Study of Manufacturing and Testing Of VFD Panel

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Abstract: In any manufacturing industry, where there is continuous process or control of more than one machine at a time is required, various control panels are used. This project work includes panel designing and testing for a pipe manufacturing plant. In this process various motors are used like main motor, cutter motor, polishing motor, dressing motor, blower motor, coolant pump etc. For controlling of these motors we use Variable Frequency Drive (VFD) Panel. In which we can control the speed of motors. The aim of this project is designing, wiring and testing of VFD panel. The factory acceptance test that demonstrates that the equipment is properly designed to meet customer requirements. Type test, routine test and special test as per international standards are included in the factory acceptance test. The paper has developed knowledge of different aspects of manufacturing process and testing of VFD Panel.

IndexTerms **– Variable frequency drive, Factory acceptance test, Control Panel**

I. INTRODUCTION

Control panels are today widely used in industries to provide proper control of operations of any electrical and mechanical equipments. These can also be used to protect the electrical equipments from being damaged because of various faults like short circuit, overload and earth leakage etc. Each and every panel is designed to control specified equipment with specific equipment arrangement and devices.

In fast growing variable frequency drive (VFD) industry it is more important for technicians and maintenance personnel to keep VFD installation running smoothly than ever. Variable frequency drive changes motor speed by changing voltage and motor power frequency. The name plate volts/Hertz ratio must be maintained in order to maintain a proper power factor and reduce excessive motor heating. This is the variable frequency drive's main task.

This project work involves the design and testing of panel for a pipe manufacturing process. Different motors such as main motor, cutter motor, dressing motor, blower motor, polishing motor, coolant pump etc. are used in this process. We use the Variable Frequency Drive (VFD) panel to control the speed of the motor.

II. MANUFACTURING PROCESS OF VFD PANEL

In this section variable frequency drive panel will be explained briefly. The various motors mentioned above have its own specific applications i.e. cutter motor is used to cut the pipe at a specific length requirement. The main function of this panel is to control the speed and the direction of the main motor like forward run, forward inching and reverse inching of the motor. This can be achieved by using variable frequency drive.

Variable Frequency Drive (VFD) is used to Control the motor by varying the fixed frequency and voltage. When a three-phase AC voltage source is connected to an induction motor's stator windings, a rotating magnetic field within the stator body is established. The following equation describes the speed of this rotating magnetic field: $N_s = 120\ f / p$. The speed of rotating magnetic field (Ns) is directly proportional to the frequency (f), as the number of poles is fixed. The speed can be controlled by varying the system frequency. VFD consist of following three main subsystems:

1. Converter
2. Filter
3. Inverter

The converter converts the incoming AC fixed frequency power to the DC. Then the DC power is filtered to make it smooth and stored to provide a surplus of power. In most of the VFDs capacitor is used as a filter and it stores the power as a charge. Finally, the inverter takes the DC power and converts into an AC sinewave.

According to the rating of the main motor we select VFD size. With the help of these above motor ratings we calculated the size of contactors, MCBs, thermal overload relays, transformers, choke coil etc. After these calculations we designed the panel and did the wiring connections of panel. Finally we performed various testing like factory acceptance test, type test, routine test, no load test and full load test etc.

III. DESIGN OF VFD PANEL

1. Power Circuit

Three phase power supply is given to the motors through MCB, contactors and thermal overload relay. When start push button is pressed, contactor coil is energized and contactor gets closed hence the path is completed so the supply is fed to the motor. During the running condition of the motor, whenever the motor is continuously drawing excessive current over a period of time under too much load, thermal overload relay is tripped. MCB is used to trip the circuit instantly when the

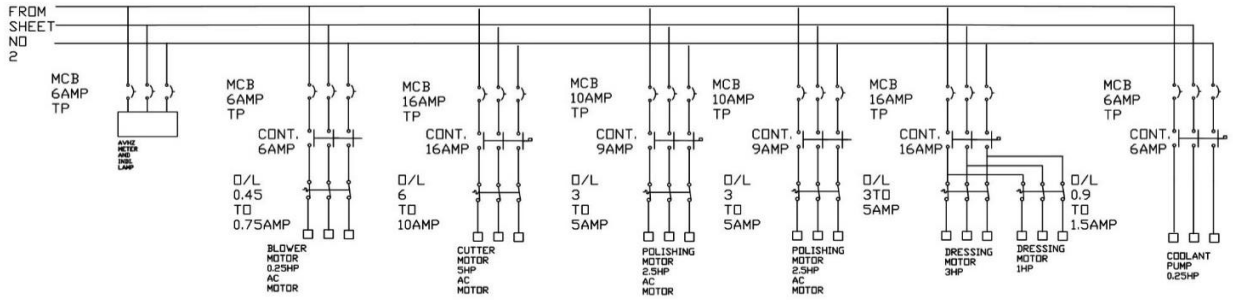

Figure 1Power Circuit

current reaches a certain threshold. It is usually set to travel at ten or more times the normal running current of the motor in order to avoid tripping during normal motor starting.

