# EFFECT OF FLASH GAS BYPASS ON PERFORMANCE OF VCR SYSTEM

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## Abstract

*In this paper performance of vapor compression refrigeration system (VCRS) with R134a in direct expansion (DX) mode and flash gas bypass (FGB) mode are compared. The performance of system can be improved in FGB mode. When system is operated at same operating conditions, in DX and FGB mode, then it is observed that COP increases from 2% to 7% in FGB mode and cooling effect at low load is 2% to 16% more. Discharge temp in case of FGB mode is less than DX mode. Also pressure drop across evaporator is less in FGB mode. In DX mode vapor does not participate in cooling effect but it will create pressure drop across evaporator and because of it compressor work increases. In FGB mode vapors are bypassed because of it less pressure drop is created across evaporator and less compressor work.*

***Keywords:*** *Flash gas bypass, direct expansion and VCRS etc…*

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## 1. INTRODUCTION

Improving the efficiency of vapor compression refrigeration system is important for its application. One possible method is flash gas bypass (FGB) which was described by Stefan Elbel et al. [4] and by Niraj Agrawal et al. [5].

In current research, flash gas bypass system is used. Flash chamber is developed for separating [7] the flash gas formed during expansion process. Bypassed gas is directly send to the compressor and only liquid is send to the evaporator. The main advantage of it is that to reduce pressure drop in evaporator and to improve the refrigerant distribution. Also cooling effect is increased due to improved refrigerant distribution [4] and compressor work reduced due to reduced pressure drop across evaporator.

This Paper presents the results of experimentation performed on refrigeration system in direct expansion mode and flash gas bypass mode with R134a. The experimental results of the flash gas bypass system are directly compared with conventional system with direct expansion.

## 2. FLASH GAS CONCEPT

In a conventional vapor compression system with *direct expansion (DX*), refrigerant under high pressure is expanded to a lower pressure before it enters the evaporator. The refrigerant state at the outlet of the expansion device is in a two-phase condition, provided that the fluid crosses the saturated liquid line during the isenthalpic expansion process. As a result, some fraction of the refrigerant flow enters the evaporator already in a vapor state without having a significant cooling effect. The idea behind the *Flash Gas Bypass (FGB)* concept is to bypass this vapor flow around the evaporator and by feeding the evaporator with liquid refrigerant, pressure drop is reduced and refrigerant distribution is improved.

Fig. 1 shows the schematic of a flash tank. A flash tank is a pressure vessel; wherein the refrigerant liquid and vapour are separated see fig. 2 and point 3. The refrigerant from condenser is first expanded to low pressure. In the flash tank, the refrigerant liquid and vapour are separated (point 3). The separated liquid is fed to the evaporator (Process 5-4). The vapour in the flash tank is bypassed to compressor (Process 3-6) and compressed to the condenser pressure. In the absence of flash tank, the refrigerant condition at the inlet to the evaporator would have been point 3 i.e wet vapour.

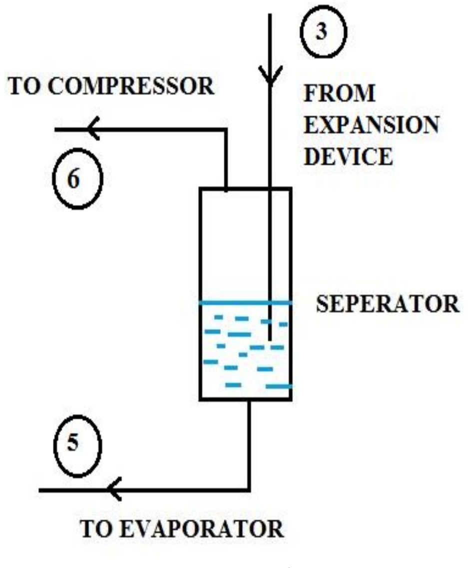


**Fig-1:** Line diagram of Flash Tank

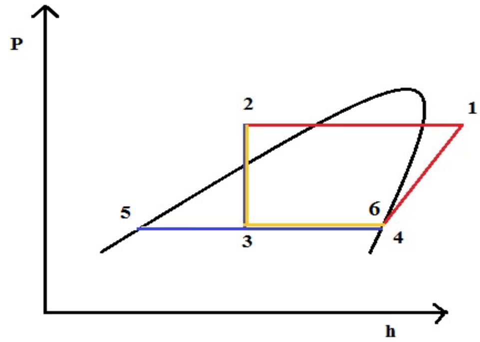


**Fig -2:** p-h digarm

## 2. OBJECTIVE

The prime objective of research is to compare the performance of the direct expansion (DX) system with Flash gas bypass (FGB) system with variation of the load on the system.

