The Experimental Study Of Substitute Refrigerants

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Abstract: *Coolants are the job medium for cooling systems that evaporate from the cooled area by collecting heat to ensure a cooling impact. The background of coolant production was based on a range of factors such as protection, stability, longevity, economic or environmental problems, thus promoting modern safety and performance research and equipment enhancement. The coolants may be divided into the following generations. In the early 20th century, chlorofluorocarbons (CFCs) substituted traditional coolants. Midgely and his colleagues also chosen R-12, dichlorodifluoromethane as a cooling compound suitable for use as a stable yet non-toxic and non-inflammable refrigerant testing product in 1928. R-12 was launched in 1931 and was followed by R-11 in 1932 and R-13 in 1945. Chlorofluorocarbon (CFC) and hydrochlorofluorocarbons of R-22 and zeotropic R-502 is controlled for the second generation of coolants. In the second half of the 20th century, these refrigerants flourished. Only the most used industrial coolant, the natural coolant, was ammonia.*

Keywords: Compressor, COP, Capillary

1.Introduction

The effects of alternating coolant mixtures (50 per cent R290/50 percent R600a) are experimentally examined with the conventional R134a system which operates at medium temperature applications. This section contains the experimental framework and steps for this study.

2.Visi Cooler

A medium temperature cooler is a cooling system often used for cooling flasks containing cold drinks and other fluids. The liquids are typically cooled to 20°C to 40°C. The cooling machine evaporates temperature between -70C and -100C. In general, R12 or R134a was used for cooling purposes. It is comprised of a plate-finished air-cooled condenser, a capillary hose, A standard evaporator spindle and compressor hermetically sealed.

3. Experimental setup

The research plant for experimentation has been specifically planned and manufactured. There are two related cooling circuits as shown in Figure 1.

Figure 1. Photo of the experimental configuration

Cylinder1: mixture1: 5% R134a/47.5% R600a/47.5% R290

Cylinder2: mixture2: 15%R134a/42.5%R600a/42.5% R290

Cylinder3: mixture3: 25%R134a/37.5%R600a/37.5%R290

Cylinder4: mixture4: 35%R134a/32.5%R600a/32.5%R290

Cylinder5: mixture5: 45%R134a/27.5%R600a/27.5%R290

Can1: “R134a”

Can2: “HC mixture: 50%R600a/50%R290”

R12 coolant is used in circuit1 and R134a is used by circuit2, and tests have been conducted on R134a circuit in the current analysis. Instruments for recording the requisite data are installed at all important locations. At the outlet of the evaporator and at the inlet of the condenser pressurized gages of ±0,5% precision is set. The temperature sensors PT100 RTD with accuracy of ±0.250C were mounted in all the necessary states to calculate temperature on the required points. A float gage to get the coolant flow rate was put in the circuit. For energy consumption, the compressor was moved to a precision watt meter of ±1W. The evaporator coil was placed in a saline solution of a calorimeter (ethylene glycol). The calorimeter is a 223 mm diameter and 223 mm high container insulated in the outer wall with a PUF and thermo-rex to minimize the thermal leakage. In the calorimeter, the heater is positioned suitably to vary the salt solution temperature. To control the temperature, a mixer was given. In order to obtain an average temperature, three RTD sensors were installed in different heights to calculate salt solution temperature. A wattmeter was attached for measuring the heater load. Indicators for measuring strain, temperature and flow were given throughout the control panel. To control the refrigerant leakage, the circuit had a pressure gage attached. A visual glass was provided at the water source to see the condition of the coolant. The entire

configuration was maintained in a climate regulated space to compensate for the influence of changes in the atmosphere.
The aim of this study is to maximize the capillary tube's duration. The gate valves used for experimentation with coolant To this end, four capillaries with a diameter of "1,1mm, 1,8m, 2,7m, 3,3m and 4,5m" in length were attached to R134a. The required capillary distances may be applied to the circuit by using the gate valves. In order to configure the capillaries for the HC-mix for minimum intake, because of lower viscosity levels, the duration of the capillary tube is twice as long as the length of the R134a. For the experimentation of HC mixture, four capillaries were chosen of set 1.1 mm and 4.5 m diameter, 5.4 m, 6.3 m and 7.2 m high. Since the alternative blend is an R134a and HC combination, the predicted optimal capillary longitude is between the optimal R134a and HC capillary distances.