2. Control Circuit

As we have seen the power circuit of VFD panel, now let's move on to the control circuit. The main aim is to prevent the main motor from damaging itself by preventing one element from changing state due to the state of the another element. The main motor mechanism is equipped with an interlocking system that prevents the forward inching and reverse inching when the motor is in forward running condition and similarly it goes for forward inching and reverse inching.

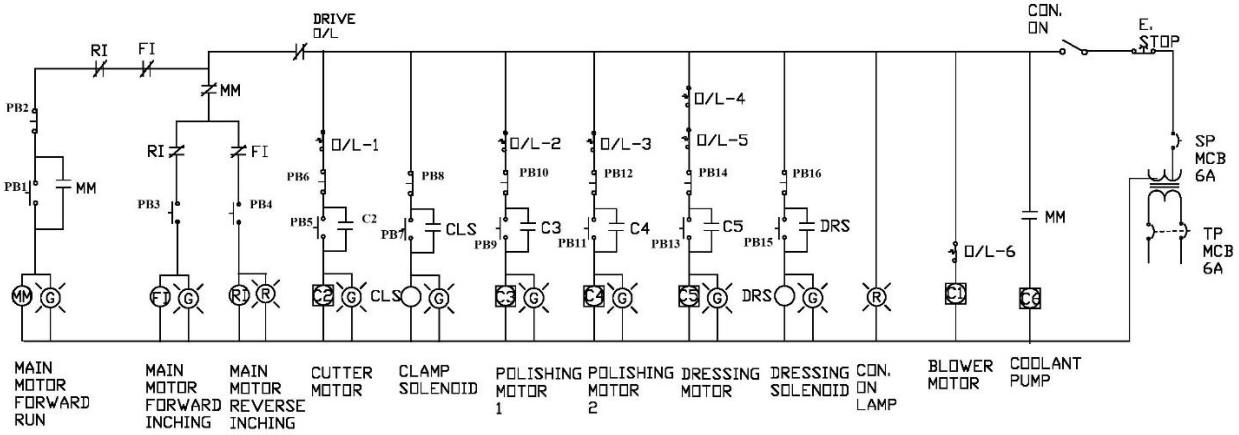

Figure 2 Control Circuit

When we push the start push button (PB1) relay coil MM will get energized and NO contacts of MM will become NC and at the same time NC contact become NO. When MM contact gets closed supply is passes through FI-RI-PB2-MM and motor is running in forward direction continuously. When stop push button (PB2) is pressed then the coil gets de-energized so the MM contact becomes from NC to NO hence the motor is disconnected. Similar operation are done for the rest of the motors for their specific function.

3. VFD Connections

Our main motor rating is of 20HP so we select the drive (ABB ACS560) according to it. Three phase supply is fed to the drive through choke coil and MCBs. Choke coil is used to reduce harmonics present in the supply and MCB is used for protection. Potentiometer is connected to drive which is used to change the voltage and by change in voltage, speed can be changed. For forward running condition MM contacts, for forward inching conditions FI contacts and for reverse inching RI contacts should be closed respectively (We can relate and compare from control circuit diagram).

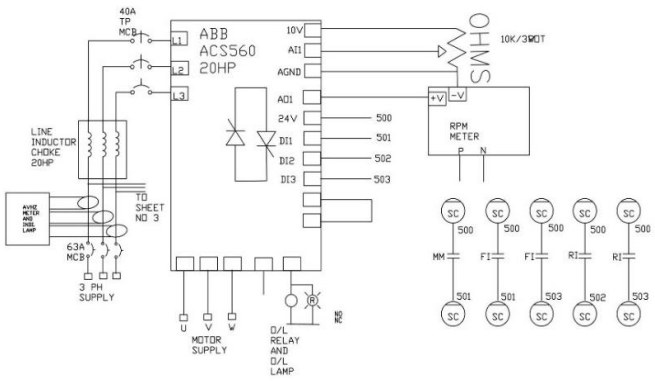

Figure 3 VFD Connections

Figure 4 Wiring of VFD

IV. ABB ACS560 SINGLE DRIVE PARAMETERS

We selected the following parameters according to our requirement. These parameters are taken from ABB ACS560 drive manual.

