Hydropower Plants: Generating and Pumping Units
Solved Problems: Series 6

1 NON-DIMENSIONAL NUMBERS FOR A TURBINE MODEL TEST

When performing model testing, an accurate calculation of the non-dimensional numbers is of key importance for the operation of hydraulic turbines and the transposition of the efficiency from the model scale to the prototype scale. Three non-dimensional parameters are particularly important: the IEC speed factor n_{ED}, the IEC discharge factor Q_{ED}, and the Thoma number σ.

1) When performing the model test of a turbine, which important quantities need to be monitored for comparing the efficiency and the operating condition of the prototype scale with that of the reduced scale turbine?
   Also, which component/parameter must be exactly the same in the prototype and model scales?

2) Express the non-dimensional parameters n_{ED} and Q_{ED} as functions of the reference diameter D_{ref}, the discharge Q, the turbine specific energy E, and the rotational frequency n [s^{-1}].

3) Express the specific speed ν and IEC specific speed n_{QE} as functions of Q_{ED} and n_{ED}.

For questions 4) to 6), use the information about the installation of the turbine and the setting level h_s which are depicted in Figure 1.
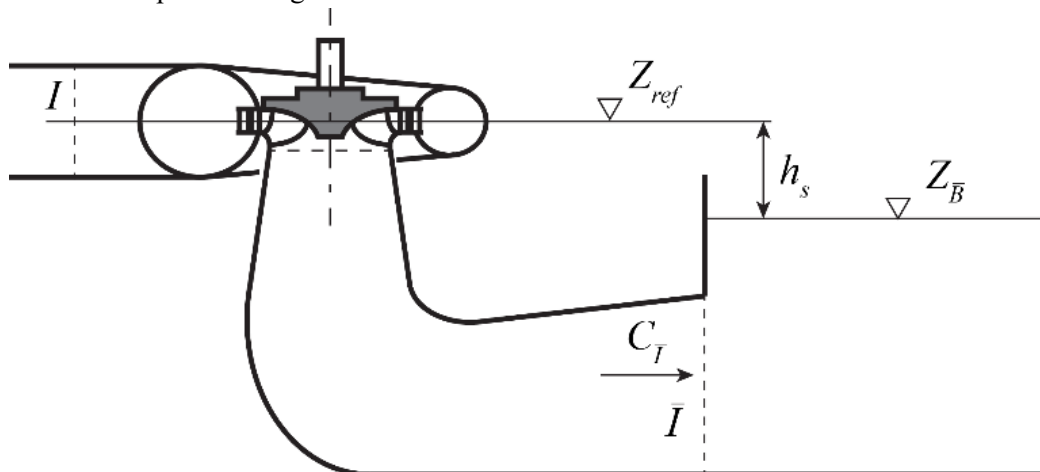

Figure 1: Machine setting level

4) Express the Net Positive Suction Specific Energy (*NPSE*) as a function of $gH_{\bar{T}}$, Z_{ref}, and the saturated pressure p_v.

5) Express the Thoma number σ defined by $\dfrac{NPSE}{E}$, using the setting level $h_s = Z_{ref} - Z_{\bar{B}}$, the flow velocity $C_{\bar{I}}$, the saturated pressure p_v and the atmosphere pressure p_a. Take the singular losses term $gH_{r\bar{I} \div \bar{B}}$ into account, knowing that the draft tube outlet can be considered as a water outflow with $K_v = 1$.

6) Describe what is the risk of operating the plant at a low Thoma number.