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Selection of Reconfigurable Assembly System Strategy using Fuzzy-TOPSIS

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Abstract: **-- In present time, the market fluctuates in terms of demand and variety of the products produced from a manufacturing industry and that have been increased a lot due to the emerging competition in the global market. Therefore, the prime need for the manufacturing industry is developing the capability of producing a large variety of products along with maintaining the fluctuating demand as per the requirement of customers. Hence, a new paradigm of assembling system should be implemented in the existing systems of industries to withstand the issues related to varieties and demands. This paradigm is Reconfigurable Assembly Systems (RAS), which can reconfigure assembling systems quickly to change the quantities of products to be assembled along with the variety of products that are to be assembled within a product family. This paper is based on a case study on an industrial assembling system, where a complex multicriteria decision-making problem was structured in order to find an ideal alternative solution based on RAS strategy. Several criteria and feasible alternatives related to RAS strategies were selected with the help of the decision makers from various departments of that Industry. The linguistic ratings of each criterion for the alternatives were collected from the decision makers based on a long-term planning horizon of the industry in the case study. This conflicting multi-criteria decision making (MCDM) problem was solved using TOPSIS method in a fuzzy environment to select the best alternative for the existing assembling system.**

Keywords: Assembly, Fuzzy-TOPSIS, Multi Criteria Decision Making, RAS, Strategy

INTRODUCTION

The manufacturing industries consists of an assembly line in which the parts (interchangeable parts) are assembled as per the given sequence by mechanically moving it from one assembling station to next, until the final assembled product is produced. Basically, it consists of a finite set of tasks, in which specific assembling time and sequential relations with each assembling station, which specifies the acceptable task orders [1]. The traditional assembly systems have hardly succeeded in meeting the requirements in the present market in terms of quality, mass customization and cost, and also it has the ability to assemble two to three models in the same assembly line, however it requires lots of improvement related to functionality, variability, scalability along with various types of models and customizing each variety with addition and removal of required alternative components [2]. The Assembly systems which produces modular products usually takes the advantage of part modularity that results in assembling of more variety with more product flexibility. But issues arise such as product delay, bottleneck and low responsiveness to customer demand and market fluctuations [3]. Nevertheless, other issues include such as, over or under producing of products if there is a sudden change in demand. If there is modification of the existing assembly line for a new product or model, it may get delayed due to time-consuming and expensive retooling which also includes reconfiguring by redefining and hard coding of each station in the assembly line. As a result, lengthy change over effort and time are formed.

Reconfigurable assembly systems (RAS) are those type of assembly systems which can rapidly change its capacity (quantities that are to be assembled) and functionality (product type, within a product family) in order to cope up with the fluctuating market demand 4. In other words, it is defined as an integrated, computer-controlled system consisting of assembly robots, modular components, and tools that can be used for assembling variety of products and quantities of products that are to be assembled. It possesses the characteristics of customization, convertibility, diagnosability, responsiveness, functionality, and scalability where customization is re-designing of a system for an entire product family, convertibility is the ability to switch from the assembling of one variety of product to the assembling of a different variety of product within a product family, diagnosability is the identification of quality issues quickly that occurs during assembling process at each workstation, responsiveness is the ability of the assembly system to respond the present fluctuating market demand and variety quickly as well as implementing it to these systems, functionality is the

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variety of assembling tasks as well as reconfiguration in hardware and software for different varieties of products to be assembled in a single assembly station, and scalability is the ability to change system throughput in a relatively short time to match the fluctuating demand in the market [4].

II. LITERATURE REVIEW

The assembly systems are generally classified into manual assembly systems, flexible assembly systems, and dedicated assembly system [5]. Manual assembly systems consist of human assemblers who assembles the semi-finished parts with the help of simple tools and fixtures, flexible assembly systems consist of automated machines, robots, as well as human assemblers and dedicated assembly systems consists of fully automated assembly systems for mass productions. The manual assembly systems are the most reconfigurable assembly systems as it includes human workforce which can adapt to the rapid changes quickly whenever there is a requirement in scalability and convertibility. But the issue is that if the product variety increases then the reconfigured assembly becomes complex that results in the human error and also affects the system performance. Thus, a limited number of products are assembled here.

