

Compressor Performance and Optimization: Automation Concerns

A real benefit of reciprocating compressors is their ability to run rather efficiently over a wide range of pressure ratios. By using volume pockets (to add volumetric clearance) or by deactivating ends, these types of machines can adjust the gas flow so that the amount of power required is within the rating of the driver (engine or motor).

However, maintaining safe operation of reciprocating compressors over a wide range of pressures can pose a real challenge. Issues like rod loading, pin non-reversals, high pressures, and very low volumetric efficiencies can cause damage to the rods, pistons, valves, packing, cross-heads, and even crankshafts. Damage to any of these items can either cause the damage of other pieces of hardware or can consequentially lead to catastrophic damage to the entire unit, the station, and even to anyone close by.

Thus, it is very important that when controlling reciprocating compressors, much care is taken to insure that they are being operated within the ranges for which they were sized, designed and built. It is important to recognize that this applies equally to units that are manually controlled by operators as well as to units that are automatically controlled by logic panels. Since the rod loads, pin-reversals and valve losses of high-speed units generally vary more with speed than do low speed units, proper control of high-speed units is even more important.

Figure-1 details a Load Step Robustness Plot as perceived too often by automation groups. This particular plot highlights the suction versus discharge pressure combinations where the unit can "safely" operate, but it assumes that speed is always at rated speed, and it assumes the average suction temperatures at each stage of gas for the rated

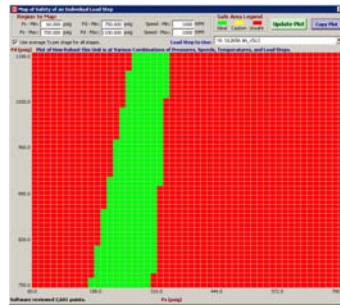


Figure 1

design point. Green areas indicate "safe" areas of operation, while red areas indicate "unsafe" areas. Unfortunately, this is the type of perceived safe-operating-map-per-load-step that is often programmed into PLC logic to control the unit. That is, a reduction in the areas of allowed operation in favor of a more conservative (and easier to program) approach. The word "unfortunate" is used because too often a "more conservative approach" misleadingly implies a more safe approach.

Figure-2 also details a Load Step Robustness Plot. However, this time, speed is allowed to vary from minimum to maximum, and various combinations of suction temperatures to all stages are also reviewed.



Figure 2

Again, green indicates "safe" areas of operation, red indicates "unsafe" areas, and now yellow indicates areas that are safe under certain combinations of speed and tempera-

tures, and unsafe at other combination of speed and temperatures. We quickly notice that Figure-2 allows for more operating map coverage, albeit with caution. However, to program a PLC to intelligently determine when a particular load step is safe in regards to combinations of speed and temperatures can be a bit complex.

For added clarity, Figure-3 details

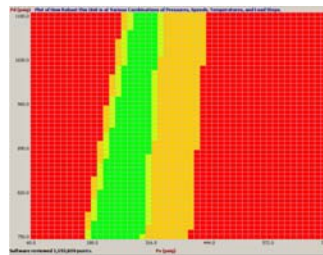


Figure 3

an overlay of Figures 1 and 2. The orange areas are areas that the conservative approach would prevent the unit from running, even though it can possibly run at many of these operating points safely. The yellow areas reflect areas that the conservative approach has indicated are safe, when in fact there are combinations of speed and temperatures that will make this particular load step unsafe to use.

In short, automation groups that try to oversimplify controls of reciprocating compressors can often reduce the operating range of the unit, sometimes dramatically, and yet can still let the unit operate with load steps that are unsafe. Neither consequence is desirable.

Figures 1, 2, and 3 detail a situation where simplified PLC models could greatly limit the operating map of the unit. While the model is too conservative, it does control the unit fairly safely – not too many yellow areas in the overlay plot, although even one area is poten-

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Look for ACI at these Events:

- March 5-7 Gas Compressor Association Expo; Galveston, TX*
- May 7-9 Eastern Gas Compression Roundtable; Coraopolis, PA*
- September 10-13 Turbomachinery Symposium; Houston, TX*
- October 1-3 Gas Machinery Conference; Dallas, TX*

Compressor Performance and Optimization: Automation Concerns (cont.)

For more information on how ACI can assist with your automation concerns, please contact Dwayne Hickman at (740) 435-0240 Ext. 508

tially one too many. This is likely the situation of many current control panels that are overly conservative in their controls.

In other cases, someone may make assumptions about rod loads and pin non-reversals always getting “better” at lower speeds, and thus the safe operating map is based on the unit’s rated speed, instead of reviewing its performance over its entire allowed range of speeds. Not a good assumption.

