A Case Study

Performence Characteristics of R11 & R123 (In Case of Retrofitting)

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***Abstract*— As a result of environmental problems related to global warming & depletion of ozone layer caused by the use of synthetic refrigerant (CFCs, HCFCs & HFCs). Experiences over the last decades, the return to the use of natural substances for refrigeration purpose, appears to the best long term alternative. In this paper we will go through the case-study of possibilities of Replacement of 500TR Vapor compression refrigeration system with R11 as a working fluid, in the GSFC (Fiber Unit) – Kosamba (Gujarat – India), used for process air conditioning requirements, will be replaced by the Vapor compression refrigeration system with R123 as a working fluid.**

Keywords— Retrofitting, refrigerants

I. INTRODUCTION

At GSFC (Fiber Unit – Kosamba – INDIA), they are having 500TR centrifugal liquid chilling system running with the use of R11 refrigerant (CFC). To follow the phase out schedule of CFCs, Kyoto agreement & Montreal protocol – company decided & has replaced R11 by R123.

Table – 1 Environmental Data for historical, current and candidate chiller refrigerants

Refrigerant	ODP	GWP
R-11 R123	1 0.020	3800 90

The specific objective of this study are mentioned as below.

- To study and analysis of existing refrigeration system.
- Performance evaluation of the existing system for new refrigerant (R123).
- To compare Vapor-compression-refrigeration system (i.e. R11 with R123)

I am analyzing the system for the purpose, & my observations & study is covered in this Paper.

II. REPLACEMENT OF R11 (IMPLICATIONS FOR REFRIGERATION)

The refrigeration industry is now well aware of the nature of the impacts of the zone related decisions. Officially, at least, the CFCs have disappeared, and they are soon to be followed by HCFCs. These remain only on an interim basis. There has been considerable work aimed at identifying suitable replacements and overcoming application problems, including for retrofit applications. The problems include efficiency & capacity changes, loss of temperature range, lubrication difficulties and lubricant compatibility. Some of these have been overcome, but some remain. There would not be an illegal trade in CFCs if all of the problems had been solved.

Table -1.2 : Some candidate Replacements of CFCs & HCFCs refrigerants.

Refrigerant	Normal Boiling Point (NBP) ° C2	Ozone Depletion Potential (R-11 = 1)	Global warming potential (GWP) (CO2 = 1)	Retrofit of new
CFC-11	23.8	1.0	3800	
HCFC-123	27.9	0.020	90	Both
HCFC-141b	32.2	0.110	630	New
HFC-245fa	15.3	0	900	New
n-pentane	36.19	0	0	Both
Ammonia	-33.4	0	0	New

The range of possible alternatives fluids is extensive and a list of some candidate fluids is given in table 1.2, where it is clear that the possibilities include both refrigerant mixtures and natural fluids. [4]

HCFC 123 has 4.3 degree centigrade higher boiling point then CFC 11; it is therefore lower pressure replacement for

CFC 11. Thus having larger specific volume of suction vapor, hence its use results in 10 to 15 % reduction in capacity if used in existing CFC 11 centrifugal compressor. [5][6]

III. THERMODYNAMIC ANALYSIS OF VCR SYSTEM (R11 & R123)

A schematic vapor-compression system is Shawn in figure No.3.1. It consist of a compressor, condenser, economizer for throttling devices and evaporator. The vapor at low temperature enters the compressor where it is compressed and its temperature and pressure increase considerably.

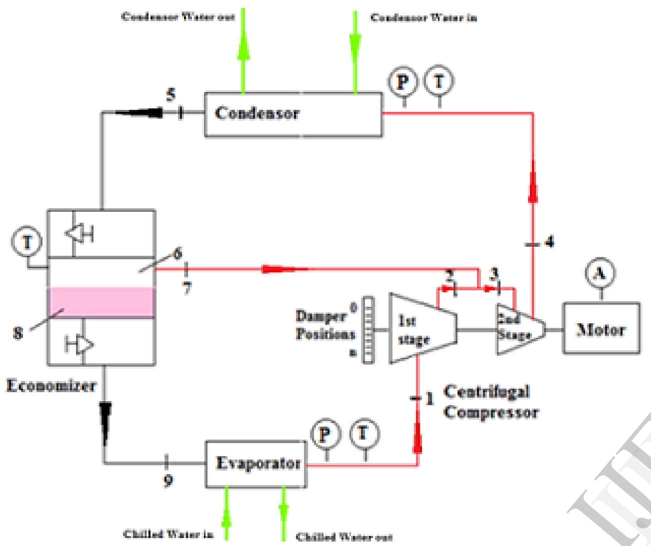

Fig.-1 Schematic diagram of VCR system. (R11 & R123)

