

'Neo-Suterian' pump-turbine characteristics and their benefits

P. K. Dörfler

Abstract

Conventional representations of the various operation modes of a pump-turbine (4-quadrant characteristics) have important disadvantages. While curves of Q_{11} vs n_{11} have singularities at $E=0$ and multiple values in the 'unstable' ranges, the curves E_{nD} (Q_{nD}) get singular at $n=0$. As a remedy, one may split the characteristics into separate parts, and switch between them. Another approach introduced by P. Suter (1966) defines a different set of variables which avoids singularity and always remains unique-valued. Suter described this artifice for non-regulated pumps; but using it for regulated machines without modifications is not practical due to large distortions at small guide vane opening. A decisive improvement has been described by C.S. Martin. It avoids the distortion of the head-vs-flow curves at low load. The present paper describes how further improvement is possible, in particular with regard to the representation of torque. A modified torque parameter is obtained by subtracting the shutoff torque; this parameter can be handled in the same practical way as the discharge.

Other improvements concern the correction for leakage at small guide vane opening, and the treatment of very small and zero opening. These details are concerned with the problem of closed gate where Suter's concept does not work. Applications are demonstrated, not only how to represent the hydraulic performance (head vs. discharge and torque vs. discharge), but also for other characteristics, such as the development of pressure and pressure pulsation in various locations, or the steady-state and unsteady guide vane torque. The advantage of a set of continuous, single-valued functions for all those physical properties greatly simplifies computation of their behavior during transients. Moreover, the 'Suterized' properties of pump-turbines of different specific speed are less different from each other than the conventional ones, a fact that facilitates application of available test data for later projects.