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Analysis of Air Conditioning System by Utilizing HVAC & R Technique

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ABSTRACT:

Air conditioning is part of engineering science which manages investigation of conditioning of air for example providing and keeping up with beneficial inner air conditions for human solace, independent of outside conditions. In more extensive sense, it likewise manages conditioning of air for modern reason, food handling, capacity of food and different materials. Today we can see advancement in each part of society and economy and on account of improvement expectation for everyday comforts of individuals improving; subsequently higher day to day environments is requested. So, it is critical to focus for treating indoor air for solace of tenants. Just bringing down .and ascending of temperature doesn't satisfy the state of solace.Henceforth, full cooling connotes programmed control of a barometrical climate either for solace of individuals or creatures or for appropriate execution of some modern or logical reason. In certain applications, even the control of pneumatic stress fall under the domain of forced air system. Solace cooling manages cooling of private structures, workplaces space, vehicles, transports, trains, planes vets. Modern molding incorporates cooling of the printing plants, material plants, visual items, PC rooms and so forth.

Keywords:AIR CONDITIONING, VRF, PTAC,HEAT PUMPS,WATER SYSTEM, EFFICIENCY

1.INTRODUCTION:

Today we can see advancement in each part of society and economy and on account of improvement expectation for everyday comforts of individuals improving; subsequently higher day to day environments is requested. So, it is critical to focus for treating indoor air for solace of tenants. Just bringing down .and ascending of temperature doesn't satisfy the state of solace. If there should be an occurrence of machine parts, alongside temperature, moistness likewise must be controlled and in the event of people solace alongside these two boundaries, air movement and neatness are additionally significant variables.
Henceforth, full cooling connotes programmed control of a barometrical climate either for solace of individuals or creatures or for appropriate execution of some modern or logical reason. In certain applications, even the control of pneumatic stress fall under the domain of forced air system. Solace cooling manages cooling of private structures, workplaces space, vehicles, transports, trains, planes vets. Modern molding incorporates cooling of the printing plants, material plants, visual items, PC rooms and so forth.
Cooling is a joined cycle that fills numerous roles at the same time. It conditions the air, transports it, and Introduces It to the adapted space. It gives warming and working from its focal plant or housetop units. It likewise controls and keeps up with the temperature, dampness, air development, air neatness, sound level, and strain differential in a space inside foreordained limits for solace and soundness of the inhabitants of the adapted space or with the end goal of item handling. The term HVAC&R is an abbreviation of heating, ventilating, air conditioning, and refrigerating. The combination of cycles in this ordinarily embraced term is identical to the current meaning of cooling.

1.1 1.1types of Air Conditioning System

In institutional, business, and private structures, cooling frameworks are primarily for the inhabitants 'wellbeing and solace. They are frequently called comfort cooling frameworks. In assembling structures, cooling frameworks are accommodated item handling, or for the wellbeing and solace of laborers as well as handling, and are called handling cooling frameworks.

In light of their size, development, and working qualities, there are a few decisions for the kind of cooling frameworks, each delightful the cooling framework goals with various levels of accomplishment. Extensively the cooling framework can be ordered in two general classes: 1) Decentralized frameworks: and 2) Centralized cooling frameworks.

Decentralized cooling frameworks normally serve single or little spaces from an area inside or straightforwardly contiguous the space. These are basically immediate development (DX) type, where the air is cooled straightforwardly trading heat from the refrigerant. These frameworks are generally utilized in little to medium estimated structures. For bigger and more complicated applications, concentrated cooling frameworks are utilized. These frameworks serve different spaces from one base area. These regularly utilize chilled water as a cooling medium and utilize broad ventilation work for air dissemination.

The principal advantages of decentralized air conditioning systems is lower initial costs, simplified installation, no ductwork or pipes, independent zone control, and less floor space requirements for mechanical room, ducts and pipes. A great benefit of decentralized systems is that they can be individually metered at the unit. Disadvantages are short equipment life 10 years, higher noise, higher energy consumption (kW/ton) and are not fit where precise environmental conditions need to be maintained.

