Preservation of Efficiency – *Affinity Revisited*

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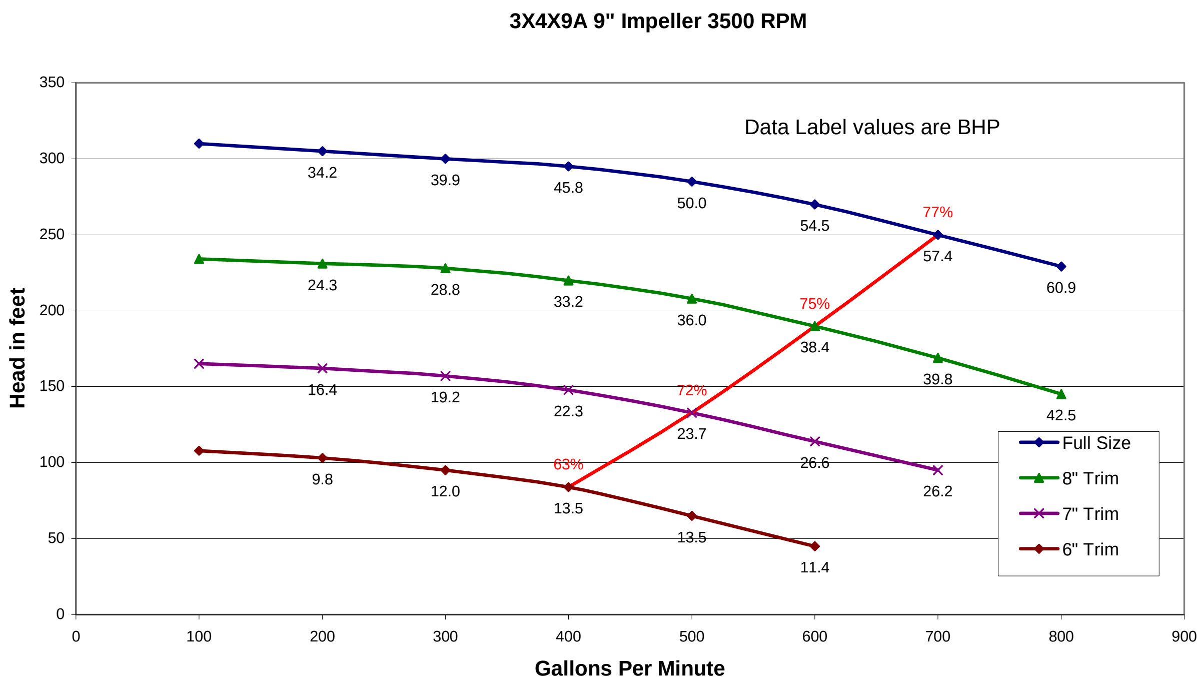
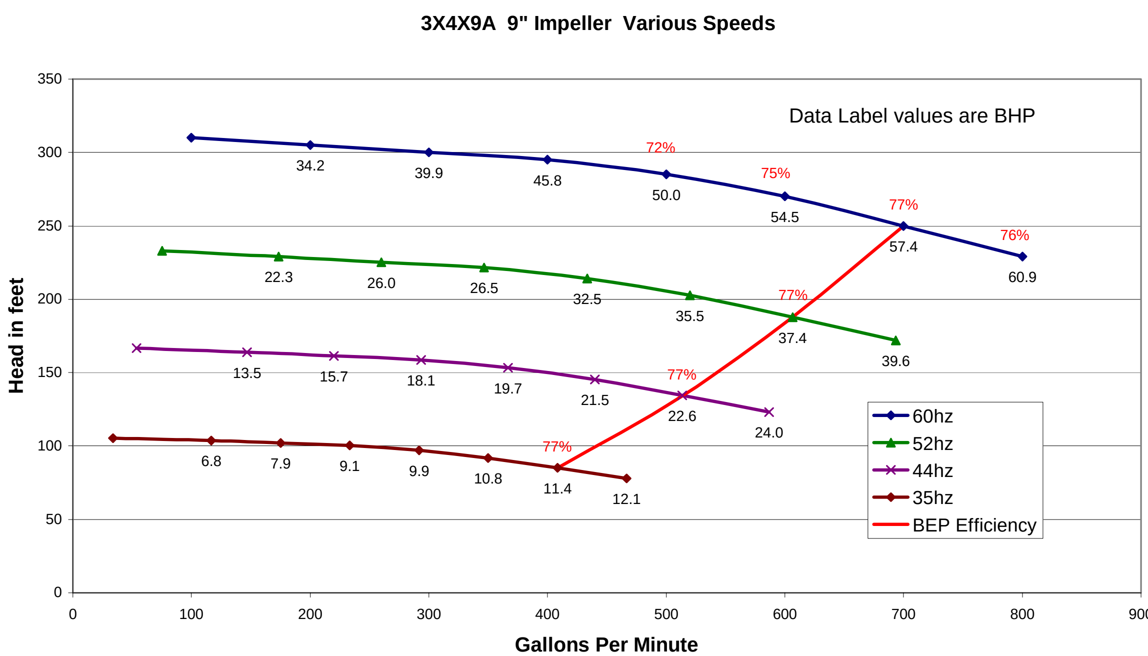
My September tutorial took a look at the affinity laws and showed why each is able to predict changes in flow, head, and power when there is a change in pump speed or impeller diameter. One thing I did not mention is that these laws assume that the hydraulic efficiency remains unchanged. Efficiency does remain nearly constant over a broad range of speeds but it can change, substantially, when an impeller is trimmed. Figure 1 shows the performance of a 3X4X9 end suction centrifugal with a full size impeller and several trims.



The red diagonal line is the BEP efficiency isomer for the four curves and is labeled with the BEP efficiency for each diameter. As you can see efficiency decreases with each successive trim and reaches a low point of 63% at 6”. The primary cause of this drop in efficiency is recirculation. As impeller diameter is reduced more of the liquid sneaks past the “cutwater” or “volute tongue” and reenters the narrow portion of the volute. And, this recirculation or “repumping”, as it could be called, reduces the hydraulic efficiency of the pump. The accuracy of the affinity laws is also sacrificed with this reduction in efficiency. According to the affinity laws, the 6" impeller should produce a BEP flow of 466 GPM at a head of 111 feet but, as you can see its flow is just 400 GPM @ 84'. The predictions are only slightly better for the 7" impeller but come pretty close in the case of the 8" trim because its efficiency, at 75%, is nearly that of the full size impeller.

Figure 2 shows the same pump, under VFD control, and operating at various frequencies (speeds). The performance curves produced by these speeds are a very close approximation (within a few feet) of the curves seen in Figure 1.



The major difference between the two figures is that the BEP efficiencies along the efficiency isomer, in Figure 2, remain the same at all speeds. And, that so called efficiency isomer is actually the "affinity parabola" that Lev Nelik mentioned in his April 2006 column. Since efficiency remains constant at each point, the resulting flows, heads, and power follow the affinity laws to a Tee. And, because efficiency is preserved, the power required at the lower speeds is less than that required by the trimmed impellers seen in Figure 1. Efficiencies to the right and left of BEP on the 60hz curve also remain constant as speed changes.

So, does this mean that we should never trim an impeller? Not at all. Small trims can have a low impact on efficiency but, if an impeller requires a trim that reduces efficiency significantly, other alternatives should be considered.

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