AN OVERVIEW ON ENGERGY EFFICIENT ELECTRIC DRIVES

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Abstract— **The electric motor drives are very important in our everyday life. In the area of industry or other purpose, the electric drives of motor are essential.So in this topic we are discussing the different types of electric drives namely, AC Drives and DC Drives. This paper also discusses about the most efficient drive which is commonly used in industries and its impacts. The advantages, disadvantagesand its applications are also explained in this paper**

I. INTRODUCTION

An electric motor is an electric machine that converts electrical energy into mechanical energy. The reverse conversion of mechanical energy into electrical energy is done by an electric generator. Whenever the term electric motor or generator is used, we tend to think that the speed of rotation of these machines are totally controlled only by the applied voltage and frequency of the source current. But the speed of rotation of an electrical machine can be controlled precisely also by implementing the concept of **drive**. The main advantage of this concept is the motion control is easily optimized with the help of drive. In simple words, the system which controls the motion of the electrical machines, are known as **electrical drives**. A typical drive system is assembled with an electric motor (may be several) and a sophisticated control system that controls the rotation of the motor shaft. Now a days, this control can be done easily with the help of software. So, the controlling becomes more and more accurate and this concept of drive also provides the ease of use. This drive system is widely used in large number ofindustrial and domestic applications, factories, transportation systems, textile mills, fans, pumps, motors and in robots.

Drives are employed as prime movers for diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors.In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes also to produce electrical energy from mechanical energy.

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In this paper we are discussing the different types of electrical drives such as ACdrives, DC drives and other drives with advantages, disadvantages and applications.

II. WHY WE CONSIDER ELECTRIC DRIVES?

The answer is simple.We use electric drives as there is no tailpipe emissions, hence effects of air pollution and global warming are reduced,electricity used is produced domestically,renewable sources can be used to generate the electricity needed anddomestically produced electricity increases energy independence.What are the advantages of electric drives? Its advantages includes,best of both electric and conventional systems,range and efficiency can be improved,EVs and conventional vehicles are essentially driven in the same manner,all-electric systems do not produce any emissions (use grid power),Increased use = decreased reliance on foreign oil,low maintenance costs.All-electric vehicles (or BEVs) do not produce any of the typical emissions or pollutants associated with transportation. In fact, some environmental agencies refer to this type of vehicle as a "zero-emissions vehicle". An example of this is the Nissan Leaf. PHEVs and BEVs can use the existing electrical grid for charging at this point since the electric distribution network is nationwide.

III. BASIC COMPONENTS OF ELECTRIC DRIVE SYSTEM

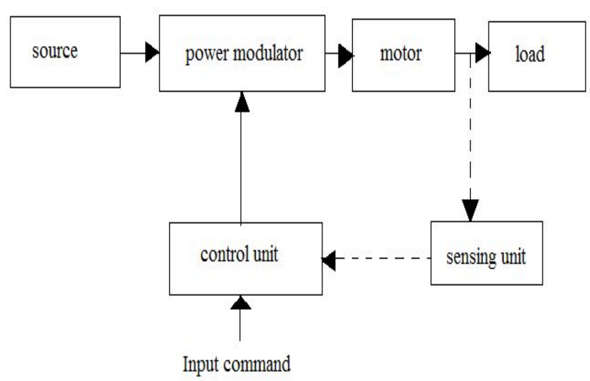

Fig 1.Basic components of an electric drive system

The electric drive system has five main functional blocks namely, a power source, PowerModulator(Converter), a motor, a mechanical load and a Controller(which incorporates sensing unit and control unit).

- The power source provides the required energy to the electric drive system. The converter interfaces the motor with the power source and provides the motor with adjustable voltage, current and frequency.

- The controller monitorsthe operation of the entire system and ensure the overall system performance and stability. The ratings of mechanical load and type of power source is not in our decision.
- The mechanical loads are determined by the nature of the industrial operation and the power source is determined by what is available at the site. But we can select the other components like electric motor, converter and controller.
- The function of converters is to convert the electric waveform of the power source to a waveform that the motor can use. For example, the available power source is AC and the motor is DC series motor, then the converter converts AC into DC. In other words, a rectifier circuit is placed in the system.
- The motor for the particular application is selected by considering various factors like cost, meeting the power level and performance required by the load during steady state and dynamic operations.

