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Compressed Air System Optimization Project Improves Production at a Metal Forging Plant

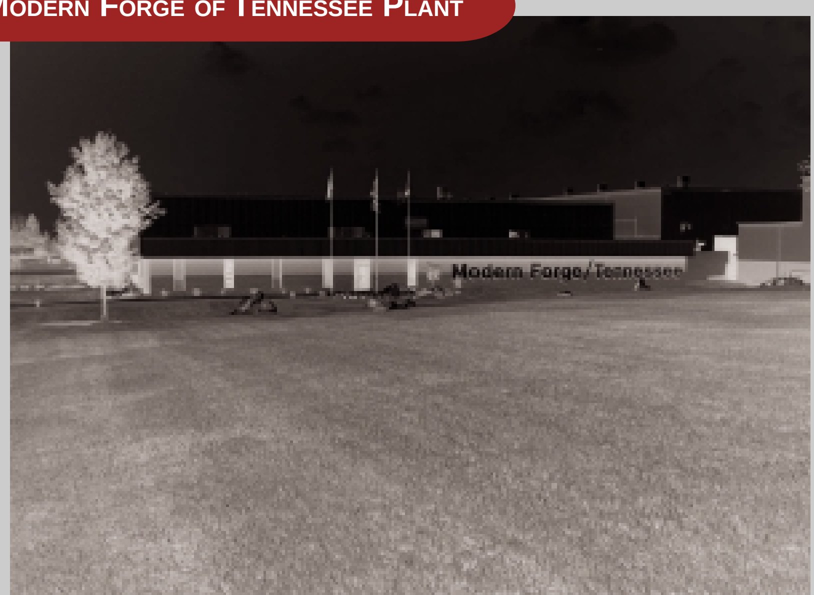
Summary

In 1995, Modern Forge of Tennessee implemented a compressed air system improvement project at its Piney Flats, Tennessee, forging plant. Due to the project's implementation, the plant was able to operate with fewer compressors and improve its product quality, thus allowing it to increase productivity. The project also resulted in considerable energy and maintenance savings. The total cost of the project's implementation was $105,000 and the annual compressed air energy and maintenance savings were $160,000, resulting in an 8-month payback. The energy savings reduced the plant's electricity costs by 8%. As a result of implementing this project, the plant also avoided spending $120,000 in capital costs for the purchase of a new air compressor.

Company/Plant Background

Modern Forge of Tennessee, located in Piney Flats, Tennessee, is a subsidiary of Modern Drop Forge Company. Its 235 employees manufacture forged metal components for the mining and construction industries, automotive suspensions and transmissions, motorcycle frames, as well as hand and

Modern Forge of Tennessee Plant



Benefits

- Saves $160,000 annually
- Increases efficiency
- Improves product quality
- Reduces maintenance costs
- Increases production

Applications

Compressed air systems are found throughout industry and often represent the largest end-use of electricity in a plant. Maintaining a stable and consistent flow of air is critical to the performance of any industrial compressed air system.

specialty tools that are distributed in regional, national and international markets. Compressed air is important in the plant's production process because it directly supports the grinding, pressing and die forging tasks that are necessary to manufacture the various parts the company produces. The forging hammers are the most important compressed air application, and require air at a minimum pressure level of 100 psig in order for their production to be reliable. Prior to the project, the plant operated five compressors housed in two separate rooms, totaling 2,000-hp with compressor discharge pressures of 120-125 psig.

Project Overview

Despite the plant's operation of all five compressors, it was not able to consistently maintain the end-use applications' minimum required pressure levels, and was considering purchasing an additional compressor. However, before going through with the purchase the plant's chief engineer decided to commission a survey of the compressed air system to determine whether another compressor was truly necessary. A system-level evaluation was performed that led to the improvement project, which allowed the plant's compressed air system to function more effectively and averted the need for another compressor.

The survey revealed two main problems that prevented the plant's compressed air system from maintaining a stable pressure level–lack of storage and excessive pressure drop. Although the hammers in the forge shop require air at 100 psig, their production cycles are such that their demand for air can fluctuate from 300 to 3000 cfm in as little as 30 seconds. Since the plant did not have much compressed air storage, it needed to run the compressors even when the air demand was low or nonexistent in order for them to be able to respond adequately during the demand spikes. In addition, the die shop's applications only required air at 85 psig. However, the plant's pressure was dictated by the needs of the forge shop, and it therefore tried to keep the system pressure above 100 psig, leading to compressed air waste from artificial demand.

