Savigent SOFTWARE

CASE STUDY

Compressed Air Control System

Industry

Automotive Assembly

Application

Savigent Platform™ and Industrial Compressed Air Systems

Background

This automotive assembly plant was using over 40,000 kilowatt hours of electricity during daily production to generate the compressed air needed for assembly operations. At $0.05 per kilowatt hour this amounted to about $2,000 per day. In addition, the compressed air system was unreliable and prone to failures that would completely stop the assembly lines. This resulted in a production loss that equaled one vehicle per minute during peak production. If the price of that vehicle was $20,000, a 10-minute outage would cost as much as $200,000.

Challenge

The first priority was to enhance the existing compressed air system such that it was reliable and was controllable from anywhere in the plant. In addition, an automatic failover system was implemented to reduce outage times to zero. The second priority was to ensure that the various compressors that fed the system were being used as efficiently as possible to reduce energy costs.

Results

An automated control system was created using Savigent Platform that provided remote system control and monitoring along with automated failover. These enhancements reduced system outage times to zero. Additionally, energy costs were reduced from 40,000 kilowatt hours per day to 22,000 kilowatt hours per day resulting in a savings of about $900 daily.

Introduction

Industrial compressed air systems are a critical part of many manufacturing operations, and in particular automotive assembly. In spite of the inherent inefficiency of compressed air as an energy source (it can take as much as seven horsepower of electrical energy to produce enough compressed air to do one horsepower worth of work) it is still the best energy source for certain applications. In automotive assembly compressed air may be used to control the assembly line conveyor, various hand tools such as torque wrenches, grinders and sanders, as well as paint spraying operations and dozens of other critical operations. These uses amount to an enormous amount of compressed air being produced and used daily inside the typical automotive assembly plant.

In this case study we will discuss how one automotive assembly plant used Savigent software to increase the reliability of their overall compressed air system while reducing the energy cost by 45 percent.

To achieve the volume of compressed air required for daily operations this automotive assembly plant uses two compressor rooms with a total of five linked compressors that all must be controlled and synchronized to produce enough compressed air to meet peak usage, while not generating an excessive overall peak pressure (very inefficient) or running more compressors than are needed at a given time (also inefficient). To get an idea of the electrical usage of the overall compressed air system it is important to understand that three of these five compressors are 2,000 hp motors and the other two compressors are 1,000 hp motors. Each 2,000 hp motor runs at 4,160 volts.

Problem Statement

The first priority was to increase the reliability of the compressed air system. This particular plant had two assembly lines in two different buildings that were almost a mile apart. The five compressors were actually split into two compressed air systems with one running in each building. However, the two systems were designed to be linked so that in the event of a failure one compressed air system could run both operations temporarily. The problem was that there was no way to monitor or control the compressed air systems remotely. This led to a higher-than-necessary failure rate since there was nobody monitoring any warning signs of a system failure.

The system also lacked an automatic failover to switch operations to the backup system in the event of a failure. This led to increased downtime when a failure occurred because it meant that somebody had to manually switch over to the backup system, which many times involved traveling the mile or so to the backup system.

Another goal of the compressed air project was to increase the overall system efficiency to reduce the operating cost. The compressed air system as a whole was using about 40,000 kilowatt hours of electricity per day. With a cost of $0.05 per kilowatt hour, this amounted to a daily production cost of $2,000.

Solution

Overview

The compressed air control system was composed of three major pieces of functionality. The most obvious was the equipment control logic that actually monitored important sensor data, enforced control sequences (for example, startup and shutdown sequences for the compressor motors) as well as specific control logic to adjust the overall behavior of the compressed air system. This logical layer was also the key to configuring the individual compressors to work together as efficiently as possible to reduce energy costs.

The second functional component was the Remote Monitor and Control User Interface. This allowed authorized plant personnel to monitor key performance information about the compressors in order to ensure that they were working properly as well as adjust how the overall system was operating from anywhere within either assembly building.

The third functional component consisted of the historical data that the plant was able to capture over time. This data could be analyzed in a variety of ways to show trends and predict the health of the various compressor units.

Equipment Control Logic

The equipment control logic was based on the State Machine Agent in Savigent Platform. This capability allowed the system developer to graphically draw out the state transitions that each compressor needed to go through during startup, shutdown, load and unload operations. Once each motor had its basic control sequences modeled, higher level logic was used to control three compressors in a way that they acted as a single efficient compressed air system.

