportation. Young's modulus is a measure of a material's stiffness and its ability to resist deformation when subjected to stress. In cryogenic applications, low temperatures can cause some materials to become more brittle, which can result in reduced stiffness and a lower Young's modulus. This can lead to increased deformation or permanent plastic deformation of the storage tank. Therefore, when designing cryogenic storage tanks, it is important to select materials with a high Young's modulus, which will maintain their stiffness and resist deformation even at low temperatures. Materials such as stainless steel, aluminum, and nickel alloys have high Young's moduli and are commonly used for cryogenic tanks. It is also important to note that the Young's modulus of a material can change at cryogenic temperatures, so testing and analysis should be conducted to ensure that the material maintains its properties at the desired operating temperature.

4) DENSITY

Density is another important factor to consider when designing cryogenic storage tanks for liquid nitrogen transportation. Density is the mass per unit volume of a material, and it can affect the weight and volume of the storage tank as well as the amount of liquid nitrogen that can be transported. When designing cryogenic storage tanks, the weight of the tank must be taken into consideration since it will impact the transportation, handling, and installation of the tank. A higher density material will result in a heavier tank, which can be more challenging to transport and install. Additionally, the volume of the storage tank must be large enough to hold the required amount of liquid nitrogen. The density of the tank material can affect the tank's volume and, therefore, its capacity. In summary, density is an important factor in the design of cryogenic storage tanks for liquid nitrogen transportation. The density of the tank material can affect the weight, volume, and capacity of the tank, and a balance must be achieved between these factors to ensure the safe and efficient transport of liquid nitrogen.

5) THERMAL EXPANSION

Thermal expansion is another important factor to consider when designing cryogenic storage tanks for liquid nitrogen transportation. Thermal expansion refers to the increase in volume that occurs in a material when it is subjected to temperature changes. In cryogenic applications, temperature changes can be significant, and materials used in cryogenic storage tanks can experience significant thermal expansion or contraction. This can result in stresses and deformation in the tank, which can compromise its structural integrity and safety. Therefore, when designing cryogenic storage tanks, materials with low coefficients of thermal expansion should be selected to minimize the effects of thermal expansion. Materials such as stainless steel, aluminum, and nickel alloys have relatively low coefficients of thermal expansion and are commonly used for cryogenic tanks. In addition, the design of the storage tank should also take into account the effects of thermal expansion and contraction. The tank should be designed with sufficient

TABLE 1. Expert information fuzzy decision matrix.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
Υ_1	[0.05,0.95]	[0.08,0.92]	[0.09,0.91]	[0.27,0.73]	[0.11,0.89]
Υ_2	[0.06,0.94]	[0.02,0.98]	[0.08,0.92]	[0.28,0.72]	[0.11,0.89]
Υ_3	[0.50,0.50]	[0.27,0.73]	[0.22,0.78]	[0.10,0.90]	[0.14,0.86]
Υ_4	[0.12,0.88]	[0.22,0.78]	[0.24,0.76]	[0.10,0.90]	[0.17,0.83]
Υ_5	[0.12,0.88]	[0.17,0.83]	[0.13,0.87]	[0.17,0.83]	[0.26,0.74]
Υ_6	[0.15,0.85]	[0.24,0.76]	[0.25,0.75]	[0.09,0.91]	[0.21,0.79]

space to accommodate any expansion or contraction without causing undue stress on the tank's structure. Furthermore, insulation is crucial to minimize heat transfer, which can result in temperature changes and subsequent thermal expansion or contraction. Proper insulation can help maintain a more constant temperature, reducing the effects of thermal expansion and contraction.

