# CHEMICALS

BestPractices
Technical Case Study

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**Benefits**

- Saves over $500,000 annually
- Improves product quality
- Improves system efficiency
- Lowers maintenance costs

**Applications**

Compressed air systems are found throughout industry and are often the largest end use of electricity in a plant. Plants with various compressed air applications that require air over a wide range of different pressure levels can present challenges during a system optimization.

# Compressed Air System Optimization Saves Energy and Improves Production at Synthetic Textile Plant

## Summary

In 1999, Solutia, Inc., implemented an improvement project on a compressed air system at its synthetic textile plant in Greenwood, South Carolina. The project greatly improved the efficiency of the plant's compressed air system, leading to substantial compressed air energy savings and better product quality. Once the project was completed, the plant was able to take two large compressors offline while maintaining minimum pressure levels required to adequately supply its end-use applications. The project achieved compressed air energy savings of over $500,000 (15,000,000 kWh) per year. In addition, the plant was able to operate fewer compressors and reduce its compressed air consumption from 20,000 scfm to 15,000 scfm. The total project cost was $1.5 million and the simple payback was less than 3 years.

## Plant/System Overview

Headquartered in St. Louis, Missouri, Solutia is a global specialty chemicals company that was the chemicals division of the Monsanto Corporation prior to 1997. The company is a leading manufacturer of chemical products such as: performance films for laminated glass; resins and additives for high-value

**Solutia Plant**

coatings; aviation hydraulic fluid and environmentally friendly cleaning solvents; and an integrated family of synthetic nylon products.

The Greenwood plant is a vertically integrated facility employing 1,500 people. It produces a full range of nylon products, including high-performance polymers and fibers, nylon molding resins, and extrusion polymers. Compressed air is essential to plant operation because it supports production processes in all of the plant's business units. The principal compressed air applications include sucker guns, aspirators, tangle processes, conveyors, and instrumentation. Although many of the business units use some of the same applications, there are four different end-use pressure requirements—225 psig, 120 psig, 115 psig, and 90 psig. Prior to the project, the plant operated four separate compressed air systems, each with its own pressure level and each served by dedicated compressors, controls, and air treatment equipment. The highest pressure system alternated two 500-hp centrifugal compressors that generated 1,509 scfm, each at 230 psig. The next system used two 800-hp centrifugal compressors that generated 3,200 scfm, each at 135 psig. The third system used two 800-hp compressors that generated 2,700 scfm, each at 125 psig. The lowest pressure system used six compressors (five centrifugal and one rotary screw) that produced 16,000 scfm at 100 psig. The highest pressure level system also had a back-pressure letdown valve to release excess air into the 100 psig system. The plant had a total of twelve compressors (11 centrifugal and 1 rotary screw) that totaled 9,500 hp. Prior to the project, the plant operated nine of these compressors, totaling 7,200-hp and producing an average of about 20,500 scfm.

## Project Overview

The plant was beset with moisture carry-over that was negatively affecting product quality. In response to this problem, and in response to high compressed air costs, engineers at the Greenwood plant commissioned a two-stage, system-level evaluation by independent consultants to devise a plan to eliminate moisture contamination and reduce energy consumption. The first stage of the evaluation focused on the supply side of the compressed air system.

The evaluation discovered three situations that caused the moisture carry-over, as well as other inefficiencies, and provided a system-level strategy to address them. The moisture carry-over came mainly from the 100 and 125 psig systems. The first problem was that the systems' aftercoolers were unable to lower the temperature of the air to 100 degrees, which was the level that would have allowed the dryers to remove the moisture to an acceptable level. This was due to insufficient flow of chilled water and contamination and deterioration in the aftercoolers' heat transfer capacity. Next, the 100 psig system had an extra set of receivers located before the dryers that were supposed to remove liquid from the air. During air demand spikes, these receivers released higher volumes of air into the dryers than they were designed to handle, leading to incomplete drying. Finally, the desiccant beds in the dryers were saturated and had become ineffectual in removing moisture. Due to gradual system changes that increased airflow through the system, the dryers had to treat greater volumes of air than they were designed to treat.

The next problem that the survey revealed was pressure drop in all four systems. Pressure loss/drop is a function of a compressed air system's dynamics—the interaction of airflow with the inherent resistance of the pipeline and air system components. Pressure drop also causes a system's pressure level to fluctuate and leads to inconsistent pressure at end-use applications. If a system has excessive pressure drop, the compressor discharge pressure must be set higher than normal, which wastes energy and increases operating costs. In both the 230 and 135 psig systems, the pressure drop across the dryers was not very acute, but did reach 3.9 psig in the 230 psig system and 6.3 psig in the 135 psig system. By contrast, in the 125 psig system the pressure loss across the dryers was more severe and reached 13.9 psig. In the 100 psig system, the overloaded dryers, various isolation and switching valves, hot taps, orifice plates, and cleanup equipment, contributed to a pressure drop of more than 15 psig. In addition, one sector of the plant was being supplied by separate headers that did not allow the most optimal flow rate in that segment of the plant and contributed to pressure loss in that area.

