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Role of Electronic Controls in evolution of Refrigeration and Air Conditioning system

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Abstract: As we follow the history of the evolution of refrigeration and air conditioning systems electronics play a vital role in making system compact, energy efficient and smart to understand the application requirement. Though its base function —operate the system through electricity power is quite simple, this function is key to ensuring system operation and performance. Understanding this evolution we will go through the various aspect of electronic control of new era like saving of the previous energy through compressor inverter technology, use of smart sensing to improve the performance of the system and use of renewable energy in HVAC & R system.

Keywords: HVAC & R, Inverter Technology, Smart sensing system, Energy efficiency, Solar refrigeration.

I. INTRODUCTION

HVAC & R means Heating, Ventilation, Air-conditioning and Refrigeration. As we go to the ancient use of this branch like for the preservation of food for long time by using salt and ice mixture as refrigeration medium or cooling the living room by running the cold water through walls of the building [7], the invention of the electricity plays revolutionary role in evolution of this system. With the use of compressor which runs on the electricity world has move to the vapour compression cycle system surpassing the absorption cycle system which is bulky, less efficient and very slow Compressor which is nothing but the motor driving pressure pump which used to flow refrigerant through the system and improve the cooling effect is ultimately discovery of the electronic field [2]. Similarly we are going to see how electronic play a vital role in different achievements of the HVAC system in new era. Before moving to the main subject we will see the how air conditioning or refrigeration system works in short note.

Whenever it is hot and we want to feel cooler, we take a bath, we suddenly start feeling better. The moisture or water on our body evaporates by taking heat from our body and makes us feel cooler. Similarly in a refrigerator there is a refrigerant i.e.HFC (Hydro Floro Carbon), HC (Hydro Carbon), Ammonia, that moves in the pipes or coils on the rear part of the refrigerator. When it is in a liquid form, it takes the heat from the refrigerator contents and evaporates to form gas there by cooling the things kept in the refrigerator. The gas is then compressed using a compressor to convert it into liquid again, and the cycle continues. The compressor uses electricity to do its job and is the most electricity consuming part of a refrigerator [1].

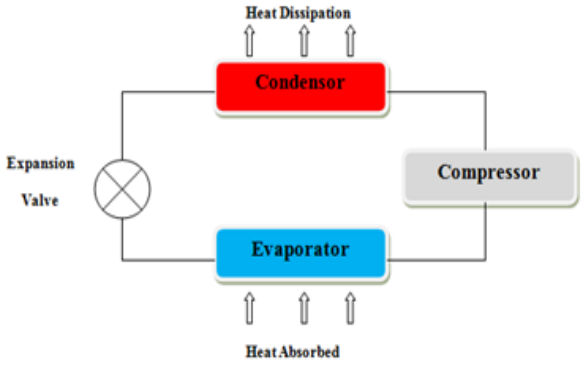

Fig. 1 Basic Refrigeration system

II. MOVING FROM MECHANICAL CONTROL TO THE ELECTRONIC CONTROL

In the mechanical control system bimetal thermostat used for the temperature sensing which makes compressor to go ON & OFF. It works as per temperature set by the user. It works on the principle of expansion and contraction of gas (which has very low boiling point i.e. R22) by heating and cooling resp., operating the adjacent switch/bimetal which further operates compressor. But thermostat has its own limitations like fixed sensing mechanism, adequacy in logic implementation, less accuracy [2].

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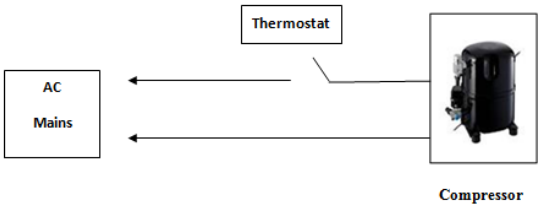

Fig. 2 Mechanical Control of HVAC system

To overcome the disadvantages of the mechanical control the electronic control system has introduced. It uses microcontroller which works as brain of the system and runs as per the logic implemented. Electronic control system consists of as said µC, Temperature sensor, User interface (UI) i.e.knob or keys and program logic [2].

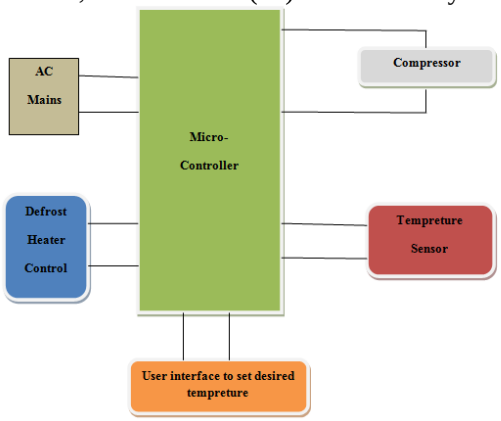

Fig. 3 Electronic control of HVAC system

With the implementation of this system we can go for different defrost algorithms depend on the uses pattern which ultimately results in the saving of the energy. System operation can be made whether/Environment friendly by sensing the ambient temperature which made system more smart and superior [2].

