



## **An Integrated Neutrosophic MCDM Methodology for Material Selection**

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### **Abstract**

Choice of materials is difficult since it requires considering several factors, assigning relative importance to those criteria, and ultimately choosing the most relevant criterion. Finally, it is important to set the criteria in a way that takes into account both the known material attributes and the needs of the application. Therefore, MCDM techniques may be used to the process of selecting materials. A possibility of incomplete dilemmas arises due to the decision maker's language inputs. Therefore, the inputs might be supplied as fuzzy numbers in order to circumvent the issue. Considering that a neutrosophic set is a metaphor to overcome uncertainty of human perceptions. To assess this recruitment process in a neutrosophic setting, this paper employs a neutrosophic-based version of the MCDM tool TOPSIS to determine which alternative materials should be used for the center console of an electric car.

**Keywords:** Neutrosophic sets; MCDM; Automotive Instrument; Material Selection;

### **1. Introduction**

The selection of manufacturing and marketing resources is of utmost significance in product development, manufacturing, and sales. However, because of the convoluted link between various opposing selection criteria for picking options, the process is both laborious and thought-provoking. This is due to the fact that there are a variety of options to choose from. The enhancement of efficiency and the reduction of costs are often the primary motivating factors behind material selection. However, other variables, like malfunction and reduced weight, may also be powerful motivators for the selection of the appropriate materials. For instance, one of the most important goals for design improvements in the aircraft industry is the decrease of the overall amount of weight[1]–[3].

If the appropriate materials are not chosen, it may be impossible to fulfil the requirements of both the makers and the consumers. It is also possible for it to result in the breakdown of an installation and a decline in quality product, which will have a negative impact on both profitability and productivity as well as the reputation of a company[4], [5].

In the body of research that has been done on the topic, a variety of approaches have been used in order to address the issue of choice of materials. The MCDM approach is one of the more well-known approaches that has been utilised. The Multiple Criteria Decision Making (MCDM) technique is a systematic strategy that helps decision makers pick the optimal choice from a list of options by concurrently using decision criteria such as benefit and expense data as well as the perspectives of decision makers. AHP, VIKOR, MAUT, and ELECTRE are just a few examples of the well-known

MCDM techniques that have been used in the past for the purpose of conducting material analysis. The tools structure assigns ranks to various options based on references to choice criteria, which in most cases are measured using a variety of distinct units.

The literature on the use of MCDM to the resolution of a wide variety of decision problems in a variety of fields of human activity has been studied by a large number of writers. The initial compromised score, also known as the VIKOR approach, was essentially presented in Rai et al.[6] as a tool for MCDM and was built on a specific measure of proximity to the optimal situation that was achieved by the use of the linear normalising methodology. The VIKOR technique focuses on picking the best option from a set of reasonable options in the face of interdependently conflicting requirements by identifying a compromise solution. This may be done by selecting the most suitable choice from among a collection of feasible options. It offers the 'majority' the most possible benefit as a group, while the 'opponents' both feel the least amount of personal loss as a result of the decision. The most significant issue with the first iteration of the VIKOR approach is that, owing to the complex calculations involved, it often results in an incorrect preference ordering for the many options that are taken into account. On the other hand, the degrees of regret, from the point of view of the theory of regret, are only impacted by the highest possible values of the criterion. In contrast hand, regret theory postulates that the unmanifested utility is the source of the amount of regret that an individual experiences. In this study, an effort is made to contrast the ranking achievements of the original VIKOR approach with the regret concept VIKOR approach to take into account that both choiceless and dissatisfaction utilitarian. This comparison is conducted in order to determine which technique is more efficient. As a result of the flywheel material choice difficulty that was described earlier, it was discovered that the regret concept VIKOR approach performs comparatively better than the initial VIKOR technique. This discovery was made after the issue was noted.

A latest version of the VIKOR technique was provided in Jahan et al. [7]in accordance with an unique normalising methodology that is built on the goal values of requirements. As a result, an exceptionally comprehensive approach was derived, with an emphasis on workable compromise in choice of materials. In addition, the new model that was presented in their paper was able to cover the primary flaw of VIKOR through the use of a more straightforward strategy. As a result, it is in a position to lessen the risk that is associated with the selection of appropriate materials based on a group of predetermined criteria. The outcomes of the applicable instances demonstrated the potential of the suggested complete VIKOR in MCDM. As a result, it may assist architects and stakeholders in the acquisition of more sound judgements, particularly in the context of applications involving biomedical material choice.

