Mill/Drill Conversion to Three Phase and installing a VFD

Some Background

Several years ago I purchased a Wadkin lathe made in England in late 1964. It is equipped with a very special motor that is 220V, three phase and 50 hz. Because of the special design of the motor, it has a long extended shaft that carries the four sheave pulley, and because I do not have three phase in my shop, some means of creating three phase locally was needed. I do have 220V power and the 50 hz design of the motor is not a problem. I knew about rotary phase converters and so called static phase converters, but neither really seemed to fit my needs. While doing my research of possible solutions, I learned about Variable Frequency Drives (VFDs). This seemed like the answer that I needed and further investigation showed that several manufacturers of new machinery were using the 3 phase motor/VFD to provide better control over machine speed, soft start (programmable acceleration) and forward/reverse.
I looked at several different VFD brands and found the ones from Automation Direct best fit my application. I liked the keypad set up and the ease of programming the VFD to my lathe and really liked the ability to mount the keypad remotely with the optional extension cable. I even programmed the display to show actual spindle lathe RPMs, a real nice feature.

After I had my lathe up and running and found how well the Automation Direct VFD worked out, I decided to convert my Rockwell ram type radial drill back to 3 phase and install another VFD on it. It had been converted to single phase before I purchased it by the previous owner. Because this only has a ½ hp motor I was able to use a VFD with 120V single phase input and 220V 3 phase output. Again I went with Automation Direct and used a remote control for the forward/off/reverse and speed controls.

I had been experimenting with the programming, changing things like the acceleration times, method of stopping, what the display showed, and some of the other programmable functions. Once I became comfortable with the programming procedure (it really is very straightforward), I found that I could customize the VFD to my exact needs.

The remote controls that I used in both of these installations are simple to build and in fact, so simple that I called the support team at Automation Direct to be assured that it was as simple as it looked. I was pleased to find that the support people were located here in the States, spoke English I understood, and were able to explain things in a manner that clearly answered my questions, not like talking to someone in India trying to get a computer problem solved.

I have many visitors to my shop for woodworking group meetings and classes. Also, I often give assistance to people with machine problems and several have asked me to do VFD installations on their machines. I have become a big advocate of the VFD and of Automation Direct because of the ease of installation and good performance. To date, I have been involved with ten or a dozen VFD installations.

Issues with the milling machine that I wanted to correct with this installation

I recently purchased a milling machine for my shop. Actually it is one of the Asian Mill/Drills patterned after the Rong Fu model that has become popular. I would have liked a full sized Bridgeport, but my shop floor would not sustain the load of one. I soon found that there were some issues with the machine that I felt could be corrected with the three phase motor/VFD conversion. One thing I found was that because it is a three pulley, two belt drive setup with the center pulley acting as an idler with both belts on it, that whenever I wanted to change the spindle speed, it required removing and changing the position of both belts. This was very time consuming and inconvenient. Also it had a capacitor start/ capacitor run motor that while powerful, was not smooth running. One other thing not related to the actual motor itself was the flimsy motor mount that kept bending. Replacing the motor and adding a VFD would give
me electronic speed and reverse control, add soft start and a smoother running motor as well as give me the opportunity to fabricate a new stronger motor mount.

Materials required to do the conversion

I decided to keep the same size motor, 2 hp. I used a chart to find the NEMA frame size of the new motor which would match up to the motor presently on the machine. The NEMA frame size determines the physical dimensions of the motor base and location of the mounting holes, the height of the shaft from the mounting base and the diameter and length of the shaft. If you have a motor with a NEMA frame, then all you need to do is get a replacement with the same frame number and it will bolt right in without any modifications. The same NEMA frame size can have different horse power, different base RPMs, and be either single or three phase. The motor I used is from Automation Direct and is a model MTCP-002-3BD18. This is a NEMA 145T and most closely matched the metric/Asian motor on my mill. As I was replacing the motor mount anyway, the difference in mounting holes for the motor base was not a problem and the other dimensions were the same.


The VFD used is an Automation Direct GS2-22P0 rated for my 2 HP motor. I also used the optional extension cable, GS-CBL2-1L, to allow me to mount the keypad on the outside of the door of the N1C121208 steel enclosure. For the remote control unit to be mounted on the mill/drill itself, I used a SA-106-40SL enclosure, a GCX1370-22 Forward/off/reverse switch, and an ECX2300-5K potentiometer.

