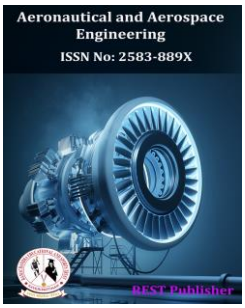
Aeronautical and Aerospace Engineering

Vol: 2(1), March 2024

REST Publisher; ISSN: 2583-889X (Online)

Website: http://restpublisher.com/journals/aae/

DOI: https://doi.org/10.46632/aae/2/1/5



Performance and Safety Analysis of Standardized Refrigeration Topologies Using WSM Method

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Abstract. *After the discontinuation of ozone-depleting substances, various pieces of equipment such as air conditioners, water chillers, and medium-temperature commercial and home refrigeration systems used the refrigerant medium-pressure hydrofluorocarbon (HFC) R-134a. However, R-134a has a Global Warming Potential (GWP) of 1300, meaning it has a detrimental influence on the environment. It is now regulated by the Kigali Amendment to the Montreal Protocol (UNEP, 2016). Since the invention of the earliest vapor compression refrigeration system by Jacob Parkin in 1834, numerous chemical compounds have been tested as refrigerants. Ammonia, carbon monoxide, sulfur oxide, and methyl chloride were the main refrigerants used in the 1930s. Benzyl sodium chloride, propane, iso-butane, and freshwater were utilized to a lesser extent. However, the class of chemicals that includes chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) became the predominant types of refrigerants after the development of dichlorofluoromethane compounds in 1930 by Thomas Middleton and Albert Henna. The weighted sum technique is a decision-making process that considers numerous possibilities and factors before choosing the best option. A weighted collection of sums, or weighted mean voting ensemble, is a machine learning strategy that combines predictions from various models, with each model's contribution being weighed according to its capacity or level of expertise. The benefits of using this method include ease of use, especially when dealing with complex problems, and the ability to assign weights in a straightforward manner, even when finding solutions and goals becomes challenging within an all-in solution space. Critical Temperature, Critical Pressure, Saturated Pressure, and Liquid Density are important parameters for refrigerants such as R134a, R152a, R1234yf, R1234ze (E), and R1233zd (E). The results show that R1233zd (E) obtained the highest rank, while R1234yf received the lowest rank. According to the dataset, the Weighted Sum Method (WSM) indicates that R1233zd (E) is the best refrigerant, considering breathing rate and its top ranking.*

Keywords*: Critical Temperature, Critical Pressure, Saturated pressure*

1. INTRODUCTION

A basic refrigeration cycle works by going through four steps: evaporation, compression, condensation, and expansion. However, refrigeration needs often require cooling at different temperature levels, which makes it necessary to use multiple compressors and evaporators in staged refrigeration cycles. One stage might not be sufficient to cover all temperatures between the evaporator unit and the condenser, let alone for a single refrigerated load. This may occur if the desired compression ratio is too high or the condenser's critical pressure is exceeded. That's why it's common to explore alternative designs that use complex multistage refrigeration cycles with multiple refrigerants to cover different temperature ranges. If you have any comments or questions about this article, please contact C.D. Marinas. The intricate design of refrigeration cycles, along with the wide range of refrigerant options available, combined with the significant costs and energy consumption associated with refrigeration, highlights the necessity for the development of systematic procedures to create efficient refrigeration cycles. In 1974, Barnes and King conducted one of the earliest studies on synthesizing minimum cost cascade refrigeration systems. They identified and established many standardized refrigeration topologies, discovered various trade-offs involved in creating multi-stage cycles, and developed a dynamic programming method to identify optimal refrigeration system configurations. The ability to add intricate device cost relationships and thermophysical characteristic models is a benefit of this strategy. There were no assurances for the performance of the solution, but the number of steps and their temperature ranges were chosen using a

heuristic process. Cheng and Mah provided an interactive method for synthesizing refrigeration systems in 1980 that took into account all the characteristics of refrigeration that Barnes and King had highlighted in 1974. Based on their permitted operational temperature ranges and the specific temperature of the procedure streams that required cooling, the refrigerants employed in the cycle were chosen. The best refrigerant to use will rely on a number of things, such as the application's requirements, environmental concerns, energy consumption, and safety. In the past, refrigerants like chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) were commonly used due to their desirable properties such as a low boiling point, non-flammability, and non-toxicity. However, it was later discovered that CFCs and HCFCs have a harmful impact on the ozone layer and contribute to its depletion. As a result, hydrofluorocarbons (HFCs) were developed as a more environmentally friendly alternative. HFCs, on the other hand, have a high GWP and have been progressively phased out in several nations due to concerns about the environment. The Kigali Amendment to the Montreal Protocol aims to limit the use of HFCs and replace them with eco-friendlier alternatives. At present, natural refrigerants like ammonia, carbon dioxide, and hydrocarbons are becoming more popular because of their low environmental impact and energy efficiency. However, these refrigerants also have some limitations such as toxicity, flammability, and higher operating pressures. The best refrigerant to choose will, therefore, rely on the particular needs and factors of the application, so it is essential to speak with a knowledgeable refrigeration professional before making a decision. Refrigerants are chemicals that refrigeration systems employ to transfer heat from one place to another by absorbing and releasing heat. The optimal refrigerant choice depends on various factors, including the application, environmental considerations, energy efficiency, and safety. In the past, CFCs and HCFCs were commonly used as refrigerants due to their favorable properties like non-toxicity, non-flammability, and a low boiling point. Carbon dioxide is another natural refrigerant.

