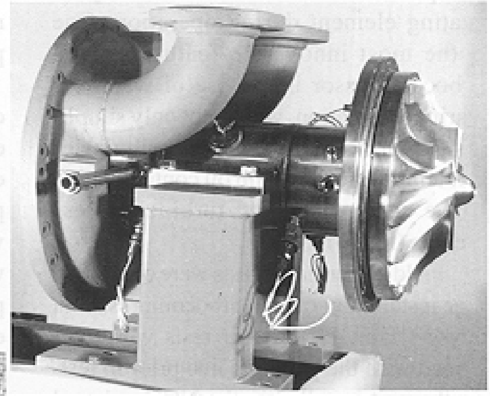
High-Performance Turbocompressor

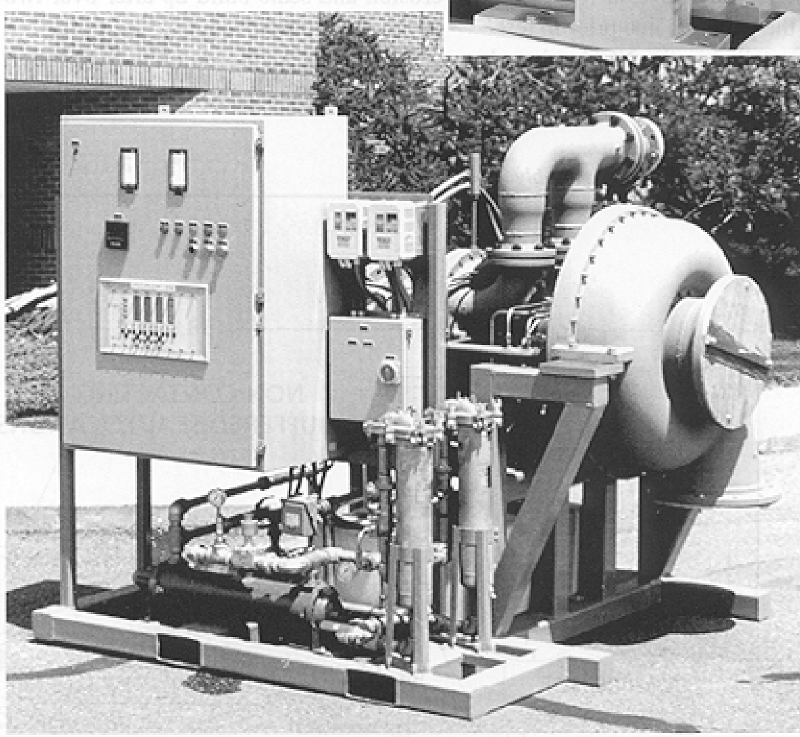
Barber-Nichols and the U.S. Department of Energy Develop an Improved Technology for Removing Non-Condensable Gas at Geothermal Power Plants

Process steam at geothermal power plants contains high concentrations of non-condensable gases (NCG). This operations fact of life requires the use of efficient and reliable equipment to remove it from power turbine condensers to maintain lowest vacuum possible and optimize system performance. An innovative, collaborative effort by Barber-Nichols, Inc., Pacific Gas & Electric Co. (PG&E), Unocal Corp., and the U.S. Department of Energy has resulted in the development of a new turbocompressor that offers an efficient and reliable alternative for removing NCG from condensers at geothermal power plants.

Most geothermal power plants currently utilize several stages of steam-jet ejectors, and occasionally a liquid-ring vacuum pump, as the final stage to remove NCG from condensers at a low vacuum pressure, with exhaust at ambient pressure. These systems perform the necessary work, but can require highly parasitic steam-flow rates in the case of ejectors, or high power requirements in the case of motor-driven liquid-ring vacuum pumps.

The new turbocompressor — designed, manufactured and tested by Barber-Nichols — has proven itself highly efficient, reliable and cost effective in nearly 13,000 hours of service since January 1997 at The Geysers Geothermal Field in northern California. Used as a replacement for the 3rd-stage steam-jet ejector in PG&E's Geysers Unit 11 NCG removal system, the turbocompressor has shown a power output increase of 1.7 to 2.0 megawatts (MW) compared to the same system with ejectors operating in all three stages.





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The turbocompressor is a compact and efficient alternative to liquid-ring vacuum pumps utilized in NCG compression. The demonstration unit at Unit 11 consists of a single stage, axial-flow steam turbine that utilizes the steam resource to direct-drive a single-stage centrifugal compressor. It can handle lower inlet pressures and larger flow rates than liquid-ring vacuum pumps, and can therefore be used in lower pressure stages. Single or multiple turbocompressors, or a combination of turbocompressor(s) and steam-jet ejectors, can replace current systems for condenser NCG removal while providing higher power plant efficiencies.

Liquid in flow streams at both the turbine (steam resource) and compressor (NCG removal from condenser) is routine in most geothermal plants. In the past, the presence of this liquid has caused problems with attempts to use turbocompressors for NCG removal, including erosion, scale build-up and subsequent maintenance problems with contacting seals and bearings.

Barber-Nichols' innovative design increases turbocompressor reliability by eliminating troublesome contacting seals and by utilizing water to lubricate hydrodynamic bearings. The air-buffered seal design with no contacting components has oven reliable during the turbocom- essor's test operation at Unit 11. In addi- n, special hydrodynamic bearings devel- ed by Waukesha Corp. handle high rota- n speed and the loads encountered by the ating element during operation. One the most innovative features of the bocompressor is the use of water for aring lubrication, which not only simpli- s the lubrication system, but eliminates oblems associated with oil contamination the compressor and turbine process eams (Fig. 1).

Field performance tests were conducted er installation of the turbocompressor at ysers Unit 11. Dry-air tests were per- med with the plant off-line prior to test- the unit installed in the NCG removal stem. At the design flow rate, pressure ratio and efficiency were approximately 10 percent lower than test results with dry air. This was caused by entrained liquid water present in the NCG stream at the compressor inlet. Calculations based on temperature rise across the compressor estimated 2.7-percent liquid water in the NCG stream.

Though this liquid degraded turbocompressor operation, its hybrid system efficiency of approximately 45 percent still exceeds predicted efficiency of only 35 percent with a steam-jet ejector, liquid-ring vacuum pump hybrid system. And even with the presence of liquid, the turbocompressor unit has shown minimal signs of erosion and scale build-up after over two years of operation.

The new Barber-Nichols turbocompressor offers a viable technology that should be considered along with steam-jet ejectors and liquid-ring vacuum pumps in identifying the most cost-effective mix for a NCG compression system. The success of the turbocompressor installation at Geysers Unit 11 proves that high efficiencies and reliability can be attained in rugged NCG removal applications utilizing the new technology. This type of small, stand-alone machine is well suited for both retrofit applications or new installations. The payback period in many retrofit applications will be less than one year. (Barber-Nichols) ■

For more information on this new turbocompressor technology, contact Jeff Shull at Barber-Nichols, 6325 West 55th Avenue, Arvada, CO 80002. Telephone: (303) 421-8111. Fax: (303) 420-4679. E-mail: <jshull@barber-nichols.corn>.

Figure 1: NCW Turbocompressor Assembly