Automation Direct website: http://www.automationdirect.com/adc/Home/Home

The cable that powers the VFD is 12/3 SOOW SO cord, a three conductor rubber jacketed cable. The cable that connects the VFD to the motor is 14/4 SOOW SO. The cable that connects the VFD to the remote control on the mill is an 8 conductor 24ga Ethernet computer cable. This is a stranded cable of 4 twisted pair of wires. You only need 6 of the conductors for the remote. These cables are readily available at electronics stores. I cut the connectors off the ends, stripped and tinned the conductors to give them some strength when I connected them. The Ethernet cable is run inside a piece of 3/8” flexible conduit to protect it.

The installation
The first thing that needed to be done was to fabricate a new motor mount.

I found the best way to mount the motor was to build a temporary platform to sit the motor on and to lower the mill into position on the motor. I temporarily moved the old motor out of the way and with the new motor in position, determined the size of the new motor mount and the location of the mounting holes. My local steel supplier has a “cut off” bin where I pick up pieces of steel to use for projects. The price is about 40% of what off the shelf product costs. I used a piece of ¼” steel plate from this source and welded on two ears for the hinge bolts. I then used the mill to machine in the four slots for the motor to ride and adjust in and drilled the hinge bolt holes. A coat of paint and I was ready to install the motor.

When mounting the motor, it is important to ensure that the pulleys line up so the belt runs true in the pulley grooves. While checking this, I found that the spindle pulley and the idler were not perfectly aligned and corrected this before adjusting the motor and idler pulley alignment.
The remote control box was mounted to the mill housing using a piece of 3” aluminum angle. This provided a very study mount and places the controls right up front where they are easy to reach. One thing I found was that if I took the knob on the potentiometer apart and turned the knob 90° when the switch and potentiometer were installed on the control box front plate there was more room for the switch mounting screws.

The VFD unit is mounted inside the steel cabinet which is mounted on the wall behind the machine. It is close enough so that the display can be read and the unit programmed using the keypad. The VFD generates a small amount of heat and to ventilate the steel enclosure, I installed four soffit vents with a fine screen inside. There are two on the bottom and one on each side near the top. This will allow for some air flow within the closed cabinet.
When connecting the power cables, it is best to use crimp on connectors because the connecting screws on the VFD are relatively small. The control cable can be connected directly if you tin the ends of the wires. You need a means of disconnecting the unit from the power source and it should be protected with a circuit breaker. My electric panel is only about 5 feet from the VFD and it is on a dedicated circuit, so my means of disconnecting is a plug on the end of the power cable and a twist lock outlet. When it is unplugged, I know it is disconnected.

The Ethernet cable has four twisted pairs of wires. They are color coded so that you can easily determine which wire is which on both ends. I used the attached wiring diagram. It does not matter which wire you use for which function. The tinned ends make it easy to insert the wires into the terminals on the switches and the VFD and prevent them from becoming crushed by the terminal screws.

The keypad is removed from the VFD unit by squeezing the two tabs on the sides and pulling out. The remote extension cable comes with six screws. Two to secure the cable to the VFD, two to secure the cable to the keypad, and two to attach the keypad to its new mount on the door of the cabinet. The cabinet door needs to have three holes drilled in it to accept the
keypad. The holes can be located using the template which is attached at the end of this article. Check the dimensions with a rule after you print it to be sure that it printed the correct size. If you do not have a hole saw, you can use another method to create the hole for the cable and plug.
Programming the VFD

After all the components are installed and the power and control cables are hooked up, the programming of the VFD to set up the parameters for the particular installation is the next step. By doing detailed programming, we are able to get the maximum benefit and performance from the VFD.

The VFD comes with a “Quick Reference Card” and a “User manual”. Both list the parameters used in programming the VFD. The information shown on the motor data plate is the first thing to be inputted. Once the scheme for inputting the programming is understood, it becomes easy to customize the VFD to your particular needs. The programming mode is entered by pressing the “Program” key on the keypad. Selections are started by pressing the “enter” key and changes are entered using the “up ▲ and down ▼” arrows on the keypad followed by pressing the “enter” key to save the selection.