Accordingly standard system is designed and developed. This system operated in direct expansion as well as flash gas bypass mode with the help of 4 service valves provided.

## 3. EXPERIMENTAL SET UP

Fig. 3 shows the block diagram of experimental setup. For DX mode open the valve V2 and close the valve V1, V4 and V3 and for FGB mode open the valve V1, V4 and V3 and close V2. DX system is regular (Standard) system. FGB mode in which vapour formed during expansion are separated at the end of expansion process in separator at point 3. After point 3 only liquid is sent to the evaporator and vapors to the compressor inlet.

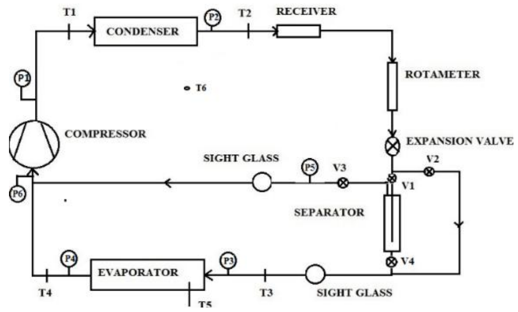


**Fig-:3** Line diagram for VCR System with DX and FGB

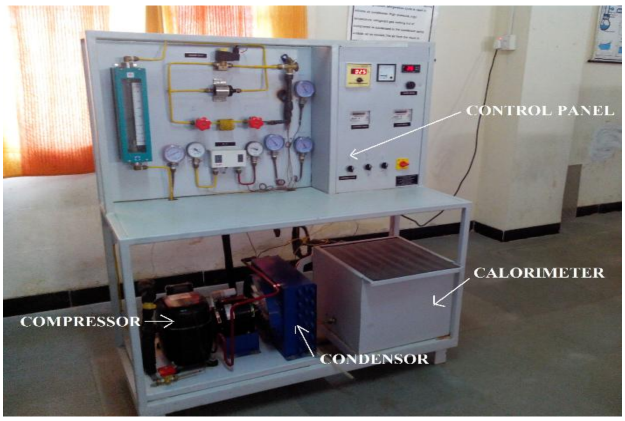


**Photo-1:** Experimental Set up

## 4. RESULTS AND DISCUSSION

To check performance of the set up number of readings are taken by using control panel. By varying the load on evaporator readings are taken.

**Table-1:** Variation of system load

| Sr. No. | Load in kW |
|---|---|
| 1 | 0.9 |
| 2 | 1.0 |
| 3 | 1.1 |
| 4 | 1.7 |
| 5 | 1.9 |
| 6 | 2.4 |

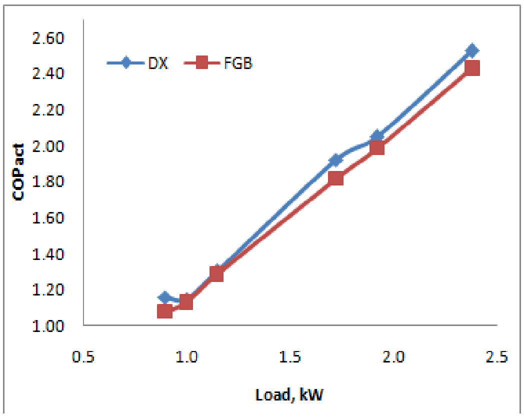


**Chart-1:** Comparison of actual COP in DX and FGB mode

Above chart no.1 shows that as the load on the evaporator increases the COP also increases. COP in FGB mode is more. Rise in actual COP in FGB mode is observed from 1.27% to 7.28% for the load change from 0.9kW to 2.4kW.

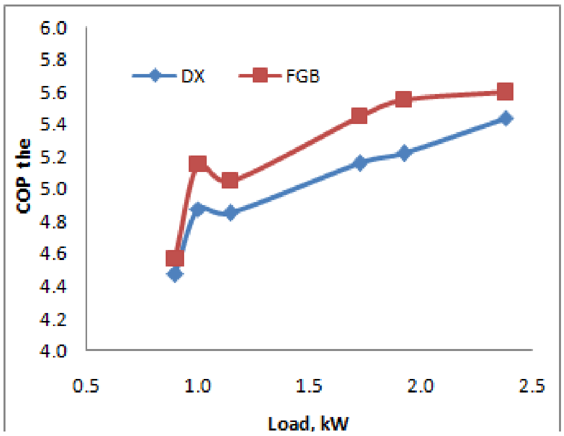


**Chart-2:** Comparison of theoretical COP in DX and FGB mode

Above chart no.2 shows that as the load on the evaporator increases the COPth in DX and FGB mode also increases. And COP in FGB mode is more than DX mode. Increase in theoretical COP in FGB mode is observed from 2% to 5.93% for the load change from 0.9kW to 2.4kW.

