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Interfacing and Commissioning of Motor and Drive to the Tandem test jig

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Abstract
The motors and drives have wide applications from servos to traction and it is mainly used in automation industry, CNC machines and robots. The application of interfacing and commissioning of motor and drive to the tandem test jig helps to achieve improved reliability and cost effectiveness. This paper mainly describes how motors and drive system is interfaced to tandem test jig.BG605 motor grader vehicle is used for grading operation and bank cutting operation of roads. Tandem is a part of BG605 Motor grader equipment and it is used for transmission of power in the equipment. Testing of the tandem before assembling on to the vehicle is very much essential.
Keywords: BG605 Motor Grader, Tandem equipment, Variable frequency drive, AC Motor.

I. INTRODUCTION

In this modern era where everything is becoming automated, the business sector especially the manufacturing companies have gained so many benefits from using machines and technology to increase their profits and productivity rate. Tandem means having two identical components arranged one behind or adjacent to the other. Tandem is a part of BG605 Motor grader equipment and it is used for transmission of power in the equipment. Testing of the tandem before assembling on to the vehicle is very necessary. Testing the tandem by manual method is a tedious job. In order to make work easy and to get quality of product automation of jig is to be implemented.

There are many disadvantages of testing tandem after assembling in BG605 Motor grader; to overcome this testing of tandem by manual method is a tedious job. In order to make work easy and to get quality of product automation of jig is to be implemented. The challenge here is to test the tandem before assembling on to the vehicle to overcome the following disadvantages:

1. Failure related to torque and speed.
2. Obtaining accuracy is not easy.
3. Time required for testing is more.
4. Has peak torque fixed to a 1% duty cycle.
5. Required power supply is 10 times more than before assembling testing.
6. Leakage problem.
7. Present of Abnormal sound.
8. Tandem heating problem.

All the protection devices and other equipment are selected based on the application rating.

Figure 1: Motor Grader

Figure 2: Tandem of Motor Grader

II. Methodology

This paper describes selection of suitable motor, selection of suitable drive, how motor-drive system is interfaced to jig using electrical circuit diagram, software parameter to auto tune the drive. The application of interfacing and commissioning of motor and drive to tandem test jig.

The principle involved in this technique is first to convert the fixed frequency, fixed voltage AC supply into a variable or constant DC voltage. This is then converted into the AC supply of desired frequency and amplitude. Hence the speed of induction motor is controlled by controlling the frequency which in turn controls the speed of tandem jig. By changing the phase sequence of the motor supply connections induction motor can be made to run either clockwise or anticlockwise. An IGBT based AC drive has to be selected for the required function and tested. The IGBT based AC drive is responsible for the speed control.

III. Proposed System

The block diagram consists of a control panel which is interfaced with the tandem jig through induction motors coupled with gears box. The gears are required for smooth torque controls. The control panel comprises of the IGBT based AC drive which are controlled by their respective push buttons. The IGBT based AC drive is responsible for the speed control.

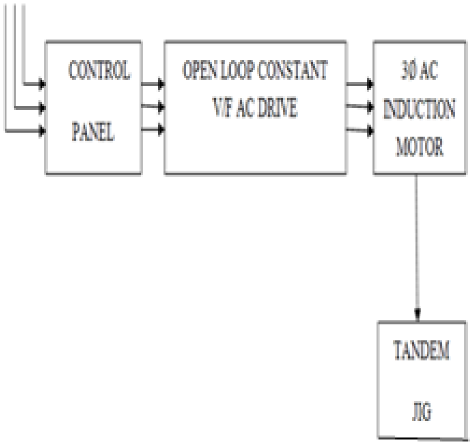

Figure 3: Block diagram of the proposed system

IV. Selection of AC Motor

Alternating current (AC) and direct current (DC) motors have traditionally served distinctly different applications due to their construction and inherent operating characteristics. In general, AC motors were smaller, less expensive, lighter and more rugged than DC motors. DC motors, on the other hand, operated better in variable-speed applications, particularly those requiring wide speed ranges, and provided more precise speed control. When the application load varies greatly and light loads may be encountered for prolonged periods, DC motor commutators and brushes may wear rapidly under this condition.

