Complete Compensation Method of Strain with Wheatstone Bridge - COMET

COMET: Abbreviation of Complete Compensation Method of Strain

When measuring strain using a strain gauge, quarter bridge method is commonly used. Quarter bridge 2-wire method is the easiest for strain measurement, while quarter bridge 3-wire method has an advantage of eliminating thermal output caused by the temperature change of the lead wire. It is known that there may be some small errors in measured values obtained by these methods, which are caused by initial unbalance and non-linearity of the bridge circuit. Most of our strainmeters already have a function of correcting non-linearity of quarter bridge circuit. However, if we look into the matter more closely, this function is not enough to completely correct the measured values, for example when the initial unbalance of the bridge is significant. Our unique technique "Complete Compensation Method of Strain" is a method which is capable of fully correcting the errors in measured values obtained by quarter bridge method without being influenced by initial unbalance and non-linearity of the bridge circuit. This method is available in our instruments listed below.

Data loggers

TS-963, TS-960, TS-560, TDS-630, TDS-540, TS-360, TDS-150, TDS-530, TDS-602, TDS-303, TDS-102, TC-32K, TC-31K

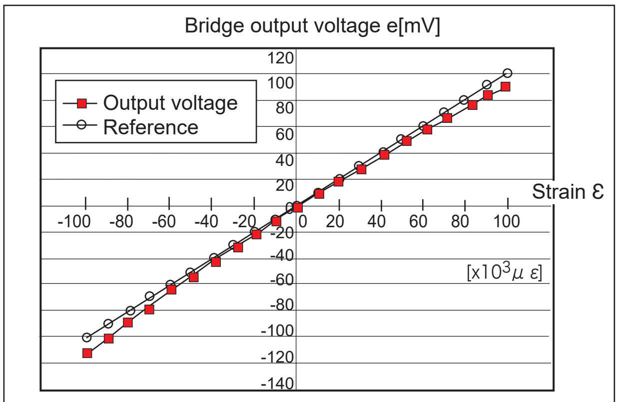
Measurement error is not caused by initial unbalance of bridge

If the resistance of strain gauge and bridge completion resistors is not exactly the same when the strain is zero, an output voltage is yielded. This should more or less occur in actual bridge circuits. The output voltage is treated as an initial unbalance and deducted from the output voltage when strain is applied. However, it causes some error in measured strain values. This error becomes zero by using the Complete Compensation Method of Strain.It is especially effective in cases as follows, in which a large initial unbalance is expected.

- The leadwire is extended during the measurement.
- The strain gauge is mounted on a curved surface.
- Strain gauges having uneven resistance are used.
- Temperature change is large during the measurement.

Non-linearity error of bridge circuit is completely corrected

The relation between the output voltage of bridge circuit and the strain is not exactly linear. Non-linearity error becomes larger with increase of strain. Conventional method for correcting the non-linearity is based on condition that the initial unbalance of bridge is zero. The Complete Compensation Method of Strain works to correct the non-linearity error even when the initial unbalance of bridge is large. It is also effective in the following cases in addition to the cases mentioned in former clause.



Leadwire resistance is supposed to be 0 Ω.

- Strain gauge is replaced with a new one when measuring large strain.
- Initial unbalance is readjusted during the measurement.

Descent of sensitivity caused by the leadwire resistance is corrected

The strain gauge sensitivity is influenced by the resistance of the leadwire. In quarter bridge 3-wire method, the lead- wire resistance is measured and the sensitivity is corrected automatically by using a data logger having the Complete Compensation Method of Strain. When measuring multiple points of strain gauges, it is not necessary to use lead wires of the same length for the purpose of simplifying the correction calculation.

