Specific Speed

At the beginning of any pump design process, neither the size nor the shape of the machine is known. The task the pump is required to perform is to use a shaft rotating at a frequency, Ω (in rad/s), to pump a certain flow rate, Q (in m^3/s) through a head rise, H (in m). As in all fluid mechanical formulations, one should first seek a nondimensional parameter (or parameters) which distinguishes the nature of this task. In this case, there is one and only one nondimensional parametric group that is appropriate and this is known as the "specific speed", denoted by N. The form of the specific speed is readily determined by dimensional analysis:

$$N = \frac{\Omega Q^{\frac{1}{2}}}{(gH)^{\frac{3}{4}}} \tag{Mbbd1}$$

Though originally constructed to allow evaluation of the shaft speed needed to produce a particular head and flow, the name "specific speed" is slightly misleading, because N is just as much a function of flow rate and head rise as it is of shaft speed. Perhaps a more general name, like "the basic performance parameter", would be more appropriate. Note that the specific speed is a size-independent parameter, since the size of the machine is not known at the beginning of the design process.

The above definition of the specific speed has employed a consistent set of units, so that N is truly dimensionless. With these consistent units, the values of N for most common turbomachines lie in the range between 0.1 and 4.0 (see below). Unfortunately, it has been traditional in industry to use an inconsistent set of units in calculating N. In the USA, the g is dropped from the denominator, and values for the speed, flow rate, and head in rpm, gpm, and ft are used in calculating N. This yields values that are a factor of 2734.6 larger than the values of N obtained using consistent units. The situation is even more confused since the Europeans use another set of inconsistent units (rpm, m^3/s, head in m, and no g) while the British employ a definition similar to the U.S., but with Imperial gallons rather than U.S. gallons. One can only hope that the pump (and turbine) industries would cease the use of these inconsistent measures that would be regarded with derision by any engineer outside of the industry. In this monograph, we shall use the dimensionally consistent and, therefore, universal definition of N.

Note that, since Q and gH were separately nondimensionalized in the definitions (Mbbc4) and (Mbbc5), N can be related to the corresponding flow and head coefficients by

$$N = \left[\frac{\pi}{\cos\vartheta}\left(1 - \frac{R_{H2}^2}{R_{T2}^2}\right)\right]^{\frac{1}{2}} \frac{\phi_2^{\frac{1}{2}}}{\psi^{\frac{3}{4}}} \tag{Mbbd2}$$

In the case of a purely centrifugal discharge ($\vartheta = \pi/2$), the quantity within the square brackets reduces to $2\pi B_2/R_{T2}$.

Since turbomachines are designed for specific tasks, the subscripted N_D will be used to denote the design value of the specific speed for a given machine.

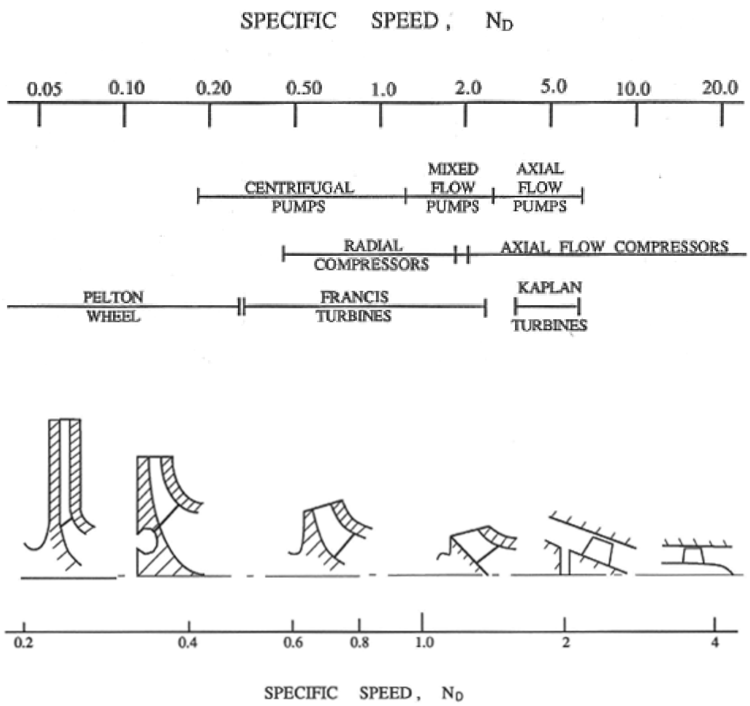

Figure 1: Ranges of specific speeds for typical turbomachines and typical pump geometries for different design speeds (from Sabersky, Acosta and Hauptmann 1989).