THE SZEWALSKI INSTITUTE OF FLUID-FLOW MACHINERY, PAS (IMP PAN)

CENTRE FOR MECHANICS OF LIQUIDS
DEPARTMENT OF HYDRAULIC MACHINERY

COMPLEX INVESTIGATIONS AND ASSESSMENTS OF TECHNICAL STATE OF STEEL PENSTOCKS AND THEIR STRENGTH AND LIFETIME

Tests and analyses performed for complex assessment of technical state of a steel penstock together with determining its strength and lifetime have the main goal in determining possibilities to extent penstock safety life.

Offered non-destructive tests include mainly visual tests, ultrasonic measurements, magnetic and radiography examination of penstock shells.

Numerical analysis of stress distributions in steel penstock shells is based on the Finite Element Method (FEM) with internal or external pressure levels as boundary conditions. Strain gauge measurements can be executed in selected spots on penstock shell under hydrostatic and hydrodynamic loads during different steady and unsteady states of hydrounit operation. The results of strain gauge measurements are principally used to verify and estimate a reliability of stress state calculation results concerning spots on a penstock shell characterized by large geometrical imperfections.

Analysis and evaluations of the penstock lifetime (residual time) are mainly based on the theory of microcracks growth connected with rainflow models for counting of stress cycles. Necessary knowledge about pressure-time changes during all different states of hydrounit operation is gathered from tests conducted *in situ* or calculated using software for waterhammer simulation. In addition, the knowledge about static and variable loads of the pipeline during its past and future operation courses is needed to perform all the analyses and assessments.

Occasionally, basing on the test results some recommendations are made to reinforce the places characterized by the highest material strains, such as pipe branches or geometric imperfections of the pipe shell (concave or convex shell bends).

