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Pump End of Curve Operting Point

Stuart Williamson
Dynamic Simulation Consultant at CB&I

If I take a typical centrifugal pump performance map then the curve usually starts at zero flow (and maximum head) at the left, and ends at the right hand end at some maximum flow value (and also a minimum head value), but what actually happens beyond the end of the pump curve. Is this the maximum flow that can be passed by the pump (similar to choked flow in a compressor) due to some physical limitation, or is it just the maximum flow coincident with the maximum (or rated) power of the motor. I have seen some curves where the power reduces beyond a maxima in the power curve, so possibly the second option is not correct.
If I start the pump up, then initially the suction and discharge presures will be equal, so the pump will run-up at its end of curve point.
So the question I have is; what does the end of curve point on a centrifugal pump performance map actually represent? Any thoughts?

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Pedro A. Arrondo Martínez likes this

8 comments

andriyadi

andriyadi saputra
Process Engineer at PT. Tripatra Engineering

The end of curve point show us the low pressure when high flow. Then it need to compare with your system curve that with this low pressure, is it possible to deliver the liquid? or when this low pressure occurs any leak happen?

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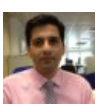

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

I know where you are coming from; trying to define the pump in dynamic simulation with the right and sensible limits.

I don't think the pump capacity at the end of pump curve is limited because of motor rating otherwise we should have seen something about the validity of curve with a particular size of motor. You very well know that pump curves are published without mentioning about the motor capacity, so they should be independent of maximum (or rated) power of the motor.

The pump power curve is simply Q x DH / pump efficiency. When moving forward on the fixed speed pump's curve, Q increases whereas DH decreases. Efficiency increases to a maximum at BEP before it starts dropping toward the end of the curve. So it is quite sensible if the combination of theses parameters produces a maximum point in the power curve.

I presume that the pump differential head sharply drops if the flow goes beyond the end of the pump curve. However, I have no idea how sharp it could be. This is most probably because the pump impeller and casing is designed to operate in the narrow window. In other words, to make use of pump RPM to convert momentum to pressure the pump has to operate against particular back pressure.

I hope I will get better answer from a vendor within next few days.

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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Hi Saeid. Yes I asked the question as I've been given various responses over the years which are variations of the above. Looking at a few curves, often the maximum power coincides with the end of curve (but this is not always the case), so it will be interesting to see what a pump vendor comment is.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Depends on (the shape) of pump horsepower curve.
(1) In some cases, the HP will keep increasing. In such cases, the motor will trip on overload
(2) In others, the HP may stay flat. Such pumps will continue to operate. Most of the agriculture or engineering college lab pumps typically operate without outflow restriction and at EOC

In both cases, the motor will not burn. But if NPSHr > NPSHA, cavitation will occur and pump will be damaged. Modeling should thus consider NPSHr and HP with flow.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Clarification: I am talking about the irrigation pumps in the wheat and paddy fields in Asia. The water gushes out of pump discharge nozzle. No flow control or system curve. Seeing this and checking with a pump engineer only exorcized my fears about EOC.

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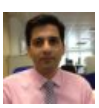
Saravanan Kandan likes this



Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

Below is the response I received. It explains why the pump curves are not shown beyond the EOC. It is basically because of the uncertainties in the operation of the pump and the design parameters; however, it does not explain how to extrapolate the curve if needed.

Response:

Please note the various problems associated with the pump operation beyond the EOC:

• NPSHr of the impeller increases sharply – not necessarily in linear way. Sometimes it becomes unpredictable. This may lead to cavitation.
• With higher flow rate, velocities in the impeller eye are quite high – at the cost of pressure head. This may lead to localized flashing of pumping liquid.
• Internal recirculation within the pump increases. Frictional resistance (disc friction) increases. This leads to drop in efficiency.
• Head of the pump decreases sharply. Pump will not be able to cater to system resistance (becomes hydraulically limited).
• Rate of wear & tear of the internal parts increases.
• Radial load on the bearings increases. This becomes critical in OH pumps.
• There is a possibility of axial thrust reversal. This becomes critical in multistage pumps.

Due to all above reasons, manufacturers normally establish Q-H curve for each impeller up to the certain flow only based on the design & followed by actual testing. Impellers are released for sales with these upper flow limits.

If at all, you need to go beyond the specified limit, manufacturer concurrence is required besides checking NPSH & power margins available from your side. Extrapolating pump curve without manufacturer's concurrence is not recommended.

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AZZUDDIN RIZAL RAMLI, PEng MIEM, Sampath Kumar R and 3 others like this

ArvindKumar

ArvindKumar Pathak
Senior Process Engineer, B.E (Chem), PGDPE, MIIChE

Dear Stuart, You are right, it is the maximum flow possible. This point is known as Cut-off Point and is point at which the energy supplied by a pump and the energy required to move the liquid to a specified point are equal. If the flow increases a bit more to this, power is not enough and no

discharge happen at the desired operating limits.

As we (Operators/Consultants) are interested in establishing designs with good operating limits, cut-off flow is not really worth mentioning over Q-H curve.

I understand this happens when the control valve at the discharge fails open fully or in complete absence of resistance to kinetic energy of the pump. what can be other operating scenarios to lead cut off?

Please correct me.

Regards,
Arvind

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Mojtaba

Mojtaba Habibi
Process Engineer at Wood Group
Top Contributor

Dear Arvind,

The end of curve operation for centrifugal pumps can happen for below cases:

- pumps in auto start service (remote control, sequence activation, etc.)
- pumps without control valve at discharge
- pumps under level control
- pumps in parallel operation

We have discussed this topic in another Chemwork discussion page and for more information you can check:

http://lnkd.in/w4rz5N

Best,
Mojtaba

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