CENTRIFUGAL COMPRESSOR PERFORMANCE

WHY ACTUAL RUNNING STATUS OFTEN DIFFERS FROM DESIGN CONDITIONS

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One of the main difficulties of analyzing the performance of centrifugal compressors begins with how the data are presented. Expected performance is generally described in terms of graphs of discharge pressures, discharge temperatures, polytrophic heads, efficiencies and absorbed power related to design inlet gas conditions, i.e., gas mixture composition, inlet pressure and temperature. However, actual performance is strictly related to field inlet gas conditions that are often different from design conditions.

The comparison of field measurements to expected values becomes complicated as expected performance needs to be adjusted to the actual suction field conditions. This requires the availability of calculation algorithms that can predict machine behavior and thermodynamic gas properties under different operating conditions.

The current practice relies on basic formulas. However, higher pressure ranges and other severe conditions tend to make these approximations unworkable. In these cases more rigorous calculations are necessary.

For a centrifugal compressor, performance is strictly linked to the inlet gas conditions. Also note that it is not possible to accurately compare different inlet conditions. It is necessary to adjust and align performances to the same reference inlet conditions.

The starting point is the availability of a centrifugal compressor performance curve, the relevant gas composition and thermodynamic conditions (pressure and temperature). Having these inputs, it is possible to perform all calculations in an automated fashion.

The most common way to set up compressor reference data is to enter performances curves expressed in terms of delivery pressure versus inlet flow rate, and delivery temperature versus inlet flow rate. In addition, it is necessary to input the considered gas composition, and the considered pressure and temperature.

It is useful to compare field measured data with expected data in order to obtain a quantitative evaluation of the compressor running status. Performance analysis provides information useful for predictive diagnostic evaluation.

Case in point

The compressor under study was running under off-design inlet conditions. Analysis provided an evaluation of performance and a comparison to design values.

Centrifugal compressor performance maps for two inlet conditions of pressure and temperature were available.

D1: Design 1 condition	D2: Design 2 condition
• Discharge pressures and temperatures map for different running speeds • Efficiency and polytropic head map for different running speeds.	• Discharge pressures and temperatures map for different running speeds • Efficiency and polytropic head map for different running speeds.
• Gas Mixture 1	• Gas Mixture 1
• Pressure 1: 40.2 bar a • Temperature 1: 50°C	• Pressure 2: 53.2 bar a • Temperature 2: 37.8°C

Table1: A comparison of the D2calc (x points) obtained versus D2 (continuous line) performances curves

Starting from the curves of the D1 condition, the expected performance curves in D2 were calculated using this approach. The obtained curves, D2calc, were then compared to the D2 curves available as input.

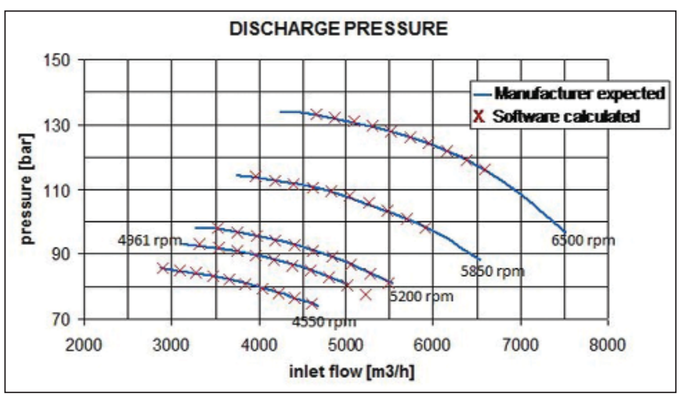


Figure 3: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

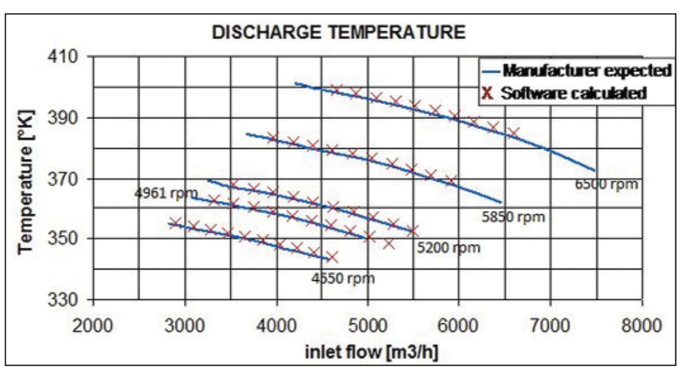


Figure 4: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

It should be noted how the curves almost overlap: The maximum error calculated is less than 0.2 % (polytropic work at maximum speed). Measured errors are considered tolerable for the purpose of the evaluation of compressor field performance. This confirms the capability of the proposed method to predict compressor performance aligned with design ratings.

One application of the proposed method is on surge protection systems and for diagnostic purposes. Typical centrifugal compressor protection systems use inlet flow and suction. Discharge pressures and temperatures are dependent on thermodynamic parameters of suction, such as pressure, temperature and gas mixture composition.

The protective action, therefore, remains valid only for the design-specified gas mixture. As a result, these systems provide limited surge protection and are valid within a small operative range.

In essence, compressor protection is incorrect or absent when inlet conditions move to off-design values, especially when approaching the higher pressure ranges of severe applications. As well as being inefficient, there is the potential for damage to the compressor. TI

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