Compressor Works

ACI Services, Inc.

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Compressor Performance and Optimization: Using 3D Plots

Compressor point performance reports give the user a lot of detail about one particular operating point, while standard performance curves give added information about how the load and flow of a unit changes with pressure, speed, and load step. However, there are times that it is very useful to see the larger picture, and thus expand basic performance curves into the next dimension.

Load: Figure-1 shows the maximum obtainable load for a particular compressor. The plot displays maximum possible loads that can be achieved by the unit based upon all allowable speeds and load steps for every combination of suction and discharge pressure. Red areas are those areas where the unit can reach its maximum rated load, while other colors reflect less than fully loaded conditions.

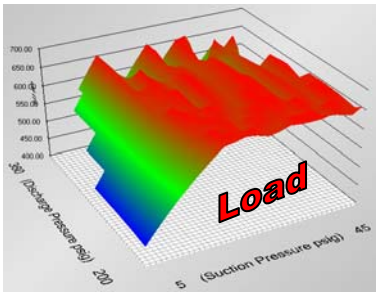

Figure-1

Especially noticeable in this surface plot is the existence of valleys. While operating at the lower discharge pressures, the unit can reach and sustain operations at rated load; however, for higher discharge pressures, the unit can only reach rated load for a few select combinations of suction and discharge pressures.

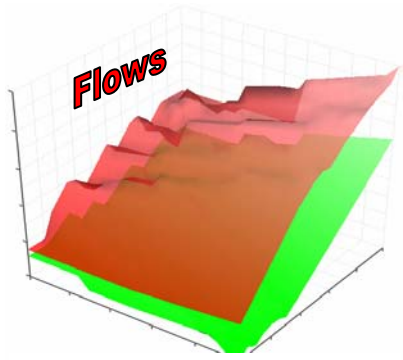

Figure-2

Flow: Figure-2 shows the same compressor unit's maximum (red) and minimum (green) flow capabilities. The maximum and minimum flow rates parallel each other fairly well. However, while the flow rates change smoothly for lower discharge pressures (right-front), they vary quite a bit for the higher discharge pressures (back-left).

Individuals are often challenged to select ideal units to meet specific goals, or to determine which unloading arrangements for existing units offer the maximum flow rates. Using 3D plots, compressor specialists can generate effective comparisons of multiple units, or arrangements, to see where in the operating map each proposed solution is more desirable than other proposed solutions.

Figure-3 shows a comparison of a unit that required additional unloading capabilities. The proposed solutions were Option #1) Add more clearance volume pockets, Option #2) Deactivate one or more ends, or Option #3) Effectively resize the unit by using a liner. The particular station had acoustic issues with other similar units with deactivated ends, so Option #2 was quickly dismissed. Option #1's flows are plotted in red, while Option #3's flows are plotted in green.

The 3D plot quickly highlights and compares the possible flow rates between the two options across the entire operating map. For lower-to-middle suction pressures, the two proposed options offer about the same flow rates. However, for higher suction pressures, the volume pocket solution provides higher flow rates. Since the costs associated with the pocket-only solution were about one third of the liner-only solution, it quickly became obvious as to which proposed option would best meet the needs of the end-user.

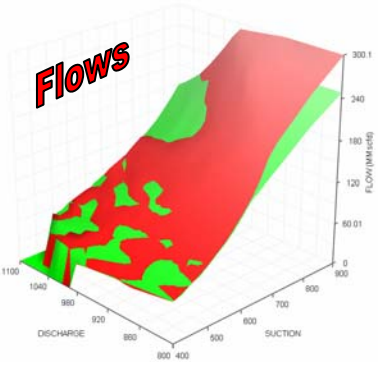

Figure-3

Inside this issue:

Look for ACI at these Events:

March 13-15 Gas Compressor Association; Galveston, TX

May 9-19 Eastern Gas Compression Roundtable; Pittsburgh, PA

June 13-15 Global Petroleum Show ; Calgary, Alberta (in cooperation with Klaus Enterprises, Ltd.)