Pressure drop is a function of a compressed air system's dynamics – the interaction of airflow rate with the inherent resistance of the pipeline and air system components. In Modern Forge's case the high pressure drop was partly due to the intermittent demand from the forge shop, but was exacerbated by poorly engineered point of use components (hoses, fittings, disconnects, regulators and lubricators) as well as dirty filtration devices. In addition, the piping system in the forging shop was partitioned by closed isolation valves in the header, which increased the pressure gradient in that part of the plant. The pressure drop caused the compressors to generate air at discharge pressures of 120 psig or higher in order for the end-use applications to receive it at 100 psig.

The next important item discovered by the survey was that the compressor controls were not operating efficiently. The control equipment was antiquated and did not have enough control points to gauge air demand and properly sequence the compressors. This caused the compressors to work against each other. The system's pressure drop created an insufficient pressure differential for a workable compressor control band, leading the compressors to enter into each other's throttling band. The result was an undependable control system that required the plant to operate all of the compressors more often and longer than necessary.

The survey also found a problem with lubricant and moisture carryover into the system. The excessive lubricant in the air was due to the erratic modulation of the compressors and improperly functioning valves on the oil-cooled, rotary screw compressors in the main compressor room. The controls were causing the compressors to unload too frequently. When they did, a blow-down valve that opens to reduce the sump pressure would emit a burst of lubricant-saturated air, which lessened the efficiency of the air/oil separator basket and allowed the lubricant to mix with the air. Since the system's filtration equipment was not working properly, the air contaminated with lubricant was released into the main header. By the time of the survey, the oil had degraded the end use components' filters to the point that they were filled with lubricant.

The moisture carryover was a result of some malfunctioning float-type condensate drains that were permitting quantities of water to build up that were too great to be effectively separated. The carryover of moisture and lubricants contributed to airflow resistance and exacerbated the system's pressure drop.

Another problem that was identified was an air leakage rate of about 20% of the system's output. Much of the leakage came from the same point of use components that contributed to the system's pressure drop. Finally, the survey discovered that on the weekends the plant utilized a 200-hp compressor for the compressed air needs of some packaging and support department operations. This compressor was much too powerful for this application, and the survey recommended that a smaller compressor be used.

Project Implementation

The survey's main conclusion was that if a system-level project was implemented the compressed air system would function effectively without the need for an additional compressor. Therefore, the plant implemented a compressed air system project that included the following recommended modifications:

- Replaced the old run/modulation sequencer with a programmable logic control (PLC) system to centralize the control of all five compressors, maintain adequate pressure differential between the compressor pressure settings, and sequence them more efficiently. In addition, the system was linked to the pressure/flow controllers to obtain accurate demand signals.
- Installed two pressure/flow controllers, one in the forge shop and one in the die shop. The pressure/flow controller in the forge shop was set to provide a stable header pressure of 100 psig and the one in the die shop was set to provide air at 85 psig.

- Added two receivers to provide 7,500 gallons of storage.
- Modified the piping distribution system to connect the dryers before the storage, and opened the valves in the forge shop header.
- Installed an additional dryer and replaced dirty filters.
- Implemented a leak detection/repair campaign that included replacing worn point-of-use components from which air was leaking and training of plant personnel about compressed air system dynamics, and the importance of managing leaks in containing compressed air costs.
- Replaced old, malfunctioning condensate drains on the compressors and dryers with eight pneumatic drains.
- Purchased and installed a dedicated 40-hp compressor for weekend packaging operations and some die shop functions. This compressor is not part of the main plant's system, but was installed so that the 200-hp compressor would not be used for those tasks.

Once all of these tasks were accomplished, the plants' system began to function more efficiently. The pressure drop that had plagued the system was eliminated and the pressure/flow controllers stabilized the system's pressure level. The compressors deliver air to the storage receivers at 120-125 psig while the forge shop pressure/flow controller maintains a pressure level of 100 psig +/- 2 psig between it and the hammers. The other pressure/flow controller maintains a pressure level of 83 psig in the die shop header. Also, the opening of the isolation valves in the forge shop header spread the load across all of the compressors and reduced the pressure gradient in that shop's header.

The plant's leak detection and repair operation eliminated the largest leaks in the system, including those at the point of use components (regulators, filters and hoses) and reduced the consumption of air by leaks by 10%. The additional dryer, the new filtration equipment and the pneumatic condensate drains eliminated the moisture carryover into the system. The new, more sophisticated PLC automated compressor sequencer managed the compressors more effectively, allowing fewer of them to run while ensuring that the needed system pressure and volume was met. The new controls also eliminated the lubricant carryover by preventing the frequent loading and unloading of the rotary screw compressors (see text box).