RAS allows the quick rearrangement in the assembling systems to alter the process flow according to the required product. Another feature is system configuration, which improves convertibility and scalability, for designing this type of configuration for assembly systems have issues with the layout of systems and assignments of the tasks to the assembling systems. System configurations are also varying with addition or removal of the modules, and the changes of the arrangements of the components for assemblies. In addition, when the market or production task varies, the assembly line will often reconstruct accordingly. Thus, it forms different system configuration. [6] Moreover, if the number of parts increases for assembling a product, the size of the systems increases makes it difficult for productivity analysis.

A design strategy for reconfigurable manufacturing system (RMS) was proposed in which various criteria and alternatives were identified for design strategy towards RMS. [7]This was carried out as a case study in a manufacturing environment. This resulted in the formation of a multi-criteria decision-making problems in which the experts related to different departments of an industry reviewed their opinions and rated the criteria accordingly. This was solved using Analytical Hierarchical Process tool, which also highlighted the manufacturing responsiveness that was taken as a new economic objective as well as considering the traditional objectives like high quality and low cost. The results were also analysed by using sensitivity analysis along with changing the priorities of criteria which helps to determine the best solutions among the alternatives.

III. A STRATEGY FOR RAS THROUGH THE USE OF FUZZY TOPSIS

Case Study:

Till the present date very few papers related to RAS strategy have been published. Thus, there is a requirement of Industrial Case Study in order to study the present assembly line, identifying its issues, and their current techniques implementation to the identified issues. For this case study an engine manufacturing industry was selected in which it has an assembly line which produces varieties of engines. This industry was selected for further survey along with the help of experts belonging to various departments.

Engine Type	Control Systems	Displacement (In Litres)	Model Name	Fuel Systems	Horse Power
Mechanical	Mechanically Control of Fuel System	5.9	BS-1	(BFS) Bosch Fuel System	130
			BS-2		150
			BS-3		180
Electronic (ISBE)	Electronically Fuel Control	5.9	BS-3		150
			BS-4		180
		6.7	BS-3		150
			BS-4		180
			DAYTONA*		230 300

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Special Upgraded (ISBE*)	Electronically Fuel Control	5.9	BS-4 (UMBRELLA)		(CFS) Cummins Fuel System and Piston	180	230
			Brake	Non brake			

Table 1. Representation of Varieties of Engines Produced in the Industry

The survey was done to find out the varieties of models, types and quantities of engines that are being assembled in the existing assembly systems. It was found that 15 different varieties of engines are assembled which consists of basic components and variant components for producing different varieties of engines. There are two major varieties of engines which are divided as per the types of fuel control systems used in those engines. These are assembled as per the requirement of the customer. First one is Mechanically Controlled Fuel Systems and the second one is Electronically Controlled Fuel Systems. The different varieties of engines that are assembled are specifically classified as per the engine type, its type of fuel controlling system, its respective displacements, fueling systems and horse power, and are briefly represented in the Table 1.

IV. OBSERVATION AND IDENTIFICATION OF ISSUES

An exhaustive study was undergone to find out the cycle time, assembly time, number of assembly stations, assembly sequence in their existing assembly system. The average cycle time for producing each type engine is 159 minutes and assembling time for each type of engine is 142 minutes. There are total of 93 assembling station including leak test and quality inspection. If the inspection test fails, then the semi-assembled engine is again send back to the re-work shop, this process is highly time and cost consuming. Total number of engines produced per shift is 200 with 85% running efficiencies which include parts movement time, downtime, bottleneck and breakdown time. The assembly systems consist of both manual as well as automated assembling systems. The semi-assembled part is moved from one assembly station to other automatically with the help of J-hook conveyer that moves with an average time of 20 seconds. The loading and unloading of parts for different variety of engines are done manually. The software and the sensors present in the assembling systems generates the signals through the codes which sends the information to all the assembling systems to identify the semi-assembled parts and the respective parts which are to be assembled further. Very few changes in hardware components in the assembly line are implemented manually to achieve trivial amount of changeover and scalability because the industrial capital cost also have to deal with their present infrastructure, layout, employees, equipment and fixtures.

Some of the major issues identified in the existing assembly line of the industry are as follows: scalability, the assembling systems are less flexible to confront the varying demands in the single assembly line, separate stations present on the assembly line for inspecting and quality testing after several assembling station (that is about after 26 stations), which causes bottleneck and increases waiting time at the preceding assembling station and less utilization in the succeeding assembling station, moreover for any defects identified it is sent back for disassembling and rework which is highly time and cost consuming.

