Volumetric Surge Control - A better solution

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Volumetric Surge Control is arguably the best method for avoiding surge. VSC out performs commercial anti-surge controllers and can be implemented on any standard control system.

Volumetric Surge Control is

- Simple
- Valid at all conditions
- Uniquely stable
- Easy to implement
- Inexpensive

If Volumetric Surge Control is so good, why isn't it common practice?

Commercial Anti-surge is a huge business that relies on the idea that surge avoidance is very complicated and can only be managed with an expensive and complex system.

Volumetric Surge Control in contrast offers very little business opportunity. It's a method of control based on simple calculations that can be implemented on a standard control system by in-house control engineers.

Volumetric Surge Control is the method I successfully implemented throughout my career. I view the sales pitch for a commercial anti-surge system as an intentional complication of a relatively simple problem in order to sell a complex, expensive, and problematic design.

VSC is Simple

Volumetric Surge Control is a method of avoiding surge that is based on the simple but powerful strategy that the best way to avoid surge is to directly prevent its root cause. As is explained in [ref 2] the root cause of surge is an insufficient inlet volumetric flow rate.

The simplicity of VSC is illustrated below. A proportion-integral controller maintains the minimum inlet volumetric flow rate. The controller setpoint is calculated to maintain the desired distance from surge. The controller measurement is calculated from inlet measurements.

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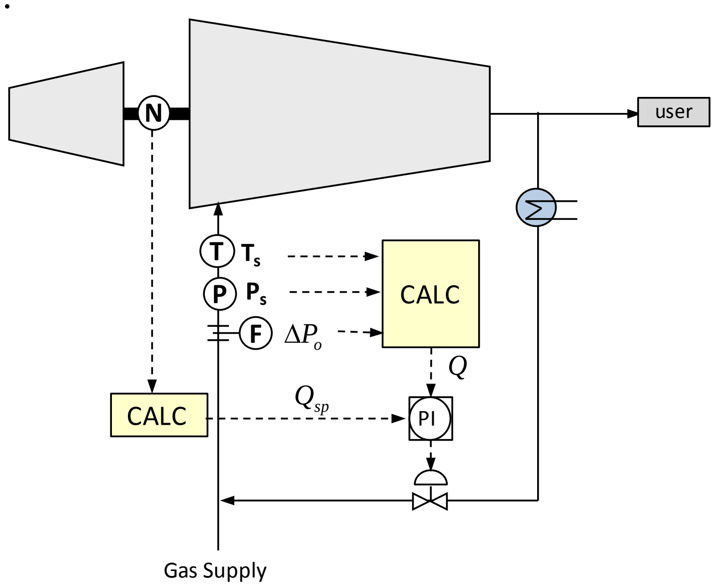


N	Compressor speed
T_S	Suction temperature
P_S	Suction pressure
ΔP_o	Flow meter head differential pressure
Q_{sp}	Volumetric Flow Rate setpoint
Q	Volumetric Flow Rate

VSC is valid at all conditions

A primary benefit of avoiding surge by preventing its root cause is its inherent validity over the entire operating range. Maintaining a sufficient inlet volumetric flow will prevent surge regardless of operating conditions. There is no need for retesting or retuning as operating conditions change.

VSC is Uniquely Stable

Commercial anti-surge systems are inherently unstable at surge [ref 3].   Their normal control response to surge is to close the surge valve! To counter this characteristic these controllers must employee high speed detection and override control to prevent surge. That remedy adds complexity, creates the need for specialized hardware and causes unnecessary process disturbances.

VSC is its stable at all conditions. VSC naturally recovers from surge. There is no need for detection of probable surge with emergency override control action. Surge, if it does occur is mild in comparison.

VSC is Easy to Implement

VSC can be implemented on any standard control system. The calculations are straight forward. Once you're familiar with how it works, implementation and support should be easy.

VSC is Inexpensive

Compared to commercial anti-surge systems, Volumetric Surge Control is very inexpensive.   VSC just becomes another control loop in your plant. There is no need for expensive hardware, complex systems or costly expertise.

