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Application of Variable Frequency Drive

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Abstract: By adjusting the frequency and voltage of the motor input, a variable frequency drive (VFD), a form of adjustable speed drive, may regulate the speed and torque of an AC motor. By lowering the amount of energy that motors use, VFD aids in limiting demand and electricity consumption. Smooth motor starts and energy conservation in many industrial applications are properties of VFDs. This essay aims to provide readers a fundamental grasp of how VFDs work and their advantages. This paper will also go through some fundamental VFD applications in the industrial setting.

Keywords: Variable frequency drive, Cement industry, Air conditioner, Irrigation system

I. INTRODUCTION

Drive with variable frequency is a VFD. In addition to variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro drive, and inverter, VFD can also be referred to as. It is a system that uses frequency and voltage control to regulate the speed of an electric motor. The speed of an electric motor is directly proportional to frequency. Speed may be changed to suit needs or applications by altering frequency. The output variable is readily regulated and the process is dependable thanks to VFD. There are several types of variable frequency drives, including voltage source inversion (VSI), current source inversion (CSI), and pulse width modulation (PWM). PWM-based VFDs are mostly utilized in industry since VSI has a low power factor and CSI needed a huge inductor during construction. VFD lengthens the life of the motor. Numerous applications employ VFD to reduce power consumption. The many uses for VFD are discussed in this study. Cement manufacturing is one area where VFD is used. Every step of the cement manufacturing process uses a VFD. This study discusses the necessity for VFDs in the cement industry. Conveyors need variable speed drives to regulate torque and speed. We also employ VFD in several of our household appliances. VFD is utilized in air conditioner systems to save electricity. In a document, it is explained how energy may be saved by employing VFDs. VFDs are applicable to irrigation systems. Using a VFD, it is possible to regulate the water flow in accordance with the needs. With a VFD, multi-flow pumping is feasible. There are several uses for this. There are many applications where VFD is suitable. As it saves lots of amount of energy; it is also used in many industries.

II. RELATED WORK

I] WORKING PRINCIPLE OF VARIABLE FREQUENCY DRIVE:

A variable frequency drive converts incoming 50 Hz power into DC, then converts to a variable voltage, variable frequency output. In [1] block diagram of variable frequency drive figure is mentioned.