The principal advantages of central air conditioning systems are better control of comfort conditions, higher energy efficiency and greater load-management potential. The main drawback is that these systems are more expensive to install and are usually more sophisticated to operate and maintain [1-2].

Decentralized air conditioning systems commonly known as by various generic names viz. local systems, individual systems, floor-by-floor systems, unitary systems or packaged systems provide cooling to single room/spaces rather than the building. These are also referred to as—Direct Expansion or DX types since the cooling is delivered by exchanging heat directly with a refrigerant type cooling coil and these do not use chilled water as an intermediate cooling medium.

1.2 Working Principle Of Air Conditioning System

There are many methods to implement air conditioning, such as the vapour compression Refrigeration process and the absorption refrigeration system. The most common method in practice is the vapour compression refrigeration process. Simple vapour compression refrigeration cycle consists of four main components, which are cooling coil or evaporator, compressor, condenser and an expansion valve.

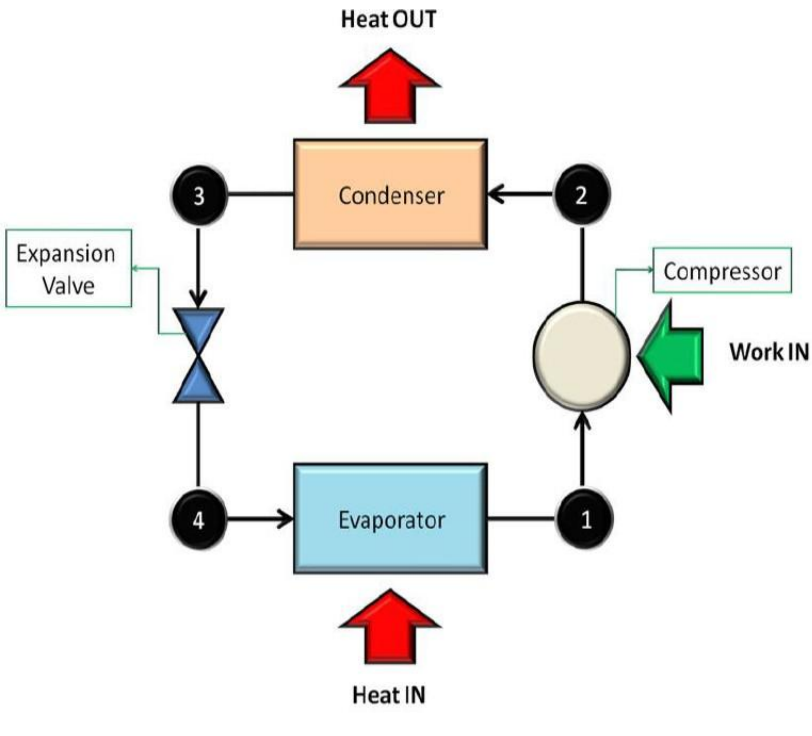

Figure1: VapourCompression Refrigerationcycle.

In this process, warm air is forced to pass through an evaporator coil where air is cooled bye low-temperature two-phase refrigerant in tine coil. If the evaporator surface temperature is lower than the air dew-point temperature, the air is dehumidified by the coil. The heat, which is transferred from warm air, changes the refrigerant from liquid to vapour. The compressor removes the low temperature and low pressure refrigerant vapour from the evaporator coil and discharges that vapour at a high temperature and high pressure to a condenser. In the condenser, the heat of the refrigerant is removed by a coolant, which often is water or air, causing the refrigerant to return to a liquid state at that high pressure. The high pressure liquid refrigerant passes through a throttling device and becomes a low pressure and low temperature two-phase, vapour plus liquid, state refrigerant. The refrigerant then passes into the evaporator to cool and to dehumidify warm air. After heat and mass are transferred, the lower temperature and lower humidity air is sent to the air-conditioned space to balance heat and humidity load of air conditioned space. It should be observed that the system operates on a closed cycle. The system requires input in the form of mechanical work. It extracts heat from a cold space and rejects heat to a high temperature heat sink.

