Affinity Law Deviations in High Pressure LNG Pump Performance

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Abstract

Liquefied natural gas pumps are subject to the affinity laws and divergence from an affinity law surface fit is common. According to American Petroleum Institute (API) Standard 610, deviations are measured from the tested data point to the surface fit curve only in the vertical direction. However, as suggested by Hjorth et al (2006) and Pauly et al (2002), the true deviations of a tested point to the surface fit curve occur in both the vertical and horizontal directions, thereby the error being measured by the shortest distance, or perpendicular distance between the tested data point and the surface fit curve. The error related to the shortest distance produces smaller deviations between the tested data and the surface fit than the API error. High pressure LNG pump performance data is utilized to investigate the shortest distance error.

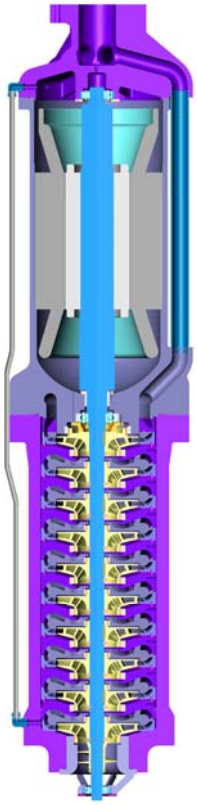

Fig. 1: Multi-Stage High Pressure Pump

High Pressure Pump

The LNG high pressure pump data employed is from an Ebara International Corporation (EIC) multi-stage high pressure pump, model number 8ECC-1516. This particular pump is designed for land-based applications, has an 8 in discharge flange, 15 in impeller diameter, and has 16 stages. Figure 1 is a solid model of a similar Ebara multi-stage high pressure pump.

Deviations

The high pressure pump performance data was applied through a least square error fit to both traditional affinity law performance equation (Kimmel, 1996) as well as general performance equation (Alison-Youel, 2008). The standard deviation for the tested data was found to be 29.41 for the traditional performance equation and 28.07 for the general performance equation (Fig. 2).

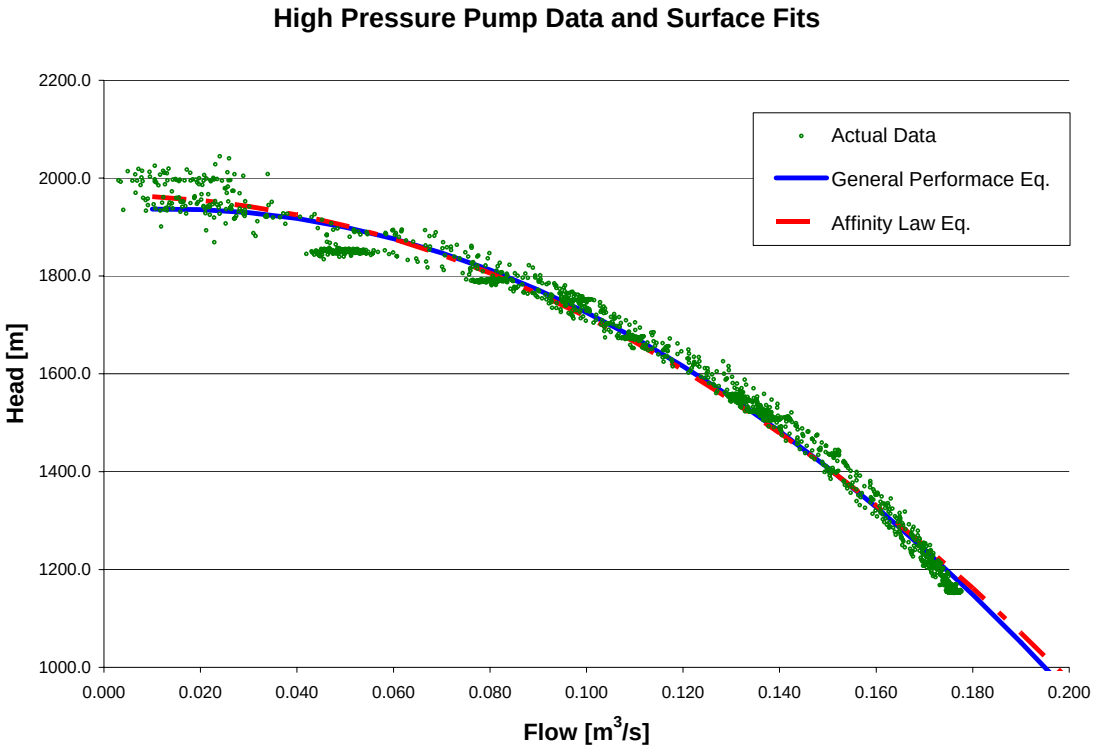

Fig. 2: Typical Performance and General Performance Equation Surface Fit to Tested High Pressure Pump Data