Choice of materials for an automobile parts often includes the consideration of a number of different criteria; hence, Girubha and S.Vinodh [8] made use of the VIKOR technique in order to find a solution to the issue of choice of materials. Plastics, in overall, are used in the car sector because they contribute to a lower vehicle weight while allowing the added load of new protective gear. Additionally, plastics are resistant to corrosion which can provide an extended life for the vehicle. Plastics are also thought to be a crucial component in paints that are used to safeguard other components. It is essential to pay more thought to the environmental consequences generated by the product in this day and age, especially in light of the proliferation of environmentally aware goods. Therefore, utilising SolidWorks Sustainability Xpress, an accurate evaluation of environmental effects may be evaluated by supplying the material, form of the product, and the related production method. After taking into consideration the various ways of evaluation, it has been determined, in the end, that polypropylene may serve as an acceptable replacement for ABS in the construction of the center console. The task may be made more extensive by picking the most efficient method of producing the product as well as the many design options. As a result of the fact that the product's materials, designs, and production processes all play a vital part in determining the product's overall degree of sustainability. In addition, the same mix of fuzzy VIKOR and ecological consequences may be used to choose the most suitable production procedure.

Recent developments in the automobile industry have resulted in improvements to the sector's standards for both safety and environmental efficiency. These technological advancements play a vital role when thinking about the form and choice of materials. The first thing that must be done is to choose which material would work best for the vehicle component. Selecting the appropriate materials may help save resources and achieve more effective cost management. When selecting a material or substituting a current one with an alternative that has elements that perform much better, the decision

makers will often use techniques based on trial and error or past testing. This results in a waste of time and a significant rise in cost. As a result, having an appropriate model to use when selecting materials is quite important. Since fuzzy MCDM approaches are utilised for handling competing concepts with various criteria that take linguistic assessment into account, they are capable of resolving selection of procurement issues that include competing standards. For the purpose of resolving issues pertaining to choice of materials, Gul et al.[9] suggested using a fuzzy PROMETHEE approach that is based on trapezoidal fuzzy interval variables with regard to two distinct preference functions. Regarding the validity of this fuzzy PROMETHEE-based model, the outcome of the suggested technique is contrasted with the outcomes of three distinct fuzzy MCDM approaches (fuzzy VIKOR, fuzzy TOPSIS, and fuzzy ELECTRE). In addition, the Spearman's correlation coefficient is used to examine the correlations among the approaches that are being contrasted and the situations that are being presented for fuzzy PROMETHEE. The goal here is to choose the material that is the most appropriate. Styrene maleic anhydride and polypropylene have been identified as potential candidates for use in the construction of the casing for the car instrument panel. The ability to account for ambiguity, ambiguity, and vagueness in the judgement context is one of the most significant benefits offered by the technique. It has been shown that the technique presented here is both practicable and effective as a tool for the choice of materials provided that the decision-makers choose the appropriate preference function. The decision-value maker's system need to have a significant role in determining the material rank. If this is not the case, the individual(s) responsible for making the choice will be unhappy.

A number of tonnes of structural steel have been used in the production of instruments for the cutting, shaping, and other forms of metallurgical sectors. While the first tool steels were made of simple carbon steel, modern tool steels include a variety of intermetallic compounds, such as tungsten, vanadium, molybdenum, manganese, and chromium, in order to offer the characteristics that are required for the wide range of applications that are carried out by these steels. Because no one material combines the greatest levels of wear rate, tenacity, processability, safety in tempering, and non-deformability, there are many different kinds of tool steel materials available. This is one reason why there are so many different kinds of tool steel materials. Each kind of tool steel material has unique mechanical and physical properties, both of which contribute to the material's suitability for a certain application. In addition, there may be more than one substitute steel alloys material available for a particular application. Because of this, it is very necessary to choose the tool stainless steels that is the most suited for the app and has the attributes that the manufacturer requires. Both Maity and Chakraborty[10] went through a list of ten different types of tool structural steel and rated their capabilities based on a set of nine different selection criteria. After this, the preference ranking organisation technique for enrichment evaluation (PROMETHEE II) is used to the issue of tool steel material selection in order to acquire the entire ranking of the material alternatives that were taken into consideration. The two materials that come to mind first are molybdenum-type elevated steel and tungsten-base high-speed tool steel. Both of these are excellent options. The material that is least favoured for use as tool steel is carbon steels.