IV. TYPES OF DRIVES

1) AC DRIVES

With modern power electronics and advanced microprocessor technology, Delta's AC Motor Drives are able to efficiently control motor speed, improve machine automation and save energy. Taking advantage of our strong position in power electronics technology, Delta's VFD Series of AC motor Drives has evolved rapidly. Each Drive series is designed to meet specific application needs. Our AC Drives accurately control speed and torque, smoothly handle an increased load, and provide numerous custom control and configuration operating modes. Our AC Motor Drive product line provides a full range of motor control technologies and is used throughout a wide range of industries, to enhance and improve machine automation.

Variable-Frequency Drive (VFD)

A variable-frequency drive (VFD) (also termed adjustable-frequency drive, variable-speed drive, AC drive, micro drive or inverter drive) is a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage.

VFDs are used in applications ranging from small appliances to the largest of mine mill drives and compressors. However, around 25% of the world's electrical energy is consumed by electric motors in industrial applications, which are especially conducive for energy savings using VSDs in centrifugal load service, and VFDs' global market penetration for all applications is still relatively small. This highlights

Especially, significant energy efficiency improvement opportunities for retrofitted and new VFD installations.

Over the last four decades, power electronics technology has reduced VFD cost and size and improved performance through advances in semiconductor switching devices, drive topologies, simulation and control techniques, and control hardware and software

Drive operation

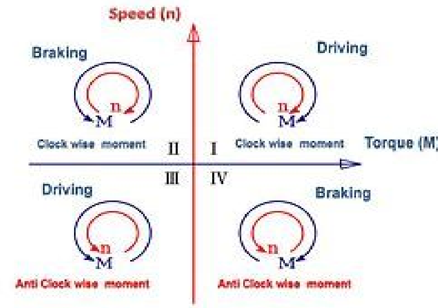

Fig 2.Electric motor speed-torque chart

Referring to the accompanying chart, drive applications can be categorized as single-quadrant, two-quadrant or four-quadrant; the chart's four quadrants are defined as follows:

- Quadrant I - Driving or motoring forward accelerating quadrant with positive speed and torque
- Quadrant II - Generating or braking, forward braking-decelerating quadrant with positive speed and negative torque
- Quadrant III - Driving or motoring, reverse accelerating quadrant with negative speed and torque
- Quadrant IV - Generating or braking, reverse braking-decelerating quadrant with negative speed and positive torque.

Most applications involve single-quadrant loads operating in quadrant I, such as in variable-torque (e.g. centrifugal pumps or fans) and certain constant-torque (e.g. extruders) loads.

Certain applications involve two-quadrant loads operating in quadrant I and II where the speed is positive but the torque changes polarity as in case of a fan decelerating faster than natural mechanical losses. Some sources define two-quadrant drives as loads operating in quadrants I and III where the speed and torque is same (positive or negative) polarity in both directions.

Certain high-performance applications involve four-quadrant loads (Quadrants I to IV) where the speed and torque can be in any direction such as in hoists, elevators and hilly conveyors. Regeneration can only occur in the drive's DC link bus when inverter voltage is smaller in magnitude than the motor back-EMF and inverter voltage and back-EMF are the same polarity.

In starting a motor, a VFD initially applies a low frequency and voltage, thus avoiding high inrush current associated with direct on line starting. After the start of the VFD, the applied frequency and voltage are increased at a controlled rate or ramped up to accelerate the load. This starting method typically allows a motor to develop 150% of its rated torque while the VFD is drawing less than 50% of its rated current from the mains in the low speed range. A VFD can be adjusted to produce a steady 150% starting torque from standstill right up to full speed. However, motor cooling deteriorates and can result in overheating as speed decreases such that prolonged low speed motor operation with significant torque is not usually possible without separately-motorized fan ventilation.

With a VFD, the stopping sequence is just the opposite as the starting sequence. The frequency and voltage applied to the motor are ramped down at a controlled rate. When the frequency approaches zero, the motor is shut off. A small amount of braking torque is available to help decelerate the load a little faster than it would stop if the motor were simply switched off and allowed to coast. Additional braking torque can be obtained by adding a braking circuit (resistor controlled by a transistor) to dissipate the braking energy. With a four-quadrant rectifier (active-front-end), the VFD is able to brake the load by applying a reverse torque and injecting the energy back to the AC line.

AC drive characteristics:

• AC drives utilize a solid-state adjustable frequency inverter which adjusts frequency and voltage for varying the speed of an otherwise, conventional fixed speed AC motor. This is achieved through Pulse-Width Modulation (PWM) of the drive output to the motors.

• Voltage and frequency are maintained at a constant relationship at any motor speed to maintain a constant torque. This is known as the volts per hertz ratio.

• Integrated drive/motor packages available.