The API error is the vertical distance between the tested data point and the surface fit curve. In the case of high pressure pump performance the API error is strictly measured in terms of the head. The arithmetic mean of the absolute API deviation with respect to the general performance equation surface fit curve was found to be 21.57. The magnitude of the perpendicular distance, or shortest distance between each tested data

point and the general performance equation surface fit curve was then calculated, whereby the arithmetic mean of the shortest distance was found to be 5.87. The shortest distance deviation method accounts for the deviations seen in both the head and the flow while more accurately describing the data fit (Fig 3).

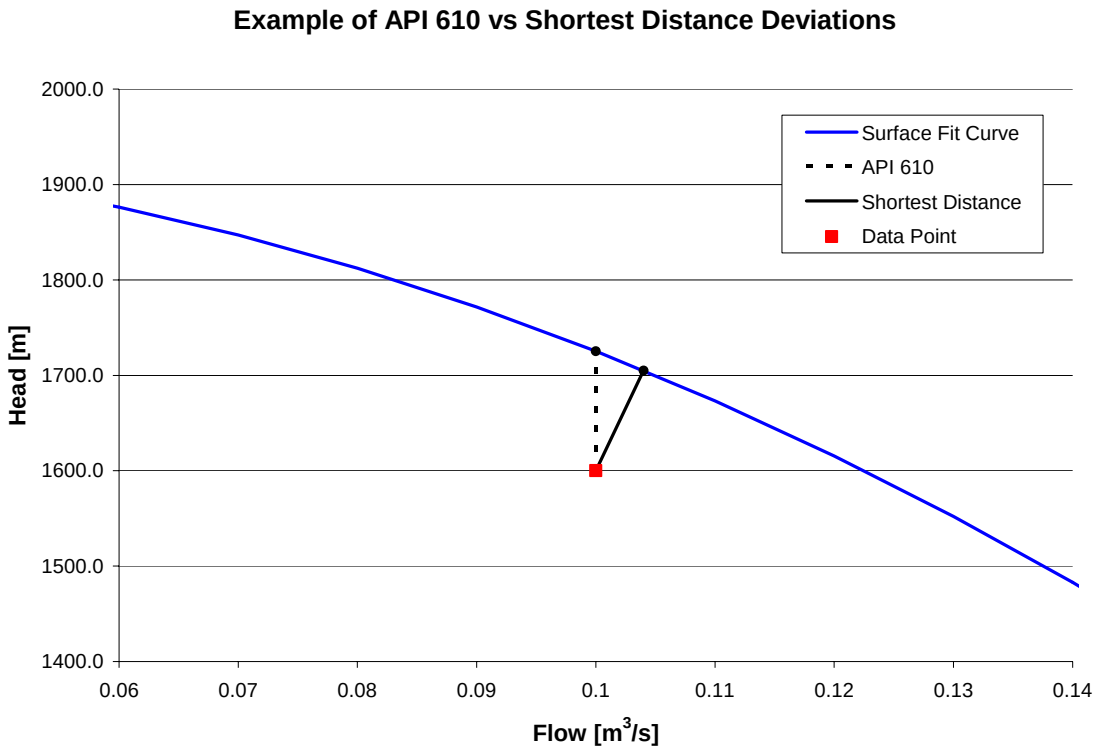

Fig. 3: Sample plot showing difference between API error and shortest distance error

Summary and Conclusions

By calculating the perpendicular distance between the surface fit curve and the tested data point the true deviation is known. The shortest distance method includes error in both the vertical and horizontal directions, in the case of high pressure pumps this is deviations in both the flow and the head. This result not only produces smaller errors; the errors found are the correct measure of the deviation between the tested data and the surface fit curve.

References

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