B. DECISION MODEL

The decision issue from Section IV-A is resolved in the following using the C-IF-TODIM decision model. The steps involved in the answer and the outcomes of the calculation are outlined below:

- First, since hardness is regarded as the most crucial component of service quality, we use criterion $\hbar_1$ as the reference criterion. As a result, $o_r = 0.28$ is the reference criterion's weight. The loses will add with their actual value to the overall value of [39] while we select $\theta = 1$. The beneficial and non-beneficial of the alternative Υ_i over the alternative Υ_k are then calculated for each parameter $\hbar_j$ using (10). We can compare the size of the ranking of options with respect to each criterion, which is expressed by C-IFSs, depending on the score functions $\S(u)$.
- When comparing them, we should make the shorter one longer until they are both the same length. We should also take into account how many values are in each C-IFS so that we can figure out their distances more accurately. In accordance with the rules stated in equation (2), we assume that the decision-makers in the aforementioned decision problem are negative and alter the data in Table 1.
- Additionally, we can determine the supremacy degree of each alternative over the others, which is enumerated in Table 9, by averaging the wins and losses of the alternative Υ_i over the alternative Υ_k regarding each criterion $\hbar_j$ by using (11).

Step I: The company expert gives the information of data in the form of membership and non-membership that was given in Table 1 that has already been normalized.

After this, we convert expert information into C-IFSs by adding the radius with the use of equations (3) and (4) which were written in Table 2.

Step II: Weight vector criteria is w = {0.28, 0.24, 0.12, 0.27, 0.09} then using the (6) to calculate the relative weight vector.

$$o = \{1.00, 0.86, 0.43, 0.96, 0.32\}$$

TABLE 2. Circular intuitionistic fuzzy decision matrix.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
Υ_1	[(0.05,0.95) ; 0.10]	[(0.08,0.92) ; 0.05]	[(0.09,0.91) ; 0.05]	[(0.27,0.73) ; 0.21]	[(0.11,0.89) ; 0.01]
Υ_2	[(0.06,0.94) ; 0.07]	[(0.02,0.98) ; 0.13]	[(0.08,0.92) ; 0.04]	[(0.28,0.72) ; 0.24]	[(0.11,0.89) ; 0.00]
Υ_3	[(0.50,0.50) ; 0.36]	[(0.27,0.73) ; 0.04]	[(0.22,0.78) ; 0.04]	[(0.10,0.90) ; 0.21]	[(0.14,0.86) ; 0.14]
Υ_4	[(0.12,0.88) ; 0.07]	[(0.22,0.78) ; 0.07]	[(0.24,0.76) ; 0.10]	[(0.10,0.90) ; 0.10]	[(0.17,0.83) ; 0.00]
Υ_5	[(0.12,0.88) ; 0.08]	[(0.17,0.83) ; 0.01]	[(0.13,0.87) ; 0.06]	[(0.17,0.83) ; 0.00]	[(0.26,0.74) ; 0.12]
Υ_6	[(0.15,0.85) ; 0.05]	[(0.24,0.76) ; 0.07]	[(0.25,0.75) ; 0.09]	[(0.09,0.91) ; 0.14]	[(0.21,0.79) ; 0.03]

TABLE 3. Score value of circular intuitionistic fuzzy set.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
Υ_1	-0.181	-0.192	-0.193	0.019	-0.221
Υ_2	-0.193	-0.185	-0.202	0.040	-0.248
Υ_3	0.225	-0.082	-0.114	-0.097	-0.095
Υ_4	-0.154	-0.083	-0.053	-0.148	-0.204
Υ_5	-0.153	-0.190	-0.158	-0.204	-0.029
Υ_6	-0.149	-0.079	-0.056	-0.133	-0.126

TABLE 4. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_1$.

	Υ_1	Υ_2	Υ_3	Υ_4	Υ_5	Υ_6
Υ_1	0.00	0.07	-1.06	-0.41	-0.39	-0.51
Υ_2	-0.25	0.00	-1.07	-0.33	-0.32	-0.44
Υ_3	0.30	0.30	0.00	0.29	0.29	0.28
Υ_4	0.12	0.09	-1.02	0.00	-0.13	-0.30
Υ_5	0.11	0.09	-1.02	0.04	0.00	-0.32
Υ_6	0.14	0.12	-1.00	0.08	0.09	0.00

TABLE 5. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_2$.