Lastly, the training session led to a more rational use of the system by the plant personnel. Prior to the survey, there had been considerable confusion about the end-use pressure requirements. Some personnel had the belief that the operating pressure needed to be 10-20 psig higher than the minimum pressure level stated on the end-use equipment. Once this notion was dispelled, plant personnel were able to operate with the lower pressure level that was being generated.

Results

Modern Forge's compressed air system project produced considerable savings in energy and maintenance, and allowed for better productivity. Prior to the project, the plant operated five compressors totaling 2,000-hp, sometimes at full capacity and at other times at partial load. Since the project's implementation, the plant has been able to operate with between 650 and 850-hp for normal demand and 1100-hp for peak use. In addition, the lower leakage rate reduced overall air demand. The plant's compressed air power needs declined substantially, allowing for annual electricity savings of $120,000 and 2,400,000 kWh. This represents about 8% of their total electric costs. Since the compressors were not used as often, their maintenance needs declined, leading to annual savings from reduced maintenance of $40,000. With total savings of $160,000 and total costs of $105,000, the simple payback was 8 months. Also, since the plant did not purchase a 450-hp compressor, it achieved a cost avoidance of $120,000.

The new condensate traps, filters, the new dryer and the placing of dryers upstream of the storage receivers, allowed the system to separate moisture and lubricants from air much more effectively. This had a direct effect on the operation of the forging equipment and the overall quality of the forged metal parts. Since the air was more consistent and lubricant-free, the hammers were able to reduce the blows needed per part. In addition, the lubricant-free air helped lead to a reduction in the quantity of product rejects. Therefore, the productivity of the forging hammers was considerably increased.

Lessons Learned

When a compressed air system does not deliver air at the required volumes and pressure levels, adding another compressor should be considered only within the context of a complete system evaluation. In many cases, compressed air systems can be managed and reconfigured to operate more

STORAGE RECEIVER AND PRESSURE/FLOW CONTROLLER

effectively without the purchase of additional compressors. Ineffective controls, lack of storage, air leaks, moisture and lubricant contamination, and poorly engineered piping reduces a compressed air system's efficiency and leads to energy waste, unreliable product quality, and excessively high operating costs. In the case of Modern Forge, a compressed air system improvement project made the system more efficient by allowing it to perform at its full potential and averted the need for another compressor. In addition, the project led to substantial reductions in compressed air energy and maintenance costs and improved productivity.

Effective Control of Multiple Compressor Systems

The objective of any compressor control strategy is to turn off unneeded compressors or to delay bringing additional compressors online until necessary. Prior to the existence of automated compressor control packages, compressed air systems having multiple compressors utilized a control strategy known as cascading set points. With this approach, individual compressor operating pressure set points are established to either add or subtract compressors to meet plant air demand. As a plant's production rate increases, leading to an increase in air demand, plant pressure falls, triggering additional compressors to be brought online in a preset order. The main disadvantage of this approach is that as plants expand, the pressure band between the first and last compressor has to get progressively wider to accommodate the operating ranges of other compressors added to the system. As a result, the minimum pressure needed to signal the last compressor to start may be below the minimum pressure needed for production requirements. Since each compressor has a start-up period, there is a further delay before the first cubic foot of air is available to restore the system pressure to required operating levels.

Control strategies are now available that are capable of controlling multiple compressors with a single set point logic that coordinates their operation in response to demand needs. The most sophisticated of these strategies, system controls, can coordinate compressor operation regardless of type or make. With a system control strategy, individual compressor controls are linked together and can respond more quickly to changes in air demand patterns. All compressors operate within a single pressure band in a sequence tailored to maintain system pressure within specified limits in the most cost-effective manner. Compressors can be brought online as system pressure begins to decay, allowing them to become fully operational before the pressure falls below production's minimum requirements.

Industry of the Future—Steel

Through OIT's Industries of the Future initiative, the Steel Association, on behalf of the steel industry, has partnered with the U.S. Department of Energy (DOE) to spur technological innovations that will reduce energy consumption, pollution, and production costs. In March 1996, the industry outlined its vision for maintaining and building its competitive position in the world market in the document, The Re-emergent Steel Industry: Industry/Government Partnerships for the Future.

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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. BestPractices brings together the best-available and emerging technologies and practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

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