So, this paper introduce the neutrosophic sets integrated with MCDM approach like TOPSIS to identify the weights of requirements and rank and select best martial design in automotive instrument. This paper present the interval valued neutrosophic sets to overcome the uncertainty in the process of selection.

## **2. Material Selection in Case Study in Automotive Instrument**

The choice of materials for an automobile center console will be used to show both the analytical technique and the application of the suggested neutrosophic TOPSIS method. The choice of a material from the available options, which include Styrene Maleic Anhydride (SMA), Polycarbonate, Polypropylene, and Acrylonitrile Butadiene Styrene, is the focus of the illustrated case (ABS). These components have been given the designations A1 (SMA), A2 (Polycarbonate), A3 (Polypropylene), and A4 respectively (ABS). Because A1 (SMA) has features of contact or reaction that give desired interfacial effects, it is commonly used in blends or hybrids. These applications may be found in a variety of industries. A2, often known as polycarbonate, is a kind of plastic material that belongs to a specific category. It can be manipulated, moulded, and thermoformed without much effort. Polycarbonates may find use in many different industries, including the automotive and aerospace industries, as well as the security industry. Polycarbonate has the potential to provide benefits such as a decrease in gross weight, improved occupant containment, and more design freedom. It offers excellent load bearing capacity, optical clarity, and the advantages of thermoplastic manufacturing, but it does not function well in terms of wear resistance or weathering efficiency. A3 (Polypropylene)

hybrids are utilised for a variety of inorganic fillers like carbon black, silica, calcium carbonate, and talc. These fillers are employed in an effort to decrease the weight of automobile components and, as a result, the amount of gasoline required to operate the vehicles. The thermoplastic polymer known as A4 (ABS) is very widespread. It finds particular use in the automobile industry. ABS has several benefits, including a high value, outstanding resistance to shock, nice look, moderate toughness, and excellent barrier to acids and bases. It also has a moderate degree of strength. Furthermore, it has several downsides. It has a low resistance to the effects of weather, a medium resilience to heat, moisture, and chemicals, a relatively expensive cost, and it is combustible with a high level of smoke production[11]–[13].

The highest temperature restriction (S1), the renewability (S2), the extensibility (S3), the mass (S4), the heat capacity (S5), the tensile modulus (S6), the price (S7), and the toxicity level (S8) are the eight factors that are taken into consideration in this paper[14]–[18]. The highest temperature restriction, or S1, is a significant factor in reducing the amount of movement and vibration that automobiles experience. It ought to be set to a temperature level that is appropriate. S2 is an abbreviation for "renewability," which refers to the process of converting solid waste into new goods in order to avoid the waste of potentially usable resources, decrease energy consumption, air pollution, environmental pollution, and offer reduced emissions of greenhouse gases. As a result of the material being recycled and turned into a high-quality, brand-new product that maintains the same quality standards as the original material, the firm stands to benefit. In order to facilitate the production processes of instrument panels, it is desirable to have access to recyclable material. It is preferable for the S3 (Elastic fibers) of the material to be as low as possible. It is important that the instrument panel be securely fastened to the body of the vehicle if one want to cut down on both vibration and relative motion. A decrease in the S4 (mass) of a vehicle has a direct impact on the amount of gasoline that is used, and it also has a negative impact on the fuel efficiency of vehicles. Composite materials are increasingly being recognised as a promising opportunity to significantly reduce the body's white weight. In the process of selecting materials, heat capacity, or S5, is one of the most essential factors, and it is optimal for this property to be low. The ability of a substance to transfer heat to another is known as its thermal conductivity. The heat of the center console will rise if the substance is heated to a high enough degree and allowed to get exposed to the sun. It causes the expansion of the material, which might lead to a reduction in the clearance between the pieces, which ultimately leads to stick slip. S6 (ultimate tensile) increases as the fibre content of natural fibre reinforced polymer composites increases, until the highest or ideal value of the natural fibre reinforced composite materials rise. The price of the material is presented in the S7 (price) criteria. It includes the costs incurred during the extraction process, the costs incurred during the manufacturing process, and the costs incurred during the recycling process. It was, of course, decided upon and hoped that it would be at a low level. The S8 toxicity rating of materials takes into account any hazardous emissions that are produced at any step of the material's life cycle, from manufacture through recycling. In this regard, the most important factor to consider is the car's CO<sub>2</sub> emissions, which are directly influenced by the vehicle's overall weight. Because of this, the procedure for selecting the material should also take into account the amount of toxicity. The factors S1, S2, and S4 are considered to be advantageous, whereas the other requirements are considered to be non-benefit[19]–[21].

