SOME ASPECTS OF FIELD PERFORMANCE TESTING

by

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ABSTRACT

The incentives are well recognized for conducting field performance tests on centrifugal compressors in petrochemical service. From the maintenance standpoint, stage-by-stage changes in thermodynamic performance are valuable indicators of progressive fouling or seal leakage. Ideally, continuous measures of performance could be used by on-line process control computers to optimize the overall process operation on the basis of *current* compressor behavior rather than relying on compressor manufacturer's *design* calculations (predictions).

When contemplating such tests one must face several very real complications which set this type of performance testing apart from code-based testing done in the manufacturer's shop. A few of these items are now discussed.

1. It would be most desirable to measure performance on a wheel-by-wheel basis, but generally appropriate instrument locations are not provided in the compressor housing. Thus attention must be limited to individual stages defined by external piping connections into and out of the compressor housing.
2. Regarding piping, it would not be common to find an installation where sufficient straight runs were attached to the compressor housing to ensure the undistorted flows into and out of each compressor stage necessary for best aerodynamic behavior of that stage.
3. A similar comment applies to the location of suction and discharge pressure and temperature instrument taps in this piping. Tap locations and transducers must be judged on an individual basis, accounting for possibilities such as flow stratification in a duct or backflow at a wall tap due to an upstream disturbance. Of related concern is the accuracy of existing process transducers for measurement of these critical thermodynamic properties. It has been demonstrated if sample lines exist at appropriate locations in the piping that total pressures and temperatures can be measured independently by probes inserted into the gas streams and connected to carefully calibrated transducers.
4. Of equal importance to pressures and temperatures at each stage are the main stream and side stream flow rates for which existing plant insrumentation (flow meter and differential pressure transducer) must generally be used. Verification of plant flow meters with a traversable pitot tube is possible, although difficult.
5. Generally the gas being compressed is not simply air, nitrogen or freon as were used in the shop test, nor is it necessarily the gas or gas mixture upon which the compressor selection was based. Therefore it is very critical that representative gas samples be taken (accounting for potential condensation of some constituents at ambient conditions) and that accurate analyses be made of the gas stream composition.
6. With these measurements and an *appropriate* thermodynamic model of the compression process, it is possible to calculate the head, efficiency, and gas horsepower of each stage. Comparison of the horsepower with that being supplied by the driver is straight-forward if a torquemeter coupling is employed or if the driver is an electric motor. In the case of a steam turbine driver, its performance must be calculated from measurement of the same thermodynamic variables of pressure, temperature, and flow rate as were obtained for the compressor. Apart from the fact that the working medium is well known, many of the same experimental difficulties will be experienced with steam turbine field measurements as with the compressor stages.

As a matter of overall philosophy it is very important that the complete procedure for obtaining thermodynamic data, whether by direct measurement such as pressure and temperature or by indirect calculation such as density and specific heat, be obtained in a consistent way for use in thermodynamic model calculations. For example, erroneous results would follow from an efficiency or head calculation using *currently measured* temperatures, pressures and flow rates along with *design* gas composition and, consequently, design values for derived quantities such as density or specific heat.

One further complicating feature of field performance testing is that for data obtained under steady operating conditions, it is only possible to calculate one point on the performance curves. Data obtained at some other time when the process might be operating somewhat differently because of a different gas composition or altered suction conditions will be difficult to compare with previous results in the sense of establishing points along a performance curve. This illustrates the need for normalization techniques so that such quantities as head or polytropic efficiency may be compared from time to time.