Furthermore, there are situations where simplified PLC models can not only limit the operating map noticeably, but can also allow the unit to operate in the select areas that are potentially unsafe. These situations are what can happen if the PLC controls are relaxed somewhat. For example, to maxi-

mize the operating map where the load step can be used by the PLC, the unit is reviewed for maximum and minimum speeds and assumptions are made about the in-between speeds. Again, making general assumptions can be very misleading.

When automating reciprocating compressors, it is important to make sure that the control logic being employed is based on a thorough review of every load step, at every combination of suction and discharge pressure, across all speeds and various combinations of suction temperatures. Today’s PCs only need a few hours to run 100+ million performance points. These can then be quickly analyzed to create a set of constraints per load step that allow the unit to safely enjoy its maximum range of operating condi-

tions.

The problem is real; the danger is real. A typical solution requires a review of the unit over its entire operating map. Based on that review, a few additional lines of logic are then coded in the controlling PLC. The benefits include increased safe operating map coverage, increased flow rates, increased revenues, and most importantly, increased safety.

What’s in your PLC?

Project Success Story—ACI Custom Designed Pipeline Cylinder



Six (6) 10-in, 1500 psig (103.4 bar) MAWP cylinder assemblies prior to shipment to the compressor station.



First cylinder installed next to the original cylinder. Note the discharge bottle is still in place.

A North American Pipeline Operator identified concerns with compression efficiency on a number of their Waukesha driven Dresser Rand 6-throw HOS-6 compressor packages operating on a Mid Continent Pipeline. The compressors were originally configured with six identical cylinders with a bore diameter of 9.5-in and 160 in³ fixed volume pocket unloader assemblies on the head end of each cylinder. The typical operating pressure ranges on the suction side were 500 – 775 psig (34.5 - 53.4 bar) and on the discharge 800 – 1000 psig (55.2 - 68.9 bar) with an operating speed range of 900 – 1000 RPM. Through many iterations of engine and compressor analysis, it was identified that the parasitic losses in the compressor cylinders due to valve and gas passage restrictions resulted in much higher than expected compression horsepower requirements. The Operator set forth to identify how best to minimize these losses and increase the

overall compression efficiency.

The cylinder in use was originally designed for gas gathering services. As a result, the valve diameters (6.125-in), mechanical fixed clearances, and gas passages were designed for much greater ratios when compared to typical pipeline transmission cylinders. These design features, although great for gathering cylinders, do not create an efficient cylinder for gas transmission applications. ACI further investigated the existing cylinder and the operating conditions in detail, working with the engineers and station operators to fully understand the efficiency concerns and expectations.

Upon review of the theoretical performance of utilizing existing OEM pipeline cylinder designs and possible custom-designed cylinder solutions, the customer elected to pursue the ACI custom cylinder option. This option not only met the

goals of increased compressor efficiency it also minimized the amount of downtime required for installation as the cylinder would be designed to use all the existing piping and pressure vessels without modifications.

ACI custom engineered and manufactured a bolt-in 10-in bore diameter 1,500 psig (103.4 bar) MAWP Gas Transmission cylinder complete with an ACI 400 in³ fixed volume pocket unloader assembly. Two key design features were able to be incorporated: gas passages with minimal restrictions and larger valves (7.47-in valve nose diameter).

The cylinders were installed late 4th quarter 2005 and have been in operation for over a year. The overall compressor efficiency has been proven to have increased by over an average of 10% for the entire operating range, permitting a comparable increase in throughput.

Product Highlight—DuPlex™ Unloader Assembly

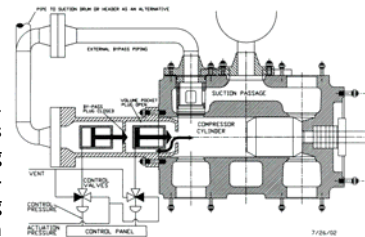
ACI DuPlex™ unloaders offer versatility and economy not possible with many other systems. They provide both clearance volume unloading and efficient compressor head end deactivation, combined in a new ACI style front head designed to replace the conventional cylinder head. These devices may be supplied on new OEM cylinders or they can be custom-designed for application to existing compressors.

The ACI custom-sized clearance volume pocket provides partial

head end unloading, and the external piping bypasses head end compression chamber gas back to suction pressure for complete head end deactivation. The external piping typically routes gas to suction through a special ACI designed valve cap, or alternately to the suction drum or suction header of the unit.

DuPlex™ operation may be either manual or pneumatic (air or gas), with local or remote control. The first step of unloading opens the clearance volume pocket plug; the

second step opens the bypass plug. This bypass concept provides efficiency advantages by eliminating the use of suction valve plate depressors (finger unloaders) or plug type suction valve unloaders often used for end deactivation. With ACI's eRCM™ compressor performance software, ACI can evaluate the advantages of integrating the DuPlex™ unloading concept into an existing application. Additionally, ACI can provide the optimum unloading sequence, the software for automation, or even the complete automation system.



The ACI DuPlex Unloader provides efficient performance control of a reciprocating compressor.