	Υ_1	Υ_2	Υ_3	Υ_4	Υ_5	Υ_6
Υ_1	0.00	-0.50	-0.64	-0.57	-0.89	-0.58
Υ_2	0.12	0.00	-0.81	-0.71	0.17	-0.74
Υ_3	0.15	0.21	0.00	0.10	0.12	-0.35
Υ_4	0.14	0.17	-0.40	0.00	0.11	-0.19
Υ_5	0.12	-0.71	-0.50	-0.45	0.00	-0.47
Υ_6	0.14	0.18	0.08	0.05	0.11	0.00

TABLE 6. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_3$.

	Υ_1	Υ_2	Υ_3	Υ_4	Υ_5	Υ_6
Υ_1	0.00	0.02	-0.76	-0.90	-0.45	-0.89
Υ_2	-0.20	0.00	-0.76	-0.92	-0.49	-0.91
Υ_3	0.09	0.09	0.00	0.53	0.08	-0.52
Υ_4	0.11	0.11	0.06	0.00	0.09	0.03
Υ_5	0.05	0.06	-0.65	-0.77	0.00	-0.77
Υ_6	0.11	0.11	0.06	-0.28	0.09	0.00

Step III: Calculate the beneficial and non-beneficial of the alternative Υ_i over the alternative Υ_k concerning each criterion $\hbar_j$ using equation (10). To calculate this, first we calculate the general score value of C-IFSs. For p is 0.9. Table 3 shows the score values of C-IFSs.

Calculated value of beneficial and non-beneficial of all alternatives according to first criteria is given in Table 4. Same as for second, third fourth and fifth criteria are written in Tables 5, 6, 7 and 8 respectively.

Step IV: Utilizing equation (11), determine the total supremacy of the alternative Υ_i over the alternative Υ_k are written in Table 9.

TABLE 7. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_4$.

	$\curlyvee_1$	$\curlyvee_2$	$\curlyvee_3$	$\curlyvee_4$	$\curlyvee_5$	$\curlyvee_6$
$\curlyvee_1$	0.00	-0.25	0.15	0.18	0.18	0.18
$\curlyvee_2$	0.07	0.00	0.17	0.20	0.19	0.19
$\curlyvee_3$	-0.57	-0.62	0.00	0.10	0.17	0.09
$\curlyvee_4$	-0.68	-0.72	-0.37	0.00	0.14	-0.24
$\curlyvee_5$	-0.68	-0.72	-0.64	-0.52	0.00	-0.58
$\curlyvee_6$	-0.65	-0.70	-0.33	0.07	0.16	0.00

TABLE 8. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_5$.

	$\curlyvee_1$	$\curlyvee_2$	$\curlyvee_3$	$\curlyvee_4$	$\curlyvee_5$	$\curlyvee_6$
$\curlyvee_1$	0.00	0.02	-0.83	-0.58	-1.12	-0.79
$\curlyvee_2$	-0.23	0.00	-0.86	-0.57	-1.14	-0.83
$\curlyvee_3$	0.07	0.08	0.00	0.07	-0.84	0.08
$\curlyvee_4$	0.05	0.05	-0.83	0.00	-0.99	-0.59
$\curlyvee_5$	0.10	0.10	0.08	0.09	0.00	0.07
$\curlyvee_6$	0.07	0.07	-0.90	0.05	-0.79	0.00

TABLE 9. Overall dominance degree of every alternative over the others.

