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USING VFD TECHNOLOGY TO IMPROVE DRAWBRIDGE PERFORMANCE

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The performance achieved while controlling the operation of drawbridges over the years has been largely determined by the prevailing motor technology, whether electrically or hydraulic, rather than by the requirements of the installation itself. Too often the piecemeal characterization of the drawbridge operation has led to a less than optimum trade-off between how the drawbridge would behave during docking or seating operation and during the raising and lowering operation. The drawbridge application has became somewhat of an art due to the loading variations that were possible due to the changes in the environment of an installion. The general approach in solving the problem has been to define the drawbridge components, such as motors, gears, couplings, brakes, and control devices so that they could handle any known condition and then..... add a "adequate" measure of safety by selecting larger ratings.

This method of selection met the safety concerns and provided for a functional installation. However, because the prevailing technologies focused on the characteristics of the individual components of the system, little insight was gained in combining the characteristics of one component with the characteristics of another component to achieve improved performance for lower installation and operating costs. With the emerging technologies of the past few years, it is now possible to achieve a significant improvement in the drawbridge performance without sacrificing safety, installation costs, operating costs or increasing maintenance costs.

CHARACTERIZING DRAWBRIDGE PERFORMANCE

In order to characterize the performance of the drawbridge operation, it would be useful to examine the nature of the load or functional profile of a drawbridge during its normal operation. As with any variable speed application, there are four basic load characteristics that must be considered. These load characteristics can be defined in terms of the torque required to match the load demanded for an unconditioned or conditioned performance.

The use of variable frequency drives (VFD's) on most applications provide for unconditioned performance. That is to say, that the speed command to the VFD is not modified in response to a momentary change in the load or to a change resulting from a change in the speed command. The torque that the motor will develop is limited only by the output capability of the VFD, at a given speed command, and the characteristics of the motor circuit. In drawbridge applications, it is often desirable to modify the torque that the motor transfers to moving members of the drawbridge in order to gain a higher degree of smoothness and softness during portions of the drawbridge operation. In order to optimize the operating characteristics of drawbridge applications, a conditioned performance would be more suitable when applying VFD's.

CHARACTERISTICS OF LOAD TYPES

Like all variable speed applications, the load characteristics of drawbridge applications can be defined be describing the four load types. The first type is defined as the breakaway load. This load type identifies the resistive force that must be overcome to get the drawbridge moving. It is a variable load due to the proportional relationship to the weight (offset by a counter-balance) of the drawbridge, the thermal properties of bearing surfaces of any moving member, the change in load after motion begins and the wind forces. Since it is a variable load, the traditional method has been to select the torque producing component for the worst case conditions. This often resulted in an excess of torque during portions of the drawbridge operation. This was a result of the unconditional performance approach defined previously. Later in this paper, an improved method will be described which will reduce the undesirable effect of excess torque without reducing the torque required to effectively contol a variable load during the breakaway operation.

The second load type is that of static running load. This type of load is also variable. Since no speed change is taking place, the forces which must be overcome relate proportionaly to the weight of the moving parts and wind forces. Since the speed command is constant during this portion of the operation, the key concern would be to provide the means to handle the variations in load caused by the wind forces and day to day weight changes that occur. For this portion of the operation, an unconditional performance approach would be suitable assuming that the torque producing components have the ability to handle bi-directional and overload torques. The advantage of a conditional performance approach would be to more clearly define the interval of time that would be spent during this portion of the operation.

The last two types of load characteristics are defined as load changes caused by a change in speed command. If the change is positive, then the load change is due to acceleration. The amount of torque that must be provided to cause a change in speed to occur is directly related to the value of load inertial and the actual change in speed commanded and indirectly related to the time desired for the speed change. If the change is negative, then the load change is caused by deceleration. A negative speed change or slowdown command often results in regeneration. This is caused by forcing the kinetic energy stored in the moving members of the drawbridge to become a torque producer which must be absorbed by the normal torque producing or driving component. During this operation, an unconditional performance approach is least effective in optimizing the performance since the driving component will always attempt to operate at the commanded speed. Unless changes in speed are programmed to fit the exact requirements of a given installation, the resulting performance can produce either excessive torque or excessive delays during the operation.

ACHIEVING OPTIMIZED DRAWBRIDGE PERFORMANCE

Defining an alternate approach to the control of the drawbridge operation assumes that some meaningful improvement can be achieved in some portion of the operation. Some undesirable characteristics have become general topics of discussion of those involved in the design, installation, retrofit or maintainence of drawbridge equipment. As mentioned at the beginning of this paper, many of those undesiable characteristics were reflections of the individual characteristics of the components used. To improve or eliminate the undesirable characterictics, it is important that the desirable characterictics or objectives be defined first and then select the hardware whose combined characteristics meet those objectives. Athough many technologies are being used to control drawbridges, this paper will limit its coverage to the VFD electrical approach.