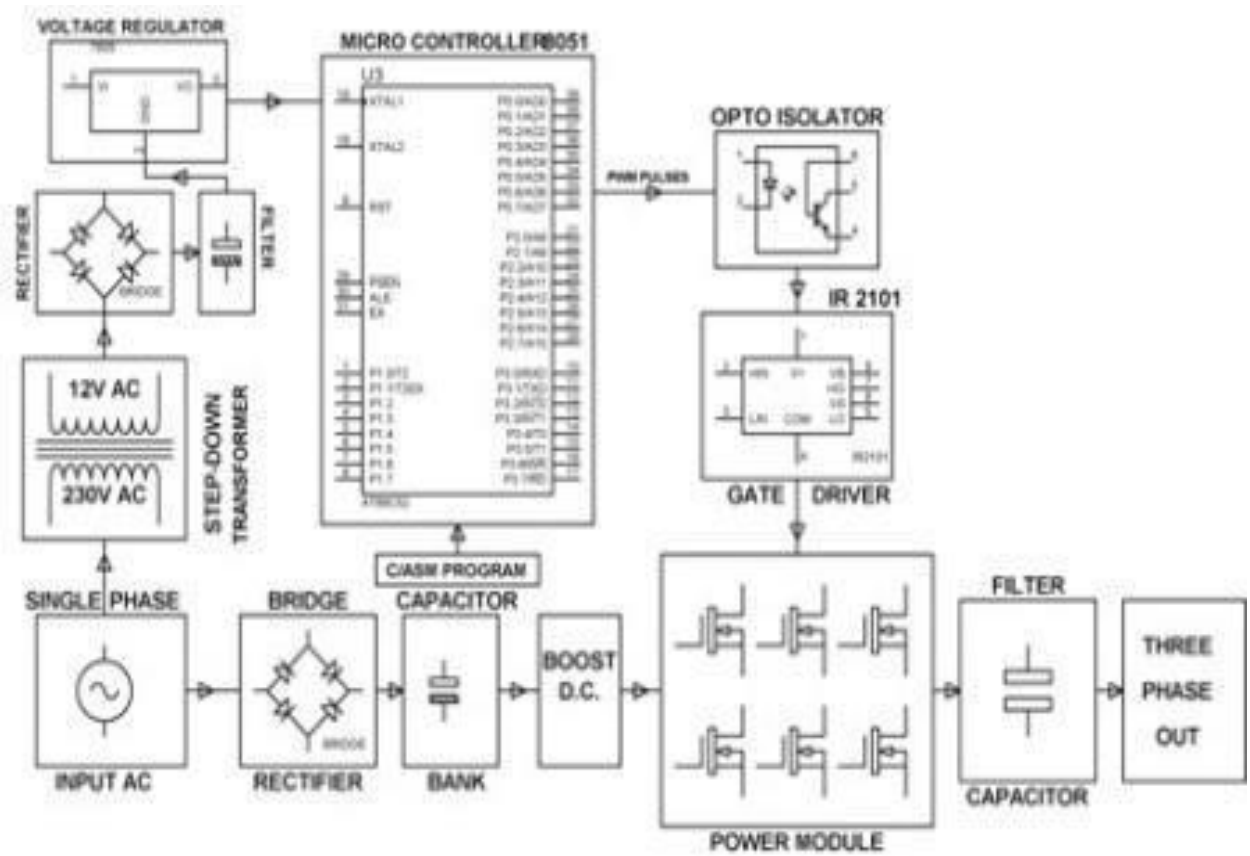

Fig. Variable Frequency Drive

Figure 1 depicts the variable frequency drive block diagram. Figure illustrates the three stages that make up the input converter, DC bus, and output inverter for a VFD. Diode bridges make up the input converter. A capacitor and an inductor make up the dc bus. IGBTs make up the output converter. Motor and output inverter are connected. The three phases of a VFD operate as follows:

Converter:

A motor controller or VFD's converter function is its initial step. Six diodes comprise the converter. The converter is provided with three phase electricity directly. Only one direction of current can be flown via a converter. When a phase voltage from L1, L2, or L3 is larger than the other two phase voltages, the diode linked to that phase voltage turns on and the same principle is applied to the diode's negative side. Six current pulses are produced at the output, hence the name "pulse 6 VFD" for this device. Building electrical systems employ 6 pulse VFDs for things like electronic ballast and uninterruptible power supply, among other things. VFD may be set up as either a 12 or 18 pulse VFD. Since 6 pulse VFD has greater harmonic distortion, 12 or 18 pulse VFD are typically employed to overcome this problem. The converter device changes the three-phase AC power flowing in to DC. 3 phase full wave Diode Bridge converter design is the most popular.

DC bus:

DC bus is the second stage of a VFD. DC buses work on the principle of eliminating ripples. The connection between the converter and inverter is the DC bus. We receive a dc signal at the rectifier circuit's output. Large numbers of ripples are present in the rectifier output, therefore the dc bus smoothes the output. Additionally, it safeguards the drive. Ripple-free DC is present at the DC bus' output.

Inverter:

Inverter is the final step of a VFD. Transistors comprise the inverter. Witches who labor for transistors. The most popular type of IGBT utilized in industry is the insulated gate bipolar transistor. If one of the top three switches is closed, the electric motor's phase will be linked to the positive DC bus, making the voltage there positive. The bottom switches operate under the same principles, and for these switches, the phase receives a negative DC bus and the voltage on that phase goes down. The phase and rotation of an electric motor may be varied by turning on switches in any order. Phase voltage may then be made positive, negative, or zero, and variable frequency is produced. Because frequency and motor speed are intimately correlated, motor speed can vary depending on the application or necessity. So an inverter is a device that converts filtered DC power into AC power, which is then supplied to an attached electric motor.

