A CRITICAL EVALUATION OF COMPRESSED AIR UTILIZATION AND ASSOCIATED ENERGY WASTAGE IN INDUSTRIAL SECTOR OF PAKISTAN

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ABSTRACT: *Pakistan is facing a critical shortfall of of energy these days. We are in a serious situation and want to cope with this situation by effectively utilizing all our available resources. A lot of projects have been planned in this connection, some are under study. But lack of interest can be observed about the significance of the energy saving activities. The industrial sector is a major consumer of energy. If this consumption is reduced by controlling the extravagant utilization, we shall be able to save energy and the associated operating costs. Usually, the utility sector of industries is a big energy carrier. Therefore the energy conservation and conditioning regarding its justified utilization is imperative and inevitable. A significant amount of electric energy is utilized to produce the compressed air for the needs of the industrial sectors of textiles and rubber manufacturing. Keeping this in view , the comprehensive investigative program "Acoustic Emissions Based Energy Audits for Compressed Air Leakages" was carried out to probe out the critical issues in the industrial sector of Pakistan. In this connection, a questionnaire was designed to take into account the problems related to the working environment, machine power ratings, compressed air leakages, leakages costs, etc. Subsequently, twelve (12) different industries were selected from Pakistan for data collection. Through data analysis, it is revealed that in most of the industries, the compressed air leakage is a crucial issue and needs appropriate remedial actions and awareness of the employees.*

Keywords: Compresser, Air Leakages, Air Utilization, Critical Evaluation

INTRODUCTION

The energy crisis has become very serious and crucial issue in Pakistan. The government of Pakistan is very dedicated to resolve this problem and is committed to utilize all available resources to produce the energy to cater and manage the current electricity shortfall of 5000 MW. The scope of vision regarding energy production is quite clear, but we should also have to ponder attention towards energy conservation strategies. In this way, we may save ample amount of energy for our industrial sector. Air compressors use 10-15 percent of total electricity in the industrial sector. Keeping this in view, the