2. Measurement Principle of Load Cells

In order to convert force into electrical signals, we bond a sensor called a "strain gauge" to the load cell. Let's examine a strain gauge in more detail.

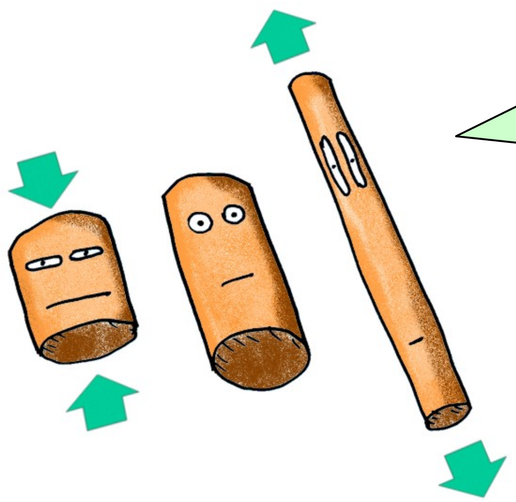
1. Strain Gauge

1.1. History

The electrical resistance of a metallic object changes due to pressure or tension. This phenomenon has been known for a long time. In 1878, Tomlinson quantitatively measured increases in resistance for each unit of resistance (called the "gauge factor).

1.2. Strain Gauge

The electrical resistance of many metals change when the metals are mechanically elongated or contracted.



The same metallic string can differ in electrical resistance depending on whether it is elongated or contracted. The longer the metallic string becomes, the larger the resistance.

50Ω 100Ω 150Ω

Figure 2.1

The strain gauge utilizes this principle and detects a strain by changes in resistance.

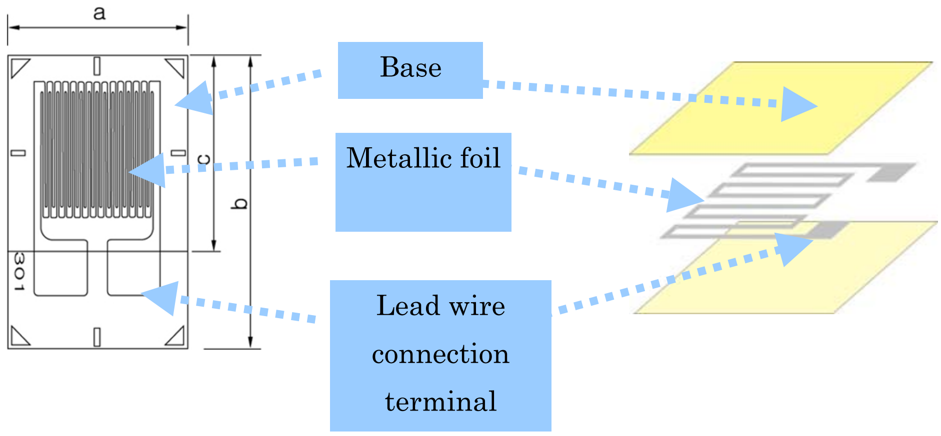


Figure 2.2

A load cell is made by bonding strain gauges to a spring material. To efficiently detect the strain, strain gauges are bonded to the position on the spring material where the strain will be the largest.

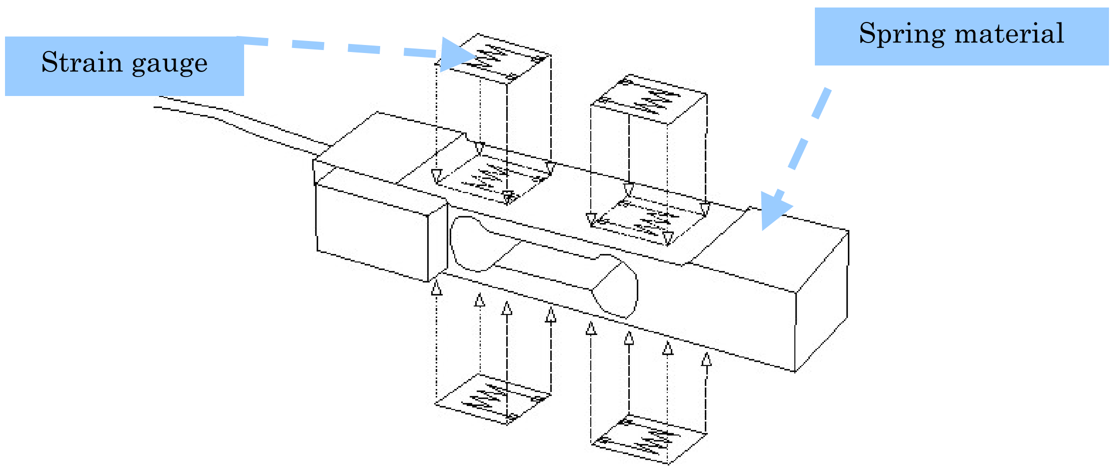


Figure 2.3

There is a linear relationship between the strain of the strain gauge and the change in its resistance. The following formula is valid:

$$\frac{\Delta R}{R} = K \times \varepsilon$$

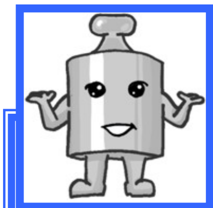
R : Initial resistance of the strain gauge (Ω)

ΔR : Resistance change caused by elongation or contraction (Ω)

K : Proportional constant (called the “gauge factor”)

ε : Strain

The gauge factor K varies depending on the type of the metallic foil used. When a copper-nickel alloy such as constantan is used (a common material used for strain gauges) the value is approximately 2.



A load cell engineer says

When the stress caused by external force to an object is below the proportional limit, the strain varies linearly with the stress. In addition, when external force is applied to a load cell and its spring material is deformed (strained), the resistance value of the strain gauge varies linearly with the deformation.

Mr. S