CASE STUDY

Steam Piping Operability Assessment

Task

The steam pipeline is operated in creep conditions. Due to the long-term operation of the steam pipeline, an assessment of further operability of the pipeline and determination of the remaining service life was carried out.

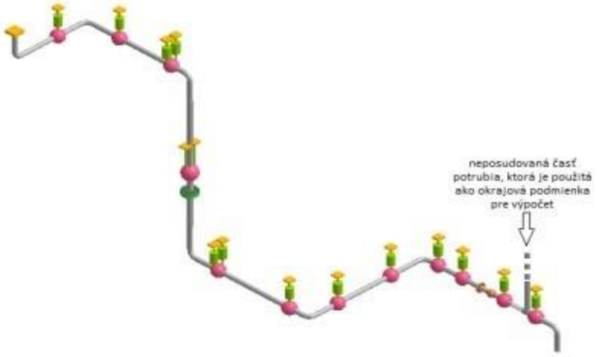

Fig.1 Computational model

Methodology

The steam pipeline is operated at a temperature of 535°C. At this temperature, it can be assumed that the pipeline is operated in creep conditions. Creep is a phenomenon of time-dependent plastic deformation of materials under constant stress. It is characterized by slow plastic deformation, which takes place even when subject to stress well below the yield stress of the material. The progress of creep at constant stress and temperature is shown on the creep curve.

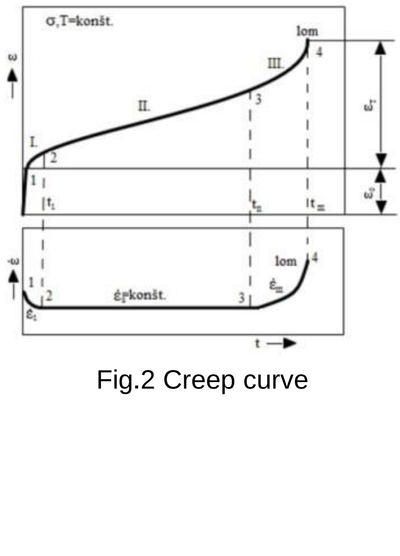

Fig.2 Creep curve

A technical assessment is presented aiming to identify the degree of material degradation by the creep mechanism in order to assess the operability and determine the remaining service life of the pipeline. For this purpose, a sequence of diagnostic and calculation steps was performed as follows:

- External assessment of the steam pipeline section and measurement of the basic geometric parameters of the pipeline (wall thickness of the pipeline, lengths of pipeline branches, etc.).
- Stress analysis of the steam pipeline under operating load conditions, in order to identify the most critical parts of the steam pipeline.
- Metallographic testing at the identified places, in order to detect the presence of cavities, clusters of cavities or cracks, which are characteristic for the phases of creep.
- Ovality measurement of the pipe in the places of the greatest stress, to determine the reference state of deformation.
- Determination of the remaining service life of the pipeline based on the results of the analysis.
- Final assessment of the pipeline with recommendations for repairs, operability assessment of the pipeline and recommendations for further operation.

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Results

External assessment

The external evaluation of the steam pipeline was carried out on the partially un-insulated pipeline, where the evaluation of suspensions and UTT measurements of wall thicknesses were performed. The result of the assessment is the quantification of the degree of corrosion damage or damage (functionality assessment) of the pipe suspensions.

ULTRAZVUKOVÁ SONDA: *ULTRASONIC PROBE*	D790	FREKVENCIA: *FREQUENCY*	5 MHz
KALIBRÁCIA: *CALIBRATION*	mierka č.1	VÄZOBNÝ PROSTRIEDOK: *BINDING EQUIPMENT*	emulzia
SPRÁVA: *MESSAGE*	x		

TABULKA / MAPA NAMERANÝCH HODNÔT [mm]
TABLE / MAP OF MEASURED VALUES [mm]