	$\curlyvee_1$	$\curlyvee_2$	$\curlyvee_3$	$\curlyvee_4$	$\curlyvee_5$	$\curlyvee_6$
$\curlyvee_1$	0.00	-0.64	-3.14	-3.13	-2.27	-2.60
$\curlyvee_2$	-0.50	0.00	-3.34	-2.33	-1.60	-2.72
$\curlyvee_3$	0.05	0.06	0.00	0.03	-0.19	-0.42
$\curlyvee_4$	-0.27	-0.30	-2.56	0.00	-0.78	-1.29
$\curlyvee_5$	-0.29	-1.18	-2.73	-1.62	0.00	-2.07
$\curlyvee_6$	-0.19	-0.22	-2.08	-0.03	-0.34	0.00

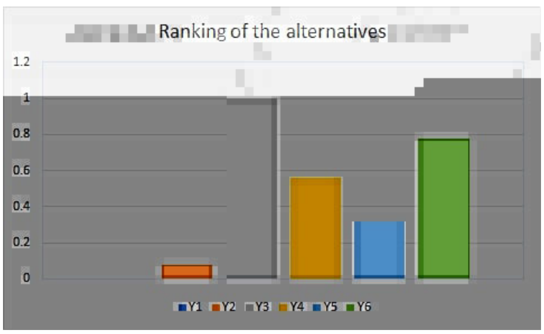

FIGURE 4. Ranking of the alternatives.

Step V: The total worth of each alternative is determined by employing equation (12) based on Table 9.

$$\varrho(\curlyvee_1) = 0,\ \varrho(\curlyvee_2) = 0.075,\ \varrho(\curlyvee_3) = 1$$
$$\varrho(\curlyvee_4) = 0.563,\ \varrho(\curlyvee_5) = 0.316,\ \varrho(\curlyvee_6) = 0.779$$

Step VI: Lastly, based on the general values, the ranking order of the six alternatives is determined such as:

$$\varrho(\curlyvee_3) > \varrho(\curlyvee_6) > \varrho(\curlyvee_4) > \varrho(\curlyvee_5) > \varrho(\curlyvee_2) > \varrho(\curlyvee_1)$$

Apparently, $\varrho(\curlyvee_3)$ is the most desirable alternative. Figure 4 shows the ranking of each alternative using Step V.

Figure 4 shows the ranking of all the alternatives. The likely third alternative is our best choice after finding the values of the alternatives.

TABLE 10. Ranking orders of alternatives with different values of θ.

Different values of θ	Ranking orders of alternatives
$\theta = 1$	$\varrho(\curlyvee_3) > \varrho(\curlyvee_6) > \varrho(\curlyvee_4) > \varrho(\curlyvee_5) > \varrho(\curlyvee_2) > \varrho(\curlyvee_1)$
$\theta = 2$	$\varrho(\curlyvee_3) > \varrho(\curlyvee_6) > \varrho(\curlyvee_4) > \varrho(\curlyvee_5) > \varrho(\curlyvee_2) > \varrho(\curlyvee_1)$
$\theta = 3$	$\varrho(\curlyvee_3) > \varrho(\curlyvee_6) > \varrho(\curlyvee_4) > \varrho(\curlyvee_5) > \varrho(\curlyvee_2) > \varrho(\curlyvee_1)$

TABLE 11. Normalized decision matrix.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
$\curlyvee_1$	[0.67, 0.22]	[0.80, 0.10]	[0.35, 0.55]	[0.71, 0.19]	[0.56, 0.34]
$\curlyvee_2$	[0.61, 0.27]	[0.65, 0.23]	[0.61, 0.29]	[0.50, 0.40]	[0.76, 0.14]
$\curlyvee_3$	[0.55, 0.34]	[0.73, 0.16]	[0.84, 0.12]	[0.85, 0.11]	[0.71, 0.18]
$\curlyvee_4$	[0.65, 0.23]	[0.67, 0.22]	[0.61, 0.29]	[0.55, 0.34]	[0.54, 0.35]