2)DC DRIVES

DC SRC/thyristor drives and motors remain common in industries, such as metals, cranes, mining and printing. The current trend is to replace DC systems with new AC drives and motors to reduce maintenance overheads, however, this can often be a significant task that requires the machinery to be taken out of service for an extended period while mechanical and electrical rework is undertaken.

Utilizing the existing DC motor and upgrading the DC drive is often the most attractive option. DC motors are usually well built and capable of offering many more years of service, the project costs are usually much lower and the disruption and risks are minimized. Modern DC drives also provide many benefits, Control Techniques DC drives are based on our current AC drive technology, as they offer enhanced motor performance, reliability and system integration options.

DC drive characteristics:

• DC drives utilize a converter to transform AC current into DC current which is then fed to the DC motor which is designed foradjustable speed operation. Speed changes are made by increasing or decreasing the amount of DC voltage fed to the motor from the drive.

• Usually offer the lowest cost for medium and high HP Applications.

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Comparison between DC and AC drive motors:

• DC require maintenance, heavy, expensive, speed limited by mechanical construction

• AC less maintenance, light, cheaper, robust, high speed (esp. squirrel–cage type)

Control unit

• DC drives: Simple control – decoupling torque and flux by mechanical commutator – the controller can be implemented using simple analog circuit even for high performance torque control –cheaper.

• AC drives, the types of controllers to be used depend on the required drive performance –obviously, cost increases with performance. Scalar control drives technique does not require fast processor/DSP whereas in FOC or DTC drives, DSPs or fast processors are normally employed.

Performance:

• In DC motors, flux and torque components are always perpendicular to one another. The torque is controlled via the armature current while maintaining the field component constant. Fast torque and decouple control between flux and torque components can be achieved easily.

• In AC machines, in particular the induction machines, magnetic coupling between phases and between stator and rotor windings makes the modeling and torque control difficult and complex. Control of the steady state operating conditions is accomplished by controlling the magnitude and the frequency of the applied voltage; which is knownas the scalar control technique. This is satisfactory in some applications. The transient states or the dynamics of the machine can only be controlled by applying the vector control technique whereby the decoupling between the torque and flux components is achieved through frame transformations. Implementation of this control technique is complex thus requires fast processors such as Digital Signal Processors (DSPs).

BLDC motor drives:

Brushless DC motors (BLDC), or electronically commutated motors (ECMs) have become more relevant in today's environment where efficiency and minimizing power losses are a key objective of designs in all markets. Brushless DC motors provide significant improvements in efficiency, mechanical reliability, and offer superb torque-to-weight properties.

Allegro Microsystems plays a key role in enabling brushless DC motor adoption by simplifying the complexities of electronic commutation. Allegro offers a range of products targeted at BLDC applications which span the industrial, consumer, and automotive markets. Depending on the needs of a given application, Allegro products can offer integrated features such as:

Self-commutating six-step / trapezoidal state machine with Hall sensor inputs

Sensor less and sinusoidal commutation

Back EMF sensing capability

Automotive grade ICs with diagnostics and robust protection features.

V. CLASSIFICATION OF ELECTRIC DRIVES

Generally classified into 3 categories:

I. Group drive

II. Individual Drive

III. Multimotor Drive

1. GROUP DRIVE:

If several group of mechanisms or machines are organized on one shaft and driven or actuated by one motor, the system is called a group drive or shaft drive.

Advantage:

Most Economical

Disadvantage:
1. Any Fault that occurs in the driving motor renders all the driving equipment idle.
2. Efficiency low because of losses occurring in the energy transmitting mechanisms (Power loss)
3. Not safe to operate.
4. Noise level at the working spot is high.
5. Flexibility.
Single motor drives a no of machines through belt form common shaft.

2. INDIVIDUAL DRIVE:
1. If a single motor is used to drive or actuate a given mechanism and it does all the jobs connected with this load, the drive is called individual drive.
2. All the operations connected with operating a lathe may be performed by a single motor.
3. Each motor is driven by its own separated motor with the help of gears, pulleys etc.

Disadvantage:
Power loss occurs.

3. MULTI MOTOR DRIVE:
1. Each operation of the mechanism is taken care of by a separate drive motor.
2. The System contains several individual drives each of which is used to operate its own mechanism.
3. Separate motors are provided for actuating different parts of the driven mechanism.

Advantage:
1. Each Machine is driven by a separate motor as it can be run and stopped as desired.
2. Machines not required can be shut down and also replaced with a minimum of dislocation.
3. There is a flexibility in the installation of different machines.
4. In the case of motor fault, only its connected machine will stop where as others will continue working undisturbed.
5. Absence of belts and line shafts greatly reduces the risk of accidents to the operating personnel.

Disadvantage:
Initial cost is high.

