DUAL INVERTER TECHNOGY IN REFRIGERATION AND AIR CONDITIONING-A REVIEW

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ABSTRACT

From times immemorial, refrigeration and air conditioning applications are using fixed speed motor compressors irrespective of the variable cooling requirements during day and night time as well as during summer and winter. Such systems are running all the time at full load and are thus consuming more power than actually required. This gave birth to the idea of variable speed motors as per cooling requirements. Dual inverter technique fulfills this requirement. This consists of two inverters. First one converts the constant frequency AC voltage to DC voltage of 12 volts by using a rectifier and step down voltage transformer. The second inverter converts this DC voltage again to AC voltage of variable frequency by the use of a variable frequency drive. This variable frequency drive runs the motor at variable speed as per cooling requirements. Dual inverter technology is complex and costly. Its increased cost can be overcome over a period of 2 to 3 years in terms of power savings. Since the life of the refrigeration and conditioning units is 15 years or more, this changeover is necessary and requires immediate implementation. To one's surprise there are numerous applications like hospitals, telecom, I.T. and chemical processing units which this have already put it to practical use. Many more applications are in the pipeline.

Keywords: *(Dual inverter, Variable frequency drive, variable speed motor, refrigeration and air conditioning)*

1. INTRODUCTION

The conventional cooling units have fixed speed compressors which runs at 100% capacity at all time. Whereas an inverter unit starts slowly and then progressively increases its speed as well as cooling capacity as per cooling or heating requirements.There is automatic starting and stopping of fixed speed compressors. These stop automaticallyon achieving the temperature set through a thermostat and also start automatically on rise of temperature in the cooling unit.Both automatic starting and stopping are abrupt and are accompanied by a big noise. These fixed speed compressor run at 2800 or 3600 RPM. Inverter unit changes the input 220 or 440 AC voltages to12 V DC with the help of a voltage step down transformer and a rectifier. This DC power will again be changed to AC power of variable frequency with the help of another inverter called a power inverter. Thus there is a use of dual inverter. It contains various control circuits and transformers such as PWM (Pulse Width

Modulation) to produce variable voltages using digital microcontrollers and variable frequency drive (VFD)as shown in Fig.1, Fig.2 and Fig.3 respectively. A Pulse Width Modulation (PWM) of the DC in the power inverter generates AC of desired frequency. This AC current of changing frequency drives the induction motor. Since speed of induction motor is directly proportional the frequency of the alternating current, the compressor of the cooling unit operates on variable speed (1100 to 4300 RPM) and continuously controls rate of heat transfer as per cooling requirements. The existing ambient air temperature is sensed by using a microcontroller and then the speed of the compressor is adjusted accordingly.Its function is similar to an accelerator in a car to vary the speed[1-8].The inverter refrigeration and air condensing units have increased efficiency, more life and fewer fluctuations in the load as compared to the traditional cooling units. Thus inverter AC units are relatively quieter; operate with less cost and has less break downs. The initial cost of inverter AC units is much more than the constant speed cooling units. It is because ofcomplexity in the inverter technology. It has been estimated that the increased cost can easily be overcome within a maximum period of three years due to less power consumption. Under inverter technique, compressor uses a variable frequency drive to vary the compressor motor speed to control the cooling capacity. In a nutshell, matching cooling capacity with cooling requirement indicates that the part load efficiency is high. Inverter technology, related to refrigeration and air conditioning, was developed in Japan and now it has become the most efficient refrigeration technology available in the market. Variable speed operation requires a specially designed compressor and a special compressor lubrication system. Proper oil management for lubrication is a critical parameter to ensure a reasonable life for the compressor. Proper lubrication control is required during low as well as high speeds.Many manufactures have come in the inverter technology. However Samsung is one of major manufacturer of inverter compressors.

2. NEED OF INVERTER TECHNOLOGY

Compressors in regular refrigerators are single speed compressors. They are either “on” or “off” as per setting of temperature in the thermostat. These compressors run at peak load conditions all the time in summers as well as in winters. Ambient conditions are changing all the twenty-four hours. But there is wide difference in day’s peak and midnight minimum temperature. Therefore, cooling requirements are not always the same even in summer during daytime and night time. These are significantly less in winter. This aspect is applicable to almost each and every application of refrigeration and air conditioning. However, some of the vital applications include hospitals, IT & telecoms and process cooling in chemical industries. Variable cooling capacity will also be required in industrial processes to obtain better quality control. Therefore, a mechanism is required to tackle the changing cooling load requirement. This is achieved through Dual Inverter technology which controls the speed of the motor of the compressor as per cooling requirements and also results in saving of power. Low speed means less mass of refrigerant compressed and hence less power consumption. A variable-frequency drive (VFD) is used in inverter technology. It controls the speed of the AC motor and also torque by controlling the input voltage and frequency to the motor. As a rough estimate, 25% of the world's electrical energy is consumed by electric motors in various industries. The use of VFD will result in significant power saving by making the systems energy efficient at all loads. Continuous improvements are required to reduce the cost of VFD and other controls to make dual inverter technology even more popular.

