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NUMERICAL ANALYSIS FOR (H-Q) CURVE OF CENTRIFUGAL PUMPS USING NATURAL AND CONSTRAINED CUBIC SPLINE INTERPOLATIONS

Maher Abd Almeer Kadim[1], Riyad Jassim Tilefih[2], Adil Hameed Shakir[2]

[1]Technical Institute of Al-Shatra, Southern Technical University, Iraq
[2]Najaf Technical Institute, Al-Furat Al-Awsat Technical University, 31001 Al-Najaf, Iraq
[*]Corresponding Author Email: adil_najaf2000@yahoo.com

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ABSTRACT

This study is founded by numerical analysis to (H-Q) curve for centrifugal device pump with radial and axial flow fitted firstly with natural spline interpolation and secondly using reserved cubic interpolation spline. Two case studies are used, first one analyzed the (H-Q) curve for axial flow with high specific speed, NS, when the H-Q curve having undesirable dip due to incorrect design of the impeller. The second case study is the parallel operation for two devices (pumps) for different (H-Q) curves, the joint the curves of combination which having important point, until the suitable and working point which reached, the first one doesn't transfer the flow. The second pump can begin to fund to the flow, it is for this reason that in such a case, the second pump should be started first and then the first pump, locate this point provides us with energy and maintenance costs. The results shown that the normal cubic interpolation which will useful to interpolate these types of curves to obtain the undesirable overshooting points than constrained cubic spline.

KEYWORDS

Constrain and normal cubic interpolation.

1. INTRODUCTION

The capacity represents the most important characteristic of any pump device. The total amount of the fluid it moves. The capacity is decreased as the pressure at the pump discharge increases. The shape of the H-Q curve dependent on speed or on the shape and the blades of the impeller, referring to this the H-Q curves of any pump having its shape, flat or steep. The H-Q curve is one in which the difference head (H) progressively falls with the increase in flow rate Q, as shown in figure 1.

H-Q curve for centrifugal pump, radial, axial flow A process application may require operation of more than one in a single system. Several pumps would discharge their flows in a common delivery pipe. The configuration of such pumps is called as parallel operation [1-8]. When the devices operated with parallel, they work against a common pressure. In this case, the flow rates are added. Multiple pump operations are sensitive to the individual characteristics of the pump. The total current rate simple addition of the individual flow rates developed. This is especially in cases where the pumps don't need similar characteristics curves. If the pumps have same H-Q curve which will be in parallel, the mutual curve is obtained by doubling the abscissa foe each point on the individual pump characteristic, while keeping the total amount of the head as constant. When single pump operates, the rate is say Q1. The combine H-Q curve is obtained by doubling the abscissa with same head, as in figure 2.
It would be normal to assume that this would be the pump when these will be in parallel. However, this is not the case. The operation is dependent on the system resistance. In the parallel operation with a system resistance curve as in figure, a single pump would deliver a flow rate of QC1 when the next pump is also started, the system resistance takes a turn upwards and intersects the H-Q curve of the combined flows at a point, QC2 this is square relationship system resistance with the flow rate.

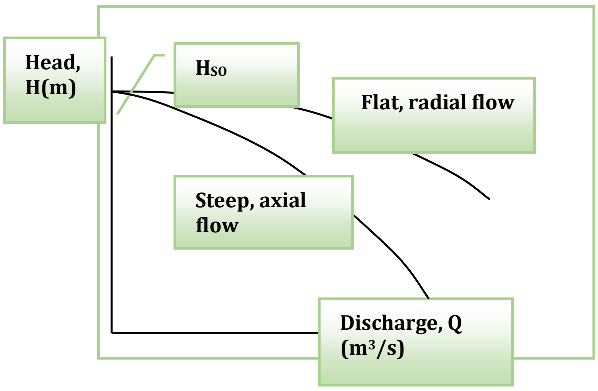

Figure 1: H-Q curve for centrifugal pump, radial, axial flow.

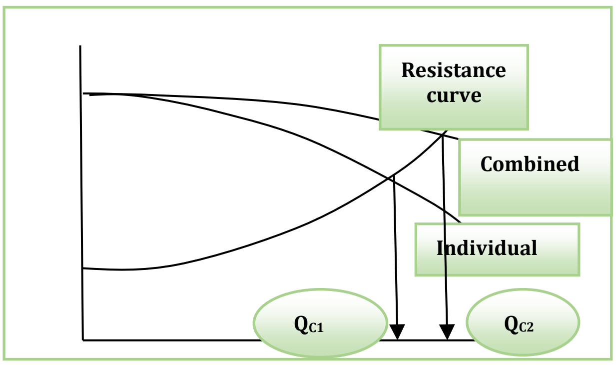

Figure 2: Operations of the pumps with similar characteristics.

