Modernization Automation of Sinter Plant by the Replacement of DC Motors/Drives with TEFC AC Motors/ Drives with VFD Control

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Abstract

Till now DC Motors/drives are used for sinter plant processing. Now we are replacing DC motors/drives by TEFC (totally enclosed fan cooled) AC motors/drives with the use of variable voltage variable frequency control for modernization and automation of sinter plant in BSP (Bhilai steel plant).

Sinter plant agglomerate iron ore fines with other fine materials at high temperature to create a product that can be used in a blast furnace. In this research paper, motor drives, AC drives, DC drives, why AC drives over DC drives, sinter plant operation, VFD control are described.

Keywords- AC drives, totally enclosed fan cooled, sinter plant, variable frequency drive,

1. Introduction

When Tesla first introduced the three phase alternating current induction motor in 1988 he knew that his invention was more efficient and reliable than Edison's direct current. In the past many years DC drives are used for the speed control of motors but now all the industries replacing DC drives with AC drives and using VFD control for controlling the speed and torque of the motor. So we will describe why AC drives are used over DC drives in sinter plant in Bhilai steel plant and other industries and what is sinter plant, AC drives with VFD control, why TEFC motor is used. Most of the drives used in the industrial motor control are electrical. Depending upon the application, some of them are fixed speed and some are variable speed. The variable speed drives had various limitations such as poor efficiencies, larger space, lower speed, etc,. However, the advent of power electronics transformed the scene completely and today variable speed drive which are not only constructed smaller in size but also obtained very efficient and higher reliable, etc. There are

probably more single phase induction motors in use today than all of the other types put together. It is logical that the least expensive, lowest maintenance type motor should be used most often. The single phase induction motor best fits this description. The induction motor can run only at its rated speed when it is connected to the main supply. However, they are constant motor.

To control the speed of these motors, a motor drive and a control system with different methods can be used. So we are using solid state control.

Over the past several years there have advances in solid state control technology and how it can be used to control motors. solid state control are usually very reliable, can give exact speeds and are becoming more economically feasible to use with fractional horse power motors.

Most of different styles of solid state controls incorporate the varying of the frequency to control the motor speed. They can vary the frequency to be higher than the normal line frequency, meaning the speed can be increased beyond what the motor is rated for. Moreover they are simple to implement and cost effective.

2. What is Sinter Plant

"Sinter plant agglomerate iron ore fines (dust) with other fine materials at high temperature to create a product that can be used in blast furnace"

The final products, a sinter is a small, irregular nodule of iron mixed with small amounts of other minerals and the process called sintering. The purpose of sinter plant is to be used converting iron into steel. About 70% of the world's primary lead production is still producing steel using sinter plant. The sintering technology was developed for the treatment of the waste fines of iron ore, coke, limestone, dolomite and metallurgical waste.

Uses of sinter in blast furnace operation

1. Improve productivity of the blast furnace
2. Minimizing the coke (fuel) consumption.
3. It is self fluxed.
4. CaO (from lime stone) and MgO (from dolomite) in sinter, eliminate the direct feeding of flux which minimize the cost of hot metal.

3. AC Drives

The AC drive industry is growing rapidly and it is now more important than ever for technicians and maintenance personnel to keep AC drive installation running smoothly. Ac drives change the speed of AC motor by changing voltage and frequency of the power supplied to the Ac motor. In order to maintain proper power factor and reduce excessive heating of the motor, the name plate volts/hertz ratio must be maintained. This is the main of VFD.

AC drives basic working principle.

1. AC drives are used to step less speed control of squirrel cage induction motors mostly used in process plants due to its ruggedness and maintenance free long life.
2. AC drive control speed of ac motor by varying output voltage and frequency through sophisticated microprocessor controlled electronics device.
3. AC drive consists of Rectifier and inverter units. Rectifier converts AC in DC voltage and inverter converts DC voltage back in AC voltage.

AC drive Operation Principle

For understanding the basic principles behind AC drive operation requires understanding three basic section of AC drive: the Rectifier unit, DC Bus and the Inverter unit.

