

Four-quadrant Performance

Either inadvertently (or sometimes deliberately) pumps are operated far from their design flow conditions defined by a design head coefficient, ψ_D , a flow coefficient, ϕ_D , and a torque coefficient, \mathcal{T}_D . Indeed sometimes the head is reversed, sometimes the flow is reversed and sometimes the rotation speed, Ω , is reversed. Under these conditions the performance is represented by *four-quadrant* performance graphs such as those shown in Figure 1 for a typical centrifugal pump with a design specific speed, $N_D = 0.66$.

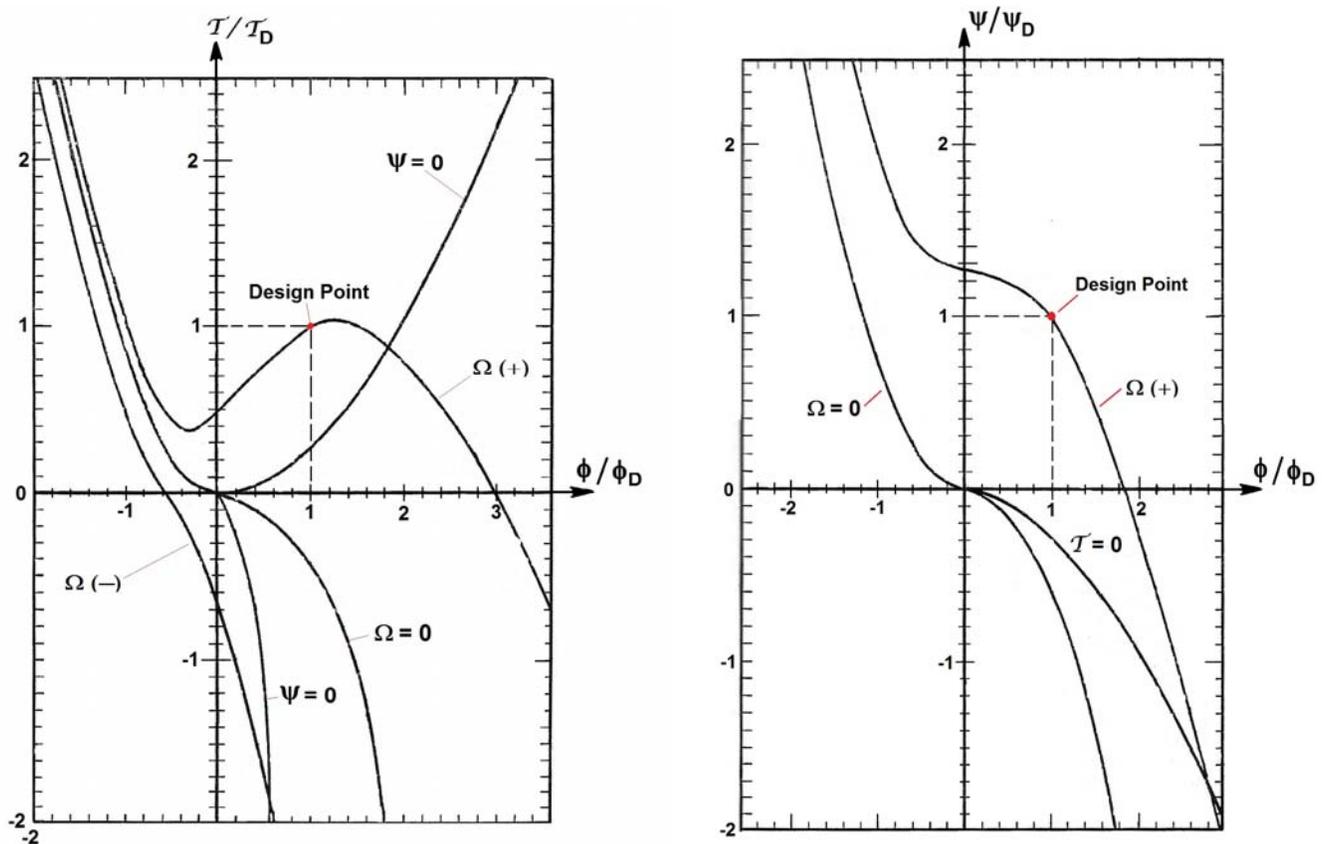


Figure 1: Four-quadrant performance curves for a typical centrifugal pump with a design specific speed, $N_D = 0.66$. Also shown are the conditions under which either the head or the torque are zero and the performance for forward rotation ($\Omega(+)$) and for reverse rotation ($\Omega(-)$) and for shutoff or zero flow ($\Omega = 0$). Adapted from Stenanoff (1948) and Knapp(1947).