This refrigeration system can also be used as a heat pump, in which the useful output is the high temperature heat rejected at the condenser. Alternatively,a refrigeration system can be used for providing cooling in summer and heating in winter.

1.2 PARTS OFAC SYSTEM

Therearefourparts ofACsystem.

1. Compressor
2. Condenser
3. ExpansionValve(expander)
4. Evaporator
5.

1.3 OBJECTIVESANDPROPOSEDMETHODOLOGY

One of the most important tasks in the early stages of air conditioning system design is to determine the appropriate air conditioning system configuration. The configuration of air conditioning system includes the decision of system type, the selection of components and the choice of control strategies. The configuration has to match the characteristics of the building, its usage and occupancy, and the climate in which it is situated, the configuration also has to make use of the available resources, and eventually fulfill the requirements of the design. The designer would also have the objectives such as delivering high quality indoor environment with minimum cost and' environmental impact. The first step of choosing a configuration for an air conditioning system design, however, is to identify the alternative solutions. The alternatives can then be evaluated and improved; and consequently the best solution that suits the design I requirements will be chosen. As the final choice is only made among the identified alternative solutions, the strategy of identifying alternatives becomes dominantly important.

For almost every air conditioning system design project, there is more than one alternative configuration that would meet the design requirement. Also, among the globe, due to the rapid increase in the number of air conditioning systems and air conditioner manufacturers, the selection of air conditioning system for particular application and selection of best alternative air conditioning configuration to meet the design requirements has become a difficult task for user as well as designer of air conditioning system. The performance is the very important criteria for the selection of air conditioning system. But also mere are many other parameters such reliability, quality, availability, environmental aspects, cost, etc. which are important during the selection of air conditioning system. Only few models are found in literature which considers few parameters for the selection of air considering system. So there is a need of the particular approach for selecting the optimal air conditioning system from the given alternatives. Multi-Attribute Decision Making (MADM) approach is a useful tool in theselection and evaluation of a system taking into consideration of large number of parameters .

Based on the above requirements, the objective of this Project is:-

To develop a methodology by which design, evaluation and selection of air conditioning system can be made comprehensive and easy, considering various factors affecting the selection.

In order to achieve the above objective, the system approach named —**Technique for order preference by similarity to ideal solution (TOPSIS) - a Multi-Attribute Decision making approach (MADM) approach** is proposed, which includes:

Identification of attributes of air conditioning .system under various subsystemsaffecting the overall system.

- Development of n-digit coding scheme to collect the information about the eachattribute.
- Development of TOPSIS procedure for attribute based-evaluation, comparison, design improvement and ranking of feasible alternatives

Final stage selection considers all aspects which have not been considered during evaluationand ranking procedure and Force Field Analysis is proposed for this purpose.

2.LITERATUREREVIEW

Neil A. Roberts and Owen R chambers [1] presented a set of results from laboratory and field testing of refrigerant R-417A comprising R125, R134a and R600. R417A (ISCEQN®59) has been primarily developed to replace R22 in air conditioning applications but has also been successfully utilized in refrigeration applications such as commercial refrigeration display cabinets. It has been founded from experiment that R417a is a suitable candidate for the replacement of R22 for both: refrigeration and air conditioning applications. It has also been establish that with the implementation of R-417A significantly higher COP can be achieved ascompared to refrigerant R-22 and R-404c.

Westra and Douglas G. **[2]** discuss the problem that industry is facing regarding CFC phase-out and the problems associated with CFC alternatives presently under development. A definition of non-azeotropic mixtures has been provided, and the characteristics and COP benefits of non-azeotropic refrigerant mixtures has been explained using thermodynamic principles. Limitations and disadvantages of non-azeotropic mixtures have been discussed, andexample systems using such mixtures have been reviewed.