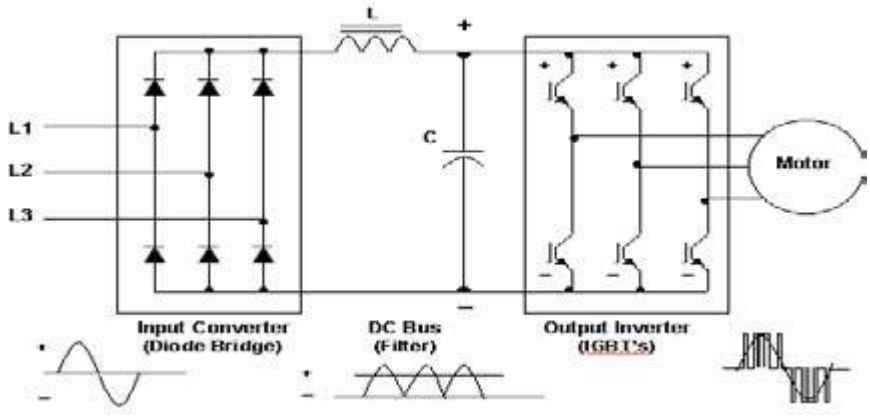

Figure1. AC drive operation principle

the supply voltage is firstly pass through a rectifier unit where in gets converted into AC to DC supply, the three phase supply is fed with three phase full wave diode where it gets converts into DC supply. The DC bus comprises with a filter section where the harmonics generated during the AC to DC conversion are filtered out. The last section consists of an inverter section which comprises with six IGBT where the filtered DC supply is being converted to quasi sinusoidal wave of AC supply which is supply to the AC motor which is connected to. From the AC motor working principle, we know that the synchronous speed of motor (rpm) is dependent upon frequency. Therefore by varying the frequency of the power supply through AC drive we can control the synchronous motor speed.

Speed (rpm) = Frequency (Hertz) x 120/No. of poles

Where:
Frequency= Electrical Frequency or the power supply in Hz. No. of poles = Number of electrical poles in the motor stator.

Thus we can conveniently adjust the speed of an AC motor by changing the frequency applied to the motor. There is also another way to make the ac motor work on different speed

by changing the no. of poles, but this change would be a physical change of the motor. As the VFD provides the frequency and voltage of output necessary to change the speed of a motor, this is done through Pulse Width Modulation VFDs. Pulse width modulation (PWM) variable frequency drive produces pulses of varying widths which are combined to build the required waveform.

Constant V/F Ratio Operation

All AC drives maintain the output voltage - to - frequency (V/f) ratio constant at all speeds for the reason that follows. The phase voltage V, frequency f and the magnetic flux ϕ of motor are related by the equation:

$V = 4.444\ f\ N\ \phi m$
or
$V/f = 4.444 \times N\ \phi m$
Where N = number of turns per phase.
ϕm = magnetic flux

If the same voltage is applied at the reduced frequency, the magnetic flux would increase and saturate the magnetic core, significantly distorting the motor performance. The magnetic saturation can be avoided by keeping the ϕm constant. Moreover, the ac motor torque is the product of stator flux and rotor current. For maintaining the rated torque at all speeds the constant flux must be maintained at its rated value, which is basically done by keeping the voltage - to - frequency (V/f) ratio constant. That requires the lowering the ac motor voltage in the same proportion as the frequency to avoid magnetic saturation due to high flux or lower than the rated torque due to low flux.

4. How AC Drive Controls Motor Speed

As the AC drive provides the frequency and voltage of output necessary to control the speed of an AC motor, this is done through PWM VFDs. PWM drives produce pulses of varying widths which are combined to build the required waveform. A diode bridge is used in some converters to reduce harmonics. PWM drives produce a current waveform that more closely matches a line source, which reduces undesired heating. PWM VFD have almost constant power factor at all speeds which is closely to unity. PWM drives can also motors on a single VFD.