Sept. 25-28 Turbomachinery Symposium; Houston, TX

Oct. 2-4 Gas Machinery Conference; Oklahoma City, OK

Compressor Performance and Optimization: Using 3D Plots

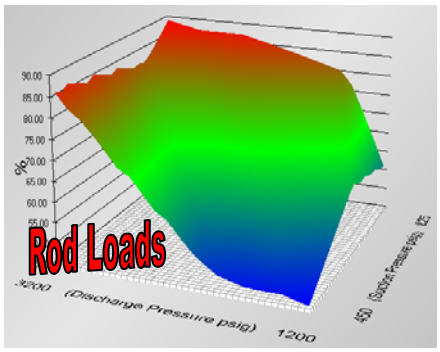

Figure-4

Rod Loads: 3D plots are not necessarily reserved for comparing flows and loads. These types of plots can quickly highlight the hidden consequences of not properly protecting a compressor against rod load and pin non-reversal limits. As shown in **Figure-4**, rod loads for any particular unit are not necessarily intuitive. In short, what is safe at one condition and safe at a second condition may not be safe for conditions in-between.

Further compounding this issue, is the requirement that reciprocating forces acting upon the crosshead pin are such that the pin is properly lubricated. **Figure-5** shows how quickly a unit can go from having plenty of degrees of pin-reversal for proper lubrication (upper red areas) to having relatively low degrees of reversal (lower blue section).

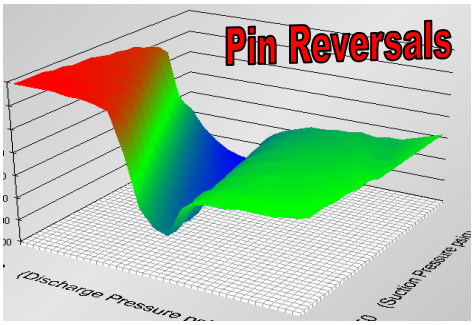

Figure-5

Today's high-speed compressors often operate in areas of high rod loads. As such, packagers, OEMs, and end-users need to review potential issues with rod loads, and pin reversals, across the entire expected operating map, and not just for a few select points.

Isentropic Efficiency: A useful plot for consultants, packagers, and OEMs is one that shows the maximum efficiency of the unit for its expected operating conditions. **Figure-6** compares the efficiency of a medium-speed compressor (750 RPM) to a low speed unit (330 RPM). You may be surprised to discover that the medium-speed unit was significantly more efficient (green plot) than the low-speed unit (red plot). However, the medium-speed unit also was running high rod loads at the maximum differentials (notice where its plot drops off at low suction and high discharge pressures) while the low-speed unit was able to cover the entire operating map without incurring any type of rod load issues.

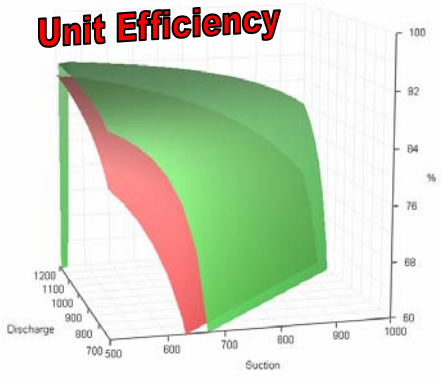

Figure-6

With the GMC's approval, ACI hopes to have a short course available to attendees at the GMC in 2006, and/or 2007. This short course will include using available 3D plot methodologies and tools to achieve specific goals. Using today's tools, users can generate reports that cover entire ranges of pressures, temperatures, speeds, and load steps. The insight these reports can provide to end-users is simply not available from more common, single-point performance reports.

For the next issue, we begin a new topic: Methodologies for Creating a Sequence of Effective Load Steps.

WS-10 Crane Scale Load Test

WS-10 Crane Scale on the test fixture.

Stork-Herron Testing Laboratories in Cleveland, Ohio conducted a load test on the 10-ton crane scale (WS-10 Model) at the request of ACI Services, Inc. The scale assembly was installed in a 200,000 pound Tinius Olsen tensile test machine. Once the test was set up, the scale was tested for functionality and safety.