Another problem that three of the four systems experienced was excessive compressor blow off. Most of the plant's compressors are centrifugal compressors, which need to vent compressed air when the system demand falls below the compressors' minimum stable flow. This is because centrifugal compressors have limited throttling capacity and run the risk of shutting down if they cannot vent enough excess air to prevent the system pressure from

HIGH PRESSURE YARN ASPIRATORS

rising above their set points. In addition, centrifugal compressors function most efficiently when their inlet valves are fully open, when they are fully loaded, and when their discharge pressures are close to their design pressure. As production would increase, leading to an increase in air demand, the plant would start additional compressors to maintain pressure levels. The pressure drop caused the plant to run the compressors longer than necessary with some of them at partial load. Furthermore, the compressors were operating at or near their throttle lines, which led them to vent soon after being started. In the 230 psig system, 600 scfm (40% of the output) was being vented because the inlet valve was partially closed. In the 135 psig system, 1,800 scfm (60% of the output) was being vented since it didn't have a letdown valve. In the 100 psig system, one of the 1,000-hp compressors had extensive blow off most of the time it was operating. Altogether, about 25% of the air being produced was blowing off into the atmosphere.

Finally, some problems were identified with the system controls on some of the compressors. In the 100 psig system, the control settings on the 1,000-hp compressors were not uniform, leading to uneven performance and loss of compressor capacity. One of these compressors was only delivering 842-hp and was producing a constant whining sound. In the 125 psig system, the controls were gradually throttling the compressors down followed by a rapid return to full load.

## Project Implementation

The plant's compressed air system improvement project was performed at system level. It included many of the evaluation's recommendations for the system's components and reconfiguration. The main features of the project were:

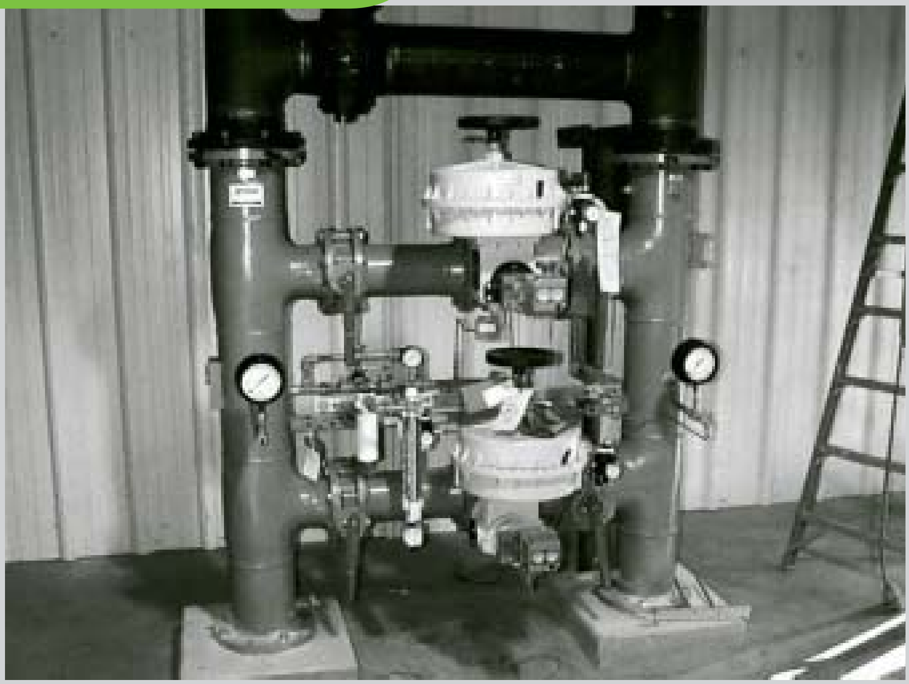
- Installation of three pressure/flow controllers and one back-pressure/flow controller along with 60,000 gallons of air storage capacity in two 30,000-gallon tanks
- Installation of new dryers and mist-eliminating filters on all dryers
- Installation of a Programmable Logic Control (PLC) compressor automation system
- Installation of a compressed air management information system (MIS)
- Installation of new piping and retrofits on existing portions of the piping system
- Repair of suboptimally performing compressors and aftercoolers

