ENERGY CONSERVATION IN PNEUMATIC OPERATED FORGING INDUSTRY

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ABSTRACT

Forging is a manufacturing process involving the shaping of metal using localized compressive forces and the compressive force is from compressed air. An air compressor is a device that converts power into kinetic energy by compressing and pressurizing air. Air compressor unit is one of the major parts of energy consumption in most industries. Compressors are used to pressurize the air for the process requirement of the industry. In a forging industry the major part of energy consumption is by the compressor units which produces the compressed air required for powering the hammer. The compressed air is stored in tanks and then supplied to these hammering units. There is huge loss of compressed air through leakage and other faults. This would lead to a condition where the compressor units have to work for a longer time than the normal time required for producing the compressed air at required pressure. And in a forging industry different types of jobs are used and the required pressure for forging would also be different.

Keywords : Compressed Air, Forging, Hammering Units, Leakage.

I. INTRODUCTION

Energy is one of the most important factors to global prosperity. It plays a key role in achieving the desired economic growth. The entire fabric of developmental goals is webbed around a successful energy strategy. Energy is a pivotal prerequisite of developed economy and social structures. One of the major problems concerning its supply is the depleting nature of the extraction of fossil resources, combined with the need for transition to renewable energy supplies. The last depends on a number of scientific and technological breakthroughs. Meanwhile, energy conservation promises to fill the gap between supply and demand. Several measures for conservation of energy are very important for consideration. The conservation of energy, therefore, is using less more wisely than before. Saving a watt is nearly always cheaper than increasing the supply by a watt. The energy industry is one of the most capital intensive. Efficient utilization of energy resource is not only conservational it also saves capital investment. Thus conservation is really the cheapest of energy resources at least until its potential is exhausted.

About half of all energy generated in falls on industrial production. At the same time about 30% of this energy is spent by turbo mechanisms like pumps, blowers and compressors. The air compressor type, model and size are important factors in the compressor's energy consumption, but the motor power rating, control mechanisms, system design, uses and maintenance are also fundamental in determining the energy consumption of a compressed air system. System design plays an important role in increasing the efficiency. Four aspects of system design that are crucial in deciding compressor efficiency are saving for times of need, straightening the path as narrow delivery lines, looping and sharp bends in the lines can create pressure drops in the system and reduce end use pressure, use of cooler intake air as the energy required to compress cool air is much less than that required to compress warmer air and the last one is the recovery of waste heat. It is said that for every 1 bar over the required usage pressure that a compressor generates air an extra amount of 7% will be added to the energy cost.

Over the first ten years of life of a typical air cooled compressor, with two shift operation, the operating cost (electricity and maintenance) will equal about 88% of the total lifetime cost. The cost of the original equipment and installation will account for the remaining 12%. As energy accounts for about 76% of the overall lifetime operating cost, it is very important to design more efficient components for your compressed air system. So the overall expected lifetime operating costs should also be considered, and not just the initial cost of the equipment. Most facilities can easily save 10-20% of their compressed air energy costs through routine maintenance such as the fixing of air leaks, lowering air pressure, and replacing clogged filters. Even higher savings numbers can be gained by choosing better compressor control, adding storage receiver capacity, and upgrading air dryers and filters. There is huge loss of compressed air through leakage and other faults. This would lead to a condition where the compressor units have to work for a longer time than the normal time required for producing the compressed air at required pressure.

II. FORGING INDUSTRY

Since the Industrial Revolution, forged parts are widely used in mechanisms and machines wherever a component requires high strength. Forging is a manufacturing process involving the shaping of metal using localized compressive forces. The blows are delivered with a hammer (often a power hammer). In a forging industry the first process would be the die design and die manufacture. According to the consumer demand required shape is designed on the die. Then it is taken to the forge shop where after heating the metal to a particular temperature and soaking it for a specific time in the furnace. Now shaping is done in the forge shop and then it is taken to heat treatment section and finally it is taken for finishing and testing is done as a part of quality assurance.

