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AIR COMPRESSORS FOR PLANT-AIR APPLICATION
MOST APPARENT PROBLEMS AND SUGGESTED SOLUTIONS

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INTRODUCTION

Noteworthy achievements of the compressor industry are being reported in other papers of this conference. In our presentation, we will not attempt to deny the value of those achievements. Our ultimate objective will be the same as the objective of other participants of this conference: more advanced, more reliable, more economical, and more practical machines. However, our approach will be different. We plan to discuss not the merits, but the drawbacks of the present-day machines and practices.

It is our contention that a better awareness of the existence of those drawbacks, will induce the compressor industry to take early corrective actions, whenever such actions are desirable or required. Thus, further improvements in the already advanced compressor technology can be introduced more promptly.

Additionally, we might find out that some other aspects of manufacturer-customer relations are open to refinement. If we succeed in establishing that these possibilities exist, additional technological and operating benefits will be within our reach.

A TYPICAL PROFILE OF THE MEN WHO SELECT, INSTALL AND OPERATE AIR COMPRESSORS IN PLANT-AIR APPLICATION

In order to gain a meaningful understanding of the problems existing in the field of compressor utilization, it is necessary to have at least some information about the men who have to face these problems.

There are a few rather isolated cases, where a large industrial organization has on its staff an engineer, or an engineering group, engaged exclusively or largely, in the selection, installation and performance studies of the air compressors for plant air application.

However, in most cases, the tasks of selecting, installing and operating of general application air compressors are entrusted to the engineers whose activities cover a wide range of machines and equipment. Air compressors form only a moderate part of their responsibilities. In some cases their involvement in the air compressors could take as much as 25% of their attention and time. More frequently it could be closer to 10 or 15%.

So, these men are not fully dedicated to air compressors, and cannot be classified as compressor experts by any means. Insofar as air compressors are concerned, all that these men look for are the machines which are dependable, reasonably economical, and which would give them the least trouble.

It might be correct to assume that most of the plant application air compressors to be sold within a year, will be sold to these men. The writer of this paper is one of them. Hence, his experience, observations and views, can be fairly representative of the views of this sector of the engineering community at large.

DATUM OF THIS PRESENTATION

This presentation refers to the air compressors of various types, usually deployed in plant air systems, within the following capacities, pressures, and mode of drive:

Machines deployed in instrument-air systems:
Capacity range 60 to 600 CFM, pressure 60 to 100 psig.

Machines deployed in general plant air systems:
Capacity range 400 to 3,000 CFM, pressure 90 to 120 psig.

Corresponding HP ratings: 15 to 700 HP.

Driving mechanism: All machines under consideration are electric motor driven (synchronous or induction), direct coupled.

THE MOST APPARENT PROBLEMS FACED BY COMPRESSOR USERS

In the judgment of this writer, the following are the most apparent and the most frequent problems with which the users of various types of air compressors are being faced:

(1) Reciprocating Air Compressors, Lubricated Type

The term "lubricated" has been accepted for general use to indicate the machines with cylinder lubrication.

It is rather surprising that any problems might exist with these widely accepted machines. Nevertheless, the operators find quite a number of problems related to these machines. In this presenta-

tion just a few of these problems will be discussed:

Capacity ratings:

No capacity ratings are shown on compressor nameplates. Neither is this data given in the machine service manuals, nor in the manufacturer's drawings.

This is not a crucial issue. This is rather a very annoying issue to the operators of these machines.

Compressor manufacturers cite several reasons why they do not show compressor CFM. These reasons lack credibility to compressor users. The Compressed Air & Gas Institute could do a good service by inducing the manufacturers to agree among themselves to show capacity ratings, on the nameplates, in service manuals and in the drawings.

Positioning of components and accessories:

Some compressor manufacturers, responding to modern trends in styling, are installing some of the most essential machine components, out of view, in the most inaccessible and impractical locations. Occasionally, these components or accessories can be crowded one next to another, one above another, and even, one on top of another. In some cases the accessibility is so bad, that safety hazards are created.

Instrument clusters:

On the compressors from the past decades, the gauges are scattered all over the machines. When a gauge fails, a spare gauge is always on hand, and the replacement can be performed within a few hours, possibly within a few minutes.

In the last decade or two, a trend toward instrument clusters has developed. This grouping of gauges on a single panel has obvious merits and is operationally convenient. However, when an instrument failure occurs, it might take a month or two, before the replacement instrument is requisitioned, purchased, delivered and installed. All this time, one of the vital functions of the machine will not be monitored. This can create risky situations and lead to a major breakdown of the machine.

Therefore, whenever the dependability of the machine is of prime concern, the concept of scattered gauges is preferable.