Once components were installed and repaired, the plant decided to reconfigure the system by repartitioning the four systems into one integrated system having three separate sections (high, medium and low pressure) with their own pressure levels. This was made possible by the PLC and MIS, which provided a new control strategy that managed all sections of the plant's header. The evaluation concluded that the 135 psig and 125 psig systems could operate in one section with two pressure/flow controllers providing the different pressure levels. The 30,000-gallon tanks were placed in the high- and medium-pressure segments of the new system. The third pressure/flow controller was placed in the low-pressure section, while the back pressure/flow controller was installed in the high-pressure section. The back pressure/flow controller would maintain a constant pressure in the high-pressure section and eliminate blow off by directing the airflow to the storage receiver as the high-pressure air demand decreased. A back-pressure valve was also installed on the high-pressure section to release excess air that would otherwise be vented in a cascading fashion. Excess air in the high-pressure section is released into the medium-pressure header and excess air in that section is letdown into the low-pressure section by one of the pressure/flow controllers in the medium-pressure section. Lastly, the aftercoolers were chemically cleaned and converted to use cooling tower water rather than chilled water.

## Project Results

The project greatly improved the operation of the plant's compressed air system and reduced energy costs. The new control strategy combined accurate anticipation of air demand shifts with effective use of storage capacity, which allowed the compressors to operate at optimum efficiency. This led to a large reduction in compressor blow off. The increased storage capacity combined with the pressure/flow controllers greatly helped to

PRESSURE/FLOW CONTROLLER



stabilize the pressure levels. The increased stability of the pressure levels was also made possible by the newly configured dryers that experienced substantially less pressure drop. Once this occurred, the plant began to lower its pressure because it realized that its end-use applications could function effectively at lower pressure levels. The system's pressure levels are now 225 psig, 120 psig, and 87 psig. Once the aftercooler problems were corrected, their heat transfer capacity improved to the point that the air was sufficiently cool for the dryers to separate the moisture more effectively, which eliminated the moisture contamination problem.

Due to the improvements in the system's performance, the plant was able to take some of their compressors offline, while maintaining the needed airflow and pressure to satisfy production requirements. The plant now base loads six compressors totaling 5,200-hp and uses a 500-hp compressor at partial load. Its consumption of compressed air has declined from 20,000 to 15,000 scfm. This has yielded annual energy savings of $512,000 and 15,000,000 kWh. One third of the total energy savings comes from the reduced need for chilled water, giving the plant a payback of less than 3 years on the project. An evaluation of the system's demand components is planned, which will lead to the second phase of the project and should result in additional energy savings and greater system efficiency.

## Lessons Learned

To achieve optimum system performance and prevent high energy costs in a compressed air system, it is essential to balance the amounts of air demanded with the amounts supplied. In this case, the control strategy and the system configuration led to a situation in which the compressors were producing more air than the end-use components required. Once the plant reengineered the supply distribution system to a more optimal level, implemented a superior control strategy, and stabilized the system pressure, it was able to match the system's supply more closely to its demand. This allowed the compressed air system to operate more effectively and led to considerable energy savings.

In addition, proper maintenance of system components reduces energy costs and helps prevent unwanted conditions. Aftercoolers can often cause problems when not adequately maintained and inspected. The chemical cleaning and conversion of the aftercoolers to cooling tower water helped eliminate the moisture carry-over situation and helped increase the efficiency of the compressed air system. A combination of optimal equipment configuration, an effective control strategy, adequate storage, proper maintenance, and air quality that meets production needs, improves productivity and saves energy.

## Industries of the Future—Chemicals

*The chemicals industry is one of several energy- and waste-intensive industries that participate in OIT's Industries of the Future initiative. In December 1996, the chemicals industry published a report, entitled* ***Technology Vision 2020: The U.S. Chemical Industry****, that helps establish technical priorities for improving the industry's competitiveness and develops recommendations to strengthen cooperation among industry, government, and academia. It also provides direction for continuous improvement through step-change technology in new chemical science and engineering technology, supply chain management, information systems, and manufacturing and operations.*

***OIT Chemicals Industry Team Leader: Paul Scheihing (202) 586-7234***

BestPractices is part of the Office of Industrial Technologies' (OIT's) Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPracticesbrings together the best-available and emerging technologies and practicesto help companies begin improving energy efficiency, environmentalperformance, and productivity right now.

BestPractices focuses on plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access tonear-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small and medium-size manufacturers.

**PROJECT PARTNERS**

Plant Air Technology
Charlotte, NC

Solutia, Inc.
Greenwood, SC

**FOR ADDITIONAL INFORMATION, PLEASE CONTACT:**

OIT Clearinghouse
Phone: (800) 862-2086
Fax: (360) 586-8303
clearinghouse@ee.doe.gov

Visit our home page at
www.oit.doe.gov

Please send any comments, questions, or suggestions to
webmaster.oit@ee.doe.gov

Office of Industrial Technologies
Energy Efficiency
and Renewable Energy, EE-20
U.S. Department of Energy
Washington, DC 20585-0121

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