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Fig. 1: Force measurement in linear drives

With electric linear drives, the force measurement method is decisive

Controlling power without pressure

The movement and power of pneumatic and hydraulic linear drives are determined first and foremost by pressure control and regulation. It's a different story with electric linear actuators, where it's the force measurement method that is decisive, in this case tension and compression force transducers.

Linear drives keep countless work processes moving, from punching of parts to the excavation of a pit. Pneumatic systems play a major role in industrial processes, mainly due to their fast and precise positioning movements. Hydraulic drives are preferred for construction equipment and agricultural machinery on account of their robustness and high concentration of forces.

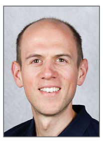
Over the years, a third type of drive has become established alongside these two classic, proven principles, namely electric linear actuators. This combination of a motor and a mechanical thrust unit is increasingly widespread, particularly in industrial processes as an alternative to pneumatic drives. There are also signs of a change taking place in typical applications for hydraulic systems in the construction machinery sector.

The advantages of e-solutions are obvious: the drives are compact and individually adaptable to each application as part of a modular system. They need no fluid or compressed air as an intermediary but convert energy directly into motion. The equipment normally required for this purpose – for instance, pumps and compressors complete with cables and hoses – can therefore be dispensed with, so that less maintenance is necessary and leakage can be ruled out as a potential source of error.

Expensive pressure

Electric drives are also economical: they only use energy to actually execute the movement, whereas pneumatic or hydraulic systems have to maintain pressure permanently. It was for precisely this reason that a German car manufacturer, for example, converted the spot welding process in the body shop from pneumatic to electric-driven: by comparison, it was quite simply too expensive to produce a constant basic pressure of 10 to 12 bar with the old system. If pressure is no longer the central drive component, it's the force measurement that is decisive with electric linear actuators when it comes to monitoring and controlling the motion sequence. The forces which must be recorded vary according to the range of applications, for instance joining forces for robot arms, shear forces for punching, contact forces for marking deliveries in the shipping department, press forces for crimping or compression forces for spot welding.

Electromechanical tension and compression force transducers are the method of choice for these tasks. These deformation bodies are deformed when a force (F) is applied. Strain gauges convert the mechanical, reversible deformation into a proportional, electrical output signal.



Author:
Dr. Markus Heidl
Product Manager
Force

Error detection as a differentiator

Although users could theoretically move the drive's terminal devices – such as welding tongs or punching tools – into the required position by means of time or displacement sensors, errors can only be automatically detected without delay by measuring the force. A force could suddenly increase beyond the defined maximum limit due to a chip or canting, for example. Especially in automated processes where a new cycle begins every second, error messages like these are vital. Without these signals, an uncontrolled force could destroy entire product batches in next to no time.

Thin-film tension and compression force transducers are ideal for drives in industrial machines owing to their excellent performance. Their sensors are made up of several thin, sputtered layers. One of these layers contains four strain gauges connected as a Wheatstone bridge. If redundancy is required, even eight strain gauges are not a problem. The finished sensor is then automatically welded into the force flow channel of the transducer body. The measuring cell is combined with an amplifier for the output signal to form a compact, temperature-compensated measuring unit.

Force transducers in this category are flexible in use. The devices in WIKA's F23 series, for example, are designed for a maximum nominal force (Fnom) of 100 kN. They work with the standard 4 to 20 mA and 0 to 10 V analogue signals and communicate using the CANopen® protocol. The version with a digital output is particularly suitable for integration into automated processes.

Freely positionable

Thin-film force transducers have a female thread and can be installed relatively simply in almost any linear drive. Their position is irrelevant because the load is identical anywhere in a drive's force chain. With the majority of drives, the measuring instrument is situated at the point of force application, in other words at the end of the thrust unit, because this is the easiest way. This is the case with inserting or punching machines, for instance. With X-type welding tongs, on the other hand, the sensor monitors the force in the motor area at the starting point of the shear movement.

Although, by and large, force transducers are freely positionable, users must consider shear force as a potential disturbance when deciding where to install them. Measurement errors could occur if 5 % of the nominal force is exceeded. A point with a smaller deflection must be selected for the measuring instrument if necessary or its location additionally supported.