SPEED CONTROL METHODS:
The methods used to control speed of electric motors are as follows:

1) V/F control

In an electric motor, the frequency and air gap flux have a direct relationship to the voltage produced in the stator. When frequency is decreased while keeping voltage constant, air gap flux increases. This is a negative outcome. In order to change speed, we must maintain a consistent V/F ratio. The V/F method makes use of a mechanism that enables several motors to be linked to a single VFD. The advantages of V/F control approaches include low beginning current and a wide speed range. Where accurate speed regulation operator is required, V/F control mechanism is not employed.

2) V/F and an encoder

V/F with encoder is utilized to have exact speed regulation. High reference frequency is offered by the encoder. Speed regulation therefore depends on the encoder's response. However, because this approach is expensive, it is not frequently employed.

3) V/F control using an open loop

In industries, open loop V/F control is utilized to provide dynamic speed response. This approach involved simultaneous changes in stator voltage and frequency. The flow of the air gap is constant. V/f ratio does not change as frequency and voltage change simultaneously.

4) V/F control in a closed loop

The feedback mechanism is utilized in closed loop V/F control. The measured and reference speeds of the electric motor are contrasted. Voltage and frequency are adjusted to maintain a consistent V/F ratio in accordance with the difference between the two speeds. Electric motor speed is measured using a sensor, and the frequency is changed using a frequency controller. Proportional controllers are typically employed. By adjusting the width of a fixed signal, the aforementioned control methods employ pulse width modulation to modify speed. Frequency may be changed by changing the breadth of a given signal. PWM gives the transistors or switches utilized in the inverter block's firing angle. The triangle wave is compared to the reference signal using PWM to produce the firing angle. PWM-based generators predominate in industries.

III. APPLICATIONS OF VARIABLE FREQUENCY DRIVE

1] Variable frequency drive in cement industry

Clay and limestone are the two main components of cement. These substances are combined after being ground into a fine powder. Every step of the cement manufacturing process uses a VFD. The speed of fans, mills, conveyors, etc. is managed by VFD. Efficiency in speed control, minimal power losses, energy savings, low pollution, and large economic savings are all results of the control process using variable frequency drives.

1) The process of manufacturing cement is depicted in the following figure.