Conclusions: Lubricated reciprocals remain the most predictable and dependable machines. Nevertheless, some problems exist. In selecting a machine, it will be practical to select a make which has the least problems incorporated in its design.

(2) Reciprocating Air Compressors, N/L Type

The term "N/L" or "Non-Lubricated" designates the machines which have no air-cylinder lubrication, and - thus - deliver oil-free air.

These machines require more attention than their lubricated counterparts. Their tolerance to neglect is low.

Many non-lubricated reciprocals have a perfect operating record. On the other hand, multiple cases can be cited where non-lubricated units have given their operators a hard time. We recall a machine which broke down after a few weeks of operation, and failed to respond to our efforts or to those of the manufacturer. Finally, at the suggestion of the manufacturer, the machine has been converted to a lubricated type. Since this conversion, it operates normally. Air valves were the critical item. A typical case of this kind of difficulty is described in more detail in William O'Keefe's column in the March, 1974 issue of POWER magazine, Reference 1. This article should be read by everyone who intends to acquire and install a reciprocal N/L machine.

Conclusions: Extreme caution has to be exercised when acquiring a non-lubricated reciprocal. If the selection is good, and if due care is given to the installation and to the operation of the machine, it can perform to the full satisfaction of the buyer.

(3) Rotary Multivane with Oil Feed

In standard shop terms, this type of compressor is known as a "rotary air compressor", or simply as a "rotary machine".

My familiarity with these machines is restricted to three compressor stations, each one in a different location, with two machines in each of the stations. On the basis of this rather moderate sample of rotaries, the writer has this to report:

Problems are evident in the area of vibrations, and in the selection of components and accessories capable of resisting those vibrations. Additionally, users encounter a series of problems related to the cylinder-lubricating oil: high oil consumption, oil leaks and emissions, poor oil separation, and malfunctioning condensate traps.

In each of the above mentioned installations, the operators took real interest in improving the machines, and upgraded them to the point that all of these machines operate normally round the clock, and give good service. The upgrading required two to three years of on-and-off effort in each of these three cases.

The sound level is high, noticeably higher than of any other air compressor that we have checked. Sound attenuation is needed in order to comply with the Walsh-Healey Act.

Conclusions: With resourceful and dedicated personnel, these machines can be upgraded by the buyer to give good, dependable service. It would be practical to hear from other compressor users about their experience with this particular type of rotary machines.

(4) Flooded Sliding Vane

These machines are being deployed for instrument-air systems, usually within the capacity ranges of 60 to 120 CFM.

Per our own experience, and per information from a sector of the chemical industry, this is a dependable machine in the size range shown above. The oil separation appears to be fully adequate for application of this air in instrument-air systems of the common type.

This machine has been put on the market under the designation of "rotary sliding vane". The term "rotary" is superfluous (what else can it be?), confuses the buyer and the user, and does not serve any purpose. Therefore, confusion of prospective buyers could be eliminated, and market penetration could be improved, by omitting the term "rotary" in the designation of this machine.

Conclusions: To the best of our knowledge, this is a dependable machine, which can do the job for which it is being offered.

(5) Wet Helical Screw

In mobile compressor-unit applications the wet screw is very practical and dependable.

With reference to the stationary wet screw, opinions are rather divided.

Many machines operate to the full satisfaction of users. Concurrently, there are numerous machines which do not satisfy the user. Usually these problems are cited: machine breakdown and/or poor oil separation. One of the writer's counterparts in the chemical industry, has experienced problems with controls on one of these machines.

Whenever problems occur, the manufacturers are busy in ironing out these problems.

This machine is usually advertised as a "rotary helical screw". The word "rotary" is superfluous, confuses the buyer, and does not serve any purpose. On the other hand, there is no indication whether this is a "wet" or a "dry" machine. Therefore, either of the following designations seems to be more advantageous: "wet helical screw", or "flooded helical screw", or simply "wet screw".

Conclusions: The potential buyer needs to give due attention to the selection of the machine and should look for a design and model with a good operating record.

(6) Dry Helical Screw

Two makes of these machines are well known on the U.S. market: one make in the intermediate capacity ranges and the other one in the larger capacities.

Little is known about these machines in general plant air application.

Conclusions: It would be highly desirable to hear more about these machines from the engineers who actually operate them either in instrument air systems or in general plant air systems.

(7) Liquid Ring

This is an interesting case of a machine with high initial cost, a high energy cost per volume air, very good dependability, and very low (near none) maintenance and repair costs. When oil-free air and a high degree of dependability are required, this machine is a good choice.

These machines are most frequently used in the capacity range 50 to 300 CFM.

Small liquid ring units in large interiors, do not give us any sound-level problems. Larger units, in confined areas, require sound attenuation.

Conclusions: Per our experience, this is a dependable machine, worth its cost.