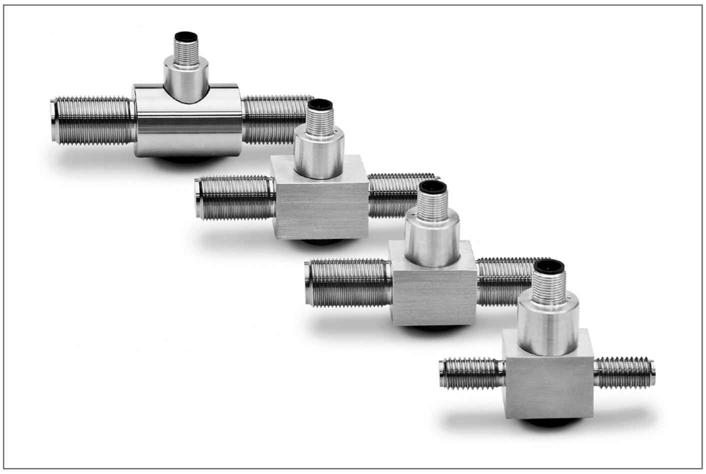


Fig. 2: Product group: Compression force transducers

Alternative for low nominal forces

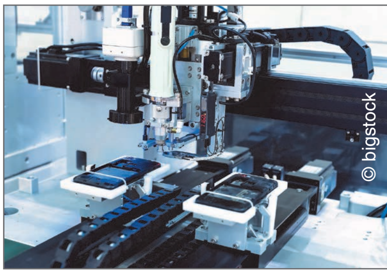
From the point of view of handling and performance, force transducers with thin-film sensors represent the most comprehensive solution for electric linear drives in industrial applications. Nevertheless, force sensors based on glued strain gauges should not be completely disregarded as they can be a useful alternative for low nominal forces. Thin-film force transducers have relatively high stiffness, so that only forces greater than 1 kN can be measured with the usual fault tolerance. By contrast, glued strain gauges can detect forces as low as 1 N and are suitable, too, wherever miniature sensors are specified. Furthermore, this force transducer type provides higher accuracy and achieves values from 0.01 % F_{nom} to 1.0 F_{nom}. The value range for thin-film sensors is generally from 0.1 % Fnom to 1.0 % F_{nom}.

On the other hand, force transducers with strain gauges are far more complicated to manufacture on account of the various manual steps which are necessary, such as the individual application and wiring of each strain gauge, compensating for temperature variations or integrating the amplifier for the output signal. Where installation space is particularly restricted, miniature sensors can also be equipped with a cable amplifier, although the distance from the sensor makes the signal more susceptible to failure.

Irrespective of the type, any tension and compression force transducer is likely to be a customised measurement solution. It is tailor made based on the nominal force that is required to perform the task at hand. However, the body which houses the sensor cell can be used for different nominal loads. According to VDI / VDE / DKD 2638, all force transducers must be designed to withstand overload equivalent to one and a half times their nominal force for short periods. Provided the defined operating conditions are observed, force transducers are robust and durable instruments that keep going for up to ten million load cycles without a single measurement error.

Conclusion

Electric linear drives are increasingly widespread in industry. In contrast to pneumatic and hydraulic linear drives, which are pressure-dependent, with electric linear actuators it's the force measurement method that is decisive for power monitoring and control, in this case tension and compression force transducers. Devices with thin-film sensors are suited for a wide range of industrial applications, and versions with a digital output signal can be supplied for highly automated and networked processes, which are rapidly gaining ground due to IIoT.



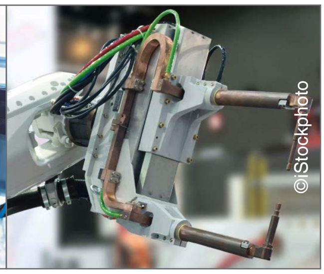


Fig. 3: Control of press forces **Fig. 4: Weld quality assurance**

Your contact:
Andrea Suhrcke
✉ andrea.suhrcke@wika.com
☎ +49 9372 132-8031