III. SOLAR REFRIGERATOR

Use of the Solar energy is necessary due to the fact that two billion people around the globe have no access to electricity in the first place Solar energy is ubiquitous these days. It uses photovoltaic (PV) cells to convert sunlight into electricity. When sunlight strikes a photovoltaic (PV) cell, the cell heats up. Heating the cell causes electrons to set loose, and these electrons are converted into electricity/current [6].

The Solar refrigerator works similar to traditional one, uses a vapour-compression system for cooling [6]. The difference between traditional refrigerator and a solar-powered refrigerator is that instead of running the refrigerators compression-expansion system by giving electricity through the power grid, you will have to plug it into a solar-panel setup [6]. To supply enough power to maintain required temperature, the unit's solar panel needs about five to six hours of sunlight a day. But it can store excess solar-generated power in battery backup, so it will stay cold for a week without sunlight [6].

Fig. 4 Solar Refrigerator system

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IV. INVERTER COMPRESSOR SYSTEM

Due to the use of Inverter compressor technology in today's HVAC systems results in Energy saving and improves system performance. It uses principle of variable frequency drive (VFD) for its operation [4].

A. Working of Refrigerator with traditional Compressor Technology

Most of the compressors used in refrigerators are single speed refrigerators. They are either goes On or Off depending on the temperature in the refrigerator and the settings in the thermocouple. Most of the compressors are designed to handle high load conditions (temperatures in summer), which means that it run at high load than in winters (when the cooling requirement is less). When refrigerator's door is opened, heat enters in refrigerator and the compressor has to handle this load as well. So most of the regular compressors are built to handle of high load plus the door opened case [5].

B. Working of Refrigerator with Inverter Compressor Technology

A compressor with inverter technology works in analogy with motor vehicle accelerator (When the speed required is more, the acceleration is more, and when it is less, and then the acceleration is less). In summer season load on the compressor is high and ultimately consumes more electricity but during winter season compressor need to handle fewer loads and consumes less electricity. Also in summer season as compared to day time night hours saves the electricity as compressor consumes less electricity as it runs lesser [5].

This kind of compressors remains working continuously as they requires to maintain the inside refrigerator temperature continuously. Its advantages are in an On/Off cycle of a most of refrigerator, inside temperature varies throughout but in case of inverter technology, temperature is more stable; compared to conventional technology using inverter technology refrigerator makes less noise; electricity consumption is lesser [5]. Refrigerator which uses inverter technology are costlier but reduces electricity bill and saves money [5].

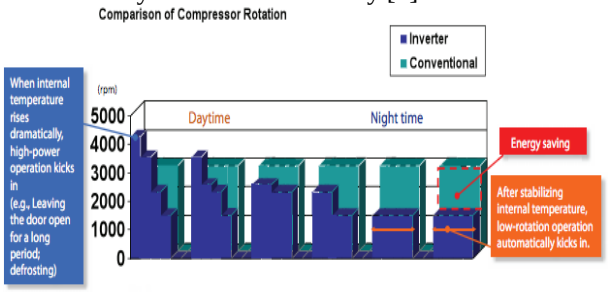

Fig. 5 Comparison of Compressor rotation in Conventional and Inverter Technology

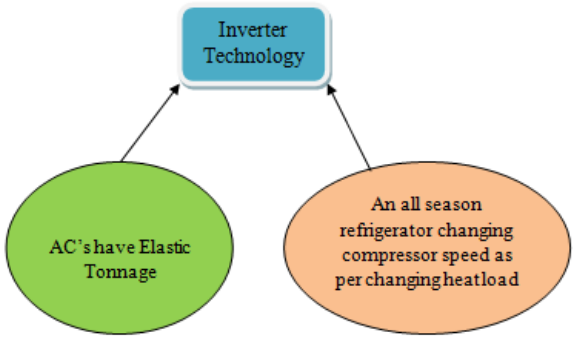

Fig. 6 Inverter Technology

Conventional motors need 3 to 4 times more current at start-up than running, so the motor size needed to run any Air-conditioner or Refrigerator increases significantly. But in Inverter Technology air-conditioners and refrigerators have variable speed motors which are start-up gradually hence needs lesser current at start-up. Thus the size of inverter/generator required at start-up is less. Example- A 1.5 ton fixed speed AC that runs at about 10 Amp current may need up to 30 Amp current at startup and thus a 5 kVA inverter/generator. But an inverter technology Air Conditioner needs about 6-7 Amp current and not much more at startup and thus a 1.5 kVA or 2 kVA inverter/generator is good enough to support it [5]. So that manufacturer can claim that his refrigerator can consume power as less as two CFL Bulbs required. 😉 [3].

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Conventional motors have much lower power factor. In commercial and industrial installations there is penalty for low power factor and rebates for higher power factor. In inverter technology refrigerator or air-conditioner motor will have power factor close to unity [5].

If solar PV is used for air-conditioner or refrigerator for air conditioning, then it is the best to use inverter technology air conditioner or refrigerator it not only reduces the size of PV panels because it consumes lesser electricity, it also reduces the size of inverter [5].

V. CONCLUSION

Role of electronic in the evolution of HVAC & R system have been described in the paper as well as refrigerator with inverter technology compressor air-conditioning system or refrigerator system and advantages have been described.

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