Since the usage of compressed air changed dramatically during production the challenge was to produce enough air in response to peak demand while not allowing the huge compressor motors to be under load when demand was low.

The basic strategy was to designate one of the 2,000 hp compressors as a lead compressor and keep it under load all the times by setting it at a peak air pressure value that could never be reached. This ensured that this compressor would always be used as efficiently as possible since running the compressor at partial capacity took basically the same amount of energy as running it at full capacity.

Next, a lag compressor was designated and set at a slightly lower pressure than the lead compressor. This provided for a quick pressure recovery as soon as compressed air usage exceeded the capability of the lead compressor. The lag compressor was kept running the majority of the time, but was only under load when the system was recovering from deficit. Because these large centrifugal compressors take several minutes to “run down” during a shutdown cycle and then several more minutes to “run up” during a startup cycle it is impractical to continuously cycle them from on to off. State logic was used to shutdown the compressor completely only if it remained unloaded for a period of 10 minutes (such as during the lunch hour). The state logic also enforced a “run down” time to ensure that the motor was not energized again until it had completely stopped. Once usage started to exceed the capacity of the lead compressor, the lag compressor was run up to operating speed and placed under load again.

A third standby compressor was then set a lower pressure than the lag compressor. This was used similarly to the Lead/Lag compressors, but only during the highest peaks of compressed air utilization to ensure there was always an adequate amount of air for production.

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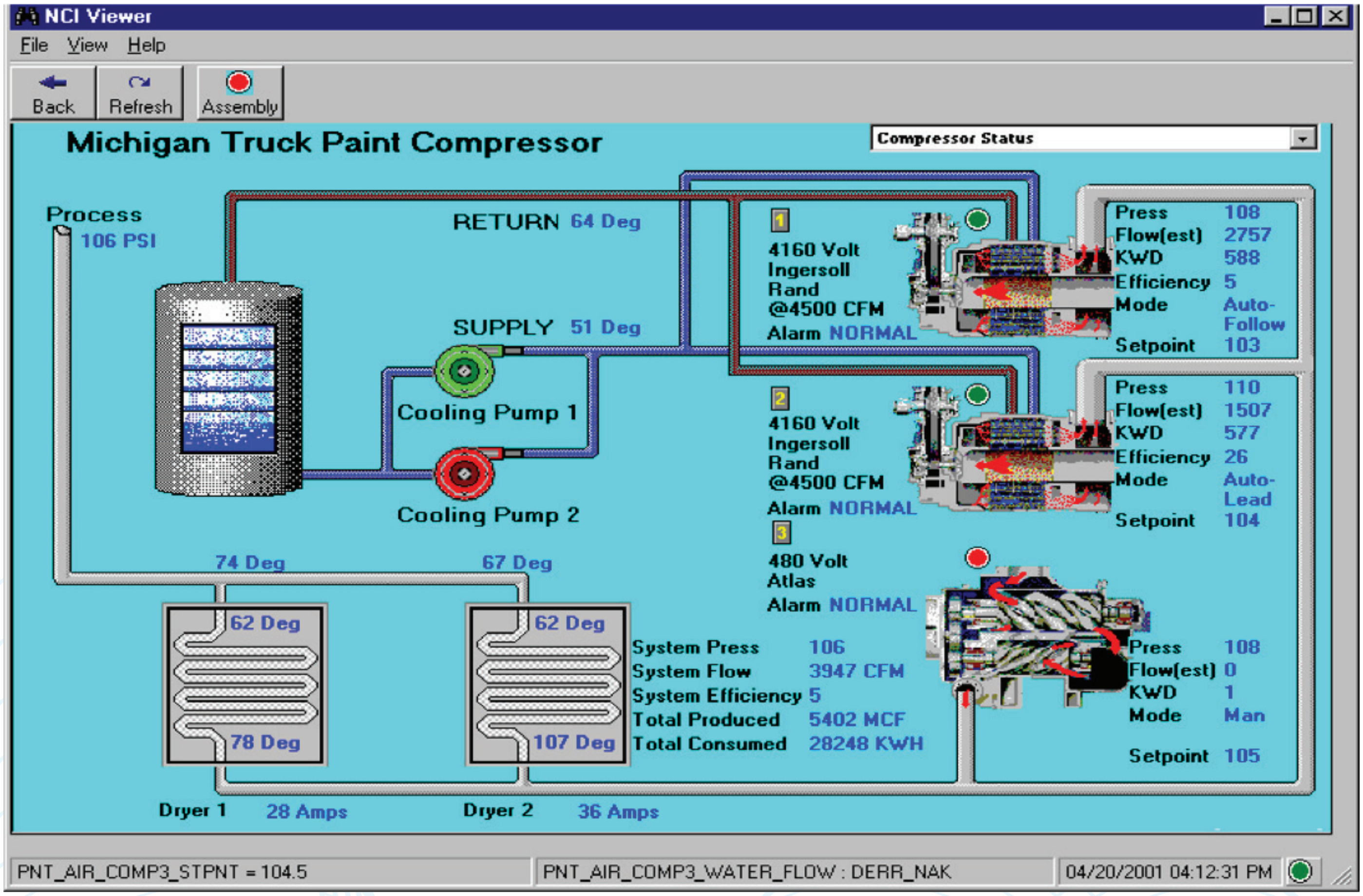
Monitor & Control User Interface

