System characteristics help in Choosing the drive

WHICH DRIVES BEST SUIT DIFFERENT TYPES OF PACKAGING MACHINE OR MACHINE FUNCTION? SIMON MARSDEN* REVIEWS PROGRESS IN THE VARIOUS TYPES NOW EMPLOYED.

Choosing the most suitable drive technology for controlling packaging machinery depends largely on the operating speed, the dynamics of the driven loads, the accuracy required and the complexity of the application.

However, there is a degree of overlap in performance – and indeed price – between the various options.

DC drives are not only simple, but are capable of generating high operating torques – up to 400 per cent nominal torque in some cases – at low speeds, although regular maintenance is needed to ensure efficiency. They tend to be used in machines and processes that are allied to packaging – such as paper and board manufacturing and converting machines – but their use in high-speed packaging applications is limited.

While AC inverter drives are more complex than DC systems, they are increasingly being employed in more demanding applications as a result of rapid advances in their performance. They are also easy to install and use, and do not require regular maintenance.

Servo motion control systems offer high levels of accuracy, repeatability and are well suited to high speed control while also being capable of co-ordinating and synchronising multiple axes of motion. In some cases, new lower cost servo drives are increasingly seen as viable alternatives to stepper drives, while elsewhere the increased performance and flexibility offered by servo drives more than compensates for any additional cost.

Nevertheless, stepper drives are more than capable of high speed, high accuracy control and are well suited to point-to-point applications such as X-Y tables. They will also remain the best option in cost sensitive areas.

Adjustable frequency AC drives

Often simply termed inverters, or AC inverter drives, adjustable frequency AC drive systems perform two functions. In basic terms they convert the AC line power source to DC and provide an adjustable voltage and frequency output to an AC motor. Varying this signal changes the current seen by the electro-magnets in the motor, which in turn affects the output torque.

The appeal of an AC inverter drive system is based on the simplicity, reliability and low cost of AC motors. There are no brushes, commutator or other parts that require routine maintenance and in high-speed applications – over 2500rpm – AC motors are generally better suited than DC motors because of the problems associated with brushes and commutation.

Limits of AC drives

There are limits when using standard AC inverter drives in some low speed applications since they are unable to generate full torque at zero or low speed. However, using the latest high performance flux vector AC inverter drives with encoder feedback from the motor will overcome these constraints since they are capable of generating 100 per cent torque at zero speed.

The versatility of AC inverter drives and the increased performance they now offer more than compensates for any complexity and so they have a wide range of applications within packaging machinery.

Stepper systems

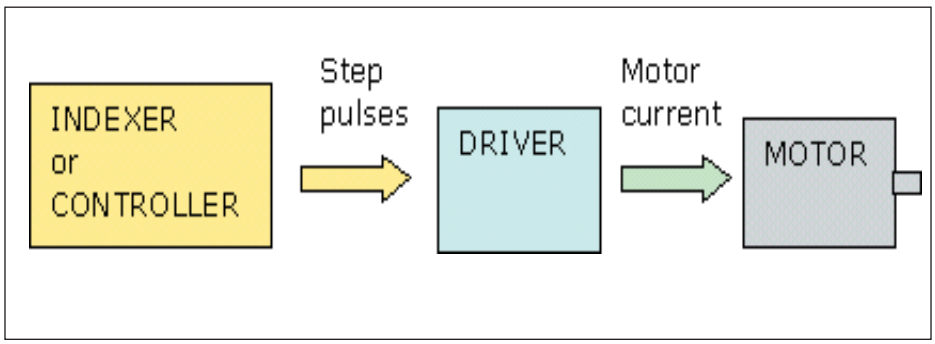
There are three basic types of stepping motors – variable reluctance, permanent magnet and hybrid – although for the purpose of this article it suffices to say that generally all three operate by converting digital pulses into mechanical shaft rotations.

Stepper systems have the advantages of low cost, high reliability, high torque at low speeds, and are built to perform in most environments. They operate under simple 'open loop' control so that the stepper drive does not require positional feedback signals from the motor.

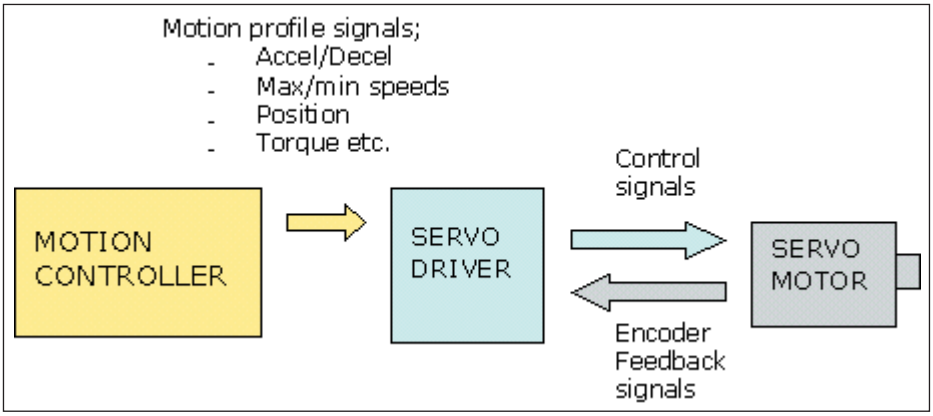
The main disadvantages are that the system often resonates at low speeds, torque decreases as speed increases, and in dynamic applications requiring high accelerations or where variable loads are involved, open loop steppers may be subjected to over-torque – with the possibility of a stalled motor – or slippage.