V. IDENTIFICATION OF STRATEGIES RELATED TO RAS

Step 1: Selection of Experts:

The decision makers were selected from different departments of the industry to identify the issues in the existing assembly line and share their view as per their knowledge and experience in their respective fields of works. These experts play a major role in the selection of various the importance of various criteria and alternatives which can be implemented in the existing assembling systems.

Experts 1: Assistant General Manager, Department of Manufacturing Engineering, Experts 2: Application Manager, Department of Industrial and Information, Experts 3: Shop Floor Manager, Department of After Testing Products (ATP) and Experts 4: Assistant General Manager, Department of Quality Control (QC)

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Step 2: Selection of Criteria

The strategic criteria related to RAS were identified as Scalability, Responsiveness, Functionality,Diagnosability, Changeover Effort and Time, and Resource Utilization. The following criteria were selected with the help of experts by identifying the importance of each criterion which are essential in their existing assembly line.

(i) Scalability: It is the ability of rapidly changing the quantities that are to be assembled efficiently.
(ii) Responsiveness: It is the capability of the hardware and software in the assembling system which can rapidly respond and reconfigure to the rapid changes in variety and demand.
(iii) Functionality: It is to the assembling of the different types of Product within a product family
(iv) Diagnosability: It is a quick identification and inspection process of assembled products and semi-assembled products at each assembling station.
(v) Changeover Effort and Time: It is the quick changeover of assembling of one products to another type of products in short time in an efficient way.
(vi) Resource Utilization: It is the extent to which an assembly system is functioning properly and efficiently.

Step 3: Selection of Alternatives

The alternatives proposed is based on the RAS strategy in which it is prioritized based on the type of planning horizon as per the expert's opinion for the existing assembling system. Thus, Long-Term planning horizon was selected that is for over 5 Years. It also includes some of the factors such as its present technology and its capability to adapt the newer technology, its capital, its existing assembling systems and equipment, a demand for products, volume of products that are assembled, training of employees and infrastructure. For a long-term planning horizon, the market fluctuations increase by an introduction of competitor's product in the market and increase in high variety of demand for various customers. These factors may vary from one industry to another. Therefore, going through all the requirements of the long-term planning horizon with the help of experts, the following alternatives strategies were generated accordingly:

(vii) Existing Assembly Systems: Existing system is a type of semi-flexible assembly systems which produces 15 varieties of engines. But it is not flexible enough to adapt sudden change in demand and changeover to different varieties of products. It requires no investment for hard ware components but only for maintenance and retooling during system breakdown.
(viii) Reconfigurable Assembly Systems: In this, each assembly station will consist of several reconfigurable hardware and software in order to cope up with a sudden change of variety and scalability. It also consists of diagnosable tools for inspecting rapidly before sending it to the next assembling station.
(ix) Partial Reconfigurable Assembly Systems: It is similar to RAS but are those types of assembling system which can be implemented at the existing assembly systems at those stations where there is a cause of bottleneck issues, lengthy changeover time, delay in a sudden change of the different variety of the product to be assembled.
(x) Fully Automated Assembly Systems: It is also called as Dedicated Assembly Systems in which a single variety of engines can be assembled in large quantities that is for mass productions of that variety.

With the help of different experts belonging to different departments of the industry, the selected criteria were rated in the form of linguistic value (Very Low, Low, Medium, High, and Very High) which will provide the weights to each criterion and also for each alternative these criteria were rated.

As the complexity and uncertainty in the ratings of a different point of view by the experts, a Fuzzy TOPSIS is implemented to this MCDM problem order to evaluate these criteria and alternatives for selecting the most suitable strategy.

Step 4: Application of Fuzzy TOPSIS for selection of strategy

This RAS strategy contains many conflicting criteria and alternatives, each having equal importance, hence it contains a lot of uncertainty in evaluating the alternatives

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and the conflicting criteria. In this methodology, the linguistic variable for both criteria and alternatives were represented in Trapezoidal Fuzzy Numbers. Four Decision Makers used the linguistic ratings to rate the criteria to find out the weightage of each criteria by using the linguistic weighting variables as shown in Fig.1. The ratings that were determined by the decision makers are shown in Table 2. The same linguistic variables from the Fig. 1 was used to evaluate the ratings of each alternatives as per the respective criteria by the four decision makers as shown in Table 3.