### **3. Selection Process**

The examination of substances that may be used for center console begins the recruitment process. This screening involves taking into consideration the features that are inherent to the application being evaluated. During the screening process, the many sorts of materials that have the potential to be applied are determined[22], [23]. At an early point in the process of selecting materials, it is essential to do research on the many kinds of materials that might potentially be utilised for the instrumental panel. After conducting an investigation into the characteristics and functions of the instrumentation panel, the following materials were considered: ABS, polypropylene, polycarbonate, and SMA. Both Kurcz and Benichou emphasised some of the scientific and commercial merits of ABS, including its great dimensional stability, extremely low warpage, strong creep resistance, light weight, high financial value, and resistance to chemicals. Polypropylene has a surface finish of a very high quality, an intermediate zone of volume compressibility, severe temperature rigidity, and impact resistance. It also has these characteristics. Instead of focusing on ABS, nylon, and other resins, Japanese and European automobile manufacturers have shown a strong adherence to the widespread use of polystyrene than US OEMs have. These manufacturers have applied specialised grades of polypropylene to parts such as bumpers, junction boxes, door panels, and other components[24], [25].

#### 4. Steps of the Interval Valued Neutrosophic TOPSIS Method

Let there be  $n$  different options, and the assessment of each option will be carried out taking into account  $m$  different criteria.

##### Definition 1

Let there be a universe of discourse designated by the letter  $A$ , and a generic component of  $A$  will be indicated by the letter  $a$ . Then, a Neutrosophic variable  $a$  is represented as  $a = (T, I, F)$ , where "T" is the degree of truthfulness, "I" is the degree of indeterminacy, and "F" is the degree of untruth; meeting the requirement that  $0 \leq \sup(T(a)) + \sup(I(a)) + \sup(F(a)) \leq 3$ . A Neutrosophic variable  $a$  is characterised by the fact that it The equation for the interval-valued Neutrosophic equivalent, which can be represented as  $a = ([T^L, T^U], [I^L, I^U], [F^L, F^U])$ , is as follows[26]–[29]:

Using the above description as a guide, we may use the following formula to determine the three membership degrees that correspond to each option and its associated aspect  $C_j$ , where  $i=1,2,\dots,n$  and  $j=1,2,\dots,m$  respectively.

$$T_{ij} = \frac{p_{ij}^{pos}}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (1)$$

$$I_{ij} = \frac{p_{ij}^{neu}}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (2)$$

$$F_{ij} = \frac{p_{ij}^{neg}}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (3)$$

As a result of the fact that the number of accessible ratings cannot be the same for each option, the quantity of those ratings varies, which creates difficulty among some of the higher precision of the 3 membership degrees specified above. As a result, in order to get rid of this impact, we are going to use a concept called statistical inference that involves interval estimation. In the confidence interval, we will refer to the interval-valued neutrosophic number as

$$T_{ij}^L = T_{ij} - z_{\alpha/2} \times \sum \frac{T_{ij}(1-T_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (4)$$

$$T_{ij}^U = T_{ij} + z_{\alpha/2} \times \sum \frac{T_{ij}(1-T_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (5)$$

$$I_{ij}^L = I_{ij} - z_{\alpha/2} \times \sum \frac{I_{ij}(1-I_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (6)$$

$$I_{ij}^U = I_{ij} + z_{\alpha/2} \times \sum \frac{I_{ij}(1-I_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (7)$$

$$F_{ij}^L = I_{ij} - z_{\alpha/2} \times \sum \frac{F_{ij}(1-F_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (8)$$

$$F_{ij}^U = I_{ij} + z_{\alpha/2} \times \sum \frac{F_{ij}(1-F_{ij})}{p_{ij}^{pos} + p_{ij}^{neu} + p_{ij}^{neg}} \quad (9)$$