ABB ACS560 Single Drive Parameters		
	Motor Parameters	**Drive Values**
10.3	RO3 SOURCE-FAULT	14
12.15	AI1 UNIT SELECTION-mAmp	DEFAULT V
12.17	AI1-MIN	DEFAULT 0
12.18	AI1 –MAX	DEFAULT 10V
12.2	AI1 SCALED AT AI1-MAX	DEFAULT 50
13.12	AO1 SOURCE-MOTOR SPEED-RPM	1
13.22	AO2 SOURCE-OUTPUT FREQUENCY	3
20.01	In1 START FWD,In2 START REV	3
23.12	ACCELARATION-1	2 SEC
23.13	DECELERATION-1	2 SEC
28.21	CONSTANT FREQ FUNCTION DIRECTION ENABLE	DEFAULT 1
28.26	CONSTANT FREQUECY-1	DEFAULT 5
28.27	CONSTANT FREQUECY-2	3 HZ
28.72	FREQUENCY ACC. TIME 1	20 SEC
28.73	FREQUENCY DEC. TIME 1	20 SEC
30.14	MAXIMUM FREQUENCY	50
99.06	MOTOR NOMINAL CURRENT	30.5AMP
99.07	MOTOR NOMINAL VOLTAGE	415V
99.08	MOTOR NOMINAL FREQUENCY	50HZ
99.09	MOTOR NOMINAL SPEED	970RPM
99.1	MOTOR NOMINAL POWER	15KW
POT		(AI-1)-3
AMMETER		AO-1
WITHOUT MOTOR TRIAL SET 31.19 0 INSTEAD OF 1,WITH MOTOR SET 1		
99.04 IF SET 0- DRIVE MODE CHANGED		
ALL PARAMETERS IN FREQUENCY-MODE IS SCALLER		
ALL PARAMETERS IN RPM-MODE IS VECTOR		
TO SET RPM - SET RPM IN 30.12, SET 22.26- RPM, 22.23-RPM		

V. TESTING

We performed the following factory acceptance test for the panel:

1. **Visual Inspection test:**
   In order to determine that no damage has occurred, a visual check will be carried out on all electrical equipment with customer, both internally and externally. All control, relay panels and electrical devices will be checked internally for compliance with approved drawings and approved cable diagrams for connection. Check the labels and the name plate.
2. **Insulation test:**
   Conduct 500V meggar test for phase to earth, phase to neutral, phase to phase and neutral to earth to measure the insulation resistance with all breakers in ON position.
3. **High Voltage Injection test:**
   Perform 500V meggar testing between each stressed phase and all other phases linked to exposed conductive parts with all breakers in ' ON ' positions. Apply 2.5kV AC voltage for 60 seconds between each stressed phase and any other phase connected to exposed conductive parts and measure the leakage current.

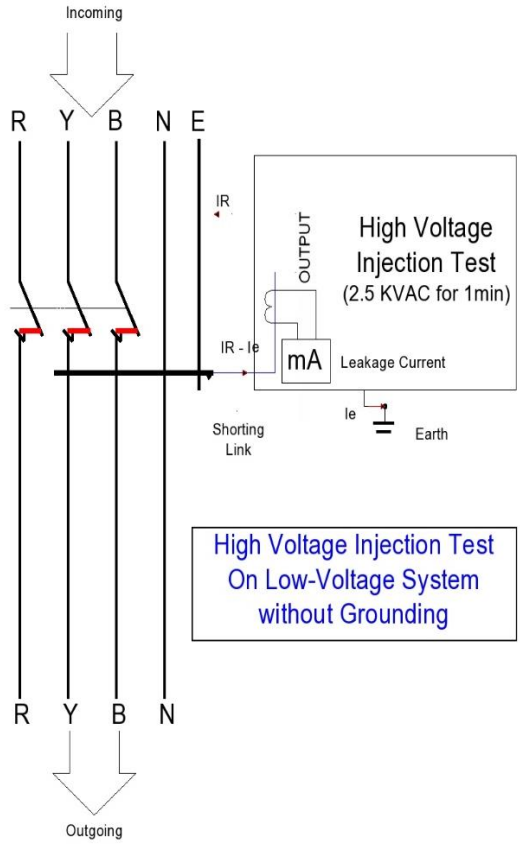

Figure 3 High voltage injection test

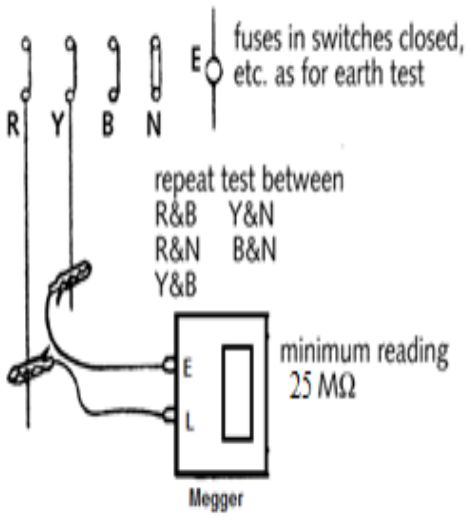

Figure 4 Insulation test

4. **VFD Test with Motor Trial:**
   We connected 20 Hp (15kW), 6 pole, 3 phase induction motor with drive panel. We checked the speed of the motor and direction with no load condition.

Table 1 Observation table

Frequency (Hz)	Speed (RPM)	Voltage (V)
5	98	41.2
10	198	82.8
15	296	126.5
20	389	165
25	492	207.4
40	785	334.1
50	981	413.9

VI. CONCLUSION

In this research paper we discussed manufacturing process of variable frequency drive panel from its designing to the final testing in factory. Factory acceptance testing is done according to international standards after completing the VFD panel in operating mode. Using VFD panel we can get the required variable speed and protection of the motors. It is also used in traction system, escalators, modern lifts and pumping system.

VII. ACKNOWLEDGMENT

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