PSSSSSSSSSSSSSSSSSST .....Is that our air compressors operating again? a US and Canadian Air Compressor Market Assessment

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Introduction

The title for this paper is a result of what happened during one of the many field interviews conducted to gather information for a Canadian and United States air compressor market assessment project.

Early one morning I arrived for my scheduled on-site meeting with an industrial plant operating engineer. We had met in the parking lot and were planning to tour the plant prior to Monday morning production was scheduled to begin. While entering the building at 6 AM, we could hear several motors running. It was because we had been talking about air systems that our attention had been drawn to the noise. As we moved towards the sound, the plant engineer turned sheepishly towards me and said..... "Is that our air compressors?"

The information presented is a Canadian and U.S. air compressor marketplace review. My industry review was done in three parts. Results were obtained by mail survey, phone interviews and on-site visits. The results presented are taken from over 1000 respondents.

Potential participants for the market analysis where Canadian and United States manufacturing firms. Combined Canada and the United States represent one of the largest industrial economies in the world. For more than 100 years the combined economies have been very robust. Yet, recently U.S. and Canadian manufacturers have been loosing a portion of their world market. The loss is due to a number of business environment reasons. Many business organizations and market analyst state a major reason for market loss is due to the inefficiency of Canadian and U.S. manufacturing firms. This is in fact is a part of my reason for conducting the study. It was my belief that several different end-uses of energy needed to be analyzed from a DSM prospective and highlighted. After some deliberation and analyses, I selected air compression as an end-use category that receives little attention from plant operating personnel. Yet, the energy consumption by this end-use category is very substantial.

Background

The industrial sector is a very large consumer of energy. In 1993, Canadian and U.S. manufacturing accounted for over 30% of the total energy consumed in both countries. This equals roughly 40 quads of energy. These 40 quads are consumed by over 400,000 Canadian and U.S. industrial plants.

Industrial energy use is directed to a number of different end-use applications. One major end-use component is air compression. It is estimated that 15% of the total energy consumed in a typical manufacturing plant is for air compression. Air compression is most often used to provide air for operating pneumatic tools.

Several different types of air compression drives are used in manufacturing. There are electric, diesel, steam and natural gas air compression drives used. The most common drive element for compression is the electric motor. The size of motors used for industrial air applications range from a low of 15 Hp to over 750 Hp. Motors are major contributors to plant kW load profiles. Therefore, any operating changes that affective air compressor motor drives could have significant impact upon the load profile of industrial customers.

Since the 1970's, numerous articles have been written about Demand Side Management (DSM) techniques that improve industrial energy efficiency. Air compression is one end-use application which has received little attention. I believe that this is due to the plant engineering attitude that air is of little consequence to plant

operation. This brief market segmentation paper attempts to quantify the importance of air compression and potential energy savings.

Research

In 1994 and 1995, Moon Lopez & Associates conducted a Canadian and United States industrial air compressor market segmentation study. The intent of this compressor study was to quantify the size of the market and investigate the operating characteristics. By doing so, estimates of the total compression consumption and potential DSM savings could be made. Please keep in mind that the sole purpose of my effort is to provide an assessment of air compressor, energy use, and to provoke interest in air system management.

Over ten thousand (10,124) surveys where mailed to firms across Canada and the U.S. The survey asked specific questions about air compressor operating characteristics. Questions such as hours of plant operation, number of compressors installed, typical air pressures and volumes were asked. The response rate to our survey was 9.1% (921 responses). In addition, another 210 firms were contacted and interviewed either in person or by phone.

For the purposes of this paper, information is limited to the size and distribution of larger compressors, compressor operating characteristics and potential air compressor energy savings.

Marketplace

As mentioned earlier, over 400,000 manufacturing facilities are located throughout Canada and the United States. The results of our study indicate that the total Canadian and U.S. installed industrial air compressor base is 369,000 units. For the U.S. only, the estimated total number of units is 280,000 compressors. With a typical operating life of between 10 to 15 years, roughly 34,000 air compressors over 50 Hp are replaced annually.

The U.S. Department of Commerce reports that annual compressor replacement shipments are valued at $ 2.1 billion. The compressor market is comprised of two major components, new units and parts. Compressor parts account for 43% of total shipment value or $ 903 million. The new air compressor unit value is estimated to be $ 1.2 billion. The expected annual growth for the compressor market is projected to be 3.9% annually.

Much like gas and electricity, compressed air is considered an intangible product. Typically, intangible products or services tend to be over looked and forgotten until they are not available. This partially why I believe air systems tend to be forgotten until there is a problem. Intangible products have the difficult market position of depending on surrogate circumstances to draw attention to their value. For example, people take electricity and gas for granted until its not available at the flip of a switch or ignition of a pilot. For compressed air systems is very similar and attention obtained when pneumatic tools won't operate.

