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

CENTRE FOR MECHANICS OF LIQUIDS

DEPARTMENT OF HYDRAULIC MACHINERY

NUMERICAL COMPUTATIONS OF WATER HAMMER (FLUID TRANSIENT) IN PENSTOCKS OF HYDRAULIC TURBINES

Water hammer (or hydraulic transient) courses in the pipeline systems of hydraulic machines are simulated numerically using the HYDTRA (HYDraulic TRAnsients) computer code developed in the Szewalski Institute of Fluid-Flow Machinery in Gdańsk. Basic assumption of the computational algorithm is that pipelines (delivery and suction conduits) are modelled as distributed elements and the hydraulic machine and its cut-off valve or bypass valve - as lumped elements. The method of characteristics (MOC) is applied for solving equations governing the unsteady liquid flow in the pipelines. Static characteristics of an analyzed machine in the wide range of unit parameters (unit rotational speed n_{11}, unit discharge Q_{11} and unit torque M_{11}) are needed to perform calculation. Such an approach is typical in the hydraulic transient analyses. The code has been validated on several occasions using numerous experimental results. The discrepancy between calculation and experimental data is usually below a few percent.

HYDTRA was used for examples for:

- optimisation of the wicket gate (guide vane) closure course of pump-turbines in order to protect penstocks form the excessive pressure rise, and motor-generator from the excessive rotational speed increase,
- analysis of by-pass valve application in order to diminish water hammer level.

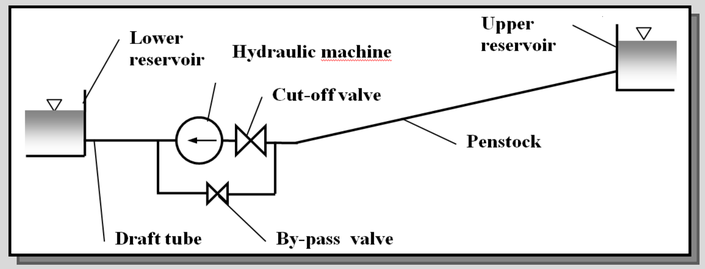

Fig. 1. Layout of the flow system considered in HYDTRA code.