##### The steps of the TOPSIS method

Developed by Yoon and Hwang, the outranking method known as the Technique for Order Preferences by Similarity to Ideal Solution (TOPSIS) ranks preferences in descending order. It is predicated on the premise that the optimal option should have the smallest distance possible between itself and the positive ideal solution, and the greatest distance possible between itself and the negative ideal solution. The positive ideal solution is the optimal answer because it satisfies all of the criteria

with the highest possible value, while the negative ideal solution satisfies all of the criteria with the lowest possible value. It is a well-known strategy to outranking that is used for choice in a variety of areas, including the selection of suppliers and websites, amongst other applications. The following is a list of the steps: figure 1 shows the steps of the TOPSIS method.

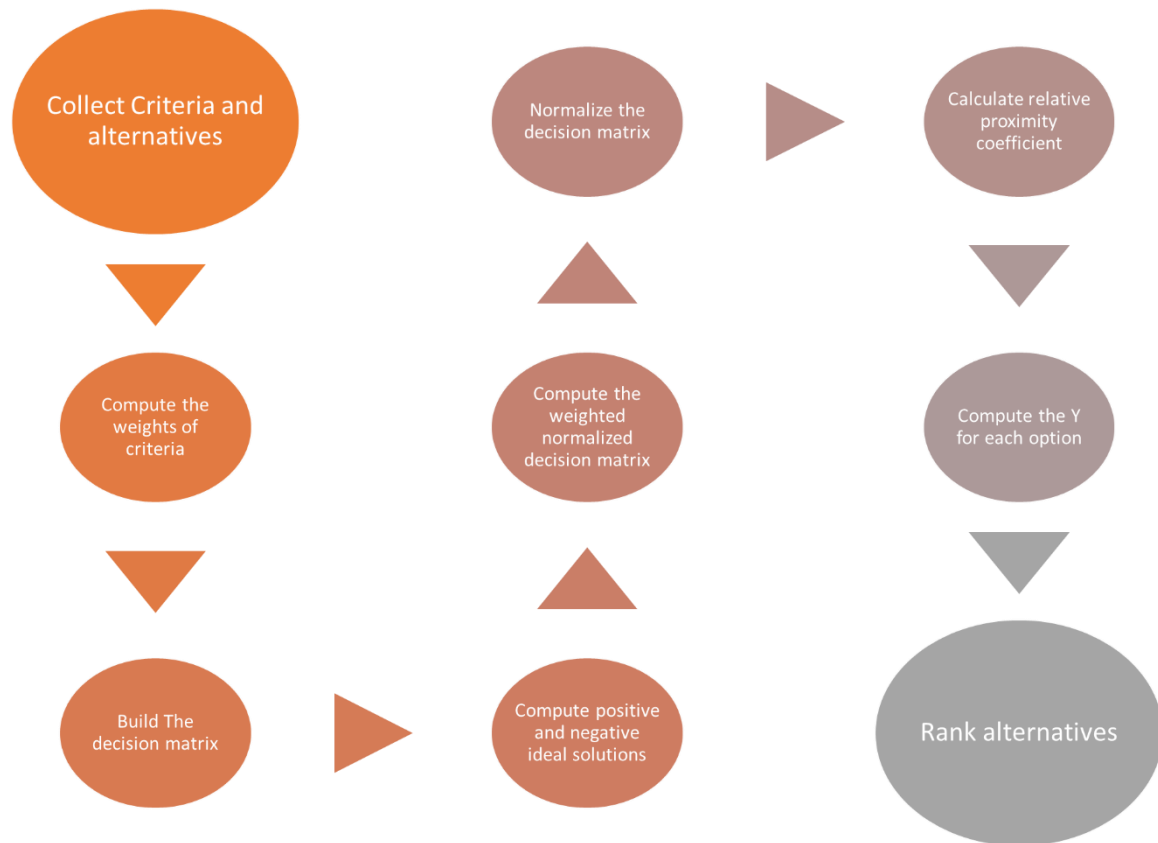


Figure 1: The steps of the TOPSIS method

First, do the calculation to create the weighted matrix.