VI. COMMONLY USED ENERGY EFFICIENT ELECTRICAL DRIVE IN INDUSTRIES

In industrial plants, drives account for just under 70 % of the electrical energy requirement. By installing inverters and high efficiency motors, 43 TWh of energy could be saved in the European Union alone – this equates to electricity costs of at least 3 billion euros or the energy generated by 19 fossil-fuel fired power plant units. Electric drives represent almost two thirds of the total industrial power demand. First, the bad news: As energy prices rise, this cost factor will have an increasingly negative impact on production costs. Now the good news: Almost every company can tap into an enormous energy saving potential. The reason for this is that up to 70 % energy saving is possible using energy-efficient drives, especially in areas requiring a large amount of energy. In drive technology, operating costs are comparatively high in relation to the procurement costs. To illustrate: Operation accounts for 97 % of the life cycle costs of a motor, of which the energy costs are usually by far the highest cost factor. Enormous potential for saving is just waiting to be harnessed. The biggest potentials for saving are offered by pumps, fans, and compressors that are still operated with mechanical throttles and valves. Converting to variable-speed drives can produce considerable economic benefits.

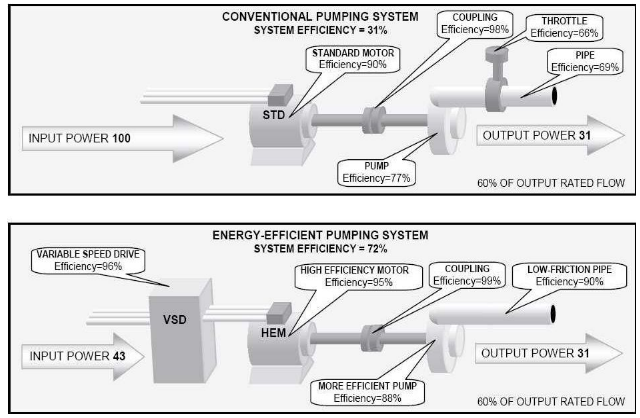

Fig 3.Comparison of a typical and an energy efficient pump system

VII. VARIABLE SPEED DRIVES (VSDS)

In applications where the motor is required to serve a variety of load conditions or has a continuously variable demand, an effective solution for reducing energy consumption is to adjust the speed of the motor to the process demands by equipping it with a VSD. In addition to the energy saving opportunities VSDs offer further benefits including:Improved process control (and hence output quality),the ability to control more than one motor. VSDs are particularly beneficial in variable torque load applications such as fans and pumps where the output is controlled by other means such as inlet or outlet throttling, or damper adjustment. For example, savings of up to 50% of energy use are achievable by reducing the fan or pump motor speed by 20%. VSDs are usually more expensive than simple motor controls, however in some applications when applied correctly they can payback in less than two years. VSDs can also be beneficial in constant torque load applications such as screw or reciprocating compressors, conveyors, grinders, mills or mixers where output varies. Variable speed is obtained with frequency and voltage power converters, usually of indirect type with DC circuit, called voltage source inverters (VSI). Power electronics converters are also consumers of reactive energy, because of switches nonlinearity. So, in indirect frequency converters the rectifier consumes reactive power from the grid and reactive power is generated in the circuit of the inverter and the motor, because DC circuit does not cross reactive power. The solution of these problems is in using condenser banks and filters, passive or active. However, consumption of reactive and disturbance energy in power converters is neglected. Objectively this consumption exists and it is approximately a few percentage of the active energy consumption, without costs for condenser banks and filters.
Adjustable speed drives can increase system efficiency and improve system reliability. For example, in many conveyor systems, lines are controlled by energizing and de-energizing

a series of motors. These frequent starts and shutdowns are tough on motors and line components because of repeated stresses from starting currents and acceleration and deceleration of mechanical components. Using variable speed drives can smooth out line motion for more efficient and effective operation. Another common method of controlling speed is to use induction motors combined with VFDs. Induction motors are widely used in industrial applications because of their inherent advantages in terms of cost, reliability, availability, and low maintenance requirements. Mechanics and operators are usually familiar with these motors, which facilitate repair and maintenance tasks. It is strongly recommended that individuals orcompanies installing VFDs secure the services of a professionalspecialist qualified in VFDs in order to understand andmaximize the available benefits.

CONCLUSION

In this topic we discussedthe need of the electric drives, types of drives such as AC drives, DC drives, etc., its advantagesand general classification such as group drive,individual drive, multi drive and its application. These topics help to understand the general idea of electric drives, its importance .This paper also discussed about the most efficient electrical drive which is most widely used in industrial applications.

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