The hammers used here are mainly pneumatic hammers and uses compressors to provide the compressed air for its operation. The compressors are mainly reciprocating type and are run with the help of induction motors. Due to this there is large energy consumption.

III. COMPRESSED AIR

Compressed air is used widely throughout industry and is often considered the "fourth utility" at many facilities. Almost every industrial plant, from a small machine shop to an immense pulp and paper mill, has some type of compressed air system. In many cases, the compressed air system is so vital that the facility cannot operate without it. Compressed air systems consist of a supply side, which includes compressors and air treatment, and a demand side, which includes distribution and storage systems and end-use equipment. A compressor is a machine that is used to increase the pressure of a gas. A modern industrial compressed air system is composed of several major sub-systems and many sub-components. Major sub-systems include the compressor, prime mover, controls, treatment equipment and accessories, and the distribution system. The compressor is the mechanical device that takes in ambient air and increases its pressure. The prime mover powers the compressor. Controls serve to regulate the amount of compressed air being produced. The treatment equipment removes contaminants from the compressed air, and accessories keep the system operating properly.

IV. TYPES OF AIR COMPRESSOR

A compressor is a device which is used to compress air, gas or vapour. The compressed air has wide applications in industry as well as in commercial equipment. It is commonly used in forging industry to power the hammers, in power plants for driving pneumatic tools etc.

4.1 Reciprocating air compressors

Reciprocating air compressors are positive displacement machines, means that they increase the pressure of the air by reducing its volume. This means they are taking in successive volumes of air which is confined within a closed space and elevating this air to a higher pressure. The reciprocating air compressor accomplishes this by a piston within a cylinder as the compressing and displacing element. Single-stage and two-stage reciprocating compressors are commercially available. The reciprocating air compressor is single acting when the compressing is accomplished using only one side of the piston. A compressor using both sides of the piston is considered double acting.

4.2 Rotary compressors

Rotary air compressors are positive displacement compressors. They have rotors in place of pistons and give a continuous, pulsation free discharge air. They are directly coupled to the prime mover and require lower starting torque as compared to reciprocating machine. They operate at high speed and generally provide higher throughput than reciprocating compressors. Also they require smaller foundations, vibrate less, and have a lower number of parts, which means less failure rate. The most common rotary air compressor is the single stage helical or spiral lobe oil flooded screw air compressor. These compressors consist of two rotors within a casing where the rotors compress the air internally. There are no valves.

4.3 Centrifugal compressors

The centrifugal air compressor is a dynamic compressor which depends on transfer of energy from a rotating impeller to the air. Centrifugal compressors produce high-pressure discharge by converting angular momentum imparted by the rotating impeller (dynamic displacement). In order to do this efficiently, centrifugal compressors rotate at higher speeds than the other types of compressors. These types of compressors are also designed for higher capacity because flow through the compressor is continuous. Adjusting the inlet guide vanes is the most common method to control capacity of a centrifugal compressor. By closing the guide vanes, volumetric flows and capacity are reduced. The centrifugal air compressor is an oil free compressor by design. The oil lubricated running gear is separated from the air by shaft seals and atmospheric vents.

V. COMPRESSED AIR DISTRIBUTION SYSTEMS

When a compressed air distribution system is properly designed, installed, operated and maintained, it is a major source of industrial power, possessing many inherent advantages. The primary objective of a compressed air distribution system is to transport the compressed air from its point of production to its points of use in sufficient quantity and quality and at adequate pressure for efficient operation of air tools and other pneumatic devices. However, many other considerations come into the design of the system to ensure the efficiency and safety of the total system. These include air volume flow rate, air pressure requirements, types and number of compressors, air quality, air system efficiency, air system safety, air system layout, air volume flow rate requirements.