REZ 1	koleno 1	koleno 2	koleno 3	koleno 4	koleno 5	koleno 6	koleno 7
12 hodina	30,64	29,00	25,85	28,71	28,98	27,52	24,20
3 hodina	28,18	29,55	26,66	28,45	26,73	28,90	26,14
6 hodina	28,30	28,66	29,00	26,21	27,61	27,72	25,75
9 hodina	29,71	27,48	28,95	28,14	29,79	26,10	24,18

REZ 2	koleno 1	koleno 2	koleno 3	koleno 4	koleno 5	koleno 6	koleno 7
12 hodina	31,28	28,38	26,76	29,95	29,51	28,54	23,84
3 hodina	29,54	29,64	27,32	25,95	26,37	28,33	25,85
6 hodina	27,80	28,68	28,50	24,82	27,37	28,89	25,36

Fig.3 UTT protocol

Stress Analysis

The stress analysis was calculated in accordance with the normative regulation EN 13480-3, chap. 12.3. In accordance with the aforementioned chapter, all required combinations of loads and their associated stresses (sum of primary stresses, stress S3, stress S4, stress S5) were evaluated in the static calculation.

First, the calculated state of stress was assessed with respect to the value of the allowed stress. Next, places of greatest stress were determined. Based on these results, the location and scope of the measurements and tests were determined.

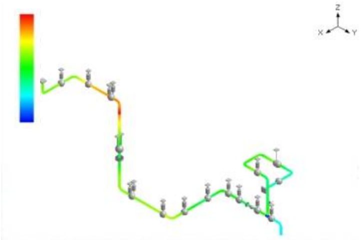

Fig.4 Stress state of the steam pipeline

Metallography

Based on the results of the stress state analysis, the most stressed part of the steam pipeline was identified. This part the highest stresses is expected to be the place where the signs of creep may manifest. For this reason, a metallographic test of the surface structure was performed and evaluated by micro and macroscopic analysis.

NT NDT010 standard was used to identify the creep phase. In accordance with this standard, time periodicity for the repeated inspections was stated.

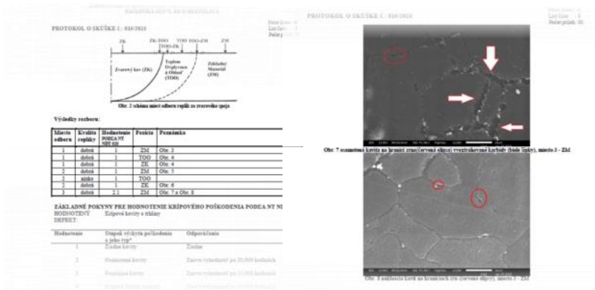

Fig.5 Metallography results

UTT Ovality Measurement

One of the manifestations of creep is the gradual increase of deformation under constant load. The ovality of the pipe was measured in the places of greatest stresses on the steam pipe. Using the future periodic, repeated measurements of ovality it will be possible to detect the development of the creep by comparing the measured pipe diameter values on the selected pipe sections.

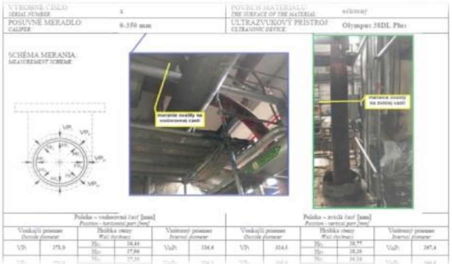

Fig.6 Ovality results

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Calculation of the remaining service life

The Larson-Miller methodology was used to determine the service life of the steam pipeline under creep conditions. The methodology is based on the extrapolation of the material properties defined by the material standard, for the conditions under the actual stress state of the structure.

$$P = T\left(C + \log t\right)$$

Where:

T.........temperature

C.........material constant

t...........time

P..........Larson – Miller parameter

The result of the calculations is the determined value of the remaining service life of the steam pipeline.

Conclusion

Based on the evaluation of the partial results of the tests and measurements, it is possible to conclude that the steam pipeline is operable. At the same time, the operator is advised, in accordance with the NT NDT010 standard, to carry out a repeated evaluation of the steam pipeline in a time period determined on the basis of the findings from the metallographic test.

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