The user interface depicted below shows the status of one compressor room. Notice the various sensor readings showing coolant temperature, line pressure, air flow, voltage, alarm status, and the setpoints of each individual compressor unit. This interface also allowed an authorized operator to change setpoints, respond to alarm conditions, and initiate startup and shutdown sequences.

Diagnostic Data

Records of the sensor data shown below were transferred on regular intervals to a database for later analysis of overall system health and efficiency. Analysis of this data during down times provided visibility into leaks in the overall system (a potentially large consumer of air). This data also provided insight into the health of each compressor unit and its various components such as the coolant system and sensors.



Results

Reliability

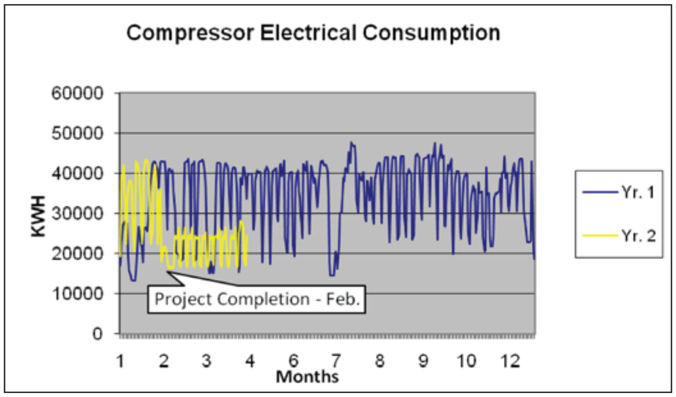
The first goal of the project was to increase reliability by creating remote monitoring capability and control as well as automated failover capability. These features allowed plant personnel to monitor critical operational variables of the compressors like oil pressure, operating temperature, and pressure to help identify a possible failure condition before it occurred and caused a stoppage on the assembly floor. The remote monitoring system helped prevent costly repairs to the compressors by allowing their health to be monitored continuously. Another benefit of remote monitoring was increased up time by reducing sudden stoppages from happening on the assembly lines.

If a failure did occur, the distributed control system developed with Savigent Platform was able to detect the failure of one compressor room and automatically use the second compressor room to supply both assembly lines with compressed air while corrective action was being taken on the failed system. This allowed production to continue as scheduled even in the event of a compressed air system failure. Since each assembly line can produce about one car per minute the cost of a 10-minute downtime event of the assembly line conveyor can be calculated by taking the number of cars not produced in the 10-minute outage (about 10 cars) times the value of each car (say, $20,000). As you can see, the time it would take to discover a compressed air outage and then manually switch to the backup system was expensive time indeed.

Since the total project cost was about $81,000, the system paid for itself the first time it prevented four to five minutes of downtime on the assembly line conveyors.

Energy Savings

The energy savings seen with the new compressed air system were probably the most surprising. The graph below shows electrical consumption for the previous year as well as the month prior to implementing the new compressed air system.



As a result of controlling the compressors more efficiently, the overall electrical consumption was reduced from about 40,000 kilowatt hours per day to about 22,000 kilowatt hours per day representing a 45 percent reduction in electrical consumption. Using a cost of $0.05 per kilowatt hour, this amounts to about $900 per day in savings. With 234 production days per year, this represents an annual savings of over $200,000.