Calculations
The following outlines the calculations needed to implement VSC.

Volumetric Surge Flow - Q_{SURGE}

The compressor performance curves can be used to develop the calculation of Volumetric Surge Flow from compressor speed.

$$Q_{Surge} = K * N$$

Volumetric Flow Setpoint - Q_{SP}

The volumetric flow setpoint is calculated to provide a safe margin from surge. For example a 10% safety margin would be.

$$Q_{SP} = 1.1 * Q_{Surge}$$

Volumetric Flow Rate - Q

The volumetric flow rate is calculated to density compensate the inlet flow meter.

$$Q = \frac{K^{M}_{meter}}{\sqrt{\rho_K}} \frac{\sqrt{\Delta P_o}}{\sqrt{\rho}}$$

K^{M}_{meter}	mass flow meter constant value
ρ_K	Gas density assumed for meter calibration
ρ	Actual Inlet Gas density

Gas Density - ρ

Gas density is calculated from inlet conditions.

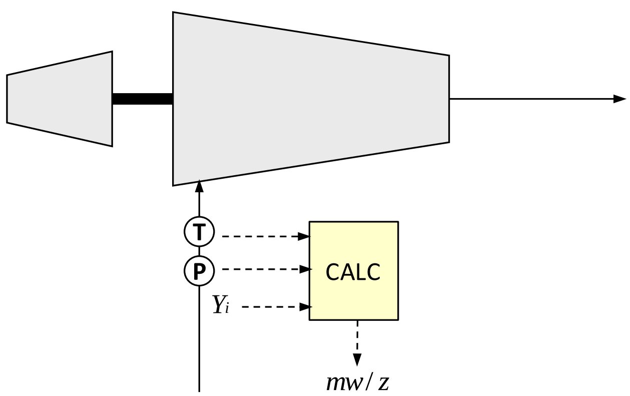
$$\rho = \frac{1}{R} \frac{mw}{z} \frac{P_S}{T_S}$$

R	Ideal gas constant
mw	Gas molecular weight
z	Gas compressibility at inlet conditions

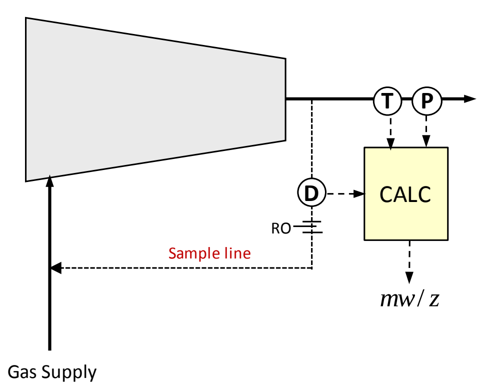
Estimating mw/z

The success of volumetric surge control depends on a good estimate of the ratio of gas molecular weight to gas compressibility. If gas composition is stable a single off line calculation of mw/z is sufficient. If gas composition changes then the estimate of mw/z can be made part of the on-line calculations.

Known Composition - *Using Physical Properties to estimate mw/z*
If gas composition is known, the ratio of mw/z can be calculated directly from the gas physical properties.

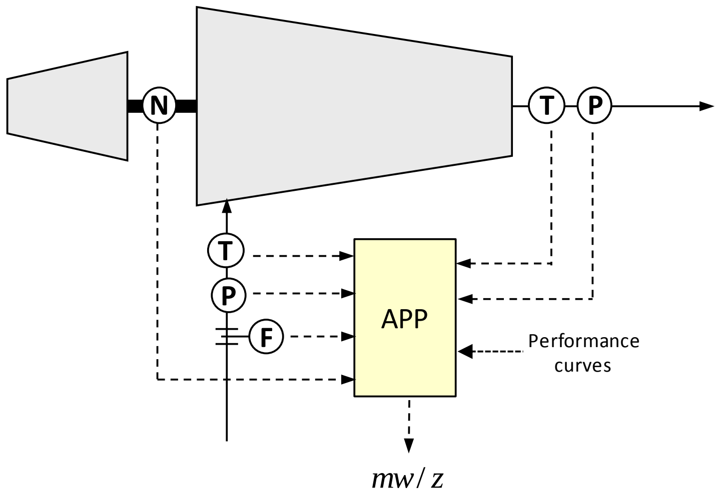


Unknown Composition - *Using a Densitometer to estimate mw/z*
If gas composition s unknown, a densitometer can be installed to provided a filtered estimate of mw/z.