3. COMPRESSOR WORKING WITH INVERTER TECHNOLOGY

The working of a compressor with inverter technology is very much similar to the working of a car accelerator. When the speed required is more, the accelerator is pressed more, and when it is less, then the accelerator is pressed less. Similarly, during daytime in summer, cooling load is more and the compressor works at peak capacity consuming more power. But during night time, in summer as well as during winter, cooling load is lesser; the compressor can run slowly and will consume less power. Thus inverter compressor never switches off even when the temperature stabilizes, but runs at a slower speed maintaining the temperature inside the refrigerator

4. DIFFERENT METHODS OF CONTROLLING COOLING CAPACITY

There are many ways to control the cooling capacity in refrigeration, air conditioning and heat pump units. Though each has its own advantages and disadvantages but most commonly used methods are as follows:

4.1 Hot gas bypass

Some quantity of hot refrigerant vapors from the compressor discharge is fed to the suction line. The mass of refrigerant coming from the evaporator to the compressor will be reduced and hence rate of flow of refrigerant as well as cooling capacity in the circuit will be reduced.

4.2 On-off cycling

Compressor stops on attaining the temperature set by the thermostat and restarts again on rise of temperature inside. All the compressors need more starting torque and hence more current. Therefore frequent stopping and starting especially during night time and in winter is disturbing and can be dangerous to the compressor motor winding.

4.3 Manifold configurations of multiple compressors

Number of compressors isused in certain refrigeration and air conditioning applications. All or a few of these compressors are run as per cooling capacity requirements. There are two combinations to achieve the peak load cooling capacity. These are either 0/33/66 or 100% for a set of three compressors and 0/50 or 100% for a set of two compressors.

4.4 Mechanically modulated compressor

It can be obtained by changing the time for compression with a control valve and not by changing the speed of the compressor motor. This results in high power consumption and hence it is not used in actual practice. It is called also called a digital system

4.5 Dual Inverter compressor

It uses an external device of variable frequency to control the speed of the motor and hence that of the compressor. Change of speed causes the change in the flow rate of the refrigerant and hence the cooling capacity is controlled. The variable frequency device is an electronic device which controls the speed of motor of the compressor and saves power.

5. DIFFERENCES BETWEEN CONVENTIONAL AND INVERTER REFRIGERATOR

There are many differences between conventional and dual inverter system. These are tabulated in tableno-1 given below.

Table no -1-Differences Between Conventional and Inverter Refrigerator

Sr. No.	Conventional refrigerator	Inverter refrigerator means a variable frequency drive.
1.	Compressor runs at constant speed.	It runs at varying speed. When more cooling is required, it runs fast. When less cooling is required, it runs slow.
2.	Consumes power at a constant rate.	Consumes power at a variable rate. Consumes less power for longer periods such at nights.
3.	It cycles off and on quite frequently and thus gives more disturbances.	It cycles off and on slowly and thus gives fewer disturbances.
4.	It is not flexible in producing cooling.	It is flexible in producing cooling.
5.	When it restarts, it gives a loud noticeable sound as it runs at high speed.	Its operation is relatively quiet. It restarts at a lower speed.
6.	It consumes more power for the same cooling.	It saves 20 to 30 % power as it runs at low speed for longer periods. Thus it is more economical.
7.	It produces cooling at a fast rate and gives you cooling at shorter periods.	It is slow in producing certain amount of cooling.
8.	There is complete safety as it is using quite safe refrigerants. These are using R-134a, R-22.	The refrigerant used is not as safe as the one used in conventional refrigerators. These are using Butane which is highly inflammable.
9.	It is cheap initially.	It is costly initially.
10.	The energy efficient ratio (EER) is low.	The energy efficient ratio (EER) is high.
11.	Its compressor is a reciprocating compressor but it handles vapors .	The inverter compressor is a reciprocating compressor which handles gas.
12.	Lubrication is easy.	Lubrication is complex.
13.	The condensation temperature is high. Hence condensation pressure is high. Power consumed is more.	The condensation temperature is low. Hence condensation pressure is low. Power consumed is less.
14.	It uses a AC motor.	Variable frequency drive (VFD) uses a brushless permanent magnet DC motor.

