COMPRESSED AIR EFFICIENCY SERVICES IN MEDIUM SIZED MANUFACTURERS

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SUMMARY

This paper presents the results of surveys of energy efficiency opportunities in the compressed air plants of medium-sized manufacturers in New England. The experience sheds light on the present compressed air market and a possible market in compressed air as an energy efficiency service. Compressed air services are a industrial cost center with potential energy efficiency gains if they are provided by a vendor who could internalize the energy cost and realize operating energy efficiency improvements. The paper outlines the terms of potential energy services contracts for compressed air.

BACKGROUND

In support of DSM programs of several utilities in New England, the author's consulting firm has surveyed operating compressed air systems in 36 medium sized manufacturing facilities in the past two years to identify retrofit opportunities to improve efficiency and reduce energy use. Compressors ranged from 10 hp to 300 hp. Total installation size ranged up to 990 hp; however, 94 % of the installations were less than 250 hp total.

The results in this paper should not be taken as representative of a random sample; sites were selected by utility staff as probable candidates for compressed air efficiency improvement. At 55% of the plants, new compressors and/or dryers were about to be purchased; the sites were selected because the utility wished to provide advice on efficiency at this opportune time.

In 50% of the plants, the survey included an on-site comprehensive review of the compressed air generation and use system. In the remainder, the survey was limited to telephone interviews regarding central equipment upgrade. In nearly all cases, estimates of compressed air and energy use were based either on electrical metering of compressors or on visual observation of unloading cycles, over representative times ranging from several hours to one week.

For the purposes of comparison in this paper, annual energy usage and savings were divided by the hours of use to determine average kW, and were divided by totaled installed compressor hp to determine average normalized consumption, expressed as kW per installed hp. For the sample, average hours of compressed air system use were 6,587 per year.

Most plants had only one or two air compressors; usually all compressors operated during peak production hours. In the results reported in this paper, all operating compressors were counted as part of the total installed hp. If the site had "backup compressors" that had been removed from service but were kept on site only for emergencies, they were not counted as part of the total installed hp.

SURVEY RESULTS

Every plant in the group had some opportunity for compressed air energy efficiency. The most common recommendations for compressed air end-use efficiency were installing regulators at the point of use, replacing open pipe blowoffs with engineered nozzles, and replacing standard hand airguns with engineered-nozzle airguns. The most common recommendations for improvements in air distribution systems were reduction of leaks, reducing pressure drops in distribution piping, installation of local storage, and reduction in operating pressure.

Recommended improvements in the generation of compressed air included compressor replacement, dryer replacement, installation of storage, and modification of operating sequence for better part-load operation. The most common recommendation was to increase system storage and operate screw compressors in "load/no-load" mode rather than allow inlet valve modulation for part load operation.

Drying systems were improved by substituting cycling or unloading dryers for hot gas bypass type dryers, and by enhancements to desiccant drying systems.

Normalized energy usage per hp varied between 0.39 and 0.91 kW/hp, with an average of 0.65 kW/hp (see Figure 1). At the eight sites where we identified savings from dryer upgrading, the savings averaged 55% of dryer energy use, or 0.052 kW per installed compressor hp. For the 28 plants with savings in addition to dryer improvements, estimated savings per hp ranged as high as 0.41 kW/hp and averaged 0.19 kW/hp (Figure 1). The percentage energy efficiency improvement ranged as high as 67%, and averaged 30% (Figure 2).

Figure 3 illustrates the percentage utilization of the compressed air plants. Percentage utilization was calculated as annual kWh after efficiency improvement, divided by annual kWh if all compressors operated at full load during operating hours. Because energy usage "after improvement" incorporates efficient part load operation, it is a better measure of utilization than energy usage 'before improvement". The resulting utilization factor varied between 42% and 99%, and averaged 71%. This utilization pattern highlights the importance of part load energy efficiency in most compressed air plants.