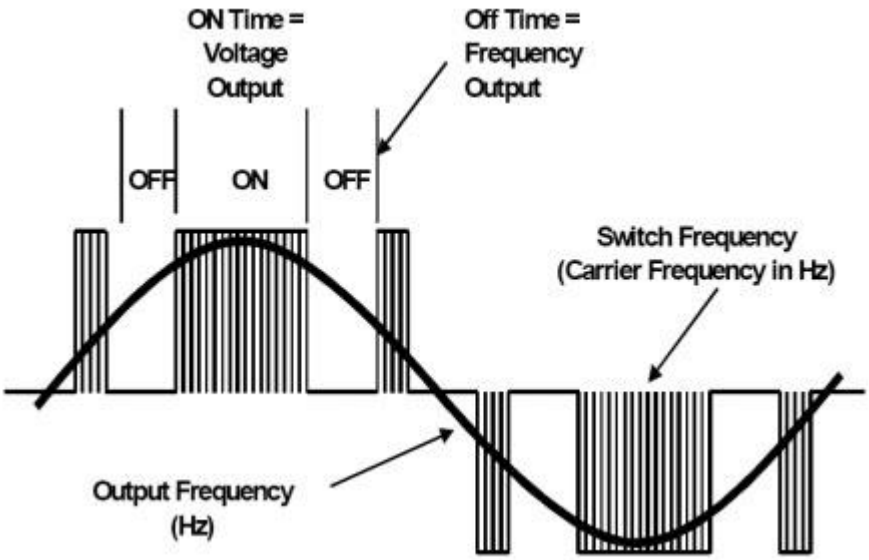

Figure2. PWM in VFD

Thus the carrier frequency is derived from the speed of the power device switch remains ON and OFF. It is also called switching frequency. Therefore higher the carrier frequency higher the resolution for PWM contains. The typical carrier frequency ranges from 3KHz to 4 KHz or 3000 to 4000 times per second as compared with older SCR based carrier frequency which ranges from 250 to 500 times per second. Thus it is clear as much as higher the carrier frequency higher will be the resolution of output waveform. It is also noted that the carrier frequency decreases the efficiency of the VFD because it led to increase the heat of the VFD circuit.

5. Benefits of AC drive

- Large energy savings at lower speed.
- Increased life of rotating components due to lower operating speed.
- Reduced noise and vibration level.
- Reduction of thermal and mechanical stresses.
- Lower KVA
- High power factor

6. AC drives in Sinter plant

Application of AC drive has reduced the maintenance expenses and a large amount of power is saved. Sinter plant is in the primary area of steel plant and mostly uses AC motor of 4MW.The process of manufacturing steel products from iron ore involves raw material preparations, primary reduction, refining, casting, hot and cold rolling, surface coating etc. The motors used in primary area (coke oven, blast furnace, steel melting shop) do not require speed regulation of high order. On the other hand motor used in finishing mills require speed regulation of high accuracy.

7. Applications:

1. AC drives for crane uses slip ring induction motor.
2. AC drives for rolling stand motor- AC synchronous motor.
3. Ac drives requirement for large machine- synchronous motors is used in exhauster and compressor.

8. TEFC (totally enclosed fan cooled) AC motor

Totally enclosed fan cooled AC motor is a type of industrial electrical motor with an enclosure that does not permit outside air to freely circulate through the interior of the motor. An external fan blows outside air over the frame of the motor to cool it. It cost more than open motors but offers increased protection against weather, dirt and moisture. TEFC motors are constructed with a small fan on the rear shaft of the motor, converted by a housing. This fan forces air over the motor frame fins, and cools the motor. The enclosure is totally enclosed. This means the motor is dust tight, and has a moderate water seal as well. TEFC motors are not secure against high pressure water nor submersible. They are also not explosion proof without additional modification.

Table1. Advantage of AC drive over DC drive

Ac Drives	Dc Drives
1. It has less moving parts.	1. It has many moving parts that are expensive to replace.
2. It is more economical and less expensive.	2. It is less economical and more expensive.
3. Power/Weight ratio is large.	3. Power/Weight ratio is too small.
4. AC motors are smaller, lighter, more commonly available and less expensive than DC motor.	4. A DC electric motor repair is usually more expensive than using a new AC electric motor with an electric convertor.
5. Speed and design rating have no upper limit.	5. Speed and design rating are limited due to communication.

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