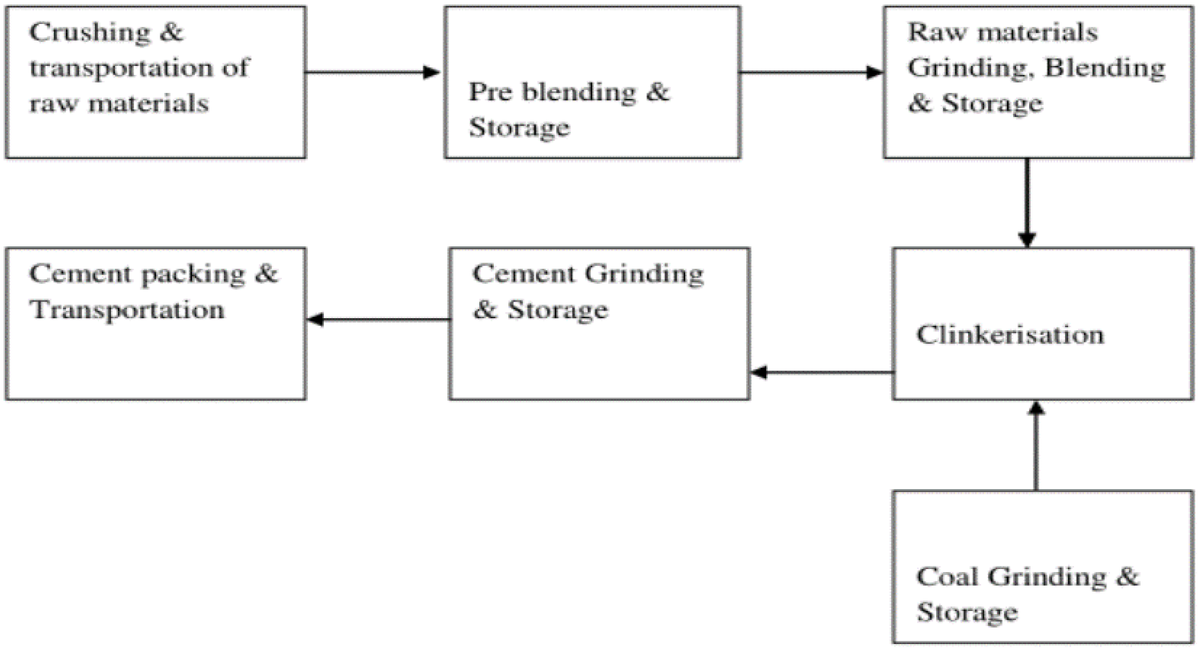

Fig.2 Block diagram of Cement making Process

Block schematic of cement manufacturing process is shown in Fig. 2. Limestone and clay are the primary basic materials used to make cement. As illustrated in the diagram, there are many processes in the cement-making process. Crushing, preliminary mixing, and grinding of raw ingredients are these processes. To stop additional chemical reactions, clinkerization is the process of cooling. Cement undergoes its final grinding after clinkerization. Cement transportation is the final stage in the production of cement. Parts make up the cement industry's total process. There are two portions, as follows:

1. Induced Draft Fan for Cement Kiln
2. Conveyors

1. Induced Draft Fan for Cement Kiln

Throughout the operation, it is necessary to maintain control over the process requirements. Previously, speed was controlled using dampers, vanes, and variable slip clutches. However, they have drawbacks including excessive power consumption and ongoing maintenance. VFD is utilized to get around this problem. The benefits of the cement business are discussed in [2].

i Upkeep of a constant operating temperature, less fan noise, and preservation of priceless floor space in the plant.

ii The ID fan may have a power of several thousand horsepower, and controlling airflow with a drive can save a lot of energy.

The fan RPM is optimized by the VFD so that it perfectly matches the system operating circumstances.

2. Conveyors

Both raw and finished materials are handled by conveyor. Conveyors are continually utilized during the cement manufacturing process, increasing the likelihood of a conveyor breaking down. It raises the expense of operations. Extending the belt's lifespan and availability is crucial for lowering operational expenses. Conveyors may be accurately torqued and speeded up using variable speed drives. This lessens the strain on mechanical equipment, particularly at start-up and stopping but also during operation and maintenance, such as gearboxes, pulleys, and belts. The conveyors' speed may be adjusted using a VFD to meet production capacity, reducing wear and maximizing energy efficiency. Run the engine for maintenance checks, belt replacements, repairs, or to prevent ice buildup.

2] Variable frequency drive in air conditioner

The output flow of a centrifugal pump or fan is directly proportional to its speed, the output pressure is directly proportional to the square of the speed, and the output power is directly proportional to the cube of the speed, according to the theory of fluid mechanics. From this, it is clear that altering the speed of the pump and fan will allow us to change the output power of both devices. Cooling water system closed-loop control block is a feature of the air conditioning system. With a maximum temperature differential of 5°C, the standard circulating water temperature for the system is 12°C intake and 7°C outflow. If there is a 3°C temperature differential between the intake and outflow, the supply is really needed at a rate of 3°C/5°C, or 60%. ByBy using VFD we can control speed of the pump to 60% of its rated speed which ultimately saves the energy.