DC motors have been the workhorse of industry in many applications where variable speed operation is needed. In these applications, DC motors are reliable and provide precise speed control under variable operating conditions. However, DC motors are expensive to purchase and to maintain. In addition, over the past 10 years, AC drives have improved to the point whether their speed control is far more precise, rivaling that of servo drives. What's more, the AC motor and drive together often cost about the same price as the DC motor alone.

Disadvantages of dc motors

- Overload can damage motor.
- Cannot operate in explosive and hazardous condition due to sparks occurring at brush.
- Increases operation and maintenance cost due to presence of commutator and brush gear.
- High initial cost.

Benefits of ac motor

The types of motors that AC drives control are normally operating at constant speed. Enabling the user to control the speed of motor potentially gives various benefits in terms of process control, system stress and energy savings.

Adjusting speed as a means of controlling a process

- Smoother operation
- Acceleration control
- Different operating speed for each process
- Allow slow operation for setup purposes
- Allow accurate positioning
- Control torque or tension
- Low coat
- High power factor

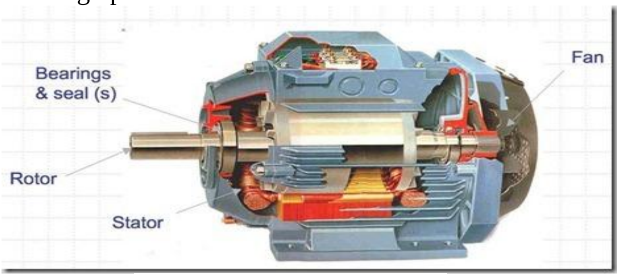

Figure 4: Induction motor

Selection of Squirrel cage Induction motor

- Squirrel cage induction motors are cheaper in cost compared to slip ring induction motor.
- Requires less maintenance and rugged construction. Because of the absence of slip rings, brushes maintenance duration and cost associated with the wear and tear of brushes are minimized.
- Squirrel cage induction motors requires less conductor material than slip ring motor, hence copper losses in squirrel cage motors are less

results in higher efficiency compared to slip ring induction motor.

- Squirrel cage motors are explosion proof due to the absence of brushes which eliminates the risk of sparking.
- Squirrel cage motors operate at nearly constant speed, high over load capacity, and operate at better power factor.

The AC induction motor is the workhorse in adjustable speed drive systems. The most popular type is a 3-phase squirrel-cage AC induction motor that is an efficient, low-cost, maintenance-free, low noise motor. The stator is supplied by a balanced three phase AC power source. The synchronous speed of the motor (Ns) is given by

$$Ns = \frac{120 * fs}{p}$$

Where, fs is the synchronous stator frequency in Hz, and p is the number of stator poles. The AC induction motor produces zero torque at the synchronous frequency and therefore must run at the speed given by a load torque. The motor speed is characterized by a slip Sr

$$Sr = \frac{Ns - Nr}{Nr} = \frac{Nsl}{Ns}$$

Where, Nr is the rotor mechanical speed and Nsl is the slip speed, both in rpm. Figure 5 illustrates the torque characteristics and corresponding slip. As can be seen from the above equations of ns and Sr, the motor speed is controlled by variation of a stator frequency with influence of the load torque.

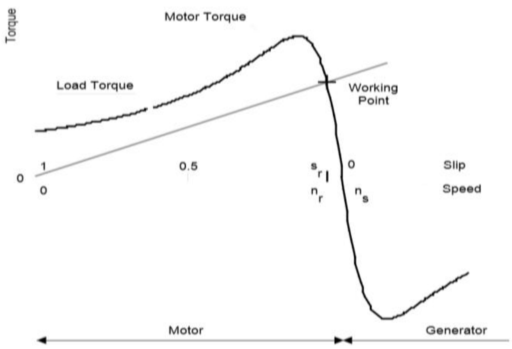

Figure 5: Torque-Speed Characteristic at Constant Voltage and Frequency

V. Selection of AC Drive

An AC drive is a device that is used to control the speed of an electrical motor, either an induction motor or a synchronous motor. AC drives are also known by various other names such as adjustable speed drives (ASD) or adjustable frequency drives (AFD) or variable frequency drives (VFD) or variable speed drives (VSD) or frequency converters (FC).

