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«The simulation of ultra-high molecular weight polyethylene cryogenic
pipeline stress-strain state»

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Vladimir Voronov and Aleksey Shalygin

Problem statement

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- LNG is becoming more and more *popular* among fossil fuels
- At present LNG pipeline transportation exists only by means of the *short-length* process lines located at terminals or plants
- The commonly used nickel-plated steels are *exorbitant*



Solution methods

- The use of ultra-high molecular weight polyethylene (UHMWPE) is proposed as a structural pipeline material due to high impact numbers at cryogenic temperatures (up to -200 °C), taking into account long-term yield point and creep modulus.

• Longitudinal stresses

$$\sigma_s = \left[\frac{2\mu p}{\left[1 - \frac{2}{SDR}\right]^{-2} - 1} - \alpha E \Delta t \right] + \frac{E \Delta t d}{2\rho}$$

• Circumferential stresses

$$\sigma_c = \frac{p d_{int}}{2\delta}$$

μ is the Poisson's ratio; p - operating pressure; SDR is the standard dimensional ratio. Δt - temperature difference; α - thermal expansion coefficient; d – external diameter of pipeline; ρ is the radius of elastic bending; E - creep modulus of the pipe material, d_{int} – internal diameter of the pipeline, δ - wall thickness of the pipeline

• Equivalent stresses

$$\sigma_{eq} = \sqrt{\sigma_c^2 + \sigma_s^2 - \sigma_c \cdot \sigma_s}$$



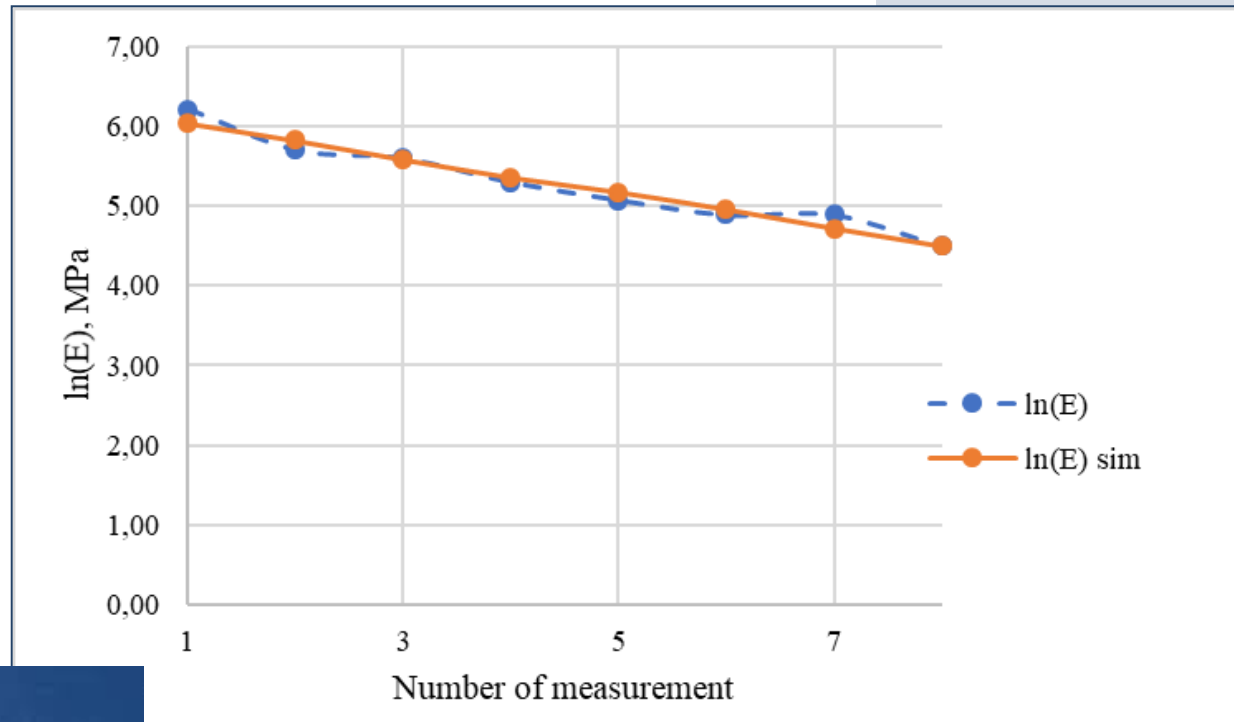
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Solution methods

- The time and operating temperature dependence for creep modulus based on nonlinear regression analysis:

$$E = 10^{12} t^{-0,009} \cdot T^{-3,86}$$



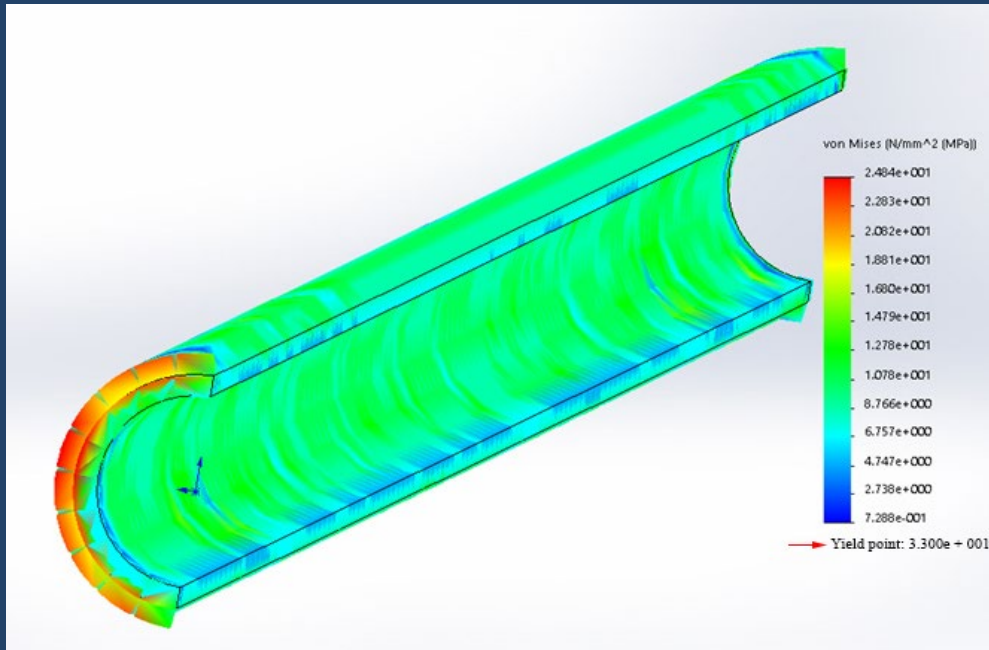
Experimentally obtained and simulated values of the creep modulus



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Conclusions



Long-term stress profile of the pipeline

- The simulation of the stress-strain state of the liquefied natural gas pipeline has been carried out
- The calculation method gives 24,85 MPa
- The result of simulation is 24,85 MPa
- Yield point is 33 MPa
- The developed model of an underground pipeline seems rather promising for the potential use of UHMWPE at cryogenic temperatures.

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