

Recently, I had a conversation with a machinery engineer at a major petroleum refinery who suspected wear on one of the pumps in the refinery. The engineer inquired as to whether a worn pump could be operated in parallel with a spare pump in good condition. The answer is "possibly", but there is a risk of accidentally forcing the worn pump to operate at shut-off.

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All pumps operate at a point where the pump's operating characteristic curve intersects the system curve. System curves describe how the system head varies with flow. Systems where there is zero differential pressure between pump suction and discharge when the pumps are in an idle condition have purely frictional system curves, where the change in system head as a result of change in flow is the result of frictional resistance (Fig 1).

Systems where there is a differential pressure between suction and discharge in the idle condition exhibit a system curve that intersects the zero flow ordinate at a head equal to the static differential pressure. (Fig 2)

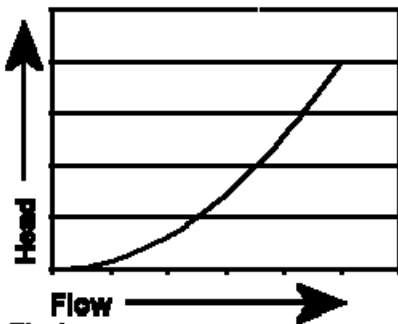


Fig 1

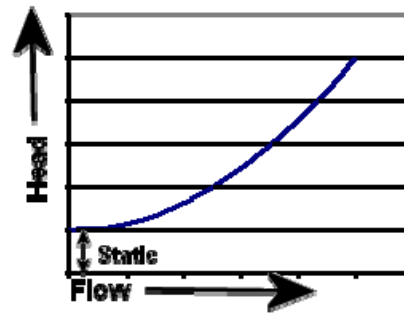


Fig 2

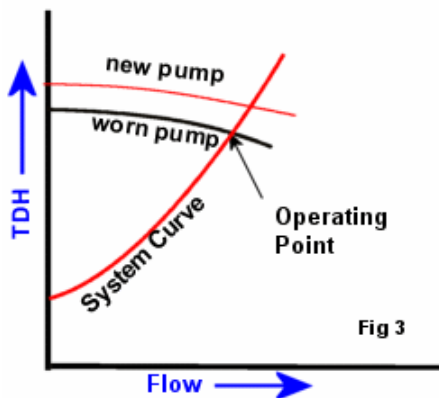
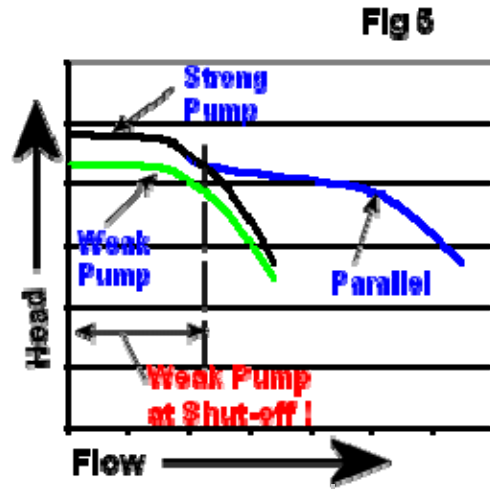
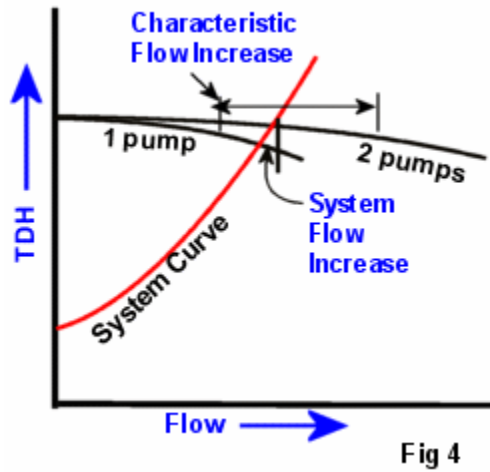


Fig 3

As a centrifugal pump wears, the amount of head that is produced for a given flow rate is reduced. The system curve remains unchanged and therefore, the new operation point will be at the flow and head that correspond with the intersection of the system curve and the worn pump characteristic (Fig 3).

When pumps operate in parallel, the flow rate at any given TDH point is additive. In the case of pumps that have identical operating characteristics, the flow would double. For example, two pumps that each had a capacity of 100 M<sup>3</sup>/hr at 50 M TDH would have a combined capacity of 200 M<sup>3</sup>/hr at 50 M TDH.

Again, the system curve does not change, so the actual change in flow that occurs with bringing a second pump on line, in parallel, is determined by the characteristic curve intersection with the system curve. This is shown graphically in Fig. 4.



When a pump is operated in parallel with another pump that has a different operating characteristic, the same rule applies as for identical pumps: for any TDH, common to both pumps, the flow characteristic will be additive. If one pump exhibits a lower shut-off TDH characteristic, it will operate at shut-off until the dominant pump moves far enough out on its curve so that its TDH falls below the shut-off TDH of the pump with lower head (Fig 5). The danger here is in the system-pump interaction. If the system curve intersection with the characteristic curve is at a higher TDH than the shut-off flow of the weak pump, the weak pump will be forced to run at shut-off and a serious failure could occur. In Fig. 5, a zero-flow condition for the weak pump will exist when the system curve intersection is to the left of the vertical dashed line.

As a general rule it is a good idea to have flow measurement installed for any pumps designed to operate in parallel. Without flow measurement, it is very difficult to determine what the load sharing is between two pumps. Motor power is often a questionable indicator of flow, as many power curves are quite flat and show small changes in load over relatively large changes in flow. Also, when wear does occur, the power draw may remain relatively constant even though performance is falling off. This is due to a decrease in pump efficiency which is not visible to the pump operator.