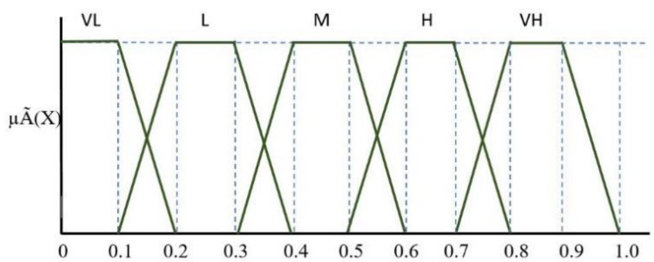

Fig1. The Linguistic variables for importance of weight of each criterion as well as alternatives

Table 2. Trapezoidal Fuzzy Numbers for Linguistic variables for both criteria and alternatives

RATING	FUZZY NUMBER
VERY LOW	(0.0,0.0,0.1,0.2)
LOW	(0.1,0.2,0.3,0.4)
MEDIUM	(0.3,0.4,0.5,0.6)
HIGH	(0.5,0.6,0.7,0.8)
VERY HIGH	(0.7,0.8,0.9,1.0)

Table 3. Ratings by The Decision Makers

CRITERIA	DECISION MAKER 1 (P1)	DECISION MAKER 2 (P2)	DECISION MAKER 3 (P3)	DECISION MAKER 4 (P4)
C1 SCALABILITY	H	H	VH	H
C2 RESPONSIVENESS	H	H	VH	H
C3 FUNCTIONALITY	M	M	L	M
C4 DIAGNOSABILITY	M	H	H	VH
C5 CHANGEOVER EFFORT AND TIME	H	H	VH	M
C6 RESOURCE UTILIZATION	M	M	H	H

The Table 4 represents the ratings of each criterion of each alternative, Table 3 is merged in this table as shown in Table 4. The linguistic evaluated that are shown in Table 4 are now converted into their respective Trapezoidal Fuzzy Numbers which is shown in table 5. For Criteria C5, VL= (0.7,0.8,0.9,1.0), L= (0.5,0.6,0.7,0.8), M= (0.3,0.4,0.5,0.6), H= (0.1,0.2,0.3,0.4), VH= (0.0,0.0,0.1,0.2).

Table 4. The Ratings of Each Criterion for Each Alternative

		CRITERIA					
		C1	C2	C3	C4	C5	C6
P1	A1	L	M	M	M	H	M
	A2	H	VH	H	H	L	H
	A3	M	H	H	H	L	M
	A4	M	M	L	H	H	H
P2	A1	L	M	M	M	M	M
	A2	H	H	H	VH	L	M
	A3	M	H	H	H	L	M
	A4	M	M	M	H	VH	H
P3	A1	VL	M	M	M	M	M
	A2	VH	VH	VH	H	VL	M
	A3	H	H	H	H	M	M
	A4	M	H	L	H	H	H
P4	A1	L	M	M	L	M	M
	A2	H	H	H	H	L	H
	A3	H	H	H	M	M	H
	A4	M	M	L	H	H	H

Then the aggregated fuzzy ratings for criteria and weights of the alternatives are calculated according to the

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expression (1) and (2) as shown in the table 6 which shows the Fuzzy- Decision Matrix along with Fuzzy weights of each criteria.

The Aggregated Fuzzy ratings (X_{ijk}) with respect to each criterion C_j can be calculated as {X_{ijk}= (X_{ijk1}, X_{ijk2}, X_{ijk3}, X_{ijk4}) such that i=1,2,…,m, j= 1,2, . . . ,n and k=1,2,…,K} and

$$X_{ijk1} = \min_k\{ X_{ijk1}\}$$

$$X_{ijk2} = \sum_{k=1}^{K} X_{ijk2}$$

$$X_{ijk3} = \sum_{k=1}^{K} X_{ijk3}$$

$$X_{ijk4} = \max_k\{X_{ijk4}\} \qquad (1)$$

Similarly Aggregated Fuzzy weights (W_{jk}) with respect to each criterion can be calculated as {(W_{jk1}, W_{jk2}, W_{jk3}, W_{jk4}) such that j=1,2,…,n and k=1,2,…,K } and

$$W_{jk1} = \min_k\{ W_{jk1}\}$$

$$W_{jk2} = \sum_{k=1}^{K} W_{jk2}$$

$$W_{jk3} = \sum_{k=1}^{K} W_{jk3}$$

$$W_{jk4} = \max_k\{ X_{ijk4}\} \qquad [8]$$

(2)