2. MATERIALS & METHODS

Weighted Sum Model (WSM): Under these assumptions, the weighted sum model involves assigning weights to each decision criterion, which represent the relative importance of that criterion in the decision-making process. Typically, the weights are normalized to sum up to 1, facilitating the interpretation of the results. For each alternative, the scores for each criterion are then multiplied by their corresponding weights, and the weighted scores are summed up to obtain a total score for that alternative. The alternative with the highest total score is considered the best choice.

Mathematically, the weighted sum model can be expressed as follows:

$$\text{Score}(A_i) = w_1 x_{i1} + w_2 x_{i2} + \ldots + w_n x_{in}$$

where $\text{Score}(A_i)$ is the total score for alternative i, w_j is the weight assigned to criterion j, and x_{ij} is the score of alternative i on criterion j.

"The weighted sum model is easy to understand and implement, and it is widely used in various fields, including engineering, management, and social sciences. However, it has some limitations, such as assuming benefit criteria only, subjectivity in assigning weights, and the inability to capture complex interactions among criteria. Therefore, more advanced MCDA methods, such as the analytic hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS), have been developed to address these limitations. Determining the weights for each objective is a crucial step in the weighted sum approach. The weights reflect the relative importance of each objective and are typically assigned based on the decision maker's preferences or expert opinions. There are various methods for determining the weights, such as the analytical hierarchy process (AHP) and the swing weighting method. The AHP involves pairwise comparisons between the criteria to determine their relative importance, while the swing weighting method involves iteratively adjusting the weights until a satisfactory solution is reached. It is important to note that the choice of weights can significantly affect the final decision, and sensitivity analysis can be used to assess the robustness of the results to changes in the weights. The correct microphone arrangement was discovered during simulations utilizing a spherical neck transmission function (HRTF). The suggested hearing aid's efficacy reaches 300CX3000Hz with an average 34.6 dB reduction in the bandwidth for the forward sound compared to the forward sound source. This performance is better compared to the prior delay and sum beam. We obtain the weights of the four-dimensional aspect vector by sacrificing eight additional vectors. We require weights because the parsing capabilities of the four attributes vary. The highest possible weight should be given to distinguishing between keywords and non-keywords in this characteristic. We offer a brand-new clustering technique created for a focused optimization challenge. This approach, based on the surplus parameter, regulates the interaction between sampling fit and the number of clusters, and the e cluster count will be changed automatically to better reflect the data. By methodically turning the values into objective functions,

Barret searches for the best solutions one by one using the weighted sum approach. In earlier studies, this strategy frequently results in poorly dispersed liquids that cover the front barre to, and the barre to does not discover the best solutions in the places where it is concentrated. Weight reduction is a broad concept in multi-objective optimization that can be used independently or as part of other techniques. Understanding the features of the weighted linear system can have a long-term effect. Although the shortcomings of this method in representing Barret's optimal set have been addressed in numerous published applications and literature, there is little in-depth debate regarding the conceptual importance of weight training and techniques to improve the method's performance and primary preference expression. Additionally, these models use the Weighting Pad Algorithm (WS-BA) to choose the ideal mixture of vertical and horizontal target angles for such luminaires. The suggested system is used on a typical tennis court. Several levels of lighting, both horizontally and vertically, are reproduced for testing. All lighting requirements are satisfied in accordance with design specifications. Simulation has always been a focus of research and development in networking."