TABLE 12. Circular intuitionistic fuzzy decision matrix.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
$\curlyvee_1$	[(0.67, 0.22); 0.08]	[(0.80, 0.10); 0.26]	[(0.35, 0.55); 0.38]	[(0.71, 0.19); 0.13]	[(0.56, 0.34); 0.08]
$\curlyvee_2$	[(0.61, 0.27); 0.02]	[(0.65, 0.23); 0.04]	[(0.61, 0.29); 0.03]	[(0.50, 0.40); 0.18]	[(0.76, 0.14); 0.18]
$\curlyvee_3$	[(0.55, 0.34); 0.24]	[(0.73, 0.16); 0.03]	[(0.84, 0.12); 0.12]	[(0.85, 0.11); 0.13]	[(0.71, 0.18); 0.02]
$\curlyvee_4$	[(0.65, 0.23); 0.07]	[(0.67, 0.22); 0.10]	[(0.61, 0.29); 0.00]	[(0.55, 0.34); 0.08]	[(0.54, 0.35); 0.09]

TABLE 13. Score value of circular intuitionistic fuzzy set.

	$\hbar_1$	$\hbar_2$	$\hbar_3$	$\hbar_4$	$\hbar_5$
$\curlyvee_1$	0.2557	0.4240	0.1660	0.3101	0.1824
$\curlyvee_2$	0.1625	0.2165	0.1701	0.1941	0.3680
$\curlyvee_3$	0.2561	0.2521	0.3663	0.3840	0.2348
$\curlyvee_4$	0.2382	0.2689	0.1315	0.1744	0.1767

C. SENSITIVE ANALYSIS

The sensitivity analysis was carried out by changing the value of the measure θ (the reduction factor of the losses) and recalculating the ordering orders of the options with the various values of θ. We can get the new ordering values of the options given in Table 10 by altering θ from 1 to 3. The rankings of the options are not affected by the value of θ, as shown by the findings of the sensitivity analysis shown in Table 10. In other words, the derived ordering values are compatible with what is expected despite the change in the reduction index of losses' worth.

V. COMPARATIVE ANALYSIS

A comparison study was carried out on the results of the VIKOR-Method [40] of multi criteria decision making, and after this, we implicated this data in the proposed method to show the exactness of our technique. His weight of attribute is: $w = \{0.1950, 0.2129, 0.1980, 0.1966, 0.1976\}$ and its relative weight are: $\{0.9159, 1.000, 0.9300, 0.9230, 0.9281\}$. A normalised decision matrix are given in Table11:

By using (3) and (4) we convert this IF into C-IF matrix. This C-IF decision matrix is written in Table 12.

The next step is to determine the score of the number on the C-IF judgement matrix. Getting p = 0.9. Score value of C-IFs is written in Table 13.

Using the equation (10), we will now determine the benefits and drawbacks of the alternative $\curlyvee_i$ in comparison to the alternative $\curlyvee_k$ in regard to each parameter $\hbar_j$. Calculated value of beneficial and non-beneficial of all alternatives

TABLE 14. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_1$.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	0.10	-0.78	0.05
Υ_2	-0.51	0.00	-0.75	-0.45
Υ_3	0.15	0.15	0.00	0.15
Υ_4	-0.24	0.09	-0.76	0.00

TABLE 15. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_2$.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	0.18	0.15	0.16
Υ_2	-0.83	0.00	-0.46	-0.37
Υ_3	-0.73	0.09	0.00	-0.51
Υ_4	-0.74	0.08	0.11	0.00

TABLE 16. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_3$.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	-1.13	-1.28	0.23
Υ_2	0.22	0.00	-0.81	0.04
Υ_3	0.25	0.26	0.00	0.17
Υ_4	-1.15	-0.21	-0.84	0.00

TABLE 17. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_4$.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	0.16	-0.54	0.14
Υ_2	-0.79	0.00	-0.95	0.11
Υ_3	0.11	0.19	0.00	0.17
Υ_4	-0.70	-0.58	-0.88	0.00

TABLE 18. Beneficial and non-beneficial of each alternative over the others regarding the criterion $\hbar_5$.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	-0.83	-0.71	0.04
Υ_2	0.16	0.00	0.12	0.17
Υ_3	0.14	-0.63	0.00	0.15
Υ_4	-0.21	-0.84	-0.74	0.00

TABLE 19. Overall dominance degree of every alternative over the others.