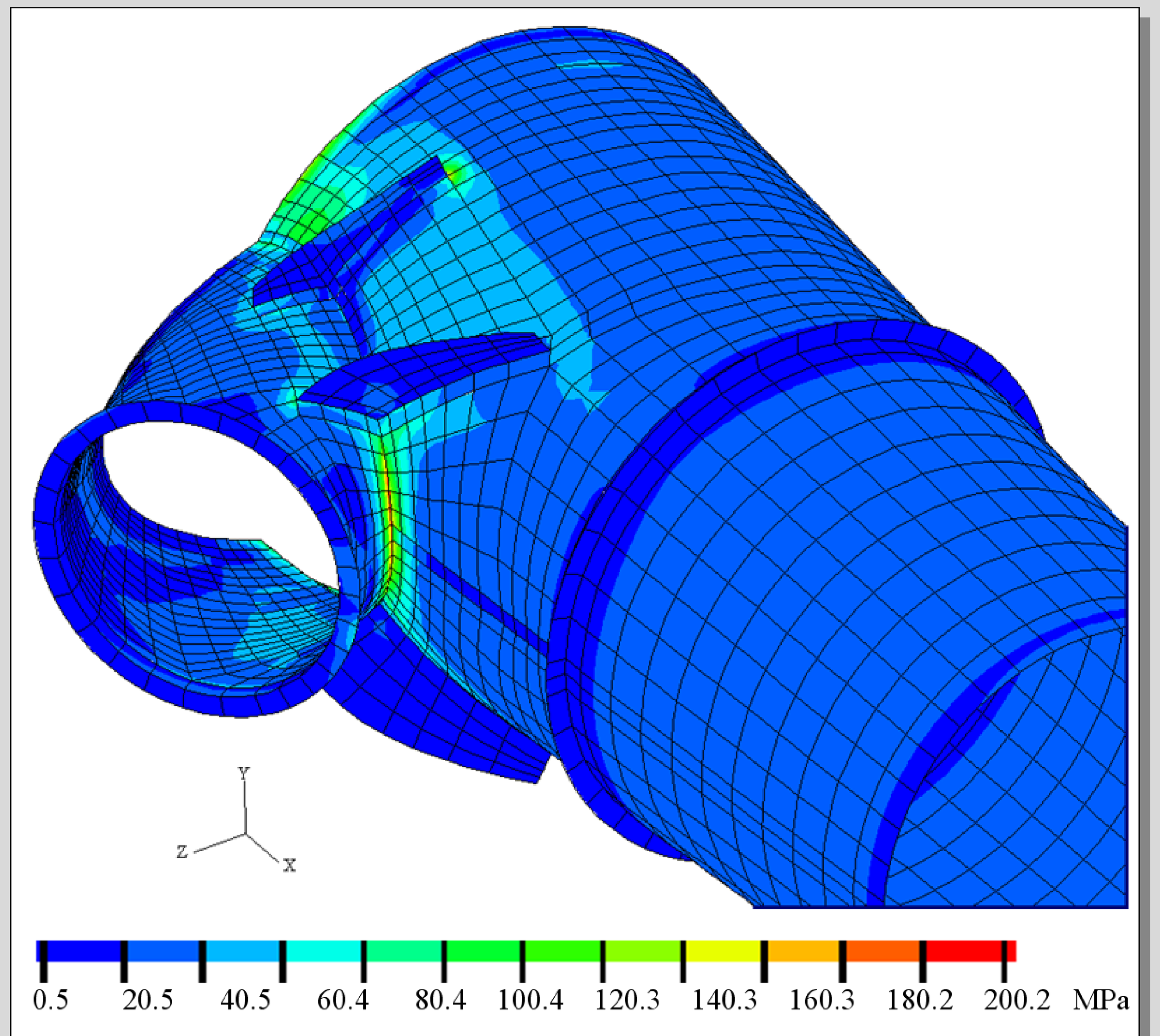

Fig. 1. Case without additional reinforcement. Reduced stresses (according to Huber-Misses hypothesis) in shell of turbine penstock branching – outer side.

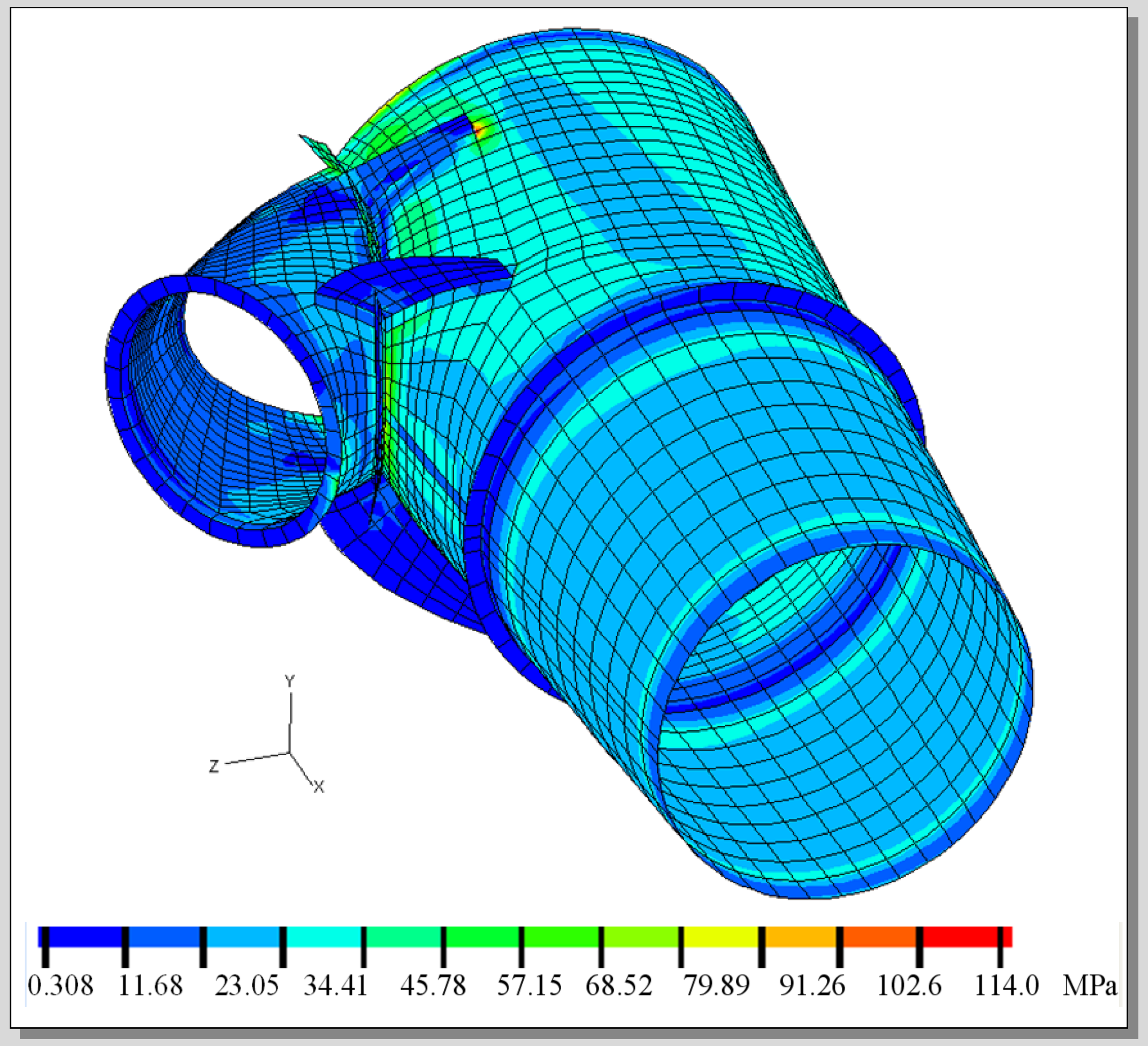

Fig. 2. Reduced stresses (according to Huber-Misses hypothesis) in shell of turbine branching reinforced with a fin.