TABLE 1. Best refrigerant

	Critical Temperature	Critical Pressure	Saturated pressure	Liquid density
R134a	31.080	139.530	29.150	22.050
R152a	29.120	142.970	33.690	27.300
R1234yf	24.080	122.580	29.180	23.100
R1234ze (E)	23.170	128.280	24.600	17.590
R1233zd (E)	33.330	186.410	27.960	18.890
	B	B	NB	NB

Table 1 shows the data set Alternative: Critical Temperature, Critical Pressure, Saturated pressure, Liquid density. Evaluation Preference: R134a, R152a, R1234yf, R1234ze (E), R1233zd (E)

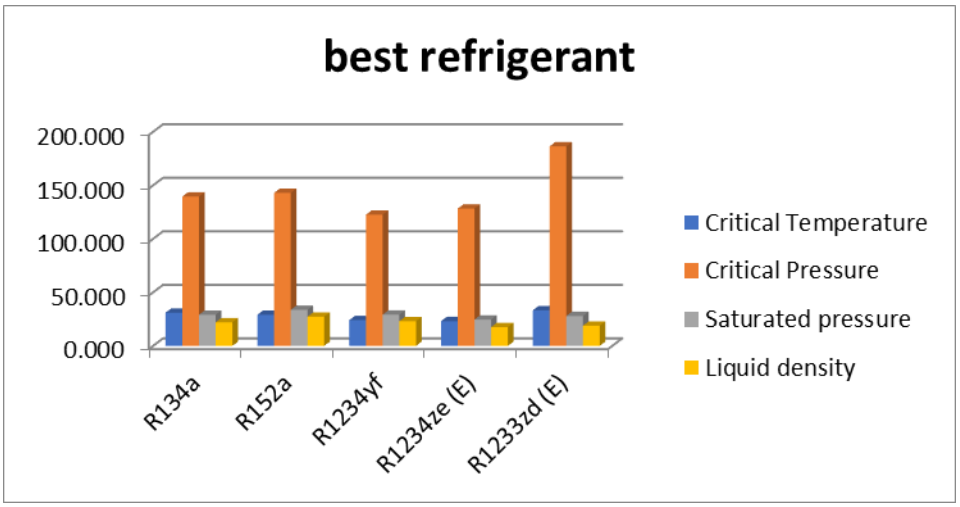

FIGURE 1. best refrigerant

Figure 1 shows the explains Alternative: Critical Temperature, Critical Pressure, Saturated pressure, Liquid density. Evaluation Preference: R134a, R152a, R1234yf, R1234ze (E), R1233zd (E)

TABLE 2. Normalized Data

Normalized			
0.93249	0.74851	0.84391	0.79773
0.87369	0.76697	0.73019	0.64432
0.72247	0.65758	0.84304	0.76147
0.69517	0.68816	1.00000	1.00000
1.00000	1.00000	0.87983	0.93118

Table 2 shows the Normalized Data for Alternative: Critical Temperature, Critical Pressure, Saturated pressure, Liquid density. Evaluation Preference: R134a, R152a, R1234yf, R1234ze (E), R1233zd (E) is also Maximum or Minimum value =C5/MAX ($C$4: $C$8), =MIN ($D$4: $D$8)/D6 Normalized Data formula used.

TABLE 3 Weightage

Weight			
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25

Table 3 shows the Weightages used for the analysis. We take same weights for all the parameters for the analysis**.**

TABLE 4. Weighted normalized decision matrix

Weighted normalized decision matrix			
0.23312	0.18713	0.21098	0.19943
0.21842	0.19174	0.18255	0.16108
0.18062	0.16440	0.21076	0.19037
0.17379	0.17204	0.25000	0.25000
0.25000	0.25000	0.21996	0.23280

Table 4 shows the Weighted Normalized Decision Matrix. Alternative: Critical Temperature, Critical Pressure, Saturated pressure, Liquid density. Evaluation Preference: R134a, R152a, R1234yf, R1234ze (E), R1233zd (E) it is also Weighted Normalized Decision Matrix value multiplication formula used.

TABLE 5. Preference Score

Preference Score	
R134a	0.83066
R152a	0.75379
R1234yf	0.74614
R1234ze (E)	0.84583
R1233zd (E)	0.95275

Table 5 shows the graphical view of the final result of this paper the R1233zd (E) is in 1st rank, the R1234ze (E) is in 2nd rank, the R1234yf is in 5th rank, the R152a is in 4th rank, and the R134a is in 3rd rank. The final result is done by using the WSM method.