Table 7

		CRITERIA					
		C1	C2	C3	C4	C5	C6
WEIGHT		0.7305	0.7305	0.3694	0.6500	0.6500	0.5500
ALTERNATIVES	A1	0.2000	0.4500	0.4500	0.3694	0.3694	0.4500
	A2	0.7305	0.7500	0.7305	0.7305	0.7305	0.5500
	A3	0.5500	0.6500	0.6500	0.5694	0.5694	0.5305
	A4	0.4500	0.5305	0.3305	0.6500	0.2000	0.6500

Construct a decision matrix Table 6, The fuzzy rating for i^{th} alternative regarding j^{th} criterion of k^{th} decision maker be shown as X_{ijk}= (X_{ijk1}, X_{ijk2}, X_{ijk3}, X_{ijk4}) and and the importance of the weights of the j^{th} criterion that given by the k^{th} decision maker as W_{jk}= (W_{jk1}, W_{jk2}, W_{jk3}, W_{jk4}). Now determine the crisp values as shown in Table 7 by De-fuzzifying the values from Table 6 with the help of the following expression by the method of Centre of Area [8] :

$$Defuzz(X_{ij}) = \frac{\int \mu(x).xdx}{\int \mu(x)dx}$$

$$= \frac{\int_{X_{ij1}}^{X_{ij2}} \left(\frac{X - X_{ij1}}{X_{ij2} - X_{ij1}}\right) \cdot xdx + \int_{X_{ij2}}^{X_{ij3}} xdx + \int_{X_{ij3}}^{X_{ij4}} \left(\frac{X_{ij4} - X}{X_{ij4} - X_{ij3}}\right) \cdot xdx}{\int_{X_{ij1}}^{X_{ij2}} \left(\frac{X - X_{ij1}}{X_{ij2} - X_{ij1}}\right) \cdot xdx + \int_{X_{ij2}}^{X_{ij3}} dx + \int_{X_{ij3}}^{X_{ij4}} \left(\frac{X_{ij4} - X}{X_{ij4} - X_{ij3}}\right) \cdot xdx}$$

$$= \frac{-X_{ij1} \cdot X_{ij2} + X_{ij3} \cdot X_{ij4} + \frac{1}{3}(X_{ij4} - X_{ij3})^2 - \frac{1}{3}(X_{ij2} - X_{ij1})^2}{-X_{ij1} - X_{ij2} + X_{ij3} + X_{ij4}}$$

(3)

Next is calculate the Normalized Decision Matrix as shown in Table 8 using the following expression [9] :

$$r_{ij} = \frac{x_{ij}}{\sum_1^j \sqrt{x_{ij}^2}} \text{ for each Criterion } C_i \qquad (4)$$

Then Weight of each criterion is multiplied to their corresponding normalized ratings to get the weighted normalized decision matrix as shown in Table 9. In this the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) is determined as shown in table 10. Then the separation between the alternatives and the ideal solutions were found

using the following relations shown in Table 11:

$$D^+ = \sqrt{\sum_{j=1}^{m} (x_{ij} - PIS)^2} \text{ and}$$

$$D^- = \sqrt{\sum_{j=1}^{m} (x_{ij} - NIS)^2} \qquad (5)$$

And relative closeness to ideal solution is calculated using following relation as shown in Table 11.

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$$C^{*} = \left(\frac{D^{-}}{D^{+} + D^{-}} \right) \quad (6)$$

Then Rank the alternatives as per the highest value of the closeness is selected as the best alternatives and others follow the ranking as per their values which is shown in Table 11. Hence from the Table 11 it is observed that, the alternative A2 that is RAS is the best alternative followed by Partial RAS, Fully Automated Assembly Systems, Then Existing Assembly Systems.

Table 8. Normalized Decision Matrix

		CRITERIA					
		C1	C2	C3	C4	C5	C6
WEIGHT		0.7305	0.7305	0.3694	0.6500	0.6500	0.5500
ALTERNATIVES	A1	0.1925	0.3713	0.3996	0.3103	0.3632	0.4092
	A2	0.7033	0.6188	0.6488	0.6137	0.7183	0.5002
	A3	0.5295	0.5363	0.5773	0.4783	0.5598	0.4825
	A4	0.4333	0.4377	0.2935	0.5460	0.1966	0.5911

