How to Correct Creep Error

1. Principle of Creep Error Correction

Naturally a sensor body, which is made from good quality material and has enough relaxation after mechanical processing, exhibits a positive creep of no more than +0.1%fs/30min. If the strain gauges to be bonded to the sensor body can exhibit a negative creep behavior of the same magnitude as the positive creep of the sensor body, but in the opposite polarity (see curve II, in Q3), the resultant creep error of the sensor after the strain gauges are well bonded to its body, can be reduced to an acceptable value like ±0.02%fs/30min.

The required negative creep from strain gauges to correct the sensor body's positive creep, can be designed by adjusting the width-ratio of the end loop of strain gauge grids.

As shown in Fig. 1, the width-ratio of the end-loops, e/s, is equal to the end-loop length (e) over the strand width (s) of gauge grids. The lower the width-ratio, the more negative the creep of the strain gauges. The strain gauges with such a modulated width-ratio (e/s) are called creep compensated gauges. All the strain gauges from BCM SENSOR for sensor application are creep compensated gauges which are classified by their creep codes (see Section 2. below).

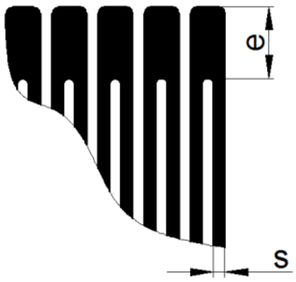

Fig. 1: Width-ratio of End Loop of Gauge Grids

Besides the width-ratio of the end loop of strain gauge grids, there are other factors contributing to the negative creep of strain gauges, like the thickness of the backing layer of strain gauges, the grid pattern of strain gauges, the gauge encapsulation, and the type and thickness of adhesive to be used to bond the strain gauges on to the sensor body.

On the other hand, the quality of the sensor body material, its heat treatment, and the strain level (i.e., loadable capacity of sensors) and the strain profile over the sensor body are the crucial factors determining the level of positive creep of the sensor bodies. In addition, temperature is another important factor to influence the creep error of sensors.

As mentioned above, a qualified sensor body normally exhibits a positive creep less than +0.1%fs/30min. This creep error can be corrected by using the creep compensated gauges from BCM SENSOR with proper creep codes. As a result, the superimposed creep can be reduced to and within a tolerance of ±0.02%fs/30min.

In practice, the superimposed creep of sensors will evolve more and more positively with time. That is why the sensor creep is often corrected to have a negative creep, rather than a positive creep, within a creep level of less than -0.02%fs within 30 minutes, as indicated by the dot-line in Fig. 2.

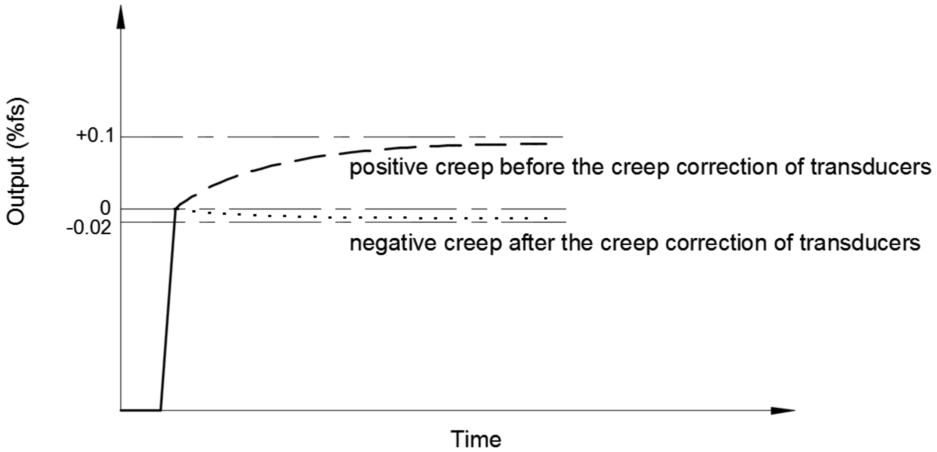

Fig. 2: Diagram of Non-Creep-Corrected vs Creep-Corrected Sensors' Output

The creep correction method as mentioned above works for sensors exhibiting a creep error within ±0.1%fs/30min. A more positive creep of more than +0.1%fs/30min is often caused by poor quality of sensor body material, while a more negative creep exceeding -0.1%fs/30min results mostly from the poor installation quality of the strain gauges.

2. Creep Compensated Strain Gauges and Their Creep Codes

As mentioned in Section 1. above, by changing the width-ratio of the end loop of strain gauge grids, one can have the strain gauges possessing different negative creep levels, which are classified by creep codes. There are 18 different creep codes available for all the creep compensated strain gauges from BCM SENSOR.

Presented below is a chain of 18 creep codes which are listed according to their negative creep levels:

N10 < N9 < N8 < N7 < N6 < N5 < N4 < N3 < N2 < N1 < O < P1 < P2 < P3 < P4 < P5 < P6 < P7

The "O" stands for the most commonly used creep code, the "P7" is the least negative creep code indicating the strain gauges which have the least negative creep, while the "N10" is the most negative creep code representing the strain gauges having the most negative creep.

