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Long-Time Loadings Monitoring of a Structure in Real Operation

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Abstract: This article includes the brief analysis of the problems in area of long-time process loading measuring in service and also explains the processing of the measured strain state without re-calculation the strain into stress in detail and presents the results from the installed in-time monitoring system of the fatigue damage in a real operation of gas pipelines.

Keywords: Monitoring; Strain Gauges; Long-Term Measuring.

1 Introduction

In today's of experiences in area of long-time measuring of service loadings there are more options as follows strain gauges, fiber optic strain sensing (FBG), digital image correlation method (DIC) for strain measuring, vibrating string gauges (VSG), etc. In consideration of problems like huge amount of data and requirement of high light intensity (DIC), long-term instability of sensor offset change (FBG), frequency range (VSG) as well as high measurement costs, the strain gauges seem to be still the most practical option. The condition for their successful using is necessary to take care for correct application of the sensor and especially compensation more than conventional approaches of temperature compensation.

2 Long-Time Measuring by the Strain Sensors

2.1 Issues of Long-Time Monitoring

After correct choice of the sensor and its correct application the long-term monitoring of the loadings on a structure in a real operation seem to be quite complex problem that involves following operations need to be performing for correct measuring:

- measuring of operational loadings and in-time processing of measured data,
- evaluation of the stress-strain state in each monitoring section,
- transformation of the calculated loadings into a critical section or notch,
- creating graphical outputs of the processed data and archiving the loading history.

So the loading process achieved using the previous steps can be used for any other evaluation or assessment of structure state (e.g. static safety assessment, fatigue damage calculation, ...).

2.2 Processing of Measured Strain Signals

Assignment of the corresponding stress to a measured strain is the step which can significantly affect the magnitude of the overall stress amplitudes that is documented in Fig. 1. From the strain value of 0.1 % is possible to identify that there is significant difference in the recalculated value of the stress for individual material models represented by curves displayed in Fig. 1. We can solve the mentioned problem in monitoring system for pipelines with an unique deployment of the strain gauges along the circumference closely to critical sections of the pipelines in order to be able to separate individual components of loading (that are tensile, bending and torsion strains). This proposed approach allowed us to calculate the final loading process in the most loaded point of the cross-section without re-calculation into stress at last [1, 2].

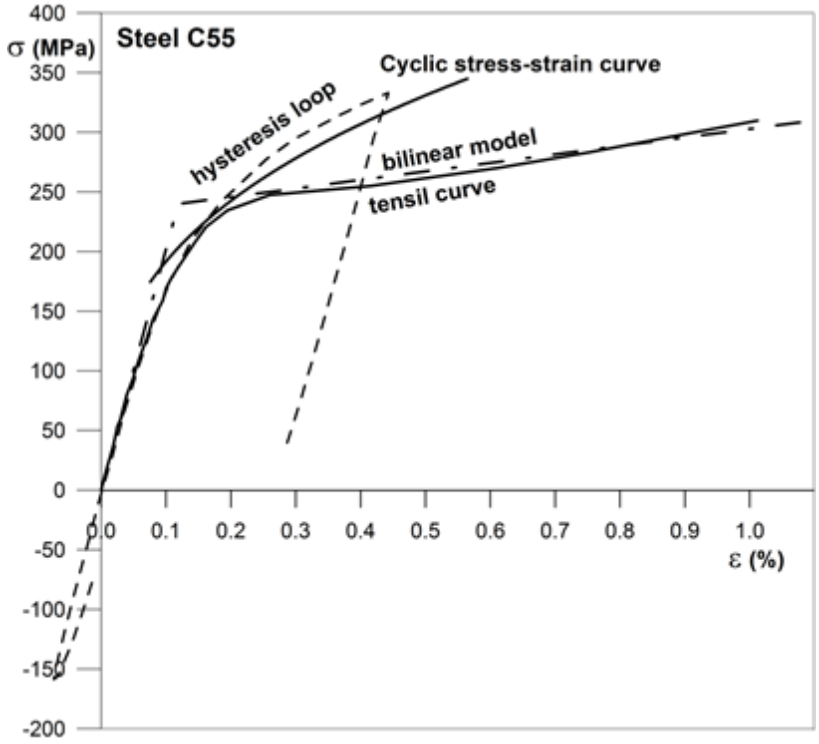

Fig. 1: Some stress-strain models measured at low carbon steel C55.