Figure 1
System Usage and Savings

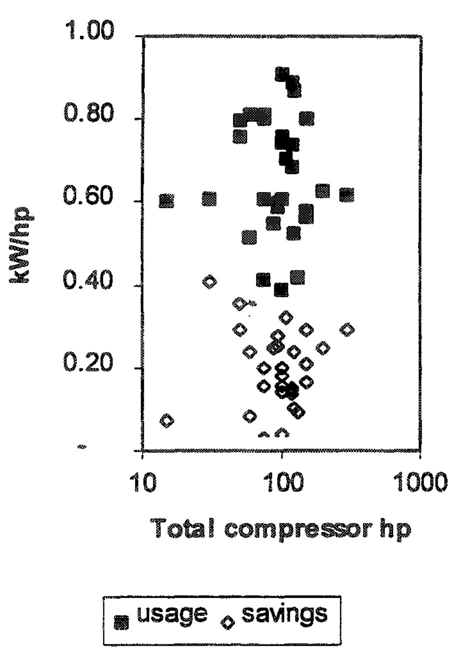

Figure 2
Percentage Energy Reduction

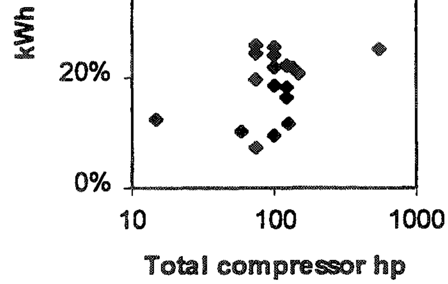

Figure 3
System Utilization

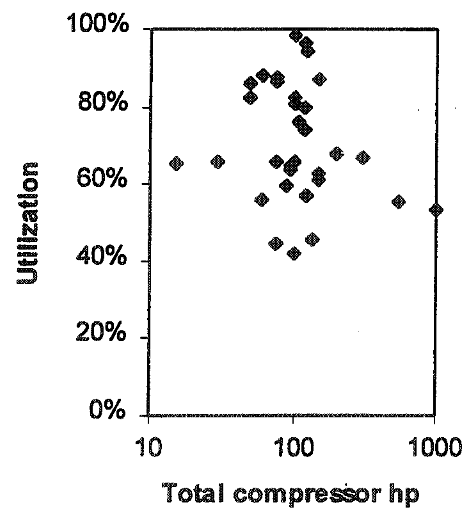

Figure 4

Life cycle cost of compressor system

	50	hp installed	
	6,600	hours per year operation	
	13	year life	
$	0.05	cost per kWh	
	33.2	avg kW	
$	20,000	install cost	
	10%	interest rate	
$	9,847	annual elec cost	67%
$	2,816	amortization	19%
$	2,000	annual maintenance	14%
$	14,663	total annual cost	100%

POTENTIAL MARKET FOR COMPRESSED AIR EFFICIENCY SERVICES

A simple financial model (Figure 4) of the life-cycle cost of a 50 hp compressor in a manufacturing plant operating 6,600 hours per year, indicates that the annual owning cost is about $15,000, of which energy represents 67% or $10,000. Typical savings of 30% would result in energy savings of $3,000. Is there a market to capture these savings? How could a vendor structure a workable contract?

THE PRESENT COMPRESSED AIR MARKET

Compressed air equipment and service is typically sold as a design-build contract. The owner has little expertise on the system's operating efficiency, and the contractor has little financial interest in providing a system that actually operates efficiently. Independent consulting advice for compressors in this size range appears to be too expensive. Compressor efficiency is often a point in a sales presentation. However, comparative ratings among manufacturers of compressor efficiency according to a single standard are not available, and part load analysis, key to efficiency comparisons, is rare.

New air compressors in the 20 hp to 200 hp size range are dominated by the rotary screw design, favored for its simplicity, low first cost, and low maintenance requirements. The least expensive screw compressor configuration uses inlet valve modulation for part load control. In recent years, as screw compressors have replaced reciprocating compressors, system efficiency has become sensitive to the thoughtful selection of system storage and compressor unloading characteristics.

From the viewpoint of plant profitability and also energy efficiency, it is unfortunate that equipment first cost is the primary driver when new compressors and systems are designed and purchased.