2. THEORETICAL ANALYSIS

Interpolation used to approximation a function value between points without knowing the actual function [3,4]. Interruption technique can be separated two categories: · Global interpolation, these approaches constructing single polynomial equation. These approaches effect in flat curves. · Piecewise interpolation, these approaches constructed on polynomial of little grade between points.

Linear, quadratic, and cubic splines may use. The upper degree of the spline, the smoother the curve. Splines of degree m will incessant offshoots up to degree m-1 at points. To get good curve and cubic frequently recommended. Generally, the behaver and incessant to second derivative at the points. Even the cubic keys are fewer disposed to to swaying or pass than worldwide equations, prevent it.

2.1 Natural Cubic Splines

Reflect a group of recognized points (x0,y0), (x1,y1), ...(xi-1,yi-1), (xi, yi), (xi+1, yi+1), ...(xn,yn). To interpolate the data points using old-style cubic splines, 3rd degree polynomial is built the point.

The calculation to the left of point (xi, yi) is designated as fi for a y value of fi+1(xi) for the point xi [3, 4]. Conventionally the cubic spline function, fi, is built based on the next criteria: · Curves are 3rd order polynomials, fi(x) = ai + bi x + ci x2 + di x3 (1) ·

Curves pass through all the recognized points, fi (xi) = fi+1(xi) = yi (2) · The slope, or first order copied, is the equal for both functions or either side of a point, fi'(xi) = fi+1'(xi) (3) · The second order derivative is the similar for both functions on either side of point, fi"(xi) = fi+1"(xi) (4) This results in a matrix of n-1 equations and n+1 unknowns. The two residual equations are based on the border circumstances for the early point, fi(x0), and end idea, fn(xn). Historically following border circumstances are used [1,2,3]: · Natural spline. The 2nd order copied of the keys with end points is zero. fi"(x0) = fn"(xn) =0 (5a) · Parabolic run out keys. The 2nd derivative of the keys at the points with the same as at the adjacent points. The obtained results that the curve becomes a parabolic curve points.

f1"(x0) = f1"(x1) fn"(xn) = fn"(xn-1) (5b) · Cubic splines.

The last two intermezzi by location the 2nd order copied of points to: f1"(x0) = 2 f1"(x1) - f2"(x2) fn"(xn) = 2 fn"(xn-1) - fn-1"(xn-2) (5c) · Clamped spline.

The 1st order of the splines points is set to known values. f1'(x0) = f '(x0) fn'(xn) = f '(xn) (5d) in old-style equations 2 -5 which will be joint with the n+1 by n+1 tridiagonal matrix is resolved to harvest the equations for all section [1,3]. As both the 1st and 2nd order for linking the functions at all point, the obtained results result is so smooth curve.

2.2 Forced the Attitude Late

The future forced cubic is to avoid passing by smoothness. This is attained by removing the condition for equal 2nd order system in all the point and trading it with stated 1st order [5,6].

Thus, similar to natural cubic splines, the proposed method is built giving to equations (2), (3) and (5a). equation (4) is replaced by, · A specified 1st order or slope with all point, fi' (xi) = fi+1'(xi) = f '(xi) (6) The key step develops the control of the slope at all the point. Intuitively the slope among the angles of the together lines will be known and must line zero with the slope of either line methods zero. The slope with all point is known, it is longer essential to solve a scheme of reckonings. The function, as given by equation (1), can be intended based on the two together with all side.

The third-degree polynomial, ai = yi-1 - bi xi-1- ci x2i-1 - di x3i-1 (7) where di = (8) ci = (9) bi = (10)

2.3 Practical Applications

2.3.1 Case Study (1)

In this case study, the (H-Q) curve for centrifugal pump with axial flow has been studied, due to mistakes in the installation or manufacturing show humps (or dip) in the curve as in figure 4. This humps undesirable to occurrence because it means that the pump gives tow discharges (Q) in the similar head (H), this situation cannot get in the case of the right operation, it may cause damage in the pump.

2.3.2 Case Study (2)

If two centrifugal pumps, radial flow, with dissimilar H-Q curves are combined in parallel as in figure (3), the joint curve of such mixture is signified by OAD. However, until reaches A, the convenient don't bring flow as it sees for itself shut-off circumstances. Point A that pump (1) can begin to donate to the full flow. It is for this reason that in such case, the pump (2) should be started first and then pump (1).