(8) Centrifugal Air Compressors

These machines illustrate the remarkable success of modern compressor technology. A most interesting presentation, introducing these machines to the engineering community, has been given by John G. Greenwood in the year 1964, Reference 2. Another very gratifying article about centrifugals, has been written by G. C. Quinn in the year 1967, Reference 3.

In actual deployment in industrial establishments, some of these machines have an excellent operating record, without any forced down-time in several years of operation.

Other machines need major repairs after 18 to 24 months of operation. In some cases breakdowns are known to occur even earlier. Many potential buyers, who need oil-free air in large quantities, are fully aware of these problems, and hesitate to acquire a centrifugal unit.

Problems related to centrifugal air compressors in plant-air application have never been discussed to any extent in any engineering forum or in the general circulation technical literature. Had these problems been discussed, solutions would have come much earlier.

Some of the problems:

Machines of an entirely new and advanced design need to be observed in operation for several years before full knowledge can be gained about their capabilities and limitations. It is quite possible that some machines were put on the market before such knowledge had been gained. Many of these machines could have been selected for applications for which they were not suitable, and problems developed. In the absence of public discussion of specific problems, the word was going around that centrifugal machines, in general, develop too many problems.

Switching over from these general considerations to specifics, it would be proper to mention, that most of the problems which existed in the initial stages of application of centrifugals have been ironed out.

For example, in the following subject areas the basic needs have been determined: intake-air filtering requirements, selection of impeller material for specific intake-air quality, selection of diagnostic devices to monitor various functions of the machine, selection of other optionals such as dual mode of compressor control, motor overload protection, sump oil heater, dual oil filters and coolers, thermostatic valves for compressor cooling water, and many others.

Of the problems which remain to be solved, the most prominent one seems to be that of premature failures of intercooler tubing and/or fins. With the presence of offensive contaminants in the intake-air, high efficiency (compact) intercoolers seem to be more subject to such failure than larger size intercoolers.

Opinions on this issue of tube failures are divided. In some cases, it is not even known to which factors these failures are primarily related; the quality of the intake-air, of the water, or perhaps, galvanic action.

If the efforts of all concerned are coordinated, this particular problem, and other problems which are still on the to-be-solved list, could be fully understood and resolved within two or three years.

Other issues:

Economics of centrifugal air compressors: The cost of installation is approximately the same as for reciprocal units; the foundations cost less, but intake-air installations usually cost more. The operating costs of machines located in areas with industrial-quality air and operated round the clock, are substantially higher than the operating costs of lubricated reciprocating units. Under other operating conditions, these costs could be comparable, as has been shown by John F. Moody, Reference 4.

Capacity ratings: The disarray over capacity ratings is an issue which deserves consideration. The capacities of centrifugal air compressors are being quoted in ACFM, ICFM or SCFM. Of course, there is a difference between each of these quotings. None of the manufacturers considers it necessary to include in his bid the definition of the rating system he might select. This is another case where the Compressed Air & Gas Institute can help the industry by establishing guidelines concerning capacity ratings for centrifugal air compressors.

Marketing: In some cases bids are being submitted without a sufficient evaluation of the suitability of the machine for the application for which the machine is being offered. Practices of this character weaken the credibility of the whole industry, and pose the buyer with a number of problems in deciding on the validity of the claims of the vendors.

Conclusions: It is the contention of the writer that centrifugals are very good machines in dire need of more information concerning their selection, installation and utilization. Until this information is readily available, extreme care needs to be exercised in deciding "to go centrifugal", and - subsequently - equal care needs to be exercised in the acquisition of a centrifugal machine.

SUMMARY OF OBSERVATIONS

- (1) Those who intend to acquire an air compressor, can find on the market a wide range of dependable machines which can fully satisfy all of their requirements.
- (2) In the low capacity range, two types of compressors can be acquired with no evident need for machine evaluation studies, and with a reasonably good expectancy of full satisfaction with these machines.
- (3) In the intermediate and larger capacity ranges, the selection of an air compressor has become a rather difficult and time consuming task. The task of selecting the most suitable type of machine requires a thorough knowledge of all types currently on the market. The process of preparing purchase specifications can be a complicated one, especially when a machine for oil-free air is to be specified. Finally, the evaluation of the bids has to be performed. This is a relatively easy task for those who are fully acquainted with all types and models of the machines which are under consideration. However, this task can be very difficult for all those who do not possess the necessary expertise.
- (4) Even a basically good machine can develop serious problems if the buyer fails to give due attention to any of the following issues: intended location of machine (quality of air, water, temperatures), intended application, specification of materials for various components, machine installation and operating practices.