FEASIBLE CONTRACTUAL ARRANGEMENTS FOR COMPRESSED AIR ENERGY EFFICIENCY SERVICE

A contract for compressed air services could potentially provide a wide range of services. The contract could include complex financial incentives to assure the plant owner that the service provider is adequately compensated to act in the plant's best interests for reliability, compressed air quality, quantity, and cost. However for small and medium manufacturers, the cost of negotiating such a global service contract is not justified by the potential value in energy or operational savings. This paper proposes some contractual arrangements that might be practical in the marketplace.

Following are key elements of a potential compressed air service contract. The more risk, responsibility, and reward associated with the contract, the more these elements must be defined. Each element included adds contract complexity, which increases the cost to both parties of coming to agreement.

In-plant services to repair leaks and make upgrades on end use efficiency
Metering to document air use before and during contract
Electrical submetering
Responsibility for pressure settings and air pressure requirements
Potential conflicts with production
Risk of requiring additional compressor capacity
Targets for energy use/demand
Acceptable fluctuations for air demands and air pressure

Contract level A: essential services

This contract form is appropriate for a small plant, with 50 hp of capacity, similar to the financial example shown in Figure 4, with potential annual energy savings of $3,000.

The contract provides essential features to capture a bulk of the savings, without reallocating risk to the service provider. The client retains all the risks of operating the system, and is simply purchasing expertise on a fee-for-service basis. There is little interference or impact on plant operations. The services would include replacement of end-using equipment to reduce or eliminate inefficient air use, installation and maintenance of an efficient part load control system, and, if applicable, installation of local storage to reduce operating pressure. The contract would also include a regularly scheduled ultrasonic leak survey service, possibly with a per-item bonus for each identified leak. Leak repair would also be an option, on a fee-for-service basis. As another option, the service provider could be rent or lease the central station equipment, including compressor, dryer, storage, controls, and cooling system.

One problem with this contract form should be noted: successful delivery of these services would tend to reduce sales of new compressor equipment; this gives a disincentive for the service firm to perform well. On the other hand, if this becomes a profitable business for the provider, it will tend to shift attention away from the desire to sell new equipment.

Contract level B: sale of compressed air to manufacturer

For a medium sized user with 150 hp operating the potential savings are $10,000. The contract could, therefore, incorporate more complex features.

This more complex contract shifts equipment risk and energy efficiency risk to the service firm. The contract is long term, with necessary provisions for buyout and early termination. The service firm owns the central station equipment, including compressor, dryer, storage, controls, and cooling system. Energy use is metered separately, and the cost of energy is borne by the service firm. Delivered air is metered, and the client purchases air on a rate schedule. The arrangement would include contractual definitions of acceptable volumes, and standards for pressure, dryness, and reliability, allowable fluctuations in pressure provided, and allowable fluctuations in air demand by the manufacturer.

Under this contract, the service firm has internal financial incentives to improve part-load (and full load) performance of compressors, and to improve the energy price. Similar to the simple Level A contract, the manufacturing plant operates the equipment and does daily monitoring, since its staff is on site. The compressor plant is much too small to afford contracted operations labor.

A major problem with this contract form is that the service firm has little or no financial incentive to help the manufacturer reduce leaks and eliminate inefficient end uses. On the other hand, the unit cost and actual usage of compressed air will be very evident to the manufacturer, which may cause increased sensitivity to its efficiency in use.

Level C and beyond

There is a third level of involvement for contract service, which allows the contractor to completely internalize the total cost of the compressed air system. However, this approach is so complex that it is not appropriate for a medium sized manufacturer. The contractor would not only own the central equipment; it would also own and maintain the distribution piping, regulators, and end use devices. This could have the greatest impact on energy use, but also has a very significant requirement to integrate the actions of the contractor into manufacturing plant operations. Its greatest potential problem is the manufacturer's perceived risk of interfering with production.

CONCLUSIONS

There is a substantial opportunity to reduce compressed air energy costs in manufacturing facilities. A simple contract which transfers little risk to the service contractor may be most acceptable to both parties. If such a service proves to be profitable, it will help to transform the compressed air market from its present focus on first cost to a focus on life-cycle cost and efficiency.

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