Fei Liu, Hui Huang, Yingjiang Ma, Rong Zhuang [3] had given the working principles and the basic features of air conditioning water heater (ACWH). According to the experimental, results, the air conditioning water heater system can function in five modes, and it can replaceair conditioner and water heater.

Alka Bani Agrawal [4] makes a comparison between different available refrigerant on the bases of their, physical, chemical and environment and safety properties.

Piotr A. Domanski [5] reviews different topics such as contemporary and future fluorochemicals, —natural fluids, including hydrocarbons, carbon dioxide, and air, and secondary loop systems using ammonia and other chemicals. The conference provided a forum for presenting diverse views on possible responses to the ozone depletion and global warming problems. Author concluded that the task of selecting —the best refrigerant for the 21st century will be difficult because the merits of different refrigerants result from a complex combination of several attributes; the most important being ozone depletion potential, system efficiency, direct global warming, safety, and cost.

Sanadly Halliday et al. [6] examined the feasibility of desiccant cooling in UK climates, using gas-solar hybrid technology for regeneration. The energy study reported by authors clearly demonstrated that it is viable to use solar energy to power desiccant cooling systems in UK applications. Gaia Research worked with Napier University to develop computer codes forthe simulation of solar energy collection and hot water, delivery to drive the desiccant cooling system, based on real meteorological data. A solar desiccant computer model was developed with the University of Leeds which analyzed the energy consumption and costs associated withdesiccant cooling using meteorological data for an inner London-site in 1994.

3.METHODOLOGY

With the development of human civilization, living standard of people is improving day byday, and higher living conditions are demanded. So, more attention is paid toward treating the indoor air to set up and maintain necessary standard of indoor air quality (IAQ) indexes such as temperature, humidity, air cleanliness, etc. Air conditioning system is used to get better IAQ. Apart from comfort air conditioning required for comfort of person, air conditioning system is used to offer condition that some processes required. These processes need certain air temperature and humidity for successful process. Air conditioning systems with greatly different capacities and specifications are offered fora wide range of applications. The selection of air conditioning system to suit a particular use, from the large number of air conditioning systems available in the market today has, become a complicated task. Also, in air conditioning system design, there are many forms and types of choice for air conditioning subsystems, therefore air conditioning designers often face .problemduring selection of optimum subsystems, which meet global market requirements with a varietyof decision-making program. Therefore there is need of a mathematical tool in selection of an air conditioning system and candidate refrigerant also. During selection process of an air conditioning system a varietyof sets of attributes are required by designer, manufacturer, maintenance person and end customer to get optimal results, Different attributes which influence the choice of air conditioning system at each phase of the process can be either quantitative or qualitative in nature. It is a very complex job to select an air conditioning system and candidate refrigerant for a particular application based on the combination of these attributes. So there is a need to build up a system approach that can take all the attributes for evaluation and optimum selection of an air conditioning system and candidate refrigerant [1].The proposed methodology used for selection of a product based on complex set of attributes is multiple criteria decision making (MCDM) approach. This chapter attempts to propose a technique for order preference by similarity to ideal solution (TOPSIS) - a MCDM approach for evaluation and optimal selection of an air conditioning system and refrigerant fora particular' application. It starts from the identification, classification and coding of the systemattributes, then the selection method proceeds to evaluate and rank the certain shortlisted alternatives by employing the TOPSIS approach [1].

3.1 **Evaluation Procedure**

A shortlist of refrigerant and air conditioning system alternatives formed as a result of 'elimination search' have to be further filtered to find out the best solution out of all i.e. an optimal air conditioning system as well as refrigerant. Hence these available alternatives are ranked in order of preference to select a best one.

3.1.1 Decision Matrix

Firstly all of the information available from the mini database about these satisfying solutions is represented in the matrix form. Such a matrix is termed as decision matrix; 'D' Each row of the matrix is allocated to one alternative and each column to one attribute.