A weighted interval-valued Neutrosophic decision problem is created by combining the weights produced via maximising deviation approach and the interval-valued Neutrosophic decision matrix that is generated.

Figure out which aspects of the perfect solution are good and which are bad.

The definitions of the positive and negative ideal solutions, respectively, for an IVN are as follows:

$$r^+ = ([\max T_{ij}^L, \max T_{ij}^U], [\min I_{ij}^L, \min I_{ij}^U], [\min F_{ij}^L, \min F_{ij}^U]) \tag{10}$$

$$r^- = ([\min T_{ij}^L, \min T_{ij}^U], [\max I_{ij}^L, \max I_{ij}^U], [\max F_{ij}^L, \max F_{ij}^U]) \tag{11}$$

Determine how far each option is from the positive and negative ideal solutions by doing the appropriate calculations.

One way to measure the distance between the various possibilities is as follows:

$$T_i^+ = \sum_{j=1}^n t(r_{ij}, r_j^+) \tag{12}$$

$$T_i^- = \sum_{j=1}^n t(r_{ij}, r_j^-) \tag{13}$$

Calculate relative proximity coefficient.

One way to define the Y for each option is as follows:

$$Y = \frac{t^+}{t^+ - t^-} \tag{14}$$

Rank the option according to the highest value of Y

### 5. Case Study

The case study was carried out at an enterprise that manufactures automotive components, and it was carried out for an automobile component called an instrument panel. The organisation is now in the process of adopting principles related to sustainability, and as a part of this process, the organisation has to choose a suitable material for the elements that are created. The instrument panel is where the primary focus is placed at first, followed by all of the other elements. The components regarding the weights of the requirements and the substance have been gathered from the policymakers in the form of neutrosophic sets. This is because neutrosophic sets was presented to assert the linguistic variables in the decision making (DM) procedure in order to identify the uncertainty and ambivalence of human judgement. The Multi-Criteria Decision Making (MCDM) approach may be used to find a solution to the issue since it incorporates several criteria. Neutrosophic TOPSIS was chosen as the most effective MCDM approach for the choice of materials by the policymakers who are in charge of the execution of environmentally friendly procedures in the case company.

There is a subset of neutrosophic numbers that are referred to as interval valued neutrosophic numbers. Finding a list of the linguistic variables, together with the neutrosophic set values that correspond to them, for each criteria and piece of material related to this research. There were three people involved in making the choice, and they analysed the criteria as well as the material options. All of the individuals in charge of making decisions were responsible for converting the linguistic characteristics pertaining to the four different potential sources of the alternative content into interval valued neutrosophic values. Figure 2 shows the weights of factors.

Table 1: Decision-makers' relative emphasis on certain factors

	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>
S <sub>1</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.4,0.5],[0.3,0.4],[0.4,0.5]⟩	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩
S <sub>2</sub>	⟨[0.6,0.7],[0.1,0.2],[0.2,0.3]⟩	⟨[0.6,0.7],[0.1,0.2],[0.2,0.3]⟩	⟨[0.4,0.5],[0.3,0.4],[0.4,0.5]⟩
S <sub>3</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.4,0.5],[0.3,0.4],[0.4,0.5]⟩	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩
S <sub>4</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.5,0.6],[0.2,0.3],[0.3,0.4]⟩
S <sub>5</sub>	⟨[0.6,0.7],[0.1,0.2],[0.2,0.3]⟩	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.5,0.6],[0.2,0.3],[0.3,0.4]⟩
S <sub>6</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.7,0.8],[0.0,0.1],[0.1,0.2]⟩	⟨[0.6,0.7],[0.1,0.2],[0.2,0.3]⟩
S <sub>7</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.6,0.7],[0.1,0.2],[0.2,0.3]⟩	⟨[0.5,0.6],[0.2,0.3],[0.3,0.4]⟩
S <sub>8</sub>	⟨[0.3,0.4],[0.5,0.6],[0.5,0.6]⟩	⟨[0.5,0.6],[0.2,0.3],[0.3,0.4]⟩	⟨[0.5,0.6],[0.2,0.3],[0.3,0.4]⟩