The programming that is most commonly used is in four sections. The first section is the motor data. The second section is the motor control. The third section is the remote control activation and the forth section is the display customization.

Begin by pressing the “Program” key on the key pad. The display changes to “P 0.00”. This is the “Motor Voltage Parameter”. Select the correct voltage, in my case 230, and press “enter”. The display changes briefly to “END” and then goes to the next parameter, “P 0.01” which is the “Motor Nameplate Amps”. Here I entered 7 and press “enter”. The next parameter is “P 0.02”, the frequency or “HZ”. Enter the name plate frequency which is 60. Parameter “P 0.03” is the motor base RPM from the data plate. I entered 1725. Press “enter” and the final motor parameter “Maximum Motor RPM” is entered. The motor specifications indicate that it will go to 5400, but I entered 4000 to be on the safe side.

The next section of the programming controls how the motor performs. The first parameter is “P 1.00”, the stop method. The VFD has the ability to apply electronic braking for limited loads. For heavier braking loads with high momentum, low friction and short deceleration times, an optional braking resistor is necessary. The factory setting is “00” which is “Ramp to Stop” using electronic braking. The other option is “01” Coast to Stop” which is what a normal motor would do when shut off. I used this.

Hitting the “Program” key takes us to “P 1.01”, the acceleration time. The factory default is 10 seconds, but I wanted 5 seconds which gives a nice soft start, so using the down arrow changed it and pressed the “enter” key to confirm. “P 1.02” is the deceleration time. If you select “coast to stop” this parameter is not used. If you use “Ramp to stop” a value is needed here. The default is 30 seconds. In some applications I have used values in the 3 to 5 second range.

The next programming section is “P 3.00”, the control location. This is where the start/stop is changed to the remote control. The value entered here is “01. This changes the start/stop function to the remote control box and leaves the stop on the keypad active. The next
parameter to change is “P 4.00 which is the frequency or speed control. The value used here is “02”. This changes the speed control from the keypad to the 5 K ohm potentiometer on the remote control box.

The last programming section that we are going to use is “P 8.00” the display function. There are many options here. I like to use one that shows the spindle or cutter speed in RPMs. This is accomplished by entering “02” which shows the output frequency multiplied by a factor. That factor is the spindle speed divided by the output frequency. This can be determined several ways. One way is to use the specifications for the machine which will show spindle speed with the standard motor speed. Another way is to use a tachometer to measure the spindle speed at a given frequency. I used an inexpensive digital tachometer to determine the spindle speed at 60 Hz and found it was 485 RPMs. 485 divided by 60 gave me 8.08 which I entered at “P 8.01”. The display now shows actual spindle speed for my particular belt and pulley configuration. If you used multiple belt configurations and have a chart showing the speed for those at a given motor RPM, then changing the display to show percentage of RPM works nicely. This is achieved by changing the value to 1.66.

This installation was on a mill/drill, but the same procedure would be used on most any machine used in a woodworking or machine shop. The power from the VFD would go to the three phase motor and the remote control would be mounted in a convenient location and you are ready to go. The only rule of sizing the VFD to the motor is that the VFD needs to be rated at least as large as the motor. If you were using a VFD on a machine such as a table saw, planer, grinder, etc. then the reverse function would be disabled by using an off/on switch and only connection to the “D11” terminal on the terminal strip. If the motor runs in reverse when you want it to go forward, swapping any two of the power leads from the motor to the VFD will correct this.

For many years it was thought that the only way to use three phase machinery was to have three phase power from the electric company or use and expensive and inefficient rotary converter or a static converter that only allowed the motor to operate at 2/3 of its rated output. For motors up to three HP, the modern VFDs have the ability to take single phase electricity, convert it to three phase with full power, speed control, reversing ability, and more.

The VFD is really a “game changer” for anyone restoring old machinery or dealing with methods of speed control, like Reeves drives and variable diameter pulleys. In the The VFD is truly “A better Way”, I have three in my shop now and have plans to install two more.
Attachments:

The drilling template for the remote control.

When you print this template, check that the dimensions are 47.00 mm by 58.00 mm.

Template for mounting keypad remotely
Dimensions in mm

The template for wiring the remote control.
Wiring Diagram for the Remote Control

GOX1370-22
Forward/off/reverse switch

ECX2300-5K
Potentiometer

Terminals on the Automation Direct GS2