Why Use Mechanical Torque Limiters in a Servo Drive System?

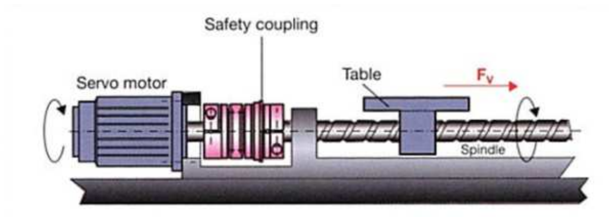
Electronic current limiting is not a 100% effective way to prevent overloads in a mechanical system

R+W Coupling Technology

On a servo drive system it is relatively easy to set torque limits in the parameter programming of the machine. When doing so, one must remember that the electronic torque limit is at the motor only. This means that, from a safety standpoint, the motor's electronics do not account for the masses of gears, couplings, shafts, etc. further along down the drive line, while in many cases a manufacturing process is many mechanical power transmission components away from the motor. As a result, the servo drive and or PLC monitoring the torque of the motor may not pick up an over-torque condition quickly enough to prevent damage from occurring. In the case of rotating equipment, there are often gearboxes and shafts which have a lot of rotating inertia not accounted for by electronic means.

Additionally, linear applications impart their inertia back into the rotating components driving them when they stop or crash.

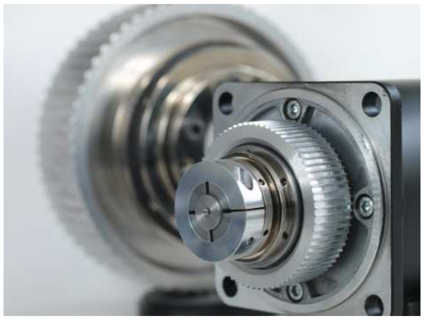
Precision mechanical torque limiters and safety couplings are often a good option where blockage or malfunction is a possibility.



When we examine what happens in a machine crash, it is often useful to look at an impact force equation. F=(.5m*v^2)/s where F=force in Newtons, m=mass in kilograms, v=velocity in meters per second, and, s= stopping distance in meters. Examining this equation tells us that the force imparted by an impact is directly proportional to the mass and or velocity, while being inversely proportional to the stopping distance. That being said, the more massive any component is and the faster it's moving, the more impact force exhorted during a crash. Because the stopping distance is in inverse proportion to the impact force, the smaller it gets, the more force is imparted by the crash. Consider also the same principle in terms of rotating inertia and torque. T= (ω /t)*J where T=torque in Nm, ω=angular velocity in radians per second, t=acceleration/deceleration time in seconds, and J=rotational moment of inertia in kg*m^2. Here we see that likewise, stopping time is inversely proportional to torque. When this equation is applied to common industrial drive applications, the torque resulting from stopping times in the 1-3 millisecond range can be astronomically high. Once pointed out this is fairly straightforward, although many engineers forget to account for this principle while limiting currents and or torque values, forgetting that in many instances the mechanical energy plays a much greater role than any additional current supplied to the motor after the impact. It can be relatively simple to find the mass moment of inertia of mechanical power transmission components and know how fast they will be moving. What is difficult to gauge is how the machine will likely crash and what will cause this to happen.

Because many people from different backgrounds are often involved in machine design, aspects of how the machine will operate holistically can be unintentionally neglected when engineers concentrate on one area alone. Mechanical drive experts may focus on the process and drive components without thinking much about the full capabilities of the motor and electronics. Conversely, electrical programmers and designers do not always remember to consider how the total mechanical inertia of drive systems can impact their overload settings.

It is common practice in electrical design to implement multiple levels of overload protection into circuits. Most industrial control boxes normally have main breakers and or fuses and protection on each branch circuit. Many individual devices also have their own overload protection. This concept has not taken as deep of a root in the



mechanical design side of machine building, often making drive components such as belts, chains, and couplings into mechanical fuses. In other cases machines are built with a series of shear pins to serve as the fuses to protect the drive line. Meanwhile, the well established technology of the ball-detent torque limiter has been refined in recent years to be much better suited to dynamic drive applications. A precision ball-detent torque limiter is essentially a mechanical circuit breaker instead of a fuse. Rather than having a component that breaks and needs to be replaced, a torque limiter can trip and be reset many times during its life.

In addition to eliminating maintenance, spare parts, and downtime after overload, another key advantage of using mechanical torque limiters over shear pins and or relying on a belt or coupling to break apart in an over torque condition is that they are much more accurate. A precision ball-detent torque limiter is typically able to maintain an accuracy of +/-5% while a shear pin is often in the range of +/-20% depending on the design and materials of construction. Most precision mechanical torque limiters are also adjustable, allowing users to fine tune disengagement torque values after installation.

The best advantage of using them in conjunction with electronic torque limiting is that they can usually be installed very close to the device a where crash could occur as well as at multiple points in the system. Mechanical torque limiters are designed to instantaneously detect an over-torque condition and disengage very quickly. In many cases mechanical torque limiters are capable of disengaging an over-torque drive line before an electronic device such as servo motor even begins to pick up the condition.

Most mechanical torque limiters allow for an integration of mechanical and electrical design. An electronic proximity switch can be positioned near an actuation mechanism which moves in the event of an overload. This system works well because the overload is detected and disengaged followed by an electronic signal to a PLC or process controller to shut down the part of the system with the over-torque condition. Because torque limiters can be placed in multiple parts of a machine, the source of the jam can be detected very quickly using proximity sensors.

To summarize, the peak process torque value should always be calculated through the driveline back to the servomotor, and the associated current limit programmed into the servo drive parameters. Bear in mind that this will only truly protect the motor from the over-torque condition. The best option to limit torque at the process is to install a mechanical torque limiter as close to the area which jams as practical (both for maintenance of the process and possibly resetting the limiter). Essentially, machine builders should be aware not to put all of their eggs in one basket when mitigating machine crashes. Circuit breakers, fuses, and electronic limiting should be used at multiple levels on the electrical design. Torque limiters, guarding and bumpers should be employed on the mechanical design. As always, consult the manufacture's of each component if there are any questions or concerns.

Learn more about R+W precision safety couplings at: http://www.rw-america.com/products/torque_limiters/