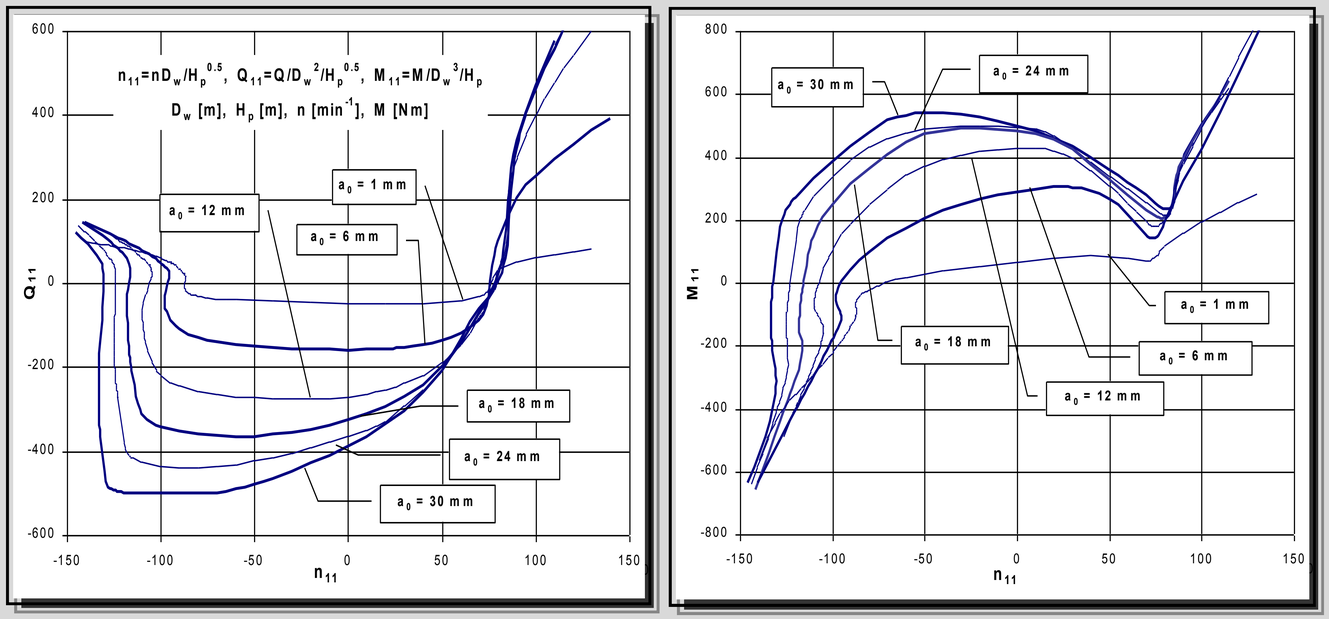

Fig. 2. An example of four-quadrant steady-state characteristics of a pump-turbine.

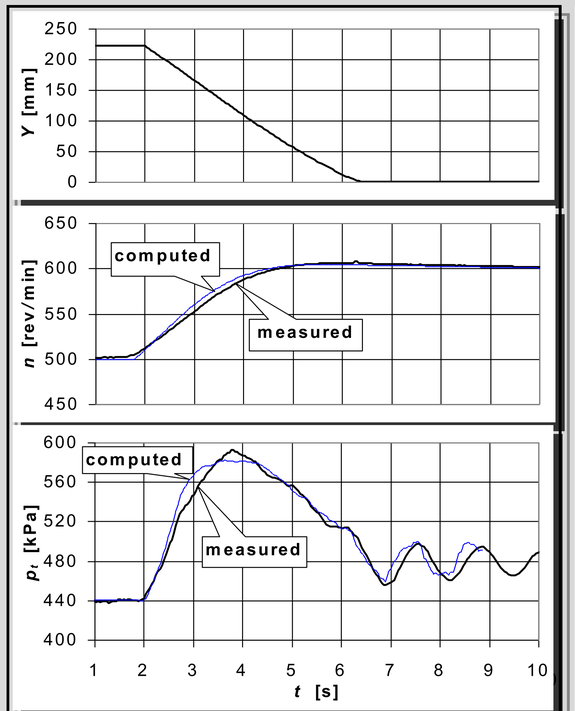

Fig. 3. The comparison between the recorded and calculated curves of pressure in the penstock (p_t) and runner speed (n) during a turbine load rejection.

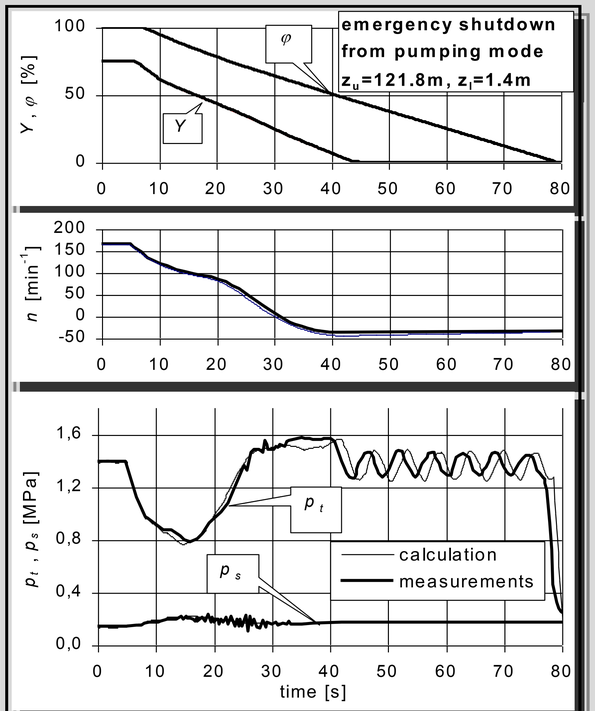

Fig. 4. An exemplary comparison between calculation and measurement results for an emergency shutdown of from a pumping mode of operation.

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