The stationary air compressor market is divided into two major classifications, shop air and process air. The major differences between shop and process air is the quality of the air with the primary focus on oil content.

Shop air compressors, which are used to power tools and machinery, are oil flooded compressors. In these units the compressor is filled with oil, both for lubrication and to maintain the air seal as in the case of screw compressors. While oil filled compressors have an oil separator as part of the system, the air produced does have an oil content.

Process air used in the production and handling of food and drug products, must under FDA requirements, have a high level of purity. In order to meet this standard, non-lubricated compressors must be used. These compressors are significantly more expensive than shop air compressors and are considered a specialty product.

The results of our study indicate that 80% of all systems are used for general plant air systems. The remaining 20% of installed air compressor base is used by institutional facilities and utilities. Most general air system applications in manufacturing and processing are for pneumatic controls, hammering, wrenching, lifting or

moving materials and products from one place to another. Results indicate that 92 % of all manufacturing facilities, classified between SICs 20 through 39, have air compression systems.

What is obvious is that the concentration of air systems is highly dependent upon the physical location of manufacturing. For example, if we review the implications of this statement on the distribution of compressors in the United States, we see that roughly 279,000 units are in operation. Tables A, depicts the distribution of compressors by U.S. economic regions.

Distribution
of
Manufacturing Facilities

Region	No. Plants [1]	% of Total	Est. of AC Units [2]	Est. of Units Over 50 Hp [3]
Northeast	91,102	25.4	116,155	70,693
Midwest	91,318	25.5	116,430	70,858
South	99,304	27.8	126,613	79,968
West	76,337	21.3	97,330	58,398
Totals	358,061	100	456,528	279,917

Table A

[1] Number of plants per Region taken from Statistical Abstract of the United States, 1994, 114th Edition, U.S. Department of Commerce.

2,3 Estimated number of units based upon the results of our Canadian and United States Air Compressor study, Moon Lopez & Associates, March 1995, Market Assessment of Industrial Air Compressors - Canada and U.S.

The results indicate that there are thousands upon thousands of manufacturing air compressors in use across both Canada and the United States. But, has energy conservation techniques and DSM strategies improved the operating circumstances of air systems. The results of our investigation indicate that less than 30% of all systems operating are maintained or operated at peak efficiency. Such factors as system layout, system specification, proper sizing and control of energy consumption are key to the effective use of stationary air. The industry consensus is that air systems tend to be poorly maintained and operated. At best systems may be meeting undefined level of acceptability that basically says, "If production isn't complaining, it must be OK." The respondents of our study indicated that the majority of compressors are driven by 125 Hp electric induction motors. These motors operate flat out and generally are not under any effective motor control.

Energy Implications

In 1995, energy consumption is estimated to top 96 quads for both Canada and the US. Total industrial energy use is equivalent to 4 % of the total or 4 quads. Further segmentation of the total energy consumed indicates that air compression represents 15% of the total. Therefore, the annual electricity consumed by plant air compression equals 2,100 billion kWh.

Energy is a rather small percentage of the total production costs for most industries and so plays a modest role in corporate decision making. Overall, energy generally accounts for only 3% of total production costs for industry.

The industrial use of energy is considered heterogeneous. There are thousands of manufacturing processes each with a different energy mix. Energy is used in motor drives, process heat, steam and electricity generation.

Motor drives utilizes a very large portion of industrial energy use. It is estimated that motor drives account for two thirds of the electricity used by manufacturing. Although for the past 20 years, motor manufacturers have made significant progress in the design and manufacturing of efficient electrical motors, results of our study indicate that it is very common to find large compressors and motors that are thirty years old still in operation. Therefore, the question arises, just how much energy and money is wasted each year due to poorly maintained and sized industrial air compressor systems?

Respondents that we talked to indicated that air compressor systems are probably not managed or controlled closely. Most of the individuals we talked with did not maintain a log or maintain a full listing of the air compressors running in their plants. In reviewing the information gathered it is apparent that energy management activities as they pertain to air compression are under developed and typically concentrate on new technologies and new equipment. An often over looked opportunity and extremely important activity is power savings through development of a fully integrated maintenance program.

Major Findings

The results of the research and analysis identify significant electric energy savings potential available through applied O&M energy measures. Recent DSM national studies affirm that air compression and compressed-air systems have the largest energy-savings potential. Following closely are motors and motor-drives.