The smaller the capacity of load cells, the more negative creep code the strain gauges need.

In the chain of listed creep codes, between any two adjacent creep codes, the difference in creep is within a range of 0.01~0.015%fs/30min (*).

If an even finer creep adjustment is required, one can employ the technique of so-called creep code mixing method. For instance, by setting up a bridge circuit containing two pieces of N3 strain gauges and two pieces of N2 strain gauges, one can have the Wheatstone bridge circuit with a resultant creep equivalent to four pieces of N2.5 strain gauges. This means that the finer creep adjustment of 0.005~0.007%fs/30min can be achieved by using the creep compensated strain gauges from BCM SENSOR.

(*) It is necessary to notice that, the given difference in creep between any two adjacent creep codes applies to the AA-gauge pattern. Thus, it can be used as a reference only. This is because the difference in creep between the two adjacent creep codes can be different for different gauge patterns. Therefore, it is only creep test which can determine correct creep code for strain gauges to be used for a specific sensor body.

3. Guidance to Select a Correct Creep Code for Strain Gauges

As mentioned in Section 1. above, there are many factors influencing the creep error of sensors made by strain gauge technology. Therefore, there is no way to predict the correct creep code for the strain gauges to be bonded to the given sensor body before purchasing big quantities of strain gauges, than through the so-called creep test.

The steps mentioned below are recommended to perform the creep test with a few strain gauges from sample purchase.

Step-1: Perform creep test with strain gauges of two different creep codes.

Select at least two different standard creep codes with at least 3 intervals, i.e., at least 2 creep codes in between the two selected codes, for example O and N3. Then order the strain gauges of these two selected creep codes by small quantities to produce 4~6 sensors, in order to conduct the creep test on these 4~6 sensors.

In the creep test, one measures and records the creep errors of these 4~6 sensors which can be classified in two groups, each group contains the sensors bonded with the strain gauges of the same creep codes, e.g., O or N3.

Step-2: Obtain "practical" interval of creep error and determine the right creep code.

Based on the creep test result, one can calculate the difference between the creep errors obtained from the two sensor groups. This difference is the creep error intervals between creep code O and N3. Dividing this difference by 3 (The 3 refers to the 3 intervals in Step 1), one calculates a "practical" interval of creep error based on the creep test result obtained from his own specific sensors.

Next, one needs to calculate the difference between one of the two creep errors obtained from the creep test (e.g., the error obtained from N3) and the creep target of the final sensor. Dividing this difference by the "practical" interval of creep error, and taking the integer of the division, one obtains a number which is the number of intervals to determine the right creep code.

The determined creep code can be either on the more negative side of N3, or on the more positive side of O, or even between N3 and O, depending on the comparison of the obtained creep error (e.g., the error obtained from N3) in respect to the creep target of the final sensor.

Step-3: Prove the Determined Creep Code.

Order a 2nd batch of strain gauge samples having the determined creep code worked out in Step-2, to make further creep test.

If the result of the creep test meets the creep target, it proves that the calculation performed in Step-2 has determined the right creep code. But if the creep target is still not met yet, one needs to do one more creep test by following the same procedure as mentioned in Step-2, in order to find the most suitable creep code to meet the creep target for the final sensor.

Step-4: Order a size quantity of the strain gauges.

After the determined creep code is approved, one can order a size quantity of the strain gauges of the most correct creep code as determined at Step-2 or -3.

Example:
Suppose that one plans to make use of 4 linear strain gauge (e.g., AA-pattern) to form the Wheatstone bridge circuit on the sensors.

Step-1:
Purchase 1st batch at least 10 strain gauges (SG) of the creep code O and at least 10 SG of creep code N3.

Step-2:
1) Manufacture at least 2 sensors with the SG of the creep code O as Group I and at least 2 sensors with the SG of the creep code N3 as Group II.
2) Conduct the creep test on the sensors of the both groups.
3) Suppose the creep test result is:
    - the creep error of Group I = +0.029%fs/30min;

  - the creep error of Group II = -0.037%fs/30min.

  so the interval between these two creep errors, which is resulted from this particular type of sensors, is {[+0.029 – (-0.037)] / 3}%fs/30min = 0.022%fs/30min.

4) Suppose the target of the creep error of the sensors is -0.02%fs/30min. Now the SG of the creep error N3 lead to the creep error of -0.037%fs/30min of the sensors in Group II, beyond the creep error target -0.02%fs/30min. This means that the creep code N3 is too negative. Thus, a more positive creep code N2 will be selected, and a creep error of [-0.037 + 0.022]%fs/30min = -0.015%fs/30min may be expected which meets the creep error target.

   Therefore, the SG with N2 creep code will be purchased.

Step-3:

Purchase 2nd batch (at least 10) of the SG of creep code N2 for the further creep test.
If the test result meets the creep target, one can go to the Step-4 for the size purchasing.
But if the creep target is still not met yet, one needs to do one more creep test by following the same procedure as mentioned in Step-2, to find out the most suitable creep code, the SG of which can meet the creep error target.

Step-4:

Purchase the size quantity of SG of creep code N2.

For detailed engineering advice on selecting a right creep code for the creep compensated strain gauges, one can contact BCM SENSOR.