Complete Correction of thermal output of strain gauge

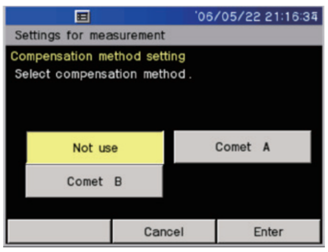
Thermal output of strain gauge is given as data under no strain, and it may somewhat differ under strained condition. The Complete Compensation Method of Strain compensates thermal output by taking the applied strain into consideration. This is especially effective when the thermal output is large.
(This compensation is available in TS-963/960.)

Correction of error caused by replacement of strain gauge

When measuring a large strain, it is a common practice to replace the strain gauge with a new one when the strain comes close to strain limit of the strain gauge. In this case, accurate strain after the replacement can be known by correcting the measured values referring to the strain value at the time of replacement. The Complete Compensation Method of Strain makes this correction automatically.

Setting of true strain measurement (COMET)

This is the setting for performing a measurement correcting the error of strain value using the function called "COMET".
When the sensor mode is quarter bridge 3-wire method, the measurement value is displayed by implementing non-linear correction even if [Not use] is selected. By selecting Comet, it is possible to obtain more correct strain value.
Half bridge common dummy can be used only for Comet A.



COMET A

This is the correction method to correct the non-linearity error by initial unbalance of the bridge, and this is effective when the initial unbalance value is large. The bridge output voltage eo is measured at initial in and memorized internally. The bridge output voltage e when the strain is generated is calculated when the measurement is performed, and the correction calculation below is implemented.

$$\varepsilon m = \frac{e - e_0}{(1-e) \times (1+e_0)}$$

COMET B (Quarter bridge 3-wire method only)

This is used when correcting the descent of sensitivity by leadwire at the same time as the correction method of Comet A.
The bridge output voltage eo at initial unbalance and both-ends voltage of lead wire resistance er are measured at initial in, and memorized internally. The bridge output voltage e when the strain is generated is measured at the measurement, and the calculation below is implemented.

$$\varepsilon m = \frac{e - e_0}{(1-e) \times (1+e_0-er)}$$

When Comet B calculation is implemented, the correction calculation that includes initial unbalance value that is recorded at initial in and both-ends voltage of leadwire resistance is implemented from the formula above, so only the measure measurement is available. Be sure to perform the measurement after implementing the initial in at the initial unbalanced status for starting measurement.

Application example of Complete Compensation Method of Strain

Measurements using our data loggers equipped with Complete Compensation Method of Strain have the advantages of the followings.

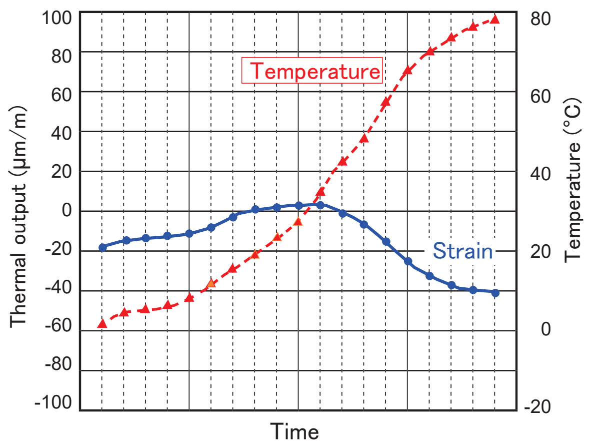
- Complete compensation of non-linearity
- No influence of strain gauge resistance
- No influence of dummy resistance
- No need of using leadwires of the same length saving costs and space for unnecessary leadwires
- No need of correcting sensitivity change caused by leadwire resistance

Accurate strain measurement is possible owing to the features above. Furthermore, measurements as in the following examples become possible by the use of Complete Compensation Method of Strain.