Obviously, a fixed speed is not suitable for all processes in all circumstances, thus the need for adjusting the speed according to need. If speed control is required, that controller is called a (variable speed) AC drive. AC drives are used in a wide variety of industrial applications. However, variable speed AC drives are commonly used in more complex and difficult environments such as water and wastewater processing, paper mills, tunnel boring, oil drilling platforms or mining.

Main Components of AC drive

1. Rectifier unit

The AC drive is supplied by the electrical network via a rectifier. The rectifier unit can be unidirectional or bidirectional. When unidirectional, the AC drive can accelerate and run the motor by taking energy from the network. If bidirectional, the AC drive can also take the mechanical rotation energy from the motor and process and feed it back to the electrical network.

2. DC circuit

The DC circuit will store the electrical energy from the rectifier for the inverter to use. In most cases, the energy is stored in high-power capacitors.

3. Inverter unit

The inverter unit takes the electrical energy from the DC circuit and supplies it to the motor. The inverter uses modulation techniques to create the needed 3-phase AC voltage output for the motor. The frequency can be adjusted to match the need of the process. The higher the frequency of the output voltage is, the higher the speed of the motor, and thus, the output of the process.

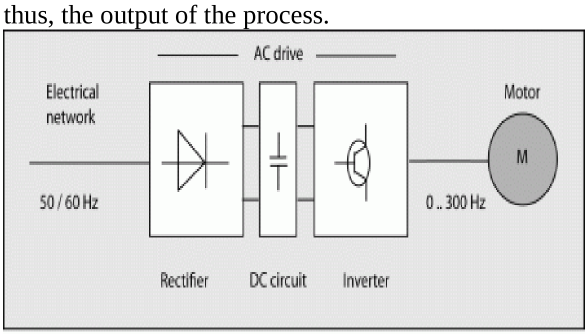

Figure 6: Block diagram of AC drive

Three-phase AC induction motor drive with Volt per Hertz Control in open loop

The design of a 3-phase AC induction motor drive with Volt per Hertz control in Opened Loop is based on Motorola's 56F80X digital signal processor (DSP) which is dedicated for motor control applications. The system is designed as a motor control system for driving medium power, three phase AC induction motors and is targeted for applications in both industrial and appliance fields (e.g. washing machines, compressors, air conditioning units, pumps or simple industrial drives). The software design takes advantage of SDK (Software Development Kit). The drive to be introduced is intended as an example for a 3-phase AC induction motor drive. It serves as an example of AC V/Hz motor control system design using Motorola DSP with SDK support. It also illustrates the usage of dedicated motor control libraries that are included in the SDK.

Motorola DSP Advantages and Features

The Motorola DSP56F80x family is well suited for digital motor control, combining the DSP's calculation capability with MCU's controller features on a single chip. These DSPs offer a rich dedicated peripheral set, including Pulse Width Modulation (PWM) modules Analog-to-Digital Converters (ADCs), Timers, communication peripherals (SCI, SPI, CAN), on-board Flash and RAM. Generally, all family members are well suited for motor control.

Volts per Hertz Control

The Volt per Hertz control method is the most popular method of Scalar Control which controls the magnitude of the variable like frequency, voltage or current. The command and feedback signals are DC quantities which are proportional to the respective variables.

This scheme is defined as volts per Hertz control because the voltage applied command is calculated directly from the applied frequency in order to maintain the air-gap flux of the machine constant. In steady state operation the machine air-gap flux is approximately proportional to the ratio Vs/fs, where Vs is the amplitude of motor phase voltage and fs is the synchronous electrical frequency applied to the motor. The control system is illustrated in Figure 7. The characteristic is defined by the base point of the motor. Below the base point the motor operates at optimum excitation, called constant torque operation, because of the constant Vs/fs ratio. Above this point the motor operates under-excited, called constant power operation, because of the rated voltage limit. A simple open-loop Volts/Hertz speed control for an induction motor is the control technique targeted for low cost, low performance drives. This basic scheme is unsatisfactory for more demanding applications where speed precision is required.