Air compressors are an integral part of manufacturing. For a variety of reasons, including cost, safety and reliability, many machines and tools in factories are powered by compressed air instead of directly by electricity. There is a current trend towards full automation of industrial facilities and it is projected that with more automation the demand for compressed air will increase.

As previously mentioned the U. S. stationary air compressor market is valued at more than one billion dollars annually. The majority of single-acting reciprocating compressors are under 25 Hp with the largest being 125 Hp. While centrifugal air compressors are typically the larger sized compression units. Centrifugal and axial make up the vast majority of compressors over 300 Hp with 50% of the total centrifugal market over 750 Hp. The most common supplier of compressors is Ingersol Rand. Industry experts believe that IR has between 45 to 55% of the compressor market.

Compressed air drivers frequently experience very high usage. The data collected indicates that the typical manufacturing facility can be characterized as:

- Operates a minimum of 16 hours per day, 50 weeks per year
- Typically work week is Monday through Saturday
- Compressor size is 125 Hp and typically two units, one used as a swing unit & back-up

There are specific variations of this data which are common to industries, but for the sake of simplicity and this paper the above characteristics are used.

Overall, "interviewees" admitted that their systems were not maintained as well as they should. Which affirmed the notion that there are a couple of major issues which plague the effective operation and use of compressed air. In most manufacturing plants air delivery systems tend to be poorly maintained and designed. Therefore, the energy used to produced compressed air is significantly greater than is really needed.

There two general characteristics that fairly describe compressed-air systems that our respondents feel are important to recognize. Most installed systems are: (1) poorly designed, and (2) not properly applied to the intended floor applications. The consequence of this poor engineering is wasted financial resources.

To obtain a better idea of the energy and cost implications of these two characteristics lets look at a few facts associated with compressed air systems:

- Well applied production and use of air: 20 - 50% of the time
- Poor applications of plant air: 10 to 25% of the time
- Leaks account for 10 to 25% of air production
- Over sized systems 10 to 20% of the time

The financial impact is a big attention getting fact. For example, at $0.07/kWh, compressed air costs roughly $1.50 to $2.50/100 scfm @ 100 psi/hr of operation including maintenance, water, depreciation, and labor. (Most plant air systems operate 4800 hr/yr.) This equates to between $7,200 and $ 12,000 per year to operate this system. For a plant that operates its compressor system around the clock the costs jump-up to between $13,140 and $ 21,900 per year. Now, a plant that tries to operate on 5% profit margins, every $ 1 wasted in the process of making compressed air for production requires $ 20 of revenue. If , for example, the wasted air costs per year total $ 100,000 a manufacturer would have to generate over $ 2,000,000 of production to offset the loss.

Energy experts such as DOE and AEE believe that through good general maintenance and the application of DSM operating techniques manufacturers should be able to save roughly 30% of the current amount of energy used for compression. This means that over 1.0 quads of energy could be saved.

Conclusions

The results from our study indicate that significant energy savings are possible. By just instituting a comprehensive compressed-air O & M program savings in excess of 30 % can be obtained. In addition, by proper sizing of systems electric demand savings can be achieved as well. To the plant operator there are other possible benefits that can be derived from paying more attention to air compression. Such things as energy savings and demand dollar savings are obvious, but what about capital expenditures savings from extended equipment life or the advantage related to extended opportunity savings. There are electrical facility and floor space savings that can be derived from instituting a good maintenance program.

An interesting outcome of our analysis turned up an interesting situation. The majority of heavy industrial plant expansion took place across Canada and the US during the mid to late 1960's. In fact economic historians point out that for ten years after the end of the Korean Conflict, Canadian and US manufacturing flourished. During this period of industrial history, capital expenditures where highest. A large portion of our survey respondents confirmed that their installed compressors were coming towards the end of their useful life cycle. Therefore, it seems reasonable that many industrial facilities are either currently or soon will be considering the purchase of new air compressors. Phone conversations with major equipment distributors tends to up hold this thought. Equipment distributors indicate that capital expenditures for plant equipment is

currently on an upswing. In addition, a majority of respondents indicate that a ten year operation cycle is used to begin evaluating air compressor maintenance.

A rather disheartening result of our study indicated that the majority of plant engineers and maintenance managers have little knowledge about rates. They can tell you how much that they have budgeted for utilities, but must have a difficult time discussing how they are charged for energy.

The results of my investigation indicate that there is still a great deal of industrial energy savings opportunity with regards to air compression and compressed air systems. Quality improvement initiatives and integrated maintenance programs will result in increased value to the plant owner and plant operator. There are definite identifiable payback when attention is paid and effective utilization realized.