Design Issue for
Machine Tool Coolant Systems

To Be Operated On 50 And 60 Hertz Power Supplies

By Polytech-Filtration

Overview

Machine tool builders, in serving world markets must configure their machines to operate on both 50 and 60 hertz AC power. The ability to operate on both frequencies with a standard machine design is a great advantage to the machine tool builder, however the coolant systems, which typically use centrifugal pumps, can be problematic. Pump selection for operation on either 50 or 60 hertz is quite straightforward, the difficulties arise when a machine tool or production process is developed in one environment and shipped to another for installation and operation.

Machine Tool Considerations

Most machine tools that Polytech encounters today have variable frequency drives controlling the tool spindle. VFDs convert AC power to DC power and then, using the drive's switching circuits create a pulse width modulated sinusoidal AC power. The rectified DC bus voltage, which is then switched to produce the output power is a function of the input voltage. When moving from one environment to another, a buck/boost transformer can be used to adjust the input voltage. When a machine tool designed for operation on, say 460 V 60 Hz power is installed on 380V 50 Hz power a transformer can provide 460V 50 Hz power and the machine can perform as designed.

Coolant/Filtration System Considerations

The volume and pressure of coolant delivered to the machine tool is often critical to maximizing the productivity of the machine tool with pumps that are carefully selected to meet the process requirements. For the coolant systems used with these machine tools, two factors must be considered when determining the system's intended power supply. The first consideration is the flow and pressure characteristics of the centrifugal pumps used for coolant supply and the second consideration is the electrical characteristics of the pump motors.

Centrifugal pumps move fluid by accelerating the fluid as it moves from the center to outside perimeter of the rotating pump impeller. The acceleration and therefore discharge pressure vary with the square of the speed of the impeller. This speed may reflect rotational speed or speed of the perimeter of the impeller as its diameter is changed. The volume of fluid pumped, for a given impeller size varies proportionately with speed. The power required varies with the cube of the speed.

An induction motor's speed depends on the number of poles and the frequency of the power supplied. The motor RPM will be 120 times the frequency divided by the number of poles. At 60 Hz a four pole motor will operate at 1,800 RPM and at 50 Hz it will operate at 1,500 RPM

A centrifugal pump properly sized for operation on 60 Hz power will provide about 17% less flow and about 30% less pressure when operated on 50 Hz power due to the reduced speed. Conversely, the properly sized pump for 50 Hz operation will flow about 20% more with 44% higher discharge pressure when sped up to 60 Hz. Even if the motor can handle the 73% increase in power required, the machine enclosure and filter may be overwhelmed and the filter performance and media use compromised.

For a machine tool builder who serves locales where either 50 or 60 Hz power may be needed, the best strategy is to make pump selections tailored to the desired service. In some cases, it is possible to pick a single pump model that can be specified with different impeller sizes or, in the case of multistage centrifugal pumps, different numbers of impeller stages to provide consistent performance in the two environments. With a comparable power requirement, a dual rated (460V 60Hz, 380V 50 Hz) motor may be used. This keeps the basic filter package the same regardless of service location.

In the case of machine tools where run off or process development takes place with one power supply and is shipped to a location with a different power supply, Polytech has provided pumps with dual rated motors and a second set of impellers or multistage pumps with empty stages that can accept additional impellers to maintain the same hydraulic performance when placed in service in the new environment.

On the motor side of the equation, the inductive reactance of the motor, which opposes or limits current flow varies in proportion to the frequency so as the frequency of the power supply is reduced, the voltage must be reduced to prevent the motor from an over current condition. The variable frequency drive provided for the machine tool spindle (or any variable speed induction motor application) maintains a constant volts/hertz ratio to prevent this problem. If the machine tool power supply is changed with a transformer and the pumps are supplied with power from the machine's line (mains) voltage and frequency care must be taken that the pump motors are not operated outside their rated range.

Assuming the hydraulics performance has been addressed, in a move from 460V 60 Hz power to 380V 50 Hz power, if a transformer is fitted to boost the machine tool voltage to the original design voltage, the pump motors will be operating outside their designed V/Hz ratio and will draw excessive current and in a move from 380V 50 Hz power to 460V 60 Hz power, if a transformer is fitted to drop the voltage to 380V the motors will experience an under voltage condition and draw excessive current.

Conclusion

In view of the foregoing discussion, Polytech recommends two basic strategies for dealing with coolant systems that must operate in different power supply environments. Both strategies are predicated on the coolant filtration delivery requirements being considered and integrated with machine tool design.

The first strategy is to select pumps with the ability, due to flexibility in impeller sizing or number, to operate in both 50 and 60 Hz environments with dual rated motors and design the machine tool electrical controls so that local line voltage is supplied to the pumps and any transformer used to adjust the voltage supplied to the machine tool spindle drives placed after that in the machine tool's power distribution.

The second strategy is to look at extending the flexibility provided by variable frequency drives to the coolant supply pumps which, in conjunction with the buck/boost transformer discussed above, allows the pump motors to operate at the design speed and V/Hz ratio. As the cost of VFDs comes down, using a standard pump(s) selection and VFDs to provide the desired frequency can simplify the coolant system design and provide more flexibility for the sale and delivery of machine tools built on speculation or for inventory. If coolant supply volume is regulated by throttling valves, the use of a VFD could provide significant energy savings, particularly if the pump's heat input to the coolant must be removed by mechanical refrigeration.