4. Experimentation

The complete trial comprises the after experiments

i. Cooling and capillary duration optimization
ii. Measure retraction
iii. Current COP, compressor power usage and cooling impact.

4.1 Charge and capillary length optimization

The load listed by the manufacturer will not be adequate as a result of the changed test rig to repair the measuring instruments, which means that a load optimization has to be made. To increase the throttle resistance through increase of the capillary longitudinal duration for alternating coolants to achieve a Therefore, the pressure difference between condenser and evaporator such as R134a is important for capillary optimism. The coolant load and capacity testing for coolants (R134a and HC mixing) and for the alternate coolant considered were also optimized. The protocol for optimizing coolant charges and capillary longitude testing is as follows.

1. Carry out a power consumption evaluation with the chosen coolant and capillary length quantity
2. The capillary lengths chosen differ without changing the quantity of the coolant.
3. Repeat phase 2 by changing the coolant mass.
4. Recover and flush the refrigerant with nitrogen gas and remove it for three hours using the vacuum pump.
5. Replicate the steps 1 to 5 for another refrigerant

4.2 Pull Down Test

The time needed to change the salt temperature of the solution is described as the time from ambient (30OC) to the final temperature desired (2OC). This measure determines the system's cooling rate. With the rise of the cooling rate, refrigeration period of time would increase. The door calorimeter was opened for 24 hours to achieve a thermal balance between saline and the environment. When the target temperature was achieved and the procedure began, the doors were shut. Temperatures of the saline solution cross 30oC-2oC Per 20 seconds during the pull-down test.

4.3 Compressor energy consumption, cooling effect and current COP

The test rig was held inside a test room to assess the compressor's energy usage. The experiments were performed at an average temperature of 320 C. After four hours, all measurements have been made in a constant state. The energy use was recorded with a ±1W accuracy energy meter.
The saline solution calorimeter is used to calculate the exact COP and cooling impact at a certain calorimeter temperature. The current cooling effect and compressor capacity of the heater were chosen at a temperature of 20C, 50C and 80C for different calorimeter calorimeters (saline solution temperature) and the heater load was dimmed. For any chosen calorimeter temperature, the machine should operate in balanced state. The balance condition was measured by maintaining at least a minimum of four hours of unchanged calorimetric shell temperature, compressor power usage, and heater. The load and power of the heater were observed in this state. The heater load was the balanced

cooling result. The experiment above has been replicated twice and the average measured. Figure 2 shows the flow diagram for the experiment.