Table 9. Weight Decision Matrix of Each Column

	C1	C2	C3	C4	C5	C6
A1	0.1406	0.2712	0.1476	0.2017	0.2017	0.2250
A2	**0.5137**	**0.4520**	**0.2396**	**0.3989**	**0.3989**	0.2751
A3	0.3867	0.3917	0.2132	0.3109	0.3109	0.2653
A4	0.3165	0.3197	0.1084	0.3549	0.3549	**0.3251**

Table 10. Representation of the types Ideal Solution

	CRITERIA					
	C1	C2	C3	C4	C5	C6
PIS	**0.5137**	**0.4520**	**0.2396**	**0.3989**	**0.4669**	**0.3251**
NIS	0.1406	0.2712	0.1084	0.2017	0.1278	0.2250

Table 11. Separations and Relative Closeness for Each Alternative

	ALTERNATIVE			
	A1	A2	A3	A4
D^{+}	0.5034	0.05	0.22	0.4362
D^{-}	0.1150	0.5938	0.3937	0.2584
C^{*}	0.1859	0.9223	0.6415	0.6279
RANKING	4	1	2	3

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Table 5. Representation of Fuzzy Numbers of Each Criterion with Respect to Each Alternatives

		CRITERIA					
		C1 P1 P2 P3 P4	C2 P1 P2 P3 P4	C3 P1 P2 P3 P4	C4 P1 P2 P3 P4	C5 P1 P2 P3 P4	C6 P1 P2 P3 P4
WEIGHT		(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.1,0.2,0.3,0.4) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)
ALTERNATIVES	A1	(0.1,0.2,0.3,0.4) (0.1,0.2,0.3,0.4) (0.0,0.0,0.1,0.2) (0.1,0.2,0.3,0.4)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.1,0.2,0.3,0.4)	(0.1,0.2,0.3,0.4) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6)
	A2	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.7,0.8,0.9,1.0) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8)
	A3	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.3,0.4,0.5,0.6)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8)
	A4	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6)	(0.3,0.4,0.5,0.6) (0.3,0.4,0.5,0.6) (0.5,0.6,0.7,0.8) (0.3,0.4,0.5,0.6)	(0.1,0.2,0.3,0.4) (0.3,0.4,0.5,0.6) (0.1,0.2,0.3,0.4) (0.1,0.2,0.3,0.4)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)	(0.1,0.2,0.3,0.4) (0.0,0.0,0.1,0.2) (0.1,0.2,0.3,0.4) (0.1,0.2,0.3,0.4)	(0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8) (0.5,0.6,0.7,0.8)

Table 6. Aggregated Fuzzy Ratings

		CRITERIA					
		C1	C2	C3	C4	C5	C6
WEIGHT		(0.50,0.65,0.75,1.0)	(0.50,0.65,0.75,1.0)	(0.10,0.35,0.45,0.60)	(0.30,0.60,0.70,1.0)	(0.30,0.60,0.70,1.0)	(0.30,0.50,0.60,0.80)
ALTERNATIVES	A1	(0.00,0.15,0.25,0.40)	(0.30,0.40,0.50,0.60)	(0.30,0.40,0.50,0.60)	(0.10,0.35,0.45,0.60)	(0.10,0.35,0.45,0.60)	(0.30,0.40,0.50,0.60)
	A2	(0.50,0.65,0.75,1.0)	(0.50,0.70,0.80,1.0)	(0.50,0.65,0.75,1.0)	(0.50,0.65,0.75,1.0)	(0.50,0.65,0.75,1.0)	(0.30,0.50,0.60,0.80)
	A3	(0.30,0.50,0.60,0.80)	(050,0.60,0.70,0.80)	(050,0.60,0.70,0.80)	(0.30,0.55,0.65,0.80)	(0.30,0.55,0.65,0.80)	(0.30,0.45,0.55,0.80)

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	A 4	(0.30,0.40,0.50,0.60)	(0.30,0.45,0.55,0.80)	(0.10,0.25,0.35,0.60)	(0.50,0.60,0.70,0.80)	(0.00,0.15,0.25,0.40)	(050,0.60,0.70,0.80)

CONCLUSION

Therefore, through an Industrial Assembly line case study, a complex multicriteria decision-making problem was developed based on RAS strategy for a long-term planning horizon with the help of experts and was solved using Fuzzy TOPSIS methodology to find out the best alternative solution. Thus, the alternative A2 that is RAS, is obtained as the best alternative in upcoming years. The factors of RAS are highly essential in present assembling systems as well as in future in order to sustain in the global market competition.

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