Fig. 3. Strengthening fin at pipeline branching.

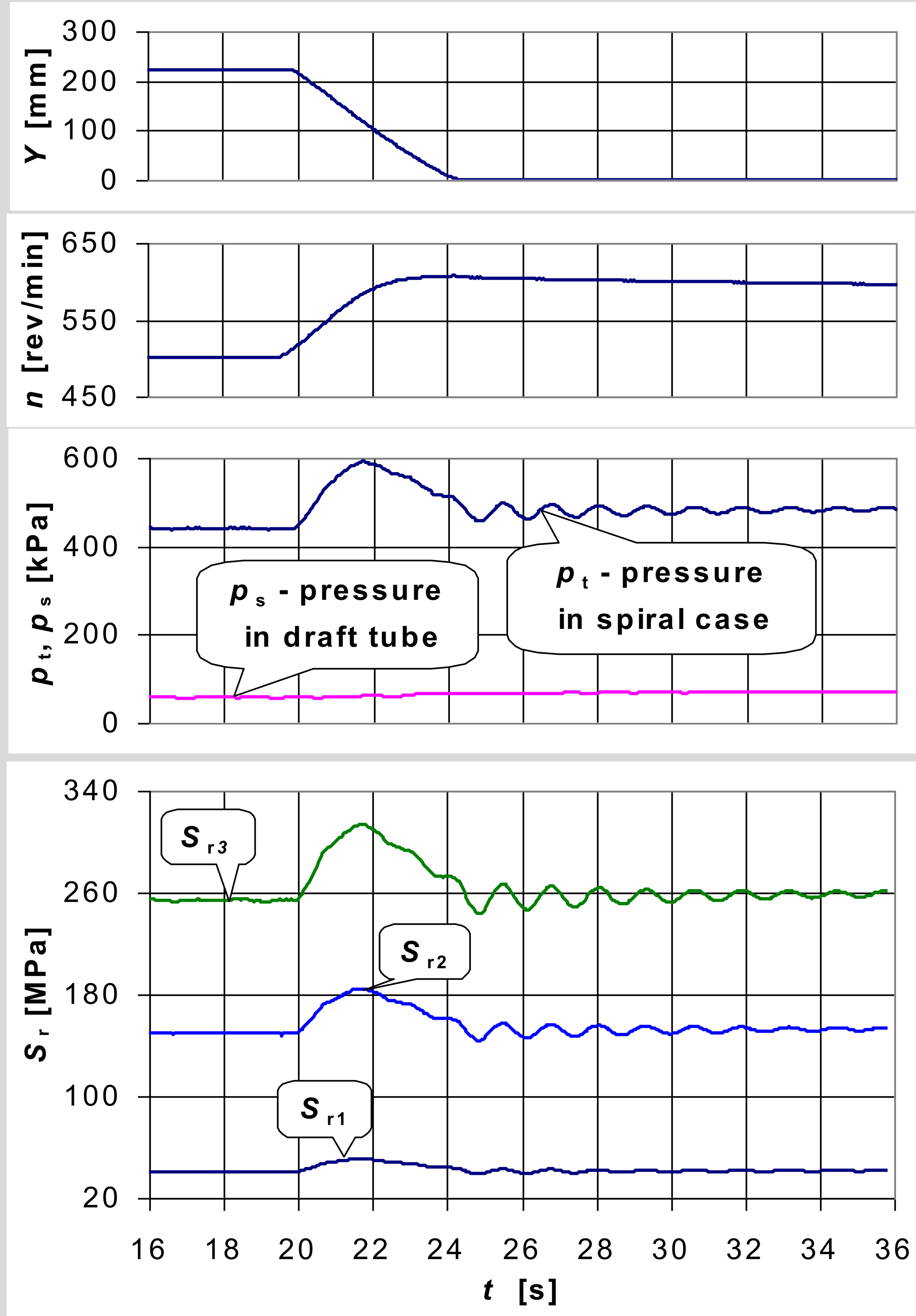

Fig. 4. Quantities measured during turbine load rejection
Y – position of the servomotor piston, n - rotational speed, p_t – pressure in the spiral case, p_s – pressure in the draft tube, S_{r1} ,S_{r2}, S_{r3} – equivalent stresses in the different shell places.

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