Electronic torque monitoring is not always the most appropriate approach to protecting machines and their operators. Geoff Spear, Lenze’s marketing manager, argues that there are many applications where mechanical torque limiters offer advantages – especially when rapid operation is needed.

In this changing world, some people may feel that mechanical torque limiters are old-fashioned and unnecessary, and that electronic monitoring can satisfy all the needs of machine protection and operator safety. What is actually needed is a device to prevent damage from accidental collisions that can lead to expensive downtime. Also, the increasing emphasis on operator safety as EN ISO 13849 approaches, demands a higher level of protection than was acceptable before. In these cases, the humble mechanical torque limiter remains the optimal answer because it disconnects the drive from the driven parts extremely quickly.

Where there is a slow increase in load – for example, due to damaged bearings or dirt contamination – electronic sensing can work well. There is time to stop the drive and the signal can be used as a preventative alarm. On the other hand, where the load increase is sudden – for example, due to a mis-feed or mechanical breakage – only a mechanical torque limiter can give protection.

By introducing a disconnection between the motor and the driven load, the torque limiter takes much of the inertial energy out of the drive train. Indeed where the limiter can be positioned at low speed close to the output, almost all of the kinetic energy can be disconnected, resulting in a greatly reduced possibility of damage or injury.

Disconnection is not instantaneous. Depending on the design and size of the limiter, it can take from single digits to tens of milliseconds. However, electronic systems cannot match this performance as they have to sense the overload and then apply a braking torque to bring the drive train to a stop. Therefore when it comes to achieving maximum protection and safety, mechanical torque limiters remain the only real answer.

Simple friction torque limiters drive using spring-loaded rubbing faces that connect to a driven wheel – often a plate wheel. These friction torque limiters are low cost, easy to adjust steplessly, and react quickly to shock loads. They are not suitable for use in oily environments, or for prolonged slippage which introduces wear and the need for readjustment. Therefore they are best used at low speeds, positioned close to the output. They are available in a wide range of rated torques from 1–23,000Nm.

Higher consistency
A higher consistency of release torque and the ability to operate in oily and dirty environments is met by stepping up to a ball or roller design of torque limiter. Both work by spring pressure, usually from disc springs that push two plates together. The plates have recesses for hardened balls or rollers and when an overload occurs, the balls or rollers rise up out of their recesses and run in a track around the plates.

Disconnection is not instantaneous because the springs have to be compressed when the plates move apart. Ball designs need less separation and can be more sensitive, while roller designs are useful to avoid nuisance tripping on small torque variations, and to transmit higher torques. The release action of ball and roller torque limiters gives an axial movement that can be detected by a microswitch or proximity switch, allowing the drive to be turned off.

Many variants are available based on the ball and roller principle. By positioning the rollers asymmetrically,
re-engagement will always be in a synchronised angular position. Alternatively multiple positions, such as every 180 or 60 degrees, are possible. The recesses can be machined to give different torques according to the direction of rotation. Models are available for in-line transmission with shaft couplings, also offset with narrow or wide gears and pulleys. These popular designs are to some extent a European standard product and come in ratings from 2 to 12,000 Nm.

Reversing and reciprocating drives in the packaging industry have triggered further development of ball-type torque limiters with backlash-free variants. These have also found uses in indexing tables, printing machines and machine tools. The internal structure of the torque limiter is modified to remove splines and usually there is a locking bush connection to the shaft. A higher degree of sensitivity is possible too by using disc springs that have a negative spring rate. Thus, as the drive plates begin to separate on overload, the spring force decreases and the release time becomes extremely fast. Such torque limiters are more complex and costly, but offer the highest levels of protection. They are typically available for torques up to 750 Nm and can be supplied in stainless-steel versions for severe environments.

Usually, mechanical torque limiters are set to release at the highest torque required by the drive, plus a service factor. In many machines, the starting torque is often the highest torque. Setting the torque limiter above this level is necessary to prevent tripping on start-up, but may result in a lack of sensitivity during the normal working part of a machine cycle. The ability to adjust the release torque easily during a cycle, or perhaps for a different product running on a machine, contributes to a higher degree of protection. Electronic monitoring can handle different levels of torque easily, but as mentioned above does not give the disconnection. The torque limiter solution is to use pneumatic actuation.

Replacing the springs
Pneumatic torque limiters are effectively clutches which can disconnect a drive. A pneumatic piston replaces the springs of mechanical limiters, and the release torque is directly proportional to the air pressure applied. Factory air pressures up to 6 bar are used and this gives the ability to vary the release torque through a work cycle, or to set a new release torque quickly for a new machine setup. Variable torques can be set for coilers and uncoilers proportional to the reel diameter. These roller-based designs synchronise input to output and give release torques in the range 7–30,000 Nm.

Over the years, mechanical torque limiters have been developed to suit several market niches. Linear force limiters trip when a set force is exceeded, either in tension or compression, and are frequently used as gearbox torque arms. A pneumatic friction design suits simple tensioning applications because the pneumatic cylinder compensates automatically for wear on the friction linings. Roller types can be supplied to give an overload signal without disconnecting the drive – a useful feature where the load might otherwise fall.

Every application has individual requirements for protection and sensitivity. Where operator safety is a factor, higher standards are needed and advice from experienced suppliers is recommended. The new EN ISO 13849-1 safety standard requires machine designers to re-assess hazards although, as a standard related to control systems, it does not deal specifically with torque limiting. Nevertheless, the review process may identify torque limiters as a means to achieving higher safety levels.

Mechanical torque limiters are available today in a wide variety of different forms to suit almost any type of machinery. The level of protection achieved depends on the sensitivity and repeatability of the torque limiter. Compared to electronic torque monitoring, mechanical torque limiters offer the important advantage of disconnection where the inertial energy on the drive side is isolated from the output, reducing damage and improving safety.