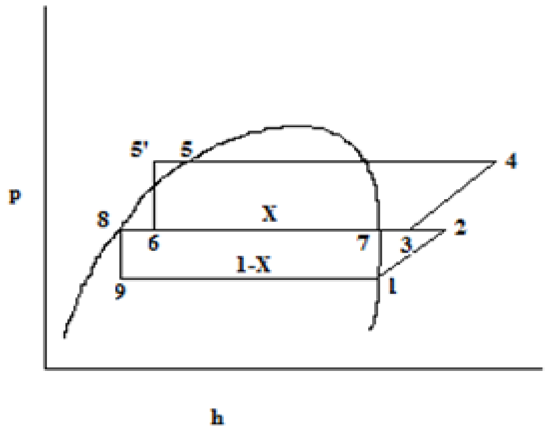

Fig – 2 P – h diagram

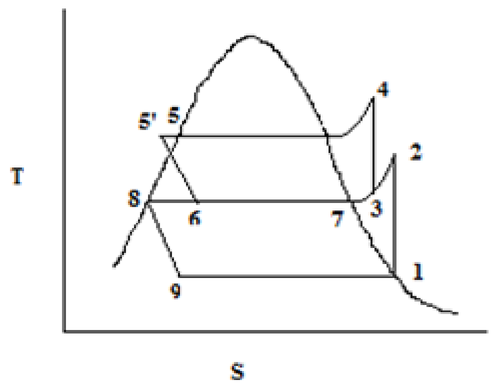

Fig – 3 T – S diagram

Assumptions considered for the thermodynamic analysis of VCR system.

1. Negligible pressure & heat drop in the piping or the system components.
2. Isenthalpic expansion of refrigerants in expansion valve
3. Heat transfer process in heat exchanger is isobaric
4. Change in kinetic & potential energy is negligible.

<u>Thermodynamic analysis for existing VCR system (R11 & R123)</u>

Enthalpy of liquid leaving the condenser,

h5'=x h7+ (1-x)h8 kJ / kg

x=(h5'- h8)/(h7-h8)

Enthalpy of Vapor at suction of compressor during second stage,

h3=(1-x)h2+ x h7 kJ / kg

Mass flow rate of refrigerant through the first stage compressor,

? ?=Q?/ q? kg / sec.

"Q?=refrigeration capacity"

=500*3.5 KW

The rate of heat absorbed by evaporator is given by

q?=(1-x)(h1-h9) kJ/kg ....(1)

The rate of heat rejected by condenser is given by

$$??_{?} = m\,(h4 - h5') \text{ kJ/kg} \ldots\ldots (2)$$

Compressor power consumption is given by

$$w? = (1-x)(h2-h1) + h4-h3 \text{ kJ/kg} \ldots\ldots (3)$$

Co-efficient of performance

$$cop ?? = q?/ w?$$

$$= [(1-x)(h1-h9)]/[(1-x)(h2-h1) + h4-h3] \ldots (4)$$

Table 3 - Properties of Refrigerants

Refrigerant	R-11	R-123
Chemical Formula	CCl3F	CHCl2CF3
Moleculer Weight	137.38	152.93
Boiling Point °C	23.71	27.85
Critical Point temp °C	197.96	183.79
Critical Point Pressure Bar	44.07	36.74

IV. EXPERIMENTAL ANALYSIS OF VCR SYSTEMS (R11 &R123)

In previous chapter we have had a look on a way, the System established (at GSFC Fiber Unit, Kosamba) & a thermodynamic analysis of the system.

I have personally observed the performance of the system & all results actually obtained by the measuring instruments placed at the system. We term these results as an **Experimental Evaluations.**

I have used

- input parameters of the system,
- the Thermodynamic analysis described in chapter-3,
- and EES (Commercial Version) – a software

to derive results and measured performance of the system. We term these results as **Theoretical evaluation** of the system.