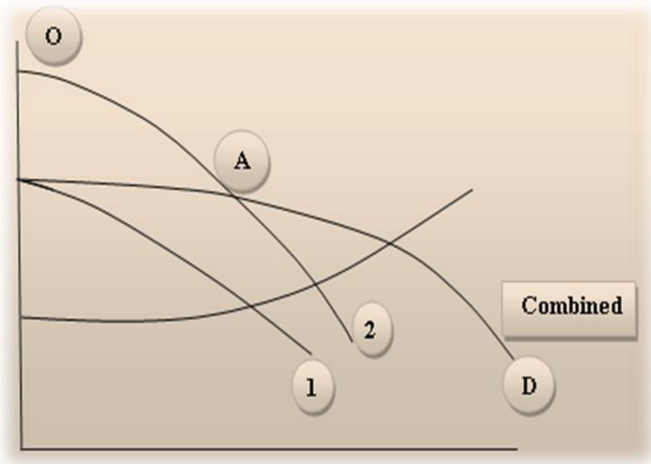

Figure 3: H-Q curve for high specific speed pump.

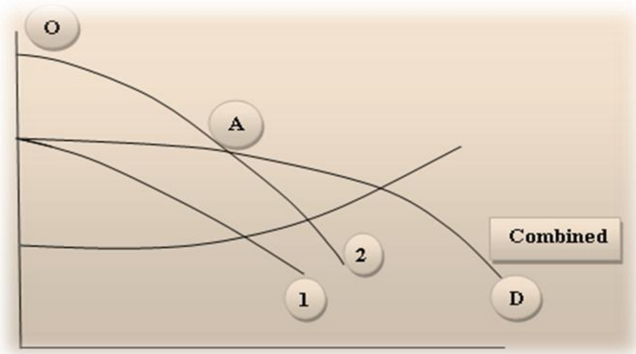

Figure 4: Parallel operation with different H-Q curves.

3. RESULTS ANALYSES

3.1 Case Study (1)

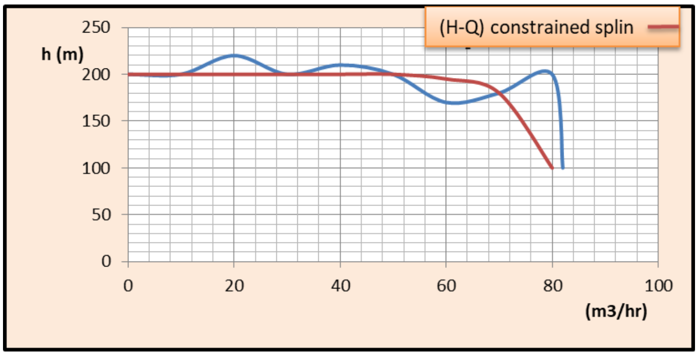

Figure 5: Numerical results for the (H-Q) curve to axial flow pump.

3.2 Case Study (2)

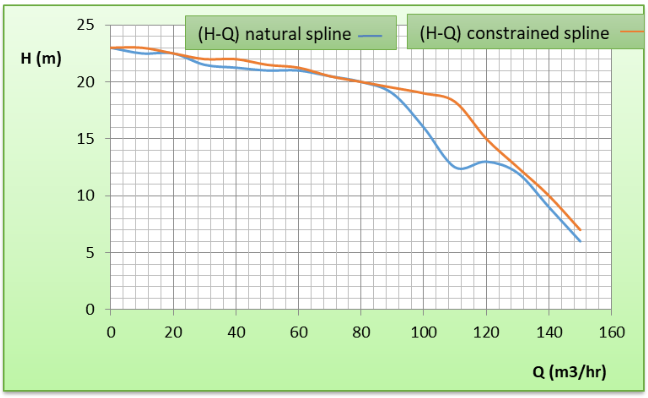

Figure 6: Numerical results for (H-Q) curve to parallel connection of pumps with different characteristics.

4. CONCLUSION

The proposed method is a powerful data analysis tool. Splines correlated data efficiently and effectively, no matter how random data may seem. The modified interpolation technique gives relatively smooth curve without any overshoots in the intermediate values, this may be getting better in several engineering applications, but in this research, the oscillation or the overshoots is very significant to shown them. Till then using forced interpolation are not clearly identified the sites of unstable points and the (H-Q) curve being smooth without any humps. Then the use of interpolation technique shows clearly identified to the sites of the undesirable operation, this identify is significant to avoid power consumption or to avoid damage of the pump.

5. RECOMMENDATIONS

From the research results, the following recommendations can be developed: · It's not always true works to select smooth curve or downing best fit or smoothing to studied curve for different applications. Avoid connects many devices (pumps) with different characteristics curves.

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