Therefore an element d_{ij} of the decision matrix, 'D' represents the value of J_{th} attribute in non- normalized form/units, corresponding to i_{th} alternative. Thus if there are *'m'* short-listed alternatives with *'n'* pertinent attributes, the decision matrix is an m x n matrix.

3.1.2 Normalized Matrix

As the elements in each column of matrix, 'D' has different units and scales, it is necessaryto normalize their values. Thus normalized matrix, 'N' is constructed to have the dimensionlessmagnitudes of all the attributes of air conditioning system on common scale of 0 to 1, which allows the comparison across the attributes. Each element n_{ij} of the normalized matrix, 'N' canfee calculated as,

$$nij = \frac{dij}{\sqrt[2]{\sum_{i=1}^{m} dij^2}} \qquad (1)$$

where d_{ij} is an element of the decision matrix, 'D'.

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3.1.3 Relative Importance Matrix

In this step, the relative importance matrix 'R' of size *n* x *n* is formed to incorporate the relative importance of the attributes over other for a given application. An element *rij* of matrix 'R' represents the relative importance of the *i*th attribute over the *j*th attribute and is defined as,

$$r_{ij} = \frac{importance of ith attribute}{importance of jth attribute} \qquad (2)$$

The relative importance of one attribute with respect to another for a set application can be obtained from the user or the group of experts specialized in a particular application. The information about the pair-wise comparison of attributes for a particular application is stored in this relative importance matrix 'R' with all its diagonal elements as unity.

3.1.4 Eigen Value Formulation and Weight Matrix

Owing to human inconsistencies, the information stored in the 'R' matrix on a pair-wise basis cannot be used straight. It must be modified into a form that gives the relative weights ofall attributes taken together so that the sum of all the weight is equal to unity. Thus Eigen value formulation is used to find weight vector matrix, 'W'. Eigen value from matrix 'R' can be calculated either manually or by MATLAB software. Weight is square of Eigen vectorcorresponding to maximum Eigen value (max).

$$RW = \lambda W \qquad (3)$$

where, $W = \{w_1, w_2, w_3 \ldots\ldots\ldots\ldots w_n\}^T$, and λ is the Eigen values.

Eq. (3) can be expressed

$$(R-\lambda I)W = 0 \qquad (4)$$

To avoid the trivial solution, we have

$$Det\ (R-\lambda I) = 0 \qquad (5)$$

The solution of Eq. (5) gives the set of 'n' Eigen values (λ_1, λ_2,…, λ_n). The solution of Eq. (4) for the maximum Eigen value 'λ_{max}' gives the weight matrix 'W' and the expression is givenas,

$$(R\text{-}\lambda I)W = 0 \qquad (6)$$

And $W = (W_1+W_2 + W_3+ +W_n) = 1$

3.1.5 Weighted Normalized Decision Matrix

In this step the weighted normalized decision matrix, 'V' is obtained by incorporating the information stored in the weight matrix, 'W' into the normalized matrix, 'N'. A true comparablevalue of each attribute is given by this weighted normalized matrix and is defined as,

$V = [vi\ j]$, where $vi\ j = wj \times ni\ j$,(7)

where $i =\ ,2,….,m$; $j = 1,2,….,n$

3.1.6 Hypothetical Best and Worst Solution

The hypothetical best solution (HBS) and hypothetical worst solution (HWS) are found by choosing the maximum and minimum values of attributes from 'V' matrix as,

HBS = A* = $v_{i\ j}$ *max*, for benefit attributes(Larger the better type), or
= $v_{i\ j}$ *min*, for cost attributes
(Smaller the better type), and…………… (8)

HWS = A^- = $v_{i\ j}$ *min*, for benefit attributes(Larger the better type), or
= $v_{i\ j}$ *max*, for cost attributes
(Smaller the better type)………………….. (9)