One problem is that the variety of points of application may require a variety of operating pressure requirements. Equipment manufacturers should be consulted to determine the pressure requirement at the machine, air tool or pneumatic device. The proper capacity to be installed is vital. The capacity rating of air compressors generally is published in terms of free air, which is at atmospheric conditions of pressure, temperature and relative humidity and not at the pressure, temperature and relative humidity required at the air tool or pneumatic device to be operated. Determination of the average air consumption is facilitated by the use of the concept of load factor. Pneumatic devices generally are operated only intermittently and often are operated at less than full load capacity. The ratio of actual air consumption to the maximum continuous full load air consumption, each measured in cubic feet per minute of free air, is known as the load factor. It is essential that the best possible determination or estimate of load factor be used in arriving at the plant capacity needed.

When a compressed air system operates at a pressure higher than required, not only more energy consumed in compressing the air, but end uses consume more air and leakage rates also increase. This increase may be referred to as Artificial Demand. To minimize the effects of artificial demand, the use of a Pressure/Flow Controller is recommended. Safety in the workplace is a primary design consideration. In a compressed air distribution system there are several factors involved. The pressure rating of all piping must meet or exceed the maximum pressure to which the system may be subjected.

VI. METHODOLOGY

Presently there are 8 compressor units and each of them run by a 270 hp motor. The compressed air distribution systemis in a ring line arrangement. There are eight storage tanks in which six of them are of 20 m^3, one of $5m^3$ and one of $3m^3$ and three hammers. There is large energy consumption by these compressor units. Here in the plant the compressors are operated depending upon the compressed air demand. At present the compressors are switched on or off as per the requirement of the hammers operated. This switching on and off the units leads to large energy consumption. The main drawback of the ring line arrangement it that air flow do not have a specific direction. Direction of flow is to the area of pressure drop and it changes depending upon the use of tools i.e. hammers. Sectioning of the storage tanks would be an effective method to reduce the operation time of compressors. It have been also identified that there is leakage of compressed air in the plant which demands more operation time for the compressor units.

Receiver filling method is used for the capacity testing of the compressor. Here the volume of the receiver is calculated. The sizes and the length of the pipes up to the isolation valves are measured. This volume is added to the receiver volume and called effective receiver volume. The valves which isolate the compressor receiver from the delivery lines are closed. Pressure gauge reading is noted. It reads zero as all the air in the receiver is drained. Compressor is started and kept on full load. The time taken by the compressor to reach a certain set pressure is recorded.

To estimate the amount of leakage in the system, start the compressor when there are no demands on the system. A number of measurements are taken to determine the average time to load and unload the compressor. The compressor will load and unload because the air leaks will cause the compressor to cycle on and off as the pressure drops from air escaping through the leaks.

Total leakage (percentage) can be calculated as follows:

$$\text{Leakage (\%)} = [(T \times 100)/ (T+t)]$$

Where: T=on-load time (minutes)

t=off-load time (minutes)

Leakage will be expressed in terms of the percentage of compressor capacity lost. The percentage lost to leakage should be less than 10% in a well maintained system. Poorly maintained systems can have losses as high as 20 to 30% of air capacity and power. Leakage can be estimated in systems with other control strategies if there is a pressure gauge downstream of the receiver.

TABLE 6.1 AVERAGEPERCENTAGE ENERGY COMSUMPTION

Air compressors	33%
Forge shop equipment	17%
Die shop equipment	10%
Heat treatment equipment	17%
Canteen boiler	3%
Lighting	4%
Oil Fired Furnaces,E.O.T Cranes, Pumps, F&D equipment etc.	16%

VII. CONCLUSION

The aim of this project was to reduce the energy consumption by the pneumatic operated equipped tools in the forging industry. Due to the ring line compressed air distribution system the pattern of operation was such that all the storage tanks have to be filled even for the use of smallest rated hammer. For this minimum of three compressors have to kept in operation and at times one of them would be running in unloaded condition which is considered as leakage. So by sectioning of the storage tanks the use of compressor units could be reduced and also the energy consumption. For sectioning motorized butterfly valves are used as the overall set pressure is below 10 kg/cm^2. This reduces the need of filling all the air receivers hence reducing the unwanted operation of compressors. And by this the compressors can be operated at different pressure as the hammers require different pressure. Lower operating pressure would reduce the energy consumption.

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