V. RESULTS & CONCLUSION

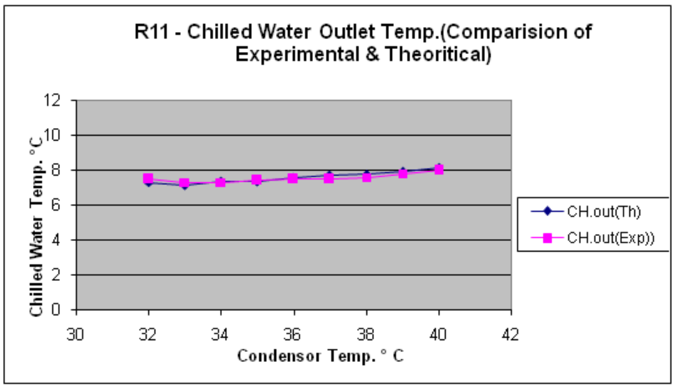

Fig.4 Effect of condenser water temperature on Chilled water outlet temperature for R-11, experimental results & theoretical results are compared.

Variations in the temperature of condenser water have been brought by changing the on-off sequences of fans of cooling tower. And also the mass flow rate of chilled water has been maintained constant.

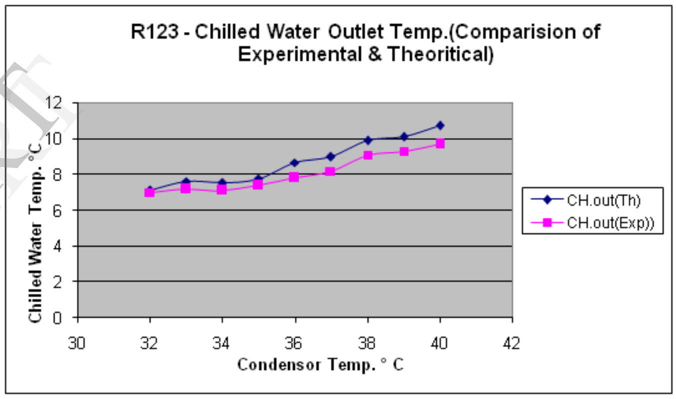

Fig.5 Effect of condenser water temperature on Chilled water outlet temperature for R-123, experimental results & theoretical results are compared.

Variations in the temperature of condenser water have been brought by changing the on-off sequences of fans of cooling tower. And also the mass flow rate of chilled water has been maintained constant.

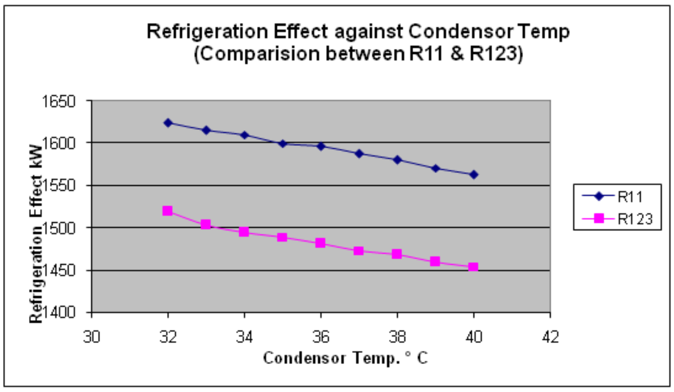

Fig. 4.7 Refrigeration Effect of R11 & R123 against condenser temperature.

Conclusion

From these thermodynamic analysis and experimental analysis, we have summarized point wise as given here under …….

Retrofitting application

R123 is the near most & best suitable refrigerant as a retrofitting application for R11

Performance

R123 cannot perform as steadily as R11, against changing condenser temperature.

VI. ACKNOWLEDGMENT

GSFC (Gujarat State Fertilizer Company Limited) – Fiber Unit, Kosamba………….. I must be thankful to the Management, staff of Utility Section (All Engineers & Technicians), for giving me full support & guidance during my Research work, helping me & providing me the atmosphere to do experiments. Also for giving full respects to me & my decisions associated with the work.

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