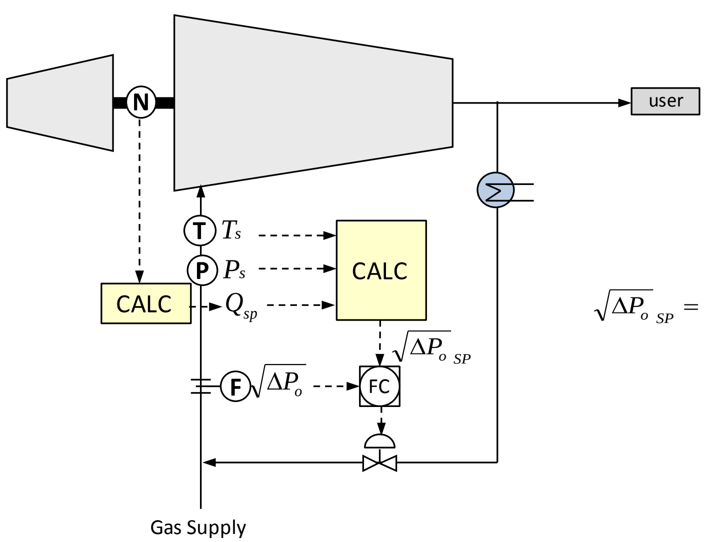
$$\frac{mw}{z} = \frac{R}{\rho}\frac{T}{P}$$

<u>Unknown Composition</u> - *Using Compressor Performance to estimate mw/z*
The ratio mw/z can be estimated from the performance curves and conventional instrumentation. Contact RMoore for more information about the windows application that estimates mw/z.



VSC - Alternate Design

Volumetric Surge Control can be implemented with the flow controller separated from the calculations. This design takes advantage of the fact that the calculations can execute at a lower frequency than the flow controller.



$$\sqrt{\Delta P_o}_{SP} = \frac{\sqrt{\rho_K}}{K^M_{meter}} Q_{SP} \sqrt{\rho}$$

Compressor Configurations

Implementation of Volumetric Surge Control is not limited to single stage compressors. VSC can be implemented on most any compressor configuration. With the addition of enthalpy calculations, VSC can be implemented on multi-stage refrigeration compressors with internal gas flow.

Volumetric Surge Control - with Inlet Guide Vanes

To see the calculation needed to implement VSC on compressors with inlet guide vanes read ref [4] *Volumetric Surge Control - with Inlet Guide Vanes*.

Contact Info

Please contact me if you need help getting started or have questions about specific compressor configurations.

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Articles in this series:

Compressor Performance - What shapes the curve
Why Compressors Surge - Exposing the real Culprit
Compressor Stability – No negative slope required!
Volumetric Surge Control - A better solution

References:

1. *Compressor Handbook* . Ed. Paul C. Hanlon. New York: McGraw-Hill, 2001. Print.

2. Moore, R. (2016). *Why Compressors Surge - Exposing the real Culprit.* Retrieved from https://simsready.com/posts/Why-Compressors-Surge--Exposing-the-real-Culprit.pdf

3. Moore, R. (2016). *The Unstable Nature of Conventional Anti-Surge Controllers* . Retrieved from https://simsready.com/posts/The-Unstable-Nature-of-Conventional-Antisurge-Controllers.pdf

4. Moore, R. (2017). *Volumetric Surge Control - with Inlet Guide Vanes.* Retrieved from https://simsready.com/posts/Volumetric-Surge-Control--with-Inlet-Guide-Vanes.pdf

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