How Does a Force Transducer Actually Work?

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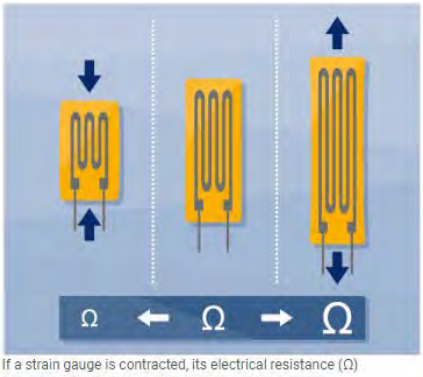
Method of operation:

To explain how a force transducer works, we first have to answer the question: how does a strain gauge (or SG) work? For most common force transducers have strain gauges inside them.

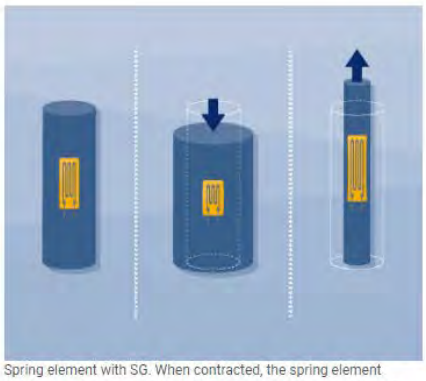
Let us digress briefly to take a closer look at strain gauges: They are electrical conductors firmly attached to a film in a meandering pattern. When this film is pulled, it – and the conductors – get longer. When it is contracted, it gets shorter. This results in a change in resistance in the electrical conductors, and on this basis we can determine the strain, for resistance grows when there is strain and diminishes when there is contraction.

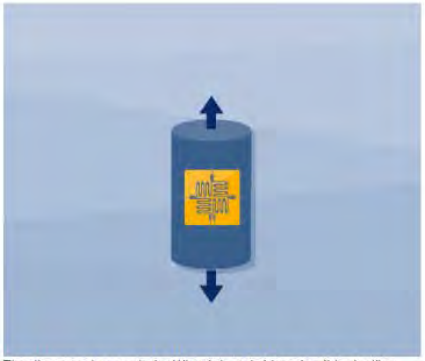
To produce a force transducer, in addition to strain gauges you also require a spring element – made of steel, for example. The strain gauge – electrical conductors on film, you recall – is bonded securely to this spring element.

As the simplest form of spring element, we can picture a steel cylinder that is either elongated or contracted under the impact of force. We will disregard further forces, such as those coming from the side, in this paper. The force acting on the steel produces mechanical stress in the material, leading to strain. And strain can also mean contraction, because from a physics point of view, this is negative strain.



If a strain gauge is contracted, its electrical resistance (Ω) decreases, if it is stretched, the resistance increases.


Spring element with SG. When contracted, the spring element becomes not only shorter, but also thicker. Conversely, as it gets longer it also becomes thinner. And the SG attached to it naturally undergoes these changes too.


The diagram shows what a Wheatstone bridge circuit looks like: Here, four SGs are connected "in a ring".

"When it is pulled, things don't just get longer, they also get thinner. Poisson's ratio indicates the ratio of transverse to axial strain. We can compare this with a rubber band, which becomes noticeably thinner when it is stretched." – Thomas Kleckers

What is the difference between a force transducer and a load cell?

In principle, they both seem really similar: the load cell measures mass or weight, the force transducer measures force (i.e. N, or Newtons). Surely, they are almost interchangeable? Simply enter 100 grams of weight for each Newton, and you can turn a force transducer into a load cell! But it's not that simple.

Difference 1:

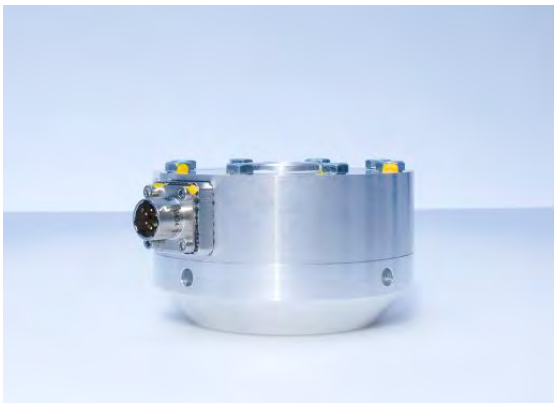
The load cell measures mass, and only ever in one direction, because the mass is always greater than 0. If a container is placed on a load cell, this cannot suddenly lift itself up and produce a negative weight. The force transducer, on the other hand, measures negative and positive forces, tensile and compressive forces.

Difference 2:

The load cell is produced then installed somewhere or other at the user's plant, then calibrated on site. Force transducers are calibrated at the factory immediately following production, and must always measure the same, even if removed and installed several times. The force transducer therefore has a more robust construction than most load cells, in order to guarantee the reproducibility of the measured values under varying conditions.

Difference 3:

The load cell must satisfy certain legal requirements, regarding legal-for-trade capability, for instance. The force transducer fulfills different regulations – standards, such as VDI 2635 or ISO 376. Unlike the load cell, the above-mentioned reproducibility, for example, is an important factor.



U10M force transducer

Z6 bending beam load cell

Fields of application

"Force transducers are used virtually everywhere – it's hard to imagine. I was particularly impressed by one test bench usage whereby a force was measured across an air gap. In other words, measurement is taking place even though the force transducer is not touching the platform. I still find it incredible today that this actually works" – Thomas Kleckers

To conclude, we'll take a look at business – a few fields where force transducers are used.

- Tests on objects test how much force is acting on them. Example: The impact on a motorcycle helmet, as in an accident.
- Reference measurements are used to produce domestic and international comparability between measured values. Here, metrological institutes around the world use especially precise force transducers to test systems. These institutes then supply reference values for the entire domestic and international economy.
- On test benches, force transducers often ensure that a desired material load can be precisely controlled: when the wing of an airplane is pushed to and from with the aid of a machine, to simulate real flying conditions, for example.
- Industrial machines and systems need force transducers for metering forces, e.g. in presses, assembly lines or end-of-line tests. Example: How firmly must the cap of a pen be pressed in order to stay on?