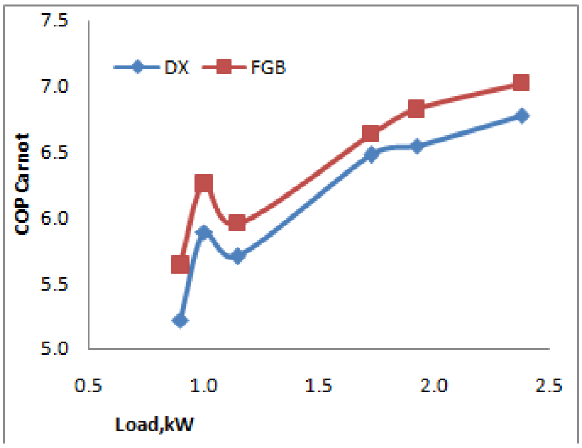


**Chart-3:** Comparison of Carnot COP in DX and FGB mode

Above chart no.3 shows that as the load on the evaporator increases the COP Carnot in DX and FGB mode also increases. And COP in FGB mode is more than DX mode. Increase in theoretical COP in FGB mode is observed from 2.38% to 7.42% for the load change from 0.9kW to 2.4kW.

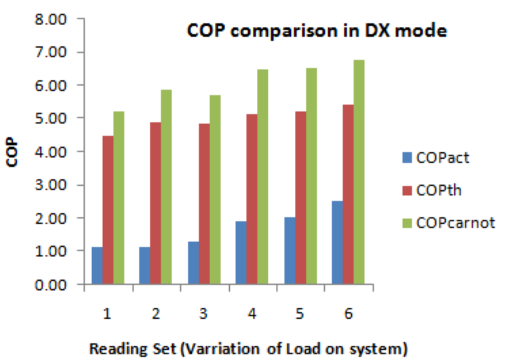


**Chart-4:** Comparison of actual, theoretical and Carnot COP in DX mode

Above chart no.4 shows the comparison of COP actual, COPth and COP Carnot in DX mode. COP Carnot is greater than COP actual and COPth. COP actual varies from 1.07 to 2.43, COP theoretical varies from 4.47 to 5.44 and COP Carnot varies from 5.22 to 6.78. It is because of losses through walls of calorimeter chamber etc.

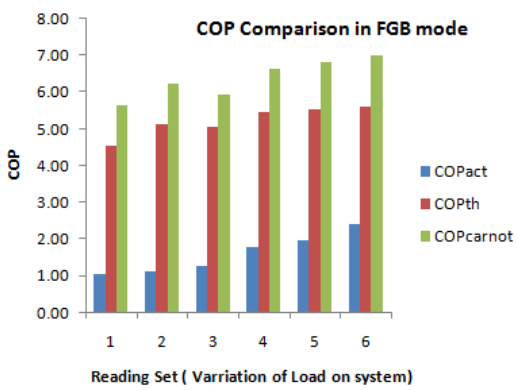


**Chart-5:** Comparison of actual, theoretical and Carnot COP in FGB mode

Above chart no.5 shows the comparison of COP actual, COPth and COP Carnot in FGB mode. COP Carnot is greater than COP actual and COPth. COP actual varies from 1.15 to 2.52, COP theoretical varies from 4.57 to 5.60 and COP Carnot varies from 5.64 to 7.03. It is because of losses through walls of calorimeter chamber etc.

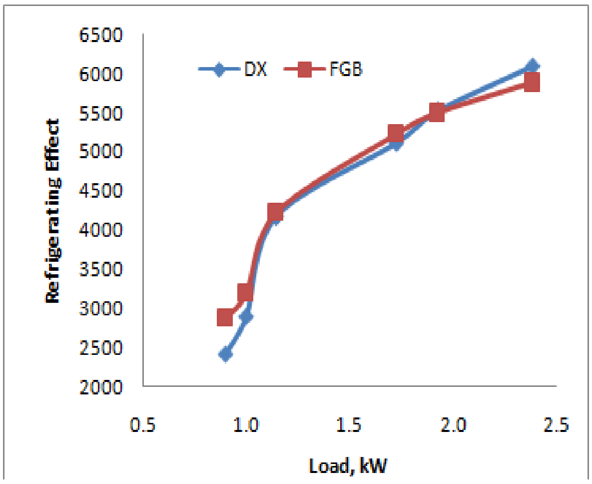


**Chart-6:** Comparison of refrigerating effect in DX and FGB mode

Above chart no.6 shows the comparison of refrigerating effect in DX and FGB mode. Refrigerating effect in FGB mode is more as compared to DX mode. It is because of flash gas bypass. Only liquid sent to the evaporator. Because of it heat transfer coefficient increases and refrigerating effect. At lower load refrigerating effect is about 16% more but as load increase refrigerating effect decreases.