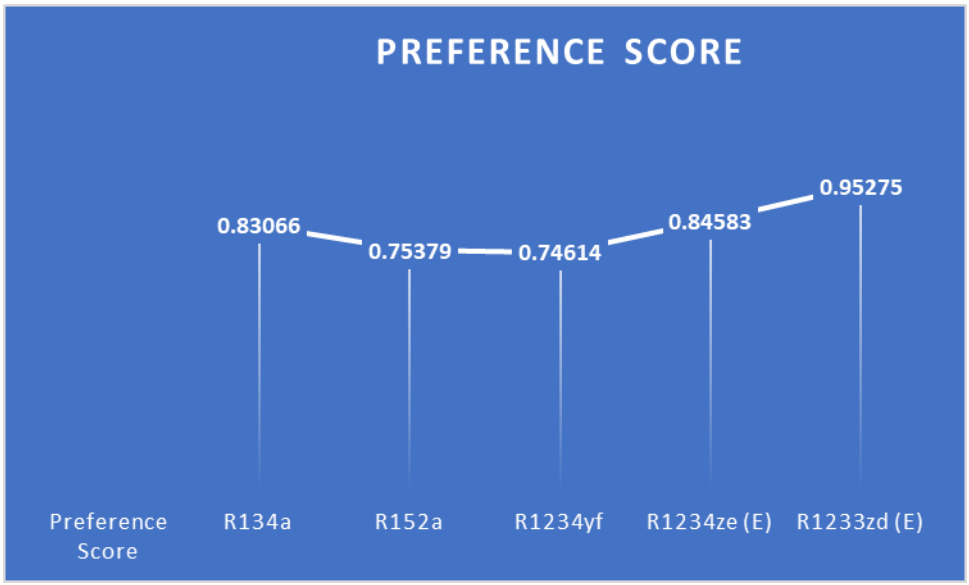

FIGURE 3. Preference Score

Table 5. shows the graphical view of the final result of this paper the R1233zd (E) is in 1st rank, the R1234ze (E) is in 2nd rank, the R1234yf is in 5th rank, the R152a is in 4th rank, and the R134a is in 3rd rank. The final result is done by using the WSM method.

TABLE 6. Rank

R134a	3
R152a	4
R1234yf	5
R1234ze (E)	2
R1233zd (E)	1

Table 5. Rank shows the graphical view of the final result of this paper the R1233zd (E) is in 1st rank, the R1234ze (E) error is in 2nd rank, the R1234yf is in 5th rank, the R152a is in 4th rank, and the R134a is in 3rd rank.

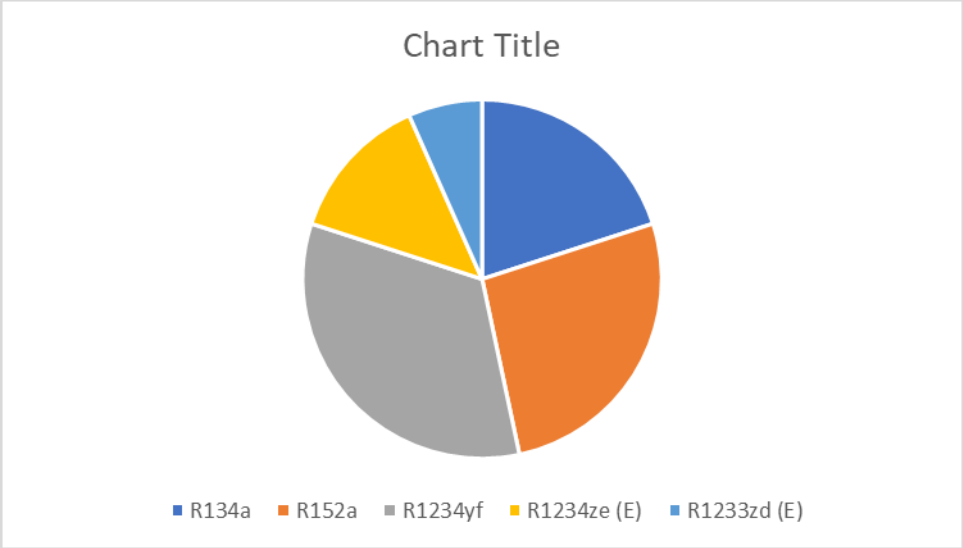

FIGURE 4. Rank

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3. CONCLUSION

The experimental work described in the report suggests that R290 (propane) has a high cooling capacity, even higher than the original refrigerant R12. Moreover, R290 has a similar COP to R12, making it a promising alternative to CFCs in small domestic refrigerators, provided that appropriate safety and operational measures are taken. Additionally, if used as original equipment, R290 would require a smaller compressor than R12. The refrigerant R401a demonstrated performance levels similar to R12, indicating that it can be used as a drop-in replacement for R12. These conclusions suggest that both R290 and R401a are viable alternatives to R12, and their use can contribute to reducing the environmental impact of refrigeration systems. It appears that R134a may not be the most optimal replacement for R12 due to its lower performance compared to R290 and R401a. However, it may still be a viable option for retrofitting existing systems that cannot use R290 or R401a due to lubrication requirements or other factors. An economic analysis would be needed to compare the lifetime service and maintenance costs of a system using R134a versus R12 or other alternative refrigerants.

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