ANALYSIS OF THE PROBLEMS

(1) Compressor Industry

The situation within the compressor industry, as seen by a compressor user, has changed radically within the last two decades. Several new types of air compressors have been developed. New manufacturers, previously not known to an average compressor user, appeared on the market. Many manufacturers have diversified their production lines. Some of the types or models of air compressors might excel in quality, others might not be that good. Some machines might give an excellent service in one location or application, and might develop problems in other locations or applications.

Basically, this situation is perfectly natural, and there is no reason to be critical of this turn of events. The main problem, which can be seen, is

the reaction of an average compressor buyer or user. Many men, familiar with air compressors for many years, have become completely lost in this complex structure of the industry and of the product.

This diversification of product lines has another shortcoming: it is more difficult to get a good "factory man" on the job. It is evident that several of the companies experience problems in the development of the necessary field servicing capabilities.

There are strong indications that the compressor market is oversaturated. Competition has become very intense. Marketing practices stress selling rather than engineering which tends to raise skepticism in the mind of potential buyers, which is not to the benefit of either of the parties.

The generation and dissemination of technical information has not been keeping pace with the developments in compressor technology and practices.

(2) Compressor Users Community

The impressive progress in compressor technology, and the radical changes in the whole structure of the compressor industry, have a pronounced impact on the compressor users community.

In the past, a buyer selecting a compressor relied on his own experience and on his personal preference for a make. This method was very simple, and gave very good results.

Currently, with the wide variety of machines on the market, and with a substantially increased number of machine manufacturers, very few compressor users can keep track of "who-is-who" in the compressor industry. Claims of the manufacturers and of the vendors are extremely difficult to verify. The information on the real merits and the drawbacks of a machine is hard to get. Therefore, entirely new methods of machine evaluation have to be developed.

Rapidly increasing interest in oil-free air for plant-air systems poses the compressor buyer with an additional series of problems. In many cases, neither the engineering section of a company nor the operating personnel, have the necessary expertise to select, install, and operate the machines for oil-free air.

Compressed air drying equipment, which becomes a necessity in many new installations (especially in oil-free air installations), and the suitable selection of compressor-dryer combination, are other new problems facing compressor users.

In view of the increasing costs of fuels and energy, the economics of the compressors to be acquired becomes a major issue.

Increasing costs of wages and employee benefits, require that those machines be acquired which necessitate the minimum of manpower in their operation and maintenance.

Availability of the information generated by compressor manufacturers is less than adequate. The exchange of factual and meaningful information in a technical forum, within the compressor users community, is practically non-existent. The need for more information is evident.

(3) Availability of Technical Information

The men whose responsibilities cover numerous fields of plant engineering need ample technical information to help them in their work.

The information from equipment vendors is always available. However, this information is restricted in its coverage of the subjects, and - quite naturally - cannot be thoroughly objective.

The only technical information with a wider coverage and more objectivity which is available to the majority of equipment users is the information which comes from general circulation engineering magazines.

When one looks through these magazines for specific and readily applicable basic information on compressor selection, installation and operation, one finds this situation:

In the last fifteen (15) years, the following items of valuable information on the issues listed above have been published:

- (a) The four articles which have already been mentioned, Reference 1, 2, 3 and 4.
- (b) Two more articles of a high practical value to each compressor buyer and/or user, Reference 5 and 6.

A breakdown of this listing by the affiliation of the authors, reveals the following situation:

The number of articles prepared by editors of technical magazines..... 3

The number of articles prepared by those affiliated with compressor manufacturers 2

The number of articles prepared by compressor users and/or consulting engineers 1

An evaluation of this data leads to the conclusion that more information can be generated and needs to be generated. In particular, it would be of a great assistance to compressor manufacturers and to compressor users in general, if more information came from the compressor users community.

THE ESSENCE OF THE PROBLEMS

- (1) The analysis of the problems which have been just presented, indicates that we are in an era of transition in all fields of activities related to compressor design, development, manufacture, marketing, installation and utilization.

- (2) This transition opens excellent opportunities. However, if this transition is left unrecognized and uncontrolled, serious problems are due to arise. These problems are already evident. The current difficulties which are being experienced by compressor users, testify to this effect.
- (3) An organized and coordinated effort of all parties involved in these areas of activity is needed in order to identify all implications of this transition and to assure that this transition proceeds along efficient and rational lines. Close cooperation between compressor manufacturers and the compressor users community is the most essential requirement for the success of this endeavor.

SUGGESTED SOLUTIONS

It is suggested that closer liaison on the engineering platform be established between compressor makers and compressor users.

Direct contacts between the engineers of both parties will result in the frankest and most fruitful exchange of observations and opinions. Also, these men are the best qualified to come forward with the most practical answers to many problems which are evident in the subject areas of air compressor design, selection, installation and utilization.

A university with an active engineering orientation could be the most desirable forum for those contacts.

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