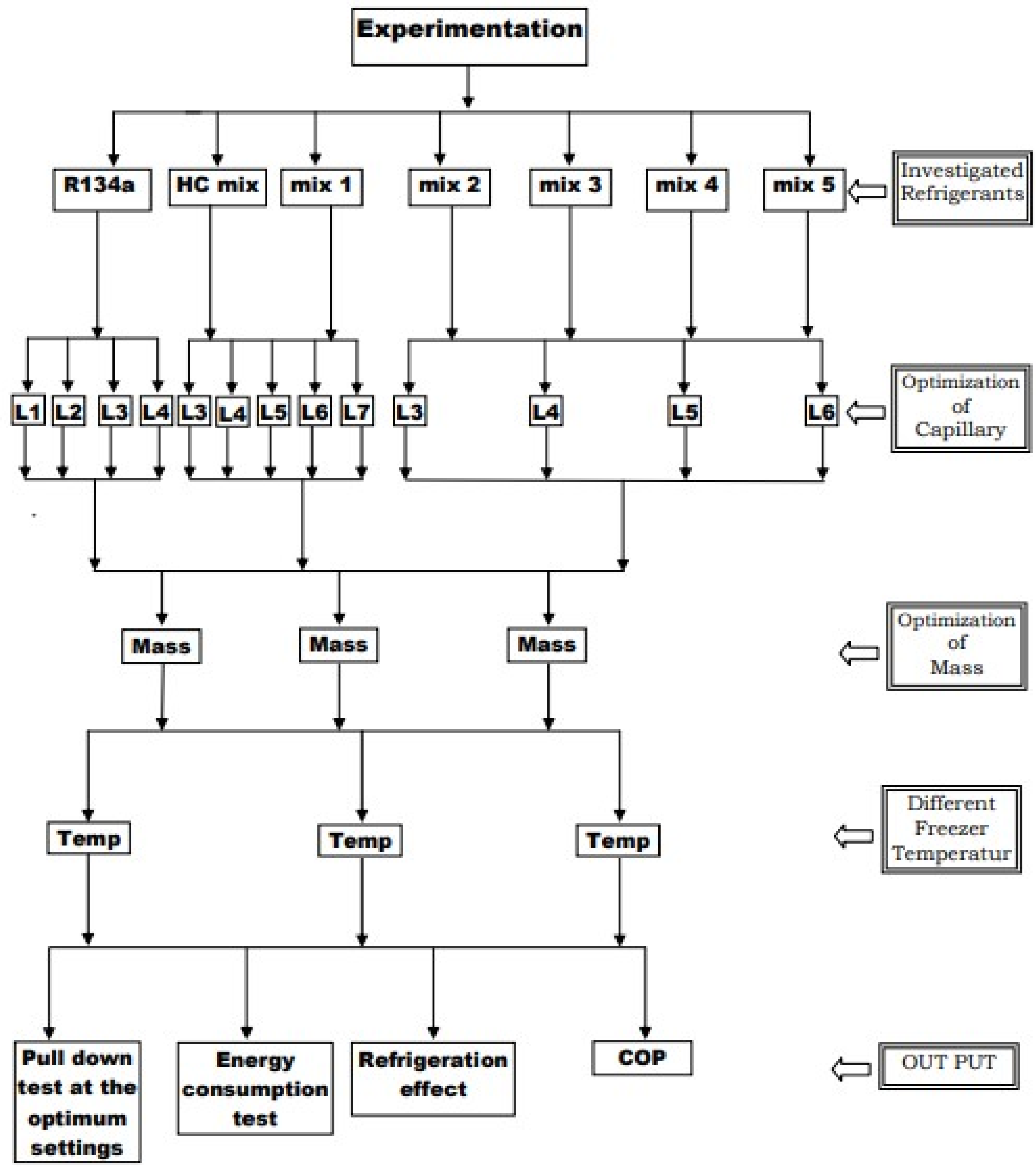

Figure 2. experimentation flow chart

5. Design of taguchi process experiments

The experimental design is a formal way in which causes and circumstances of an experiment are determined to decide the optimal design in the uniform basic partial plant arrangements (Orthogonal Array, OA). DOE is a method to define and study all potential tests with several influences or variables or criteria under all possible situations. The following two tasks should be fulfilled by the DOE: firstly, to identify the number of tests and, secondly, to set forth the criteria for each test.

The Taguchi System is focused on a radically different methodology than traditional quality engineering practices. Taguchi approach stresses the consistency design through the product or operation, whilst inspection is the most common practice. Taguchi essentially utilized traditional statistical instruments in his quality control practices and streamlined them by defining the collection of experimental sequence instructions and analyzing findings for the least number of studies. Its approach effectively improves efficiency by optimizing architecture. His methodology has also been extended to what he calls "offline management of output," which applies to attempts to increase quality before manufacture. In order to decide the factors that yield the best output of the product and method in the analysis, Taguchi has therefore added a design parameter. His methodology seeks to enhance the standard he describes as output continuity. Consistency where variance is minimized is obtained. Changes in the method quality lead to product lack of consistency. A commodity can work optimally and have less variance on its peak value in order to obtain higher efficiency. This is possible if a mean score is similarly moved to the goal value (a value that the commodity is supposed to possess). The resilient nature defines a situation where the heterogeneity of human variables affects a product or procedure least. Developing strength means being less vulnerable to variations. Simply speaking, a durable architecture will better achieve a commodity much of the time. Let all products work at the same stage (less variation between the products). Many variables are chosen in a very suitable situation, either from reference guides or manuals, or by past practice, to produce the best performance.

