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Comparison of Linear Actuators with Pneumatics and Hydraulics

When deciding whether to use hydraulic or electromechanical actuators in a particular application, the sole deciding factor is: which best meets the technical and economic demands of the application. Here, a system for a fully electric powered forklift truck is taken as an example.

Over the last few years the development of electric linear actuators has led to their increasing use in linear motion systems that would formerly have used hydraulics -- so much so that it is now good practice before designing a new linear motion system to decide which type of linear actuator might be best for the system. In addition to the technical aspects and the price of the drive concerned, it is necessary to consider the cost of any ancillary equipment, together with the costs arising over the total life cycle, including maintenance and repair costs. Also, because of the current trend to longer warranty periods it would be wise to consider questions regarding fatigue resistance and availability. *(The fully electric SKF forklift truck, shown here, demonstrates the high performance of electric linear actuators as an alternative to hydraulics.)*

Comparison

Although the cost of an individual hydraulic cylinder is less than that of an electric actuator, a hydraulic system can still be more expensive in total than its electromechanical equivalent. This is particularly the case when only one or a small number of actuators is needed for a particular application, because the costs for ancillary equipment will make a hydraulic system more expensive than an electric actuator. Ancillary equipment comprises an oil tank, a pump, possibly an accumulator, a filter system, and tubing or hoses for distributing the hydraulic fluid and returning it to the tank. Moreover, to maintain cleanliness in production and to protect the environment, a drip pan to collect leakage will also be needed.

Finally, the fluid itself must be taken into consideration: in certain cases additional costs are incurred if instead of conventional hydraulic oil, a biodegradable oil is used or -- because of increased environmental or fire protection requirements -- a water-based hydraulic fluid (types A, B or D). As every fluid has to be checked regularly for condition (type and quantity of particles contained in the fluid, water content and lubrication properties) other costs will also arise. Moreover, for applications outdoors or in cold storage areas, a heating system may be necessary to improve the flow properties of the fluid.

In contrast, electric linear actuators require only cables -- for power supply and for transmitting signals or connection to a fieldbus system. However, if many actuators are concentrated in a small space inside a machine or manufacturing/processing equipment, the ancillary equipment costs for hydraulics can be distributed over all the actuators. This means that as long as the potential disadvantages of using oil are not significant (with respect to cleanliness in production and environmental or fire protection), a hydraulic system can be more suitable than the electromechanical alternative.

Linear drives are often used as reversing drives and in many of these applications, oscillating movements occur at high frequency. With a hydraulic system this leads to stress on the seals and impairs the oil retention ability of the seal, which in turn can result in leakage of the hydraulic fluid. In the most favorable case this is unsightly, but in certain situations -- predominantly in clean processes -- it can lead to considerable production problems due to the oil having an adverse effect on the quality of the manufactured products. Problems of this nature do not arise with electromechanical systems. Without any emission occurring, acceleration factors of up to 10 g can be achieved in the system, and the reversing motion does not lead to any problems.

Advantages of Electric Linear Actuators

The above example is not meant to imply that electric linear actuators are always more appropriate than their hydraulic equivalents. The intention is to show that electric linear

actuators are becoming a genuine alternative in more and more applications from both the technical and economic viewpoints. This is necessary because an appreciation of the advantages of electric linear actuators is still not very widespread. Consequently potential users are surprised that standard actuators are available with load ratings of up to 100 kN along with strokes of up to 1,500 mm *(electric linear actuators, such as the one shown here, reveal typical features of modern mechatronics: the principles of electrical engineering, electronics, and mechanics are combined into high performance systems that can be integrated in existing equipment without problems)*. That electromechanical systems can have a trim design is also not widely known. As an illustration of these favorable aspects, SKF has demonstrated within the framework of a pilot project that in forklift trucks, hydraulic actuators can be replaced by electric ones without any problem.

If the drives are to be controlled, electric actuators reveal a further advantage. Whereas for hydraulic systems the electronic control system must be specially designed for the particular requirements of fluid engineering, electric actuators can draw upon the complete range of electronic control systems available for electric drives -- even rotational ones. As a result of large production runs, the market range is wider and unit prices lower so that in most cases cost savings can be made.

Electronic Control

Control equipment is of course available that is compatible to all readily available stored program control systems (SPS) and likewise to all available bus systems. SPS programming for all electric drives has proved to be particularly simple as the motion produced by the drives is not affected by a fluid, and the control response remains practically constant for as long as the machine is in operation. It is, however, quite different with hydraulic drives. For example, when an injection molding machine is switched on in the morning, it first produces a run of defective parts, whereas a fully electric-operated injection molding machine produces parts without defects almost from the very first operation.

Damage Arising From Obstructions

One system property does make hydraulic drives the first choice for applications such as construction machinery. If the shovel of a hydraulic excavator comes up against rock, the compressibility of the hydraulic fluid prevents damage to the moving parts of the excavator. But of course this error tolerance can be engineered into machines in other ways, e.g. by using power sensors, which switch off or reverse the drive as soon as mechanical resistance is detected.

Operating Costs

The costs of electricity have recently been increasing and unfortunately will continue to do so. This gives electromechanical systems an advantage in terms of operating costs. After all, it is well known that every form of energy conversion gives rise to loss of performance -- for example, electrical current is used in a hydraulic system to generate the fluid pressure required using pumps. This pressure is converted into motion by the working cylinder. For many pieces of equipment a high pressure must be kept in reserve, as when a peak load ensues, sufficient pressure would otherwise not be provided quickly enough.

Electric machines, on the other hand, can be operated in an extremely cost-effective manner with respect to energy. If only a low output is required, then a small amount of current is tapped. But as soon as the load increases, the current input is adapted without delay, and the system performance increases. Electromechanical systems show no losses as, for example, when reserve pressure generated is not needed later. Furthermore, electric power always is consumed only for the duration of the operating cycle.

All in all, it can be said that electromechanics is increasingly becoming an alternative system to hydraulics, from both the technical and economic viewpoints.