6. ADVANTAGES OF INVERTER TECHNOLOGY IN REFRIGERATION

1. The efficiency of air conditioners is increased since repeated starting and stopping of compressor is eliminated.
2. There is a time saving and hence cooling becomes fast.
3. The wear and tear of compressor parts is greatly reduced
4. There is about 30 % saving in power using inverter technology.
5. The life of the air conditioner increases since it is not subjected to repeated high starting torque as in conventional air conditioners.
6. Running cost of the Inverter air conditioneris less because less power consumption.
7. Inverter cooling units are less prone to breakdowns.
8. Vibrations and hence the noise is less than that in conventional air conditioner.
9. Using an “on” and “off” cycle refrigerators, inside temperature will vary throughout. But in case of inverter technology, inside temperature becomes more stable.

7. DISADVANTAGES OF INVERTER TECHNOLOGY IN REFRIGERATION

1. There is 4 to 6 % energy loss in each conversion of AC to DC and back to AC.
2. Electrical Circuit is complex.
3. Initial cost of inverter cooling units is high.

8. PRACTICAL APPLICATIONS OF INVERTER TECHNIOLOGY

It is more suitable for regions having long hot climates. However, it can also be used for the following applications.

(i) Homes, restaurants, office buildings and hospitals
(ii) IT & telecoms
(iii) Process cooling in the chemical industry
(iv) In industrial processes to obtain better quality product
(v) HVACR
(vi) Packed air conditioners
(vii) Split air conditioning units
(viii) Modular chillers
(ix) In precision cooling applications
(x) Variable refrigerant flow units both for heating and cooling applications
(xi) In condensing units
(xii) Air handling units
(xiii) Rooftop condensing units
(xiv) Close control units

9. CHALLANGES IN ADOPTING INVERTER TECHNOLOGY

1. There is a difficulty in perfect matching of compressor with the variable frequency unit.
2. Inverter technology requires very fine controls which are costly and sensitive.
3. The inverter frequency drives need special algorithms for refrigeration, heating, ventilation and air conditioning (HVAC) applications. It also makes the system complex and costly.
4. There are difficulties in optimal lubrication of the compressor and the bearings under variable speeds.

Fig.1 Variable Frequency Drive with Cover

Fig.2 Variable Frequency Drive without Cover

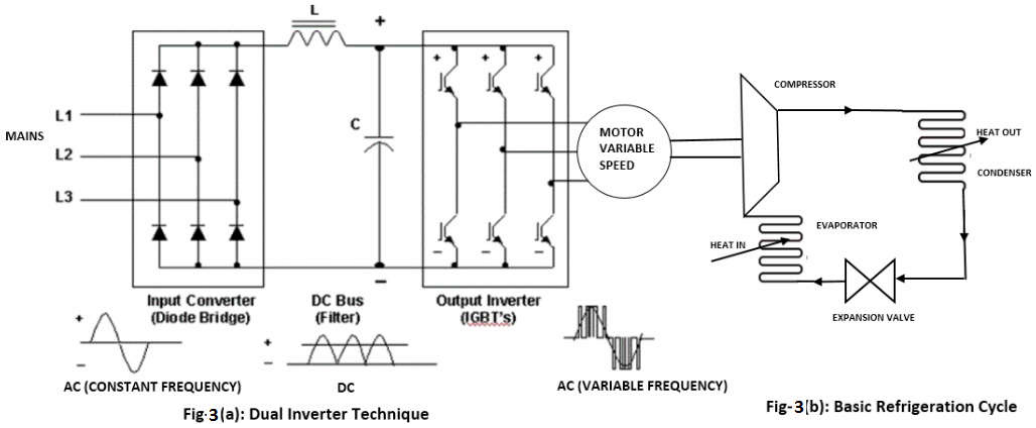

Fig-3(a): Dual Inverter Technique

Fig-3(b): Basic Refrigeration Cycle

Fig.3Dual Inverter Refrigerator

10. CONCLUSIONS

1. VFD's can be used in all types of refrigeration and air conditioning applications.
2. VFD saves 20 to 30 % power.
3. Few troubles have been reported with the use of VFD.
4. VFD is costly.
5. Continuous efforts are being made to make them cheaper and trouble free.
6. These are likely to be used in all applications in the near future.

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