Cavitating Turbine

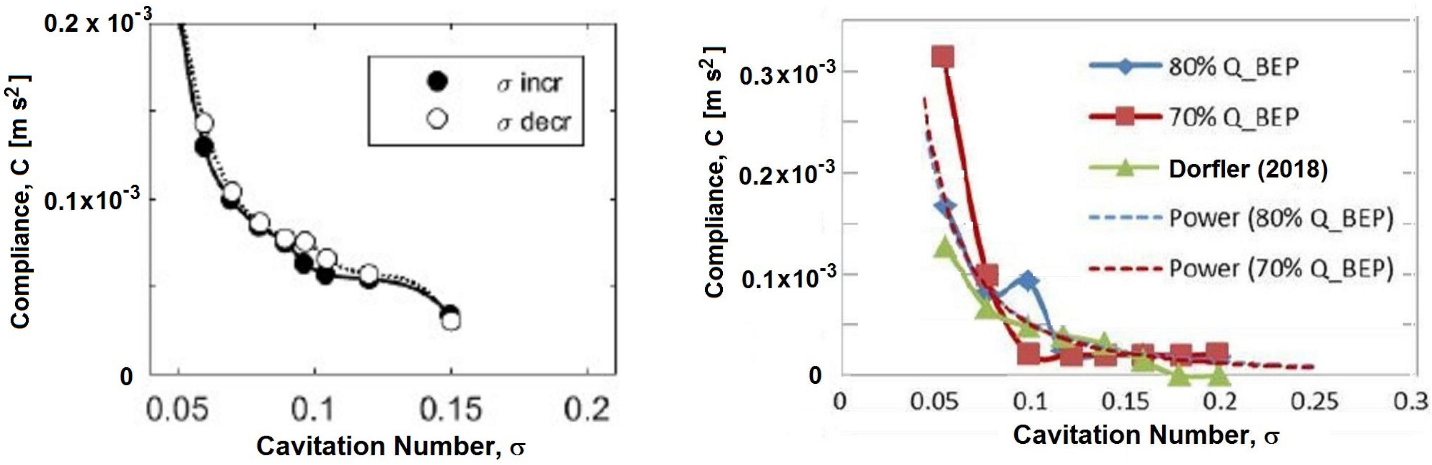

Figure 1: Compliances for a cavitating Francis turbine as a function of cavitation number, derived from experimental observations by Dorfler (2018) (left) and by Manderla *et al.* (2016) (right).

As described in Section (Nrq), two different non-dimensional frequencies, ω' and ω'', lead to two dimensionless compliances, C' and C'', related to the dimensional compliance, C, by:

$$\omega' C' = \omega C \qquad \text{and} \qquad \omega'' C'' = \omega C \tag{Nrr1}$$

so that

$$C' = CZ\Omega^2/2\pi^2 D \qquad \text{and} \qquad C'' = C\Omega^2/2\pi^2 D \tag{Nrr2}$$

and the data for C' and C'' in pumps and turbines are shown in Figure 2. Recall from Section (Nrq)

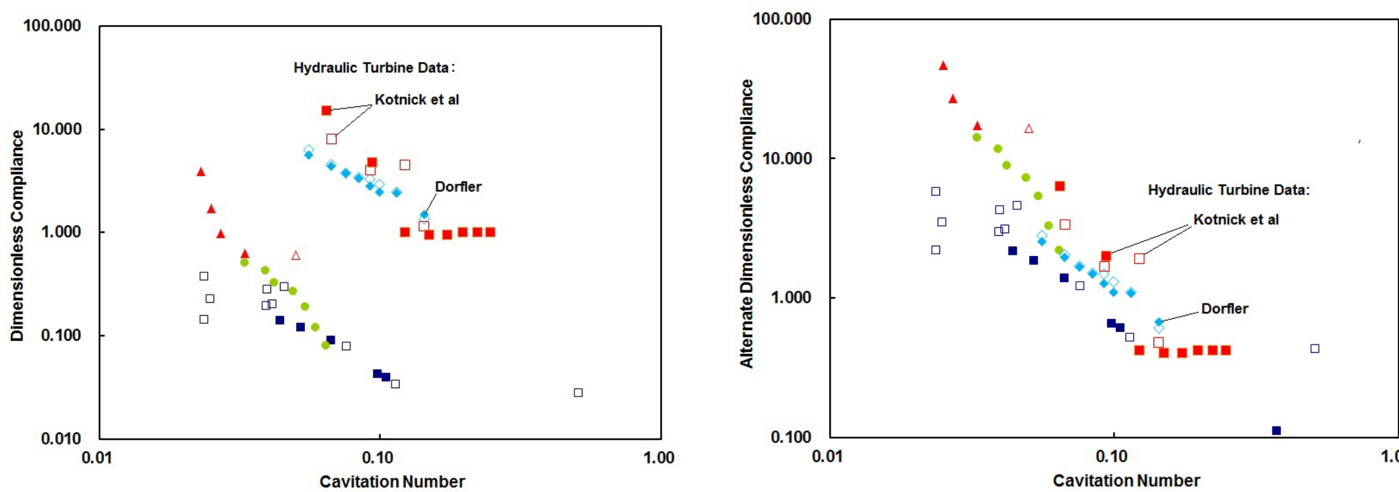

Figure 2: The dimensionless compliance, C' (left), and the dimensionless compliance, C'' (right) plotted versus the cavitation number, σ, for many inducer pumps (see Section Nrq) and for the data from Dorfler (2018) and Manderla *et al.* (2016) for Francis turbines.

that the first non-dimensionalization uses the blade passage frequency and therefore implies cavitation associated with each blade whereas the second non-dimensionalization uses the rotation frequency and therefore assumes cavitation associated with the whole flow through the turbomachine. It appears that the second non-dimensional frequency scheme does a better job of collapsing the turbine data onto the pump data. Whether this is significant or merely coincidental remains to be seen.

It does seem clear from the studies of Dorfler (2018), Alligne *et al.* (2014) and Manderla *et al.* (2016) that the draft tube vortex in cavitating Francis turbines has a complicated dynamic response that contributes to the compliance (as well as other, as yet unexplore, dynamic features like the mass flow gain factor). Dorfler (2018) has explored how wave propagation along the draft tube vortex might influence the dynamics, a feature that may play a role similar to kinematic wave propagation in cavitating pumps.