	Υ_1	Υ_2	Υ_3	Υ_4
Υ_1	0.00	-1.53	-3.15	0.61
Υ_2	-1.74	0.00	-2.85	-0.49
Υ_3	-0.08	-0.04	0.00	0.13
Υ_4	-3.05	-1.47	-3.11	0.00

according to first criteria is given in Table 14. Same as for second, third fourth and fifth criteria are written in Tables 15,16,17 and 18 respectively.

When we have finished determining this, we will use the function (11) to determine the general dominance degree of each possibility. Overall dominance of every alternatives are defined in Table 19.

TABLE 20. Ranking orders of alternatives with different values of θ.

Different values of θ	Ranking order of proposed method	Best option
$\theta = 1$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$
$\theta = 0.1$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$
$\theta = 0.9$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$

Different values of θ	Ranking order [41]	Best option
$\theta = 1$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$
$\theta = 0.1$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$
$\theta = 0.9$	$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$	$\varrho(\Upsilon_3)$

Using the equation (12), which is based on the Table 19 one can calculate the overall value of each alternative.

$$\varrho(\Upsilon_1)= 0.467,\ \varrho(\Upsilon_2) = 0.333,\ \varrho(\Upsilon_3) = 1.000,\ \varrho(\Upsilon_4)= 0$$

In the end, the order of the four choices is decided by taking each one's overall value into account, as follows:

$$\varrho(\Upsilon_3) > \varrho(\Upsilon_1) > \varrho(\Upsilon_2) > \varrho(\Upsilon_4)$$

Evidently, $\varrho(\Upsilon_3)$ is the preferred option.

Table 20 shows the best alternative with the different value of θ. Using [40] to demonstrate the accuracy of our method.

VI. DISCUSSION

In this article, we consider two examples: the first one relates to the material selection for a cryogenic storage tank for the transportation of liquid nitrogen, and the second example relates to enterprise resource planning [40]. As a point of reference, we will use the second scenario to illustrate how accurately our suggested technique works. Table 20 demonstrates the accuracy of our methodology by displaying an order of the alternatives with various values of θ. The above Table 20 also displays the ordering of the alternatives. We take the data that can be found in [40] and demonstrate how our technique functions with that data. The following thing that we observe is that the ordering of our method is same as [40], which demonstrates that the suggested method is accurate. The proposed method handles this kind of data easily, in which the radius value of membership and non-membership is necessary to calculate. Radius tells us where overvalues lie in which area.

VII. CONCLUSION

In this study, we add the C-IFSs to the TODIM model for MCDM. First, the stages in the conventional TODIM model's calculation as well as the description, comparison technique, and distance of C-IFSs are presented. The TODIM model is then created to address MCDM issues where attribute values are in C-IFSs, and its key feature is that it accurately captures the limited reasoning of decision-makers.

The fuzzy TODIM technique has incorporated C-IFSs that take into account the ambiguity in the specification of membership functions due to the discrepancies between experts' membership degree allocations. According to sensitivity analysis based on various criteria weights, the findings of the suggested strategy are solid and trustworthy. In addition, a material selection problem's rating outcomes have been contrasted using a comparative analysis with C-IFS. It has been established that the technique created using the comparison findings is accurate. The proposed technique is only applicable for those sets in which membership and non-membership are included with the radius, but if they are included with an indeterminacy degree like a neutrosophic fuzzy set, this technique cannot handle them.

Different C-IFS techniques, such as triangular, trapezoidal, or interval-valued C-IFSs rather than singular C-IFSs, can be created for further research. To contrast our suggested strategy with other MCDM techniques based on C-IFSs, different methods can be created. The proposed C-IFS TODIM method can solve any type of daily life problem in which we have membership and non-membership of given data.

COMPETING INTERESTS

All authors are here with confirm that there are no competing interests between them.

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