The objective of any drawbridge application should be to first define the performance at any movable span position and then to select the combination of components that comes closest to meeting those objectives. At any position, a torque value can be define which is suitable for control of the load at that position. It is also possible to define the speed conditions that are likely at that position. Due to the nature of the application, it is unlikely that a single value for speed will exist for any postion except when the drawbridge is in a clamped or locked position. It should be noted that in the specifications defining almost all drawbridge applications to date, a speed/torque or horsepower value is defined. If one observed the characteristics of any drawbridge application, it should be apparent that the priority of speed over position causes much of what is undesirable.

If speed is to be defined, it should be specified as a nominal speed which permits the specification of time to fully open from a closed position or close from a fully opened position. This would permit the speed to vary its instantaneous value in order to obtain the optimum characteristic for the operational command. In figure 1, the maximum torque achieveable during an uninterrupted opening of the drawbridge is shown. If the opening is interrupted by an emergency stop, the maximum torque achieveable will not change during the remaining portion of the operation. However, the speed must change in order to provide the different actions required.

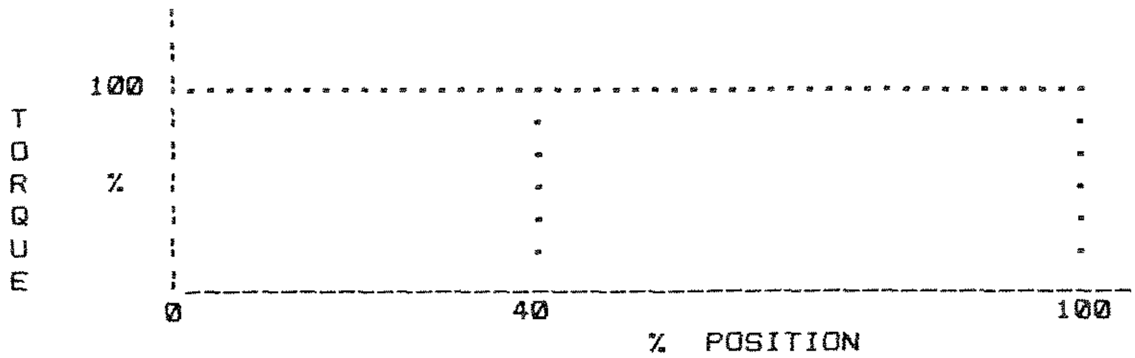

Figure 1 - Maximum torque versus % position

A casual observer might assume that the drawbridge application would best be controlled by programming torque i.e. current during the operation. Athough the concept of programming torque is sound, the traditional methods of controlling torque by means of current limiting will result in excessive torque being produced when it is not required and insufficent torque when the load demand is high. This would be due to the slow response or characteristic time constant of the motor or torque producing component. Since the load is a variable, it would be better to establish a control method whereby the torque produced was only slightly greater than the load demand.

An effective method of controlling torque would be to monitor the behavior of the load by observing the result that is expected when the torque is being produced. As was previously defined, during normal constant speed operation the characteristics of the operation are reasonably defined and controlled. However, during any programmed speed commands, speed changes should only be permitted if an expected change has occurred. That is to say, don't push harder than required to move at a predefined rate.

By applying a programmable logic controller (PLC) in a closed-loop, position monitored system, it is possible to calculate the rate of change for a given value of torque. By monitoring position changes as a function of time, a rate of change of speed can be defined. By modifying a programmed speed rate on the basis of achieved position, it is possible to optimize the performance of any variable speed system. The responsiveness of the system would be a function of the position resolution and update time. The finer the resolution or faster the update time, the smaller the value for extra torque required of the power components of the system.

Since a drawbridge application requires end point position information, the approach of applying position sensors is merely an extension of system hardware that is already in place and operating in many installations. By interfacing a postion sensor to a PLC, the resulting performance provides the torque as it is required, based on the programmed speed rate and the torque capabilities of the hardware. Excessive or insufficent torque conditions are avoided. If the system hardware is slightly undersized or the momentary peak torque demands approach the upper limits of the system hardware, the performance of the system is automatically adjusted to match the prevailing conditions.

SUMMARY

By extending the use of position information sensors that already exist in many drawbridge installations, it is possible to improve the operating performance by combining the individual characteristics of standard electrical components also used in those installations. By using the results of how these components interact, rather than attempting to control the behavior of an individual component, a more flexible system is created to reduce or eliminate the undesirable characteristics associated with todays installations.

Athough this approach can be applied to non-electrical systems, the simplicity of standard electrical components provides a predictable, reasonably priced and easily installed and maintained operating system. With some basic programming steps, the extended use of a simple postioning device and the well defined characteristics of a variable frequency drive, the goal of a smooth operating drawbridge is easily obtained.