Where $i = 1, 2,…,m$ and $j = 1,2,…,n$. Hence,

$A^* = (V^*_1, V^*_2,…., V^*_n) A^- = (V^-_1, V^-_2,. , V^-_n)$

3.1.7 Determination of Separation Measures

The TOPSIS method is based on the concept that the chosen option should be nearest to the HBS and farthest from the HWS. The separation measure of top ranked ensures that it is closestto the HBS (best possible air conditioning system) and farthest from the HWS. If Si*and Si areseparation measures from HBS and HWS, respectively. Then, the separation of each alternativefrom the HBS' is given by,

$$Si^* = [\textstyle\sum_{j=1}^{n}(yij-vj*)2]\ ½\ (i= 1, 2,3…, m)….. \qquad (10)$$

And separation measure from HWS is given by

$$Si^- = [\textstyle\sum_{j=1}^{n}(yij-vj^-)2]\ ½\ (i= 1,2, 3…,m)…….. \qquad (11)$$

3.1.8 Determination of Suitability Index

The suitability index, 'C*' is a measure of the suitability of the chosen application on the basis of attributes considered, It is defined as the relative closeness to the HBS, and is expressedas,

$$C^* = Si^- / (Si^* + Si^-), i = 1, 2\ldots\ldots\ldots\ldots m\ldots\ldots\ldots\ldots\ldots (12)$$

An air conditioning system with largest C* is preferable.

4.RESULT AND ANALYSIS :

Among the available alternatives considering various criteria,Window AC system has been found to be most preferable choice among the four alternatives. The TOPSIS method, at the first stage, consists of the composition of the decision matrix with the values of attributes (criteria) like cost, energy consumption, ease of service, availability, reliability and noise level. Based on the above matrix, the normalized decision matrix is constructed. Weighted normalizeddecision matrix has been obtained by using the normalized decision matrix and weights assigned to criteria.

5.CONCLUSION

The main outcome of this work is that approaching the system, as a whole is absolutely indispensable in order to acquire a better picture of the operation of every system component and the interaction. The thesis is focused on modeling, evaluation, optimum selection arid analysis of refrigerants and air-conditioning system using MCDM approach. The MCDM- TOPSIS methodologies are used to achieve the objectives of this work. Multi-Criteria Decision Making (MCDM) approach is presented in Chapter 3 in order to achieve the objective of evaluation and optimum selection of air conditioning system from different alternatives. It identifies the various attributes and required attributes to be considered for the optimum evaluation and selection of refrigerants as well as air conditioning systems. It also provides an n-digit coding scheme for air conditioning systems depicting the various attributes. It recognizes the need for, and processes the information about, relative importance of attributes for a given application without which inter-attribute comparison is not possible. It presents theresult of the information processing in terms of a suitability index, which is used to rank the refrigerants and air conditioning systems in the order of their suitability for the given application. The contribution of the work regarding MCDM-TOPSIS approach can be summarized as

1. The proposed method provides a coding scheme, which is a collection of 173 attributes for characterizing air conditioning system and is useful in defining the air conditioning systemaccurately and precisely.
2. Selection procedure including elimination search, on the basis of TOPSIS approach identified pertinent attributes and the separation of each alternative from generated hypothetically best and worst, air conditioning systems, helps in ranking of all the air conditioning system alternatives. The similar methodology is also opted for selection of refrigerants for air-conditioning systems.
3. The proposed methodology ensures that the selected refrigerant and air conditioning system is nearest to the hypothetical best refrigerant and air conditioning system and farthest from the hypothetical worst refrigerant and air conditioning system.
4. The developed methodology permits the consideration of both types of attributes such as larger-the-better and smaller-the-better together and provides the ranking accordingly.
5. The Window Air-conditioning system and R-417a refrigerant is selected best among all available alternatives for stated thesis problem.
6. It is recommended that the information about all the attributes related to refrigerants and air conditioning system should be maintained as knowledge base for future usage by the manufacturer. This information will be helpful to himself, apart from air conditioning system designer, maintenance personnel, user, etc.

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