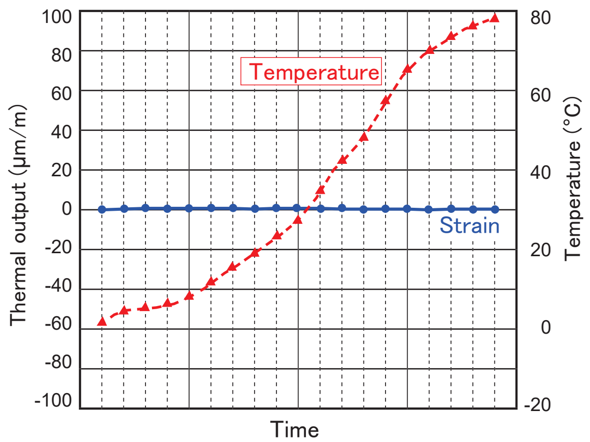
Application example 1:
Compensation of thermal output when using a temperature-integrated strain gauge

Thermal output of strain gauge is automatically compensated when measuring a temperature-integrated strain gauge with data logger TS-963/960. A polynomial representing the thermal output is attached to each strain gauge, and coefficients of the polynomial are input to TS-963/960 before starting the measurement. Thermal output of the strain gauge caused by the change of environmental temperature is calculated and corrected by the TS-963/960 with better accuracy than conventional method.

Real temperature and apparent strain measurement



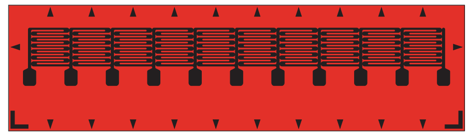
True strain after thermal output correction



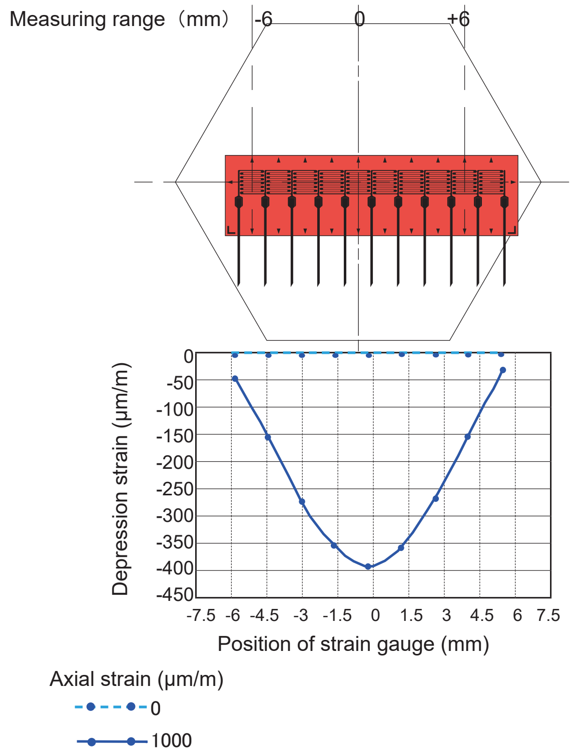
Application example 2:
Measurement of stress concentration gauge CCFXX, CCFYX

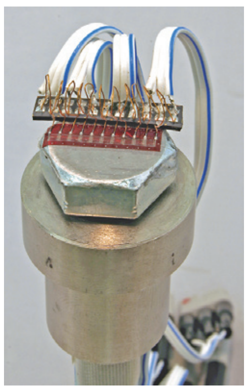
The CCFXX and CCFYX are newly developed strain gauges having 10 grids aligned continuously without interval between each adjoining grids. Different from the conventional stress concentration gauge having individual grids aligned with small intervals, it can measure strain distribution of the specimen more precisely. This strain gauge should be measured using our data logger with Complete Compensation Method of Strain. The number of leadwires is reduced to 11.

CCFXX



Measurement example
Strain caused by depression of bolt head (M10)





The number of leadwires is 30 which is required for measuring a conventional 10-element strain gauge with quarter bridge 3-wire method. The number is reduced to 11 in CCFXX/CCFYX strain gauge. This is achieved by using one leadwire for measurement of two or three grids. The adjacent grid is connected in series with one leadwire of 3-wire connection. The resistance of this adjacent grid can be ignored by using our data logger with Complete Compensation Method of Strain.