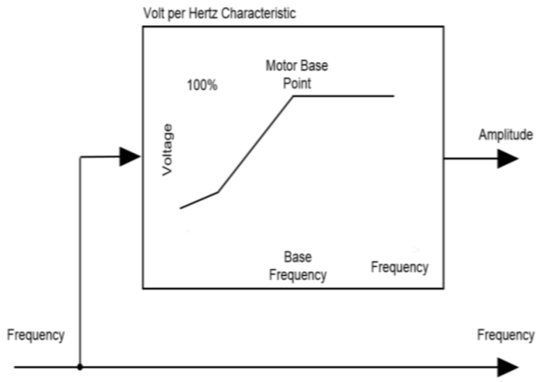

Figure 7: Volts per Hertz Control Method

For understanding the basic principles behind VFD operation requires understanding three basic section of VFD: the Rectifier unit, DC Bus and the Inverter unit. 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 (Insulated Gate Bipolar Transistor) where the filtered DC supply is being converted to quasi sinusoidal wave of AC supply which is supply to the induction motor connected to it. As we know that the synchronous speed of motor (rpm) is dependent upon frequency. Therefore by varying the frequency of the power supply through VFD we can control the synchronous motor speed.

VI. Interfacing of Motor and Drive

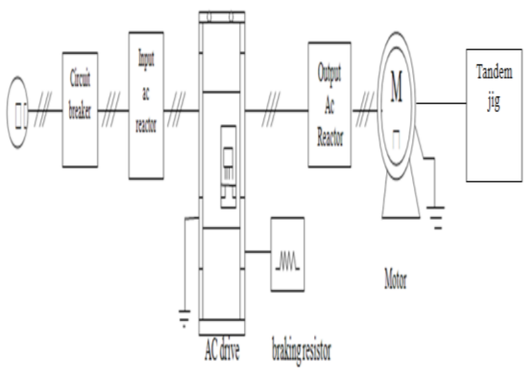

Figure 8: Connection diagram of the AC drive and motor with tandem jig

1. Circuit breaker

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow.

2. Input AC reactor

Drives are nonlinear loads. They tend to draw current only at the positive and negative peaks of the line. Since the current wave-form is not sinusoidal the current is said to contain harmonics. If a line reactor is installed, the peaks of the line current are reduced and broadened out. This makes the current more sinusoidal, lowering the harmonic level to around 35% when a properly sized reactor is used.

3. Output AC reactor

When the motor inductance is too low, a reactor may be needed. Running multiple motors on one drive may also result in a low inductance load and the requirement of an output reactor.

4. Braking resistor

For applications that require faster deceleration rates, or where motor speeds are exceeding the synchronous speed set up by the output frequency of the drive (an overhauling load condition), a braking resistor is required. Braking resistors increase the braking torque capability of a variable frequency drive, producing faster and more controlled braking. The resistor dissipates regenerated power to keep the bus voltage from exceeding the rated limit of the drive.

VII. RESULTS AND CONCLUSION

The Figure 9 shows the tandem of BG605 motor grader interfaced with induction motor through coupling bevel gear. The wheels of the grader are connected to the tandem. Once the frequency is varied the motor starts rotating in either direction. Therefore tandem jig speed can also be controlled. This would increase their productivity and efficiency. So tandem has to be tested before assembly.

The 3 phase output of the drive is connected to the 3 phase terminal of the motor. The motor is tested by giving suitable frequency using the ac drive. The motor is then made to run in both the directions. After testing the motor, the tandem is then coupled to the motor which is in turn connected to the ac drive. The tandem is then checked for rotation in both the directions i.e. forward and backward

Figure 9: Interfacing of motor and tandem jig

Characteristic		**Checking Method**	**Results**
Speed		Tachometer	500-1500RPM
Duration		Watch	2hrs
Noise level		Sound meter	100db max
Check and cleaning of strainer		Visual	Clean/free from dust
Temperature		Gauge	90° max
Oil leakage	Coupling portion	Visual	No leakage
	Weld joints of tandem		
	Centre case cage portion		
	All as cast portion		

Table 1: Results of testing interfacing

The Table 1 shows the results of testing Tandem after interfacing with motor and drive. Speed of the tandem is checked till 1500RPM and left for observation for 2 hours. After watching the tandem for 2 hours Oil leakage problem and noise was not found.

VIII. Conclusion

The IGBT based AC drive along with induction motor finds its application in controlling the movement of tandem in either directions. This system mainly requires the induction motor for smooth control of tandem jig reducing the human error and requiring minimal number of skilled workers. The tandem jig can be tested without assembling the whole motor grader which would reduce the time and increase the productivity. In future drive can be designed for larger motor graders and the overall productivity of the company can be increased.

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