5.1 Steps in the Technique of Taguchi The followed are the 16 measures in DOE utilize Taguchi.

5.1.1. Experimental design and Taguchi methodology

The Taguchi DOE method should be quickly understood. The aim here is to clarify the DOE clearly and to understand the standardization approach for the experimental design phase.

5.1.2. Definition and enhancement measures

There is no trial that does not have the tools to calculate its effects. The clearly defined purpose and methods of measuring helps one to compare two performances, but to compare the performances between a community and another, a different yardstick is needed. Person output criteria for various trials are generally different, but consistency is the way to quantify population performance. Consistent success leads to fewer variance across the target which reduces errors in all ways. The population output is calculated and compared in this step.

5.1.3. Combined tests and techniques of research

A standard method for the analysis of single or multiple variables is to measure all the others by one factor at a time. This is an appropriate method since it is straightforward. Although the findings are always misleading, and assumptions taken by such an experiment cannot be reproduced. A more efficient way to assess their effects jointly is by establishing DOE-based trials. This move should provide an idea of the fundamental principles of DOE.

5.1.4. Design of orthogonal arrays studies (OAs)

The term "Design" in "DOE" means that the tests are structured with detail about how many experiments are to be performed and how the research combines the variables. Upon determination of the goal for the experiment, after a brainstorming session, the variables and their degree are calculated. The easiest approach to structure the research is to construct the experiment in any way imaginable. A variety of regular DOE-friendly orthogonal arrays were structured. Each orthogonal frame may be used in a variety of experimental conditions to design experiments.

5.1.5. Design of two-level studies

Method parameter tests at two stages are basic and standard experiments. A range of OAs is strictly designated for two-tier factors (“L-4, L-8, L-12, L-16, L-32, L-64”, etc). These OAs may be used to design experiments in all dimensions, provided all aspects are checked at the two stages. By completing this stage, you can see how easily two-level experiments can be planned and evaluated using the Regular OAs.

5.1.6. Design of three- and four-level studies

The behavior of the factors is necessarily considered to be linear when two different levels of factors are examined. If nonlinear consequences are predicted, it is essential to study more than two levels of variables. Although a wide number of broad double-level OAs are adaptable to three-level and four-level influences, regular OAs are also usable, For example, L-9, L-18, L-27, L-16 and L-32 have changed. This stage allows to learn more complicated experiments and to analyze them.

5.1.7. Analysis of variance (ANOVA)

Averages and averages for factor-level effects of the production calculations, which require basic arithmetic operations, address important questions which were not proven in the earlier experimental phases. Nevertheless, an examination of the variance can affect the variation of the outcomes in a discrete proportion. This move shows the part of ANalysis Of VAriance estimation (ANOVA) and tends to gain trust in the interpretation of the experimental findings.

5.1.8. Experiments designed to research interactions among factors

In industrial experiments it is very normal to interact with variables, which affect one factor in another. Whether an experiment with factors produces unacceptable outcomes, or where the relationships between factors do not correspond to standards, an interaction study may be conducted. In this stage the aim is to understand how studies are designed to integrate interaction and how effects can be analyzed to assess if there is interaction. In case of major contact, it helps to determine the most suitable state.

5.1.9. Mixed level variables experiments

Experimental designs with all the variables at one stage can be done comfortably with one of the regular OA available. This basic arrays therefore cannot always handle certain mixed-factor conditions in manufacturing environments. However, the most mixed-level architectures may be done by modifying the basic OAs. The objective is to understand how columns in an array are changed such that the numbers of levels are improved and downgraded to create different columns. There are three-level and four-level columns with a dual orthogonal series. A three-step column may be decreased by a technique called "dummy therapy" to two levels in order to satisfy a factor with a lower level.

