GRUNDFOS

WHITE PAPER

Specific Speed

by Steve Wilson

The term "specific speed" is much misunderstood in the pump industry, yet terms that arise from specific speed discussions are used without full knowledge of the implications. A basic understanding of specific speed is necessary and helpful in pump selection and analysis and in discussions of impeller types. This paper is by no means intended as a complete discourse on specific speed, but rather a basic overview. For the interested, further study should be made.

DEFINITION OF SPECIFIC SPEED

Specific speed is the speed in RPM at which a given impeller would operate if reduced (or increased) proportionally in size so as to deliver a capacity of one GPM at a head of one foot. By itself, this seems meaningless, but taken into the bigger picture, the specific speed (N_S) becomes a dimensionless number that describes the hydraulic features of a pump, and more specifically of a pump's impeller(s). Designers use specific speed, coupled with modeling laws and other tools such as the affinity laws to fix curve shape, predict theoretical efficiencies, HP's, etc..

SPECIFIC SPEED FORMULA

The formula for specific speed is simplified as:

$$N_S = \frac{RPM \text{ x } GPM^{.5}}{H^{.75}} \quad \text{or} \quad N_S = \frac{N\sqrt{Q}}{H^{3/4}}$$

Where:

N_S = Specific Speed

RPM = Speed in revolutions per minute

GPM = US Gallons Per Minute

H = Head in feet

N = RPM

Q = GPM

Note on the Statement, and Calculation of Specific Speed:

- N_S of a pump is calculated using BEP of the pump at full diameter.
- On multi-stage pumps, N_S is computed for the first stage only.
- If asked specifically by a customer for the N_S of a pump being proposed, N_S should be calculated using the proposed pump's BEP at the proposed diameter.

SPECIFIC SPEED BASICS

The specific speed is largely related to the impeller discharge angle, relative to the inlet. Pumps in which the discharge of the impeller is directly radial to the suction; that is, where the flow transitions "rapidly" from one plane to the other, have a low specific speed and are called "radial vaned" or "radial flow impellers." The N_S will be in the neighborhood of from 500 to 1700. These pumps will usually exhibit a "low flow to head" ratio. At the "other end of the scale," the fluid will be discharged from the impeller along the same axis as it enters. These impellers (or propellers) have high specific speeds, generally above 9000, and are referred to as axial flow impellers (or propellers) and have a "high flow to head ratio."

Between these two extremes fall:

- Mixed Flow Impellers, with an N_S range of from around 4000 to 9000 begin to transition away from the suction axis, but discharge between the axial and radial angles, and generally exhibit a high flow to moderate head ratio.
- Francis Vaned Impellers, between mixed and radial flow, with NS values from around 1700 to 4000. Francis vaned impellers are frequently discussed in the industry, and are simply impellers which have vanes curvature such that the transition from the inlet axis to radial axis is completed more gradually.

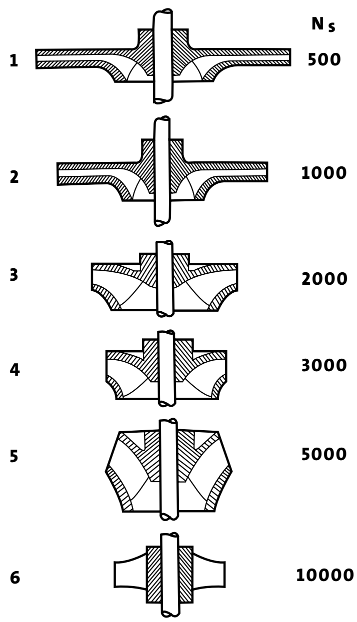

Figure 1. *Impellers of various specific speed design*

Figure 1 illustrates the general appearance of impellers of various specific speed designs, with inlet being at the bottom.

SPECIFIC SPEED AND THE PUMP CURVE

The specific speed of the pump will determine the general (theoretical) curve slope, from shutoff to runout. Low specific speed impellers will exhibit "flat head" curves and high specific speed pumps will exhibit steeper curves. (Remember that specific speed is taken for a single stage only. Many multi-stage pumps exhibit steep curves when all stages are shown together, but have a low N_S.

SPECIFIC SPEED AND POWER REQUIREMENTS

Just as pumps with low N_S values have low HQ curves, their power requirements will continue to rise as flow increases. High specific speed pumps (propellers and mixed flow) exhibit "dropping" HP characteristics: The HP requirement is highest at shutoff and decreases as flow increases. (Care must be taken in running or testing high N_S pumps at shutoff to assure motor HP is not overloaded.) Francis vaned impellers again fall in between these two extremes, with power curves that rise from shutoff but flatten out as flow increases. *Figure 2* gives a graphic illustration of the relative curve shapes for both HQ and Power.

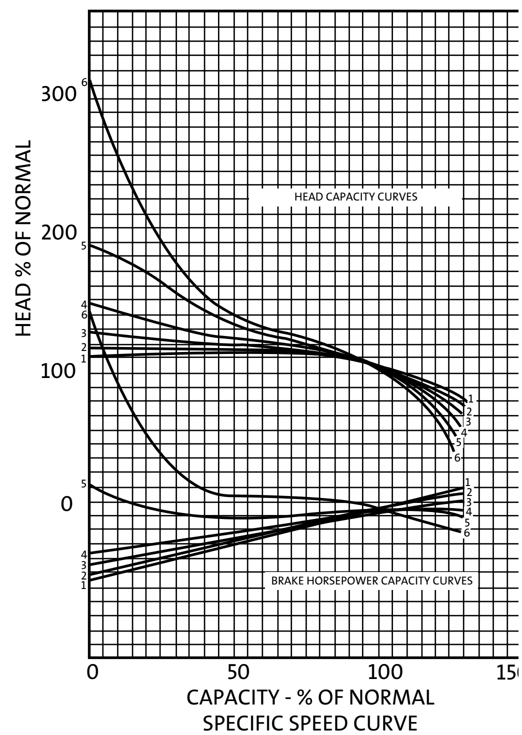

Figure 2. *HQ and BHP curves for various specific speeds*

SPECIFIC SPEED AND EFFICIENCY

The impact of specific speed on theoretical efficiency has been well studied and verified by testing. Both Karassik, in the *Pump Handbook* (page 2.203) and Lobanoff, in *Centrifugal Pumps: Design and Application* (pages 15-18) reveal the results of the studies: Pumps with specific speeds from 2000-3500 (Francis Vane Impellers) will exhibit the highest efficiencies in theory and in test. Of course, as discussed in the "High and Broad Band Efficiency" paper, pump construction and configuration will cause differences between theoretical and actual results. Further, it is not practical or possible to utilize the same range of specific speeds for all desired conditions of service or installations.

CONCLUSION

Understanding specific speed in general is helpful in understanding curve shape, horsepower requirements, efficiency, and pump design. It is a basic tool of the pump designer. Understanding the physical and hydraulic natures of flow paths of different (or similar) N_S values can be a valuable tool in assessing both proposed and existing installations.

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