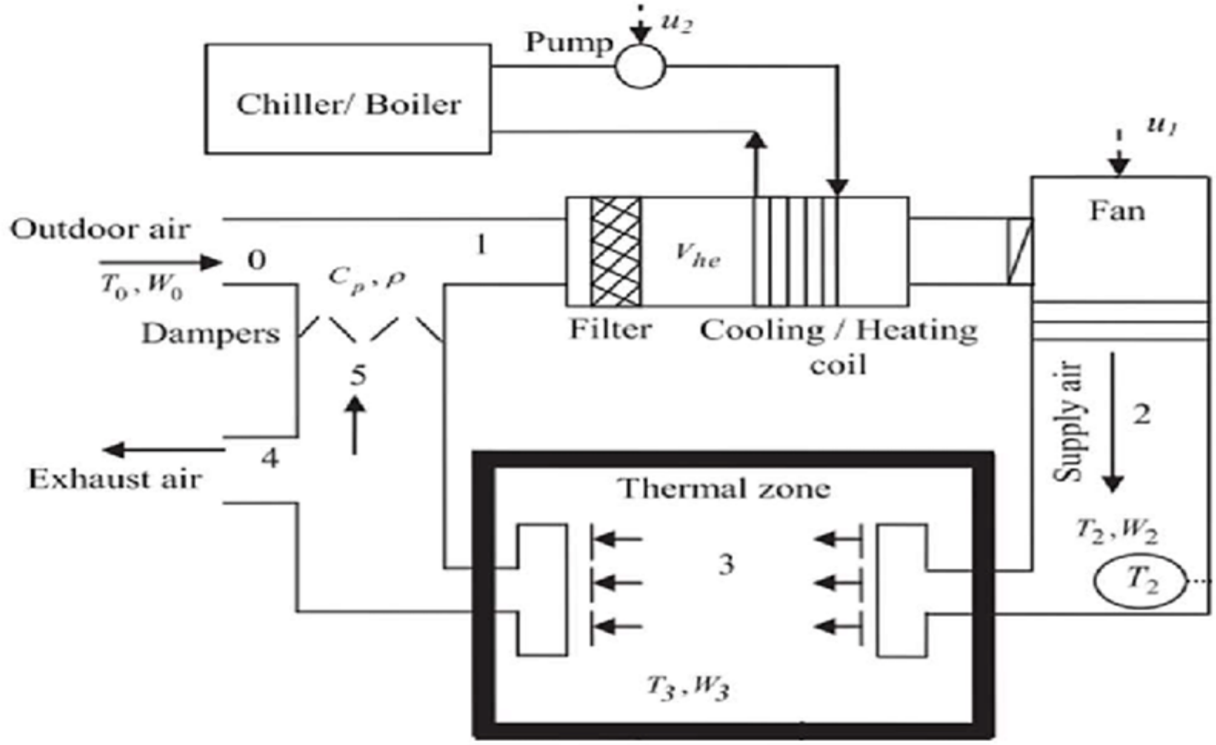

Fig.3 Block diagram of air conditioner system using VFD

Display, Microcontroller, electrical power, refers to temperature gates driver circuit Keyboard and induction motor. Utilizing VFD (seven level inverters) is one approach to conserve energy in an air conditioning system. It is indicated in [3] that the system's block diagram. The rectifier circuit receives 230V of ac power from this source. By using a rectifier circuit, ac is changed into dc. The induction motor receives this controlled dc voltage, which is then sent to the seven-level inverter that generates pure sine waves. The PWM sequences are generated by the microcontroller using the temperature information that has been provided. The phase controlled rectifier and seven-level inverter's output are the only ones that the PWM sequences, in turn, regulate. To properly operate the switches in the gate driver circuit, In turn the PWM sequences only control the output of the phase controlled rectifier and Seven- level inverter. Gate driver circuit is used to efficiently drive the switches in the phase controlled rectifier and Seven-level inverter. LCD is used to display the current and set temperature [3].

3] Variable frequency drive in irrigation system

VFD aids farmers in irrigation applications by enabling them to regulate or change the flow's pressure in accordance with their needs. Various flow variances can be controlled.

One pump, several head duty points

A VFD may be used to irrigate various regions with various water flow needs. Most irrigation systems, including micro/drip, sprinkler, and center pivot, may be equipped with VFDs. The irrigated area can be split into a number of zones in fixed block systems, such as micro irrigation, and each zone may have a distinct pressure demand. For instance, if different zones require various pressure levels, the VFD will adjust the pump speed to meet the demands of the valves as they function in their respective zones.

III. CONCLUSION

VFD aids in energy conservation in several applications. It is a tool for power conversion. It transforms a fundamental fixed frequency into an output with variable voltage and frequency. Induction motor speed is managed by this set output voltage. A VFD's main purpose in an aquatic application is to save energy. Energy savings can be significant when flow is controlled by throttling valves rather than a pump's speed. Without the need of a separate controller, a VFD is utilized to manage process temperature, pressure, or flow. Appropriate sensors and electronics are employed to link driven equipment with the VFD. Additionally, maintenance expenses can be reduced since motors and bearings last longer when used at lower speeds.

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