5.1.10. Combination designs

The variables and levels of standardized usage of the OA do not produce an economical experimental approach for such applications. Unique experimental design, such as a hybrid design, will save a significant number of samples under these circumstances. This move allows one to understand the hypotheses required to develop mixture concept experiments. This method analyzes two two-tier variables by assigning them to a three-tier column.

5.1.11. Robust design strategy

Deviations between components produced under the same requirements are normal even though attempts are taken to hold all variables at a desired standard. The ultimate aim is to reduce variations. The consumer sees the consistency of the goods as having a clear goal for results. The difference is most often attributed to uncontrolled causes, which are considered the "noise factors," too costly to monitor. The approach in robust design is not a regulation of noise variables, but an adjustment of controlling factors used in the experiment is intended to reduce their effect. This technique, advocated by Taguchi, eliminates heterogeneity without eliminating the origin.

5.1.12. Signal-to-noise (S/N) analysis ratios

The standard approach to measure means effects of the factor is to check simple outcomes averages and then to decide what level of the target factor (optimal status). In order to compare behavior in the community, it is easier to use a medium quadrate variation (MSD), which combines the mean and normal differences. In an examination of the findings for easy linearity and for general information, a logarithmic transformation of MSD (called a signal-to-noise ratio) is suggested. This step shows how MSD for different quality features is calculated and how S/N analysis is different from the standard protocol.

The strongest situation that is found for such research is to achieve consistent output while the S/N ratio is used for analysis of data.

5.1.13. Multiple assessment parameters review of results

A commodity is also supposed to meet many targets. In this scenario, the results provide several assessment metrics representing success in each of the targets. One only condition is commonly analyzed at a time so multiple targets may be measured by many criteria, each with different measuring units and relative weights. There is no guarantee that the factor mixture would always be the same when the effects are evaluated independently with various parameters and the optimal design conditions defined. An methodological method for assessing the results is to integrate the various evaluations into a standard criteria taking into consideration both measurement units and their respective weights.

5.1.14. Variation elimination and improvements in output quantification

Most DOE implementations cause an overall improvement in efficiency to be determined in an optimal configuration. Quality enhancement means either the average or the deviations (or both). When the latest and updated system is implemented (i.e., the design recommended is incorporated), scrap and other expenses are likely to be reduced. This reduction in fact compensates more than for the expense of the new layout. By using the loss function of Taguchi, the estimated monetary benefits may be determined. Via this phase, one will learn how to approximate the anticipated savings from the experimental change. In addition, you will find out how the planned performance improvements in the new architecture represent capacity improvements like Cp and Cpk.

5.1.15. Efficient preparation of experiments

With regard to the advantages of the procedure, experimental preparation among the various applications is the most critical criteria. The application method is therefore an essential first and crucial phase. Planning for DOE/Taguchi including project team members includes organized brainstorming. The essence of the conversations in this preparation meeting would probably differ from project to project, and would better be encouraged by someone who knows the methodology well.

6.Conclusions

The conclusion of experimentation is urgent programs are not implemented; implementation information derived from steps 1-15 can be daunting. The familiarization of different kinds of case studies with full test design and outcomes interpretation provides a way to create trust and enrich application knowledge. Complete case studies should discuss several of the following subjects:

- The purpose of the project (or) (s)
- Performance and assessment requirements
- Conditions and levels identified and those used in the experiment
- suspected and chosen interactions for the original experiment
- Uncontrollable conditions and how they are handled (noise factors)
- Experimental environments run sequence

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References

1. *Calm, JM & Domanski, PA 2004, 'R22 replacement status', ASHRAE J, vol. 46, no. 8, pp. 29-39.*
2. *Camporese, R, Bigolaro, G & Bobbo, S 1997, 'Experimental Evaluation of Refrigerant Mixtures as Substitutes for R-12 and R-502', International Journal of Refrigeration, vol. 20, pp. 22-31.*

3. *Chen, S., Judge, JF, Groll, EA & Radermacher, R 1994, 'Theoretical Analysis of Hydrocarbon Refrigerant Mixtures as a Replacement for R-22 for Residential Uses', International Refrigeration Conference, Indiana, pp. 225-230.*