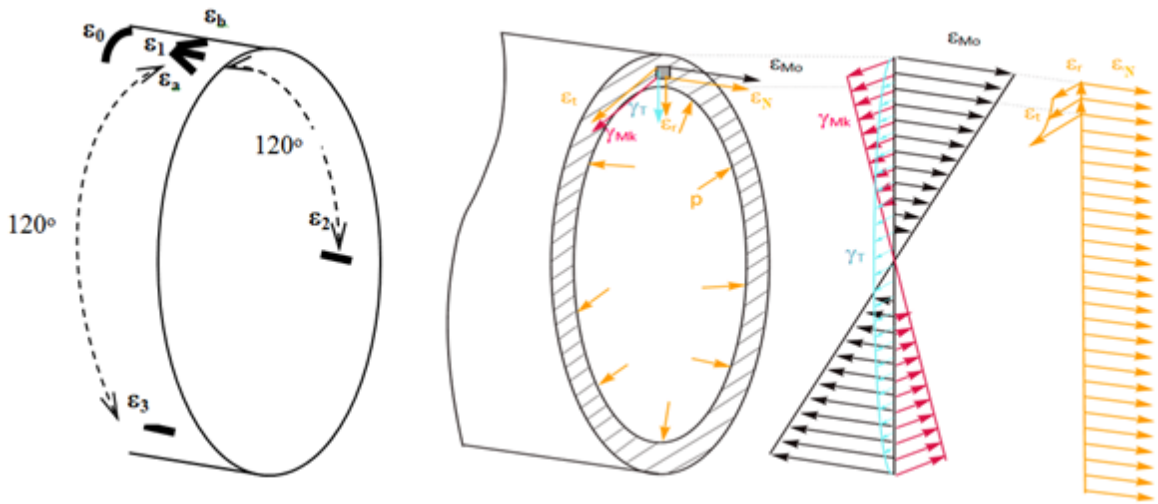

Fig. 2: Deployment of the strain gauges circumferentially along the annular cross-section in the spacing of 120 ° [3, 4] (rosette in this point of action of the transversal force in the vertical direction) allowing separation of the individual components of loading (ε_N – strain from normal force, ε_{Mo} – strain from bending moment, γ_{Mk} – shear strain from torque moment, γ_T – shear strain from transversal force, ε_r – strain from internal pressure in radial direction, ε_t – strain from internal pressure in tangential direction).

3 Results and Conclusions

Example of long-term loading monitoring of 2 year term is displayed in Fig. 3. As is shown in Fig. 3 there was recorded high descent of the mean value on pipeline 3 of the overall loading. At last from the measuring data was possible to identify the cause of this increment – it was additional bending stress that appeared in result of decrease of the subsoil due to reason of the heavily raining period during the service of the structure.

At the pipeline 1 (Fig. 3), there is possible to take note the long-term stability of measuring circuit without the time varied offset.

This long-term loading processes are obtained by monitoring systems of fatigue damage or systems for monitoring the subsoil underlay instability on the gas pipelines [5–7].

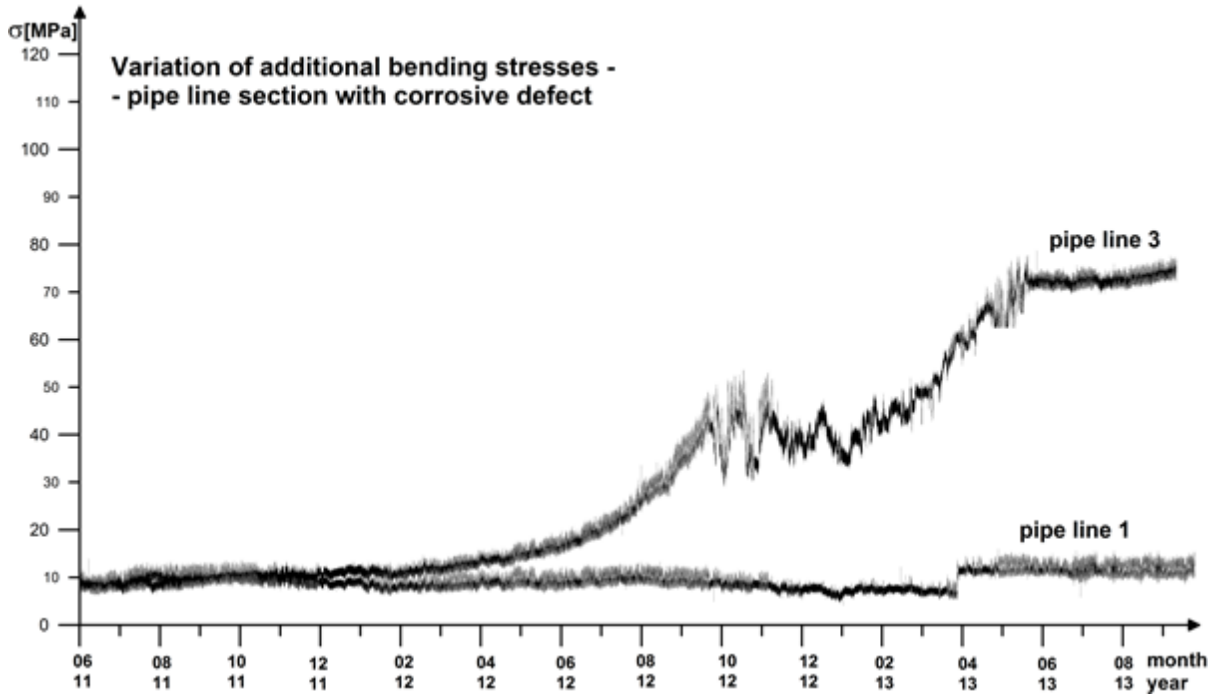

Fig. 3: Descent of the mean value appeared in the long-time period of measuring.

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