1. Functionality — Loaded and unloaded at a rate of 1,000 lb/min. and held for six minutes at various points for observation.

2. Safety — The scale was loaded at a rate of 2,000 lb/min. to 20,000 pounds, and then at a rate of 1,000 lb/min. to 100,000 pounds.

In summary, the WS-10 Crane Scale assembly functioned properly to the rated 10-ton load with an accuracy of 1-3% and was structurally sound to five times the rated load.

ACI Services Inc. Expands Manufacturing Capabilities

ACI Services, Inc. can design, engineer and manufacture custom, purpose-built compressor components for all types of reciprocating compressors and applications. We have the resources to manufacture, refurbish, repair, or re-apply all kinds of reciprocating compressor cylinders and components.

With our August 2005 move to a modern 26,500 ft^2 facility in Cambridge, Ohio, we now have co-located our engineering and administrative offices, extensive reference library and a new training room and equipped ourselves with the latest in computer systems and software. The facility also houses our expanded parts stock, inspection area, medium and large assembly bays, hydrostatic testing, pattern and tooling storage, pallet shop, and welding, cleaning and sandblast areas. It has three shipping docks and heavy lifting capacity. The newest addition will be a precision large machine work cell—lathes, VTL, HBM, surface grinder, radial drill and more—that will increase our capacity and shorten our lead-times for customer equipment repairs and small lot orders.

Cylinder Assembly Area

Cylinder Hydrotest Area

Unloader Assembly and Hydrotest Area

Our Starr Machine Division in Nelsonville, Ohio handles many of our higher volume machining needs. The 31,000 ft^2 facility has five large CNC turning centers, four turret lathes, two vertical boring mills, four engine lathes, four CNC vertical milling centers, one CNC horizontal pallet mill, two vertical knee mills, one horizontal boring mill, cylindrical and surface grinders, multiple drill presses and radial drills, and various equipment for inspection, cleaning, lapping, polishing, labeling, sawing, painting and shipment preparation. Several machines were added and/or rebuilt in 2005 as part of our ongoing quality and technology improvement programs.

CNC Machining Centers—Nelsonville

CNC Milling Centers—Nelsonville

ACI Services also maintains a network of high-quality casting, precision machining and heat treating suppliers that complement our internal capabilities and capacity. And our BSI Group affiliate, Bi-Con Services, adds metal forming and API and ASME Certified MIG, TIG, arc and gas welding to our extensive portfolio.

Don't let the sun catch you in bed — Old Texas cowboy wisdom

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Norm's Notes

As a result of a lot of hard work by our entire team, a strong market, and the confidence and loyalty of our many customers, ACI Services enjoyed what I can only describe as a *breakthrough* year in 2005. We look forward to continuing that trend as we expand our focus into a broader market base. I extend my sincere thanks to all of our team members and our customers.

We are pleased to announce that Texas Compressor Corporation (TCC) of Houston, Texas and ACI have agreed to cooperate in the pursuit of chemical, process and refinery related compressor business, principally in the Texas Gulf coast area. This gives us a major machine shop and service presence in that area.

We welcome Shane Lappert as the newest member of our ACI team. Shane works as a technician in our Cambridge shop. Speaking of shops (and offices), we are delighted with our modern, new Cambridge facility. For the first time in years, we have all the fundamental parts of our business in the same building. That includes everything except the Starr Machine Division, which we use for larger production runs that have generally longer lead-times. As you can read elsewhere in this Issue, we have made substantial investments in quality machinery, facilities, computer tools and people to help us serve our customers better, faster and more efficiently. Additional investments are either planned or already underway in 2006.

Our online used equipment clearinghouse business, Compressor Connection, continues to grow with new listings, inquiries and sales transactions. We continue to improve the equipment search screen flexibility based on user feedback, and we now have approximately 20,000 used compressor and engine items listed. Take a look by browsing to www.CompressorConnection.com or by directing your browser to ACI Services, Inc.'s principal website www.ACIServicesInc.com.

Keep your promises and commit to your commitments; be meticulous with your word. — Robin Sharma