4. *Choi, JM & Kim, YC 2002, 'The Effects of Improper Refrigerant charge on the Performance of a Heat Pump with an Electronic Expansion Valve and Capillary Tube', Energy, vol. 27, pp. 391-404.*

5. *'Climate Change 2013: The physical science basis. Contribution of working group I to the fifth Assessment Report of the Intergovernmental panel on Climate Change (IPCC), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.*

6. *Corberan, JM & Segurado, JB 2008, 'Review of standards for the use of hydrocarbons refrigerants (HCs) in air conditioners, heat pump and refrigeration equipment', International Journal of Refrigeration, vol. 3, no. 4, pp. 748-756.*

7. *Coulbourne, D & Ritter, TJ 1998, 'Hydrocarbon Refrigeration Safety: Standards and Quantitative Risk Assessments', IIF-IIR Commissions Conference, New Delhi, pp. 293-301.*

8. *David Morrison, J, Stuat Corr & Bruce E Gillbert 1997, 'Production Scale Handling of Zeotropic Blends' ASHRAE Transactions, vol. PH97-9-2, pp. 756-764.*

9. *Deng, J 1989, 'Introduction to Grey Theory', Journal of Grey Systems, vol. 1, no. 1, pp. 1-24.*

10. *Devotta, S, Padalkar, AS & Sane, NK 2005, 'Performance assessment of HC290 as a drop-in substitute to HCFC-22 in a window air conditioner', International Journal of Refrigeration, vol. 28, pp. 594-604.*

11. *Devotta, S, Patil, PA, Joshi, SN, Sawant, NN & Sane, NK 1998, 'Compressor Life tests with Alternatives to R-12', IIf-IIR Commissions, New Delhi, pp. 321-329.*

12. *Devotta, S, Waghjmare, AV, Sawant, NN & Domkundwar, BM 2001, 'Alternatives to R-22 for Air Conditioners', Applied Thermal Engineering, vol. 17, pp. 703-715.*

13. *Domanshki, PA 1999, 'Evaluation of Refrigerant Application' International Congress on Refrigeration', Milan, Italy.*

14. *Donald B Bivens, Charles C Allgood & Joseph J Rizzo 1994, 'R-22 Alternative for Air Conditioners and Heat Pumps', ASHRAE Transactions, pp. 562-571.*

15. *Donald B Bivens, Donna M Patron & Yokozeki, A 1997, 'Performance of R-32/R-125/R-134a Mixtures in Systems in Accumulators or Flooded Evaporators', ASHRAE Transactions, pp. 777-780.*

16. *Dongsoo Jung, Yongjae Song & Bongjin Park 2000, 'Performance of R-22 Alternatives', International Journal of Refrigeration, vol. 23, pp. 466-474.*

17. *Fatouh, M & EI Kafafy, M 2006, Assessment of propane/ commercial butane mixtures as possible alternatives to R134a in domestic refrigerators', Energy Conversion and Management, vol. 47, pp. 2644-2658.*

18. *Fisher, SK & Sand, JR 1993, 'Screening Analysis for Chlorine Free Alternative Refrigerants to Replace R-22 in Air Conditioning Applications', ASHRAE Transactions, vol. DE-93-6-1, pp. 627-635.*

19. *Frank R Binarcadi & Dennis R Pandy 1997, 'Modeling and Testing of Fractionation Effects with Refrigerant Blends in an Actual Residential Heat Pump System', ASHRAE Transactions, vol. PH-97-9-5, pp. 781-794.*

20. *Global Environmental Change Report 1997, 'A brief analysis of the Kyoto protocol', vol. IX, no. 24. 29. Granryd, E 2001, 'Hydrocarbons as refrigerants and overview', International Journal of Refrigeration, vol. 24, pp. 15-24.*

21. *Herbe, L & Lundqvist, P 1997, 'CFC and HCFC refrigerants RetrofitExperiences and Results', International Journal of Refrigeration, vol. 20, pp. 49-54.*