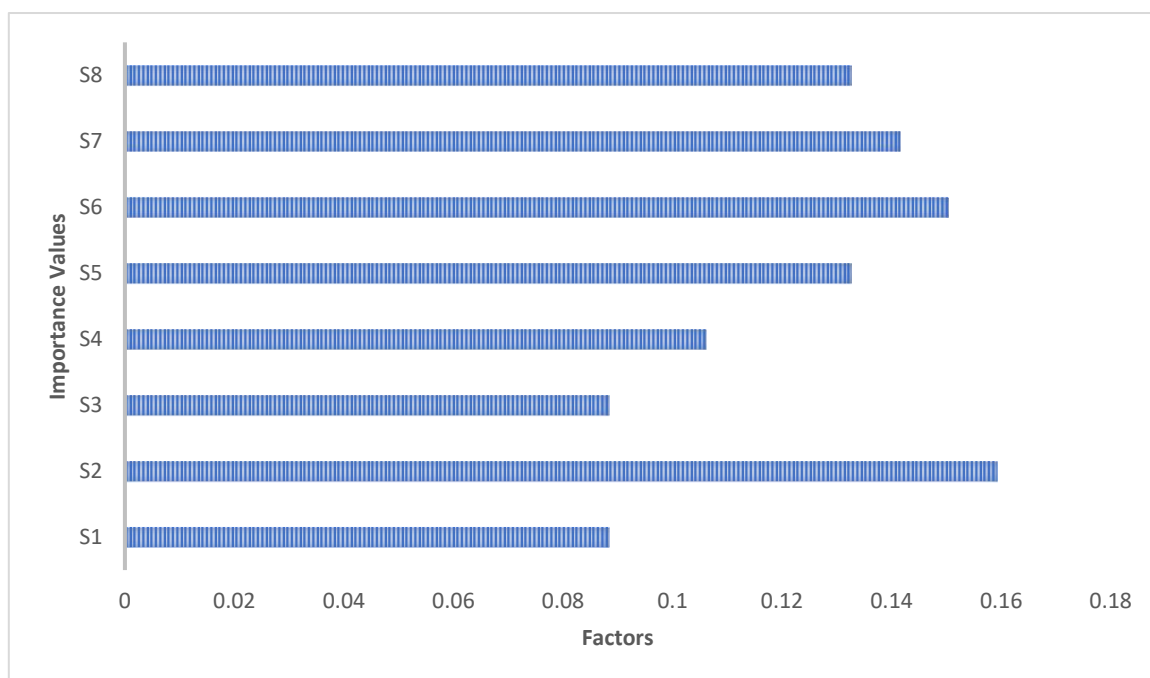


Figure 2: The Importance values of each factors.

Three decision makers evaluate the criteria and alternatives, then convert their opinions to interval valued neutrosophic numbers as shown in table 2. Then normalize the decision matrix. Then compute the weighted normalized matrix by multiplying the weights of criteria by the normalization value as shown in table 3. Then compute the positive and ideal solution and the Y value as shown in table 4. Figure 3 shows the ordering of the options.

Table 2: Relative importance of three decision makers to criteria and alternatives.

		S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>
D <sub>1</sub>	A <sub>1</sub>	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$
	A <sub>2</sub>	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$
	A <sub>3</sub>	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$
	A <sub>4</sub>	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$
D <sub>2</sub>	A <sub>1</sub>	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$
	A <sub>2</sub>	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$
	A <sub>3</sub>	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$
	A <sub>4</sub>	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$
D <sub>3</sub>	A <sub>1</sub>	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$

A <sub>2</sub>	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$
A <sub>3</sub>	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.3,0.4], [0.5,0.6], [0.5,0.6] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$
A <sub>4</sub>	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.5,0.6], [0.2,0.3], [0.3,0.4] \rangle$	$\langle [0.7,0.8], [0.0,0.1], [0.1,0.2] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$	$\langle [0.6,0.7], [0.1,0.2], [0.2,0.3] \rangle$	$\langle [0.4,0.5], [0.3,0.4], [0.4,0.5] \rangle$