Should this happen, the system loses knowledge of the motor's shaft position and must be re-initialised – brought back to its starting position – in order to regain proper control.

In critical applications this may be unsatisfactory although fitting the motor with an encoder to feed back the current shaft position will improve control.



Typical stepper drive system layout: The indexer provides step and direction output signals to the driver, these are then converted into electrical (step) pulses to run the motor. As an example, a 200-step motor requires 200 pulses from the driver to rotate the motor shaft one revolution. In micro-stepping mode over 50,000 pulses per revolution could be used to give higher resolutions. In most applications the indexer will also manage a number of control functions, including acceleration, deceleration, steps per second and distance. Additionally, it will also interface and control many other external signals.



Typical servo system layout: Unlike stepper drive systems, servo drive systems require feedback from the motor to indicate its current position, which is termed 'closed loop control'. This feedback signal is used as a comparison between current position and desired position – a control signal proportional to the difference is calculated by the drive and fed to the motor until desired and current position are equal. The advantage of this form of control is that the drive always knows the position of the motor. Therefore, unlike an 'open loop' stepper drive system, a servo system will not need to be re-initialised in the event of a stall condition occurring.

Servo systems

Servo systems are principally designed to respond to commands to change speed, position or torque. These commands may come from an external control system such as a PC or PLC, or directly from a sensing device on either the servo motor or the load being driven.

The advantage of servo drive systems is their ability to control highly dynamic applications with accuracy and speed. They are however complex systems requiring high levels of programming and applications knowledge.

Advances in drive technology

In the past, many AC inverter drives suffered from low speed power problems, particularly in applications needing full torque at zero speed. Additionally, the response of many inverters was too slow for use in dynamic applications subjected to sudden changes in load and speed.

Modern inverters address these issues through a variety of techniques such as flex-vector models using encoder feedback to improve low speed operation and positional control, through to dedicated applications software to change the inverters' characteristics specifically to suit a particular application.

Advances in electronic components have also improved AC inverter drives' processing power and switching speeds. We are also seeing AC inverter drives designed with improved programmable logic control (PLC) and communications functions built in.

This allows designers to configure control systems using just the drive, which in standalone mode can handle both its own i/o and that of the machine's, while being able to communicate and exchange data with other external systems.

Manufacturers are also designing servo drive systems offering increased functionality at lower cost while, to improve system configuration, there is an increasing use of industry standard programming and communications techniques. This coupled with improved user set-up features, such as the ability to call up libraries of standard application software, improves their flexibility, support and maintenance.

However, these improvements do not mean the skill of the designer and user can be eliminated: there is still a need for good mechanical and electrical application knowledge as well as sound programming techniques.

This is especially the case when calculating the mechanical loads in the system, in order to match the motor to the load.

Simply guessing and erring on the side of caution by installing a larger drive can have detrimental – and costly - effects. Many drives manufacturers now provide simulation and load sizing software to overcome these issues.

There is also an increasingly evident trend for control and drive systems manufacturers to package the motion control, operator display and machine logic control into one unit.

These so-called 'soft' controllers are based on PCs running a real-time operating system – outside the influence of Microsoft Windows – for all high-speed, time critical motion control and machine logic control. The familiar Windows packages run the less time critical applications, such as data entry and manipulation, operator display and external communications.

Systems of this type offer the ability to make quick changes, by downloading complete machine set-up parameters from one button on the operator panel, along with IT based support as far as the PC and Windows operating systems are concerned.

At the same time, the machinery designer is less restricted in no longer having to select a single drive manufacturer's products when planning his control system.

Packaging machine applications

AC inverter drives have a wide range of uses in packaging machines. Although they will never match the outright performance of a servo system, they are increasingly used in dynamic applications as a result of improved designs and performance. Typical applications include:

- Web tension control in which improved torque output offers smooth acceleration and deceleration to ensure the web is not damaged, while PID control functions are employed to vary reel shaft speeds in proportion to the amount of material drawn off.
- Conveyors and end-of-line equipment such as stretch wrappers, or in other applications where a combination of simple standalone logic and speed control is needed. In such situations AC inverter drives with built-in PLC functions are being used.

Servo drive systems are increasingly being applied to control advanced high-speed packaging machines to replace mechanical linkages and layshafts and to synchronise multiple axes. Examples include vertical form-fill-seal machines, cartoners, flow-wrappers, end-of-line equipment and filling machines.

Stepper drives – or low cost servo drives using pulse train control – are increasing employed in point-to-point packaging applications.

For example, labelling machines have traditionally used a combination of a clutch-brake arrangement to control the label applicator, together with a basic DC drive to control the product infeed conveyor. However, these systems struggle to keep up with modern production demands.

So labelling machinery manufacturers are overcoming these performance issues by installing stepper-servo drives in place of the clutch-brake systems, while AC inverter drives control the speed of the infeed conveyor.

This combination is both versatile and offers much improved speed and label position accuracy – advantages that more than make up for any additional cost. ■

Simon Marsden is an independent consultant and writer. He was formerly with a leading control systems and components manufacturer where he was concerned with packaging machinery. (www.marsdenconsulting.com)