Picture to the right is for an assembly ready to install on an Ariel 10-3/8 ZM cylinder.



ACI East Coast Connection—Hi-Tech Compressor and Pump

ACI is extremely excited about our new representative on the East Coast, Hi-Tech Compressor and Pump Products, Inc. located near greater Philadelphia in Tullytown, PA.

Hi-Tech, led by Todd Pollazzi, is a proven leader in the East Coast compression industry providing many years of compressor knowledge and technical expertise. They are a leading supplier for reciprocating compressor and pump

wear components for the region. They have a staff of application engineers ready to review solutions that can be offered to the customer that combines the best materials, designs and services for their specific application.

Hi-Tech has a growing staff and a state of the art facility that will allow them to further expand into the marketplace offering more and more compression services.

The ACI product line is a compliment to the services Hi-Tech is already offering to the East Coast Region. We are confident our relationship will continue to grow and are looking forward to working with Hi-Tech on many compressor related applications.

For more information please contact Todd Pollazzi at Hi-Tech or Chad Braehler at ACI.



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ACI Team Member Profile — Chuck Kerr

ACI Services, Inc. is pleased to announce that Chuck Kerr is the newest team member of ACI as a Project Manager. Chuck has over 20 years experience in the Aftermarket business in both reciprocating and rotating equipment. Chuck started his career with Cooper Energy Services and had several managerial positions in the Aftermarket business.

Chuck started his career in Chicago working for the International Harvester construction group in their management trainee program. He held various positions in leasing, product development and sales before continuing his career with Cooper Energy Services, Mt

Vernon, Ohio.

Since engine sales were forecasted to decline, a new emphasis was placed on growing the aftermarket business. To address this challenge, Chuck started as a member of the Aftermarket's Market Analysis Group, moved to Product Manager of Rotating Products and Sales, and then became a Service Manager for the Eastern Region – twenty-six eastern states, plus Eastern Canada. After the acquisition of Cooper's Rotating Products by Rolls-Royce, Chuck became an Aftermarket Sales Manager for the Americas, where he successfully developed and completed an alliance with TransCanada PipeLines

Limited, the world's largest user of Rolls-Royce products.

Adds Chuck, "My most valued experience was in the development of the Alliance with Trans-Canada in that it forced me to actually listen and understand what the customer was saying rather than what I wanted them to hear. The benefits and synergy of two companies working together can't be put in words until actually experienced."

"Depending on who you ask I enjoy golf but love to shoot Sporting Clays and spend time with my daughters and grandchild."



Chuck Kerr
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Why didn't someone think of this before? Compressor Connection™ is a vast Internet resource of used compression equipment where buyers and sellers can connect.

Buyers search CompressorConnection.com to find a huge inventory of good, serviceable, equipment— everything from *cylinders and frames* to *crankshafts and engines*; and *complete compressor packages* too.

Compressor Connection is carefully managed by ACI Services, Inc. with staff support to promote and sell the equipment offered online. ACI can also provide engineering *know-how* to reapply used equipment— to help you replace inefficient compressor cylinders with re-engineered cylinders at a considerable savings.

Point your browser to www.CompressorConnection.com today, or contact Tom Drenan (tdrenan@ACIServicesInc.com) at (740) 435-0240, extension 509.



www.CompressorConnection.com

ACI Services, Inc.

Norm's Notes

2006 was another outstanding year of growth for ACI Services. Many new and repeat customers rewarded us with business. We entered 2007 with a record backlog, and our order rate is the highest ever in our long history. We are grateful to our customers for their continued confidence and loyalty and to our team for their hard work and dedication.

Recently we welcomed Chuck Kerr, Craig Ferrari, Louis Bryant and Mike Wollenberg to the ACI team. Kerr's many years of OEM compressor and engine experience will help him grow our used equipment and spare parts offerings. Ferrari brings a strong background in information technology, computer programming and technology, which will serve him well in supporting our growing software products and services. Bryant and

Wollenberg add experience to our custom machine shop for special components and used equipment refurbishment.

We are most thankful for Tom Drenan's return to our team after battling a major illness since late summer. Tom is back in the office about $\frac{3}{4}$ time, gains stamina each week, and looks forward to again serving our customers' needs for used compressors and parts.

ACI continues to work on exciting new leading edge technologies. In October, we were awarded funding from GMRC and El Paso to research the application of finite amplitude wave technology to control reciprocating compressor pulsations without causing excessive pressure drops. Initial results look very promising and we envi-

sion field testing in the latter part of 2007. Our Cambridge Cryogenic Technologies affiliate has concluded almost four years of research and testing, and it is now entering the commercial launch of a patent pending process for producing Liquid Natural Gas at the well head with compact, modular, portable liquefaction plants.

Stay tuned! There's lots more news to come!



**We will either find a way
or make one. —Hannibal**