Table 3: The weighted normalized decision matrix

	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>
A <sub>1</sub>	0.079139	0.044779	0.052306	0.067163	0.07441	0.111479	0.067173	0.046641
A <sub>2</sub>	0.017372	0.099509	0.039229	0.033582	0.063248	0.041805	0.067173	0.046641
A <sub>3</sub>	0.023163	0.099509	0.036614	0.033582	0.037205	0.06503	0.074244	0.097947
A <sub>4</sub>	0.027023	0.059705	0.047075	0.067163	0.08185	0.06503	0.074244	0.060634

Table 4: The weighted normalized decision matrix

	T <sub>i</sub> <sup>+</sup>	T <sub>i</sub> <sup>-</sup>	Y
A <sub>1</sub>	0.102896	0.081076	0.440698
A <sub>2</sub>	0.090234	0.092385	0.50589
A <sub>3</sub>	0.083904	0.088706	0.513908
A <sub>4</sub>	0.079116	0.077134	0.493658

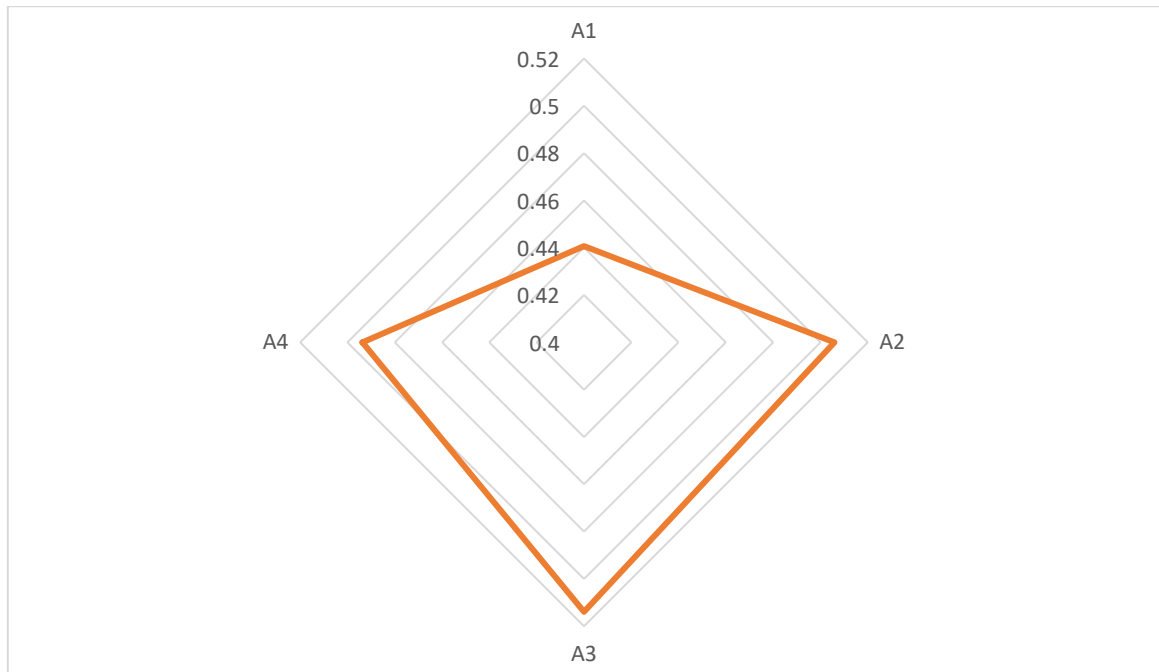


Figure 3: The order of the options.

6. Conclusion

In this article, we use the TOPSIS approach to choose the best materials for an automobile part based on a number of parameters. In the automotive industry, plastics are valued for their ability to reduce vehicle weight while still allowing for the installation of modern safety features, their resistance to corrosion (which translates to a longer vehicle lifespan) and their role as a protective coating (through paint) on other materials. Since more items with environmental consciousness are appearing on the market, the environmental effects the product will have should be given more weight.

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