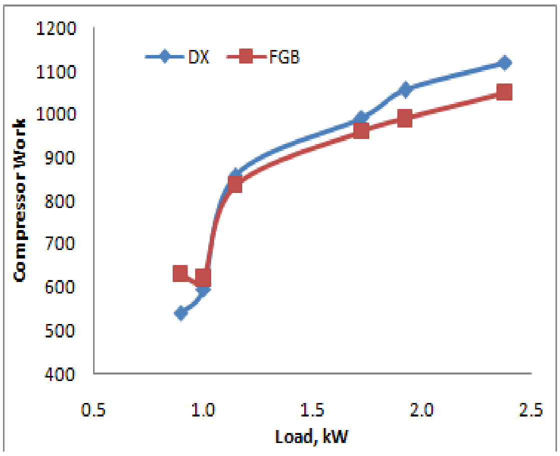


**Chart-7:** Comparison of compressor work in DX and FGB mode

Above chart no.7 shows the comparison of compressor work in DX and FGB mode. Compressor work is more in case of DX mode. It because of more pressure drop across evaporator is more in case of DX mode so more compressor work required. At higher load upto 6.67% more work required.

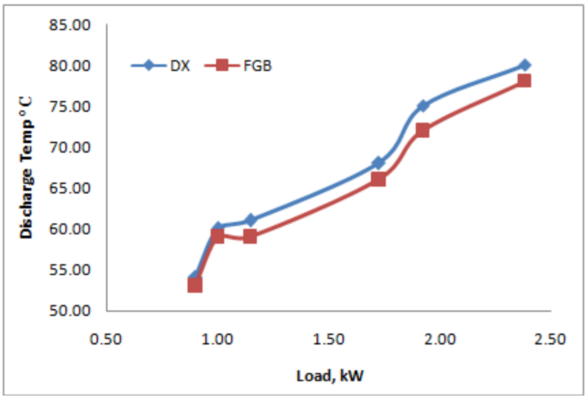


**Chart-8:** Comparison of discharge temp in DX and FGB mode

Above chart no.8 shows the comparison of discharge temp in DX and FGB mode. Discharge temp is more in case of DX mode. It because of superheat at evaporator outlet and more pressure drop across evaporator.

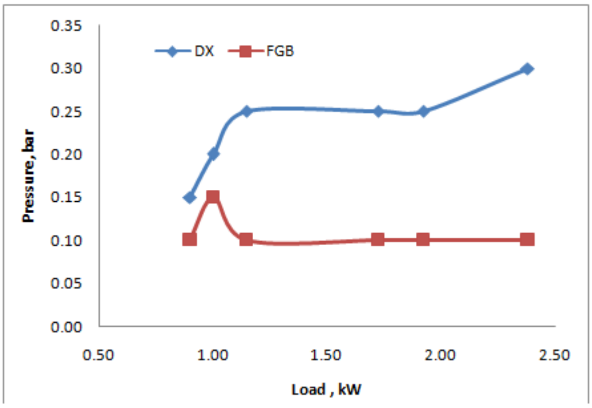


**Chart-9:** Comparison of pressure drop across evaporator in DX and FGB mode

Above chart no.9 shows the comparison of pressure drop across evaporator in DX and FGB mode. Pressure drop is more in case of DX mode. It because of wet refrigerant entering is in evaporator in case of DX mode. And in case of FGB mode only liquid is sent to evaporator.

## 6. CONCLUSIONS

Following conclusion are made from the work carried out on effect of flash gas bypass on VCR system.

When system is operated at same loading conditions in FGB and DX mode, the actual COP in FGB mode increased about 1.27% to 7.28%, theoretical COP about 2.07% to 5.93% and Carnot COP 2.38% to 7.42% over DX mode.

The main reason for the improved performance of this system in FGB mode is due to only liquid refrigerant sent the evaporator. Liquid has more heat transfer coefficient as that of vapor. Refrigerant effect also improved about 2% to 16%.

Because of Flash Gas bypass it is observed that less pressure drop in evaporator about 0.1bar. Due to less pressure drop compressor work is reduced to 9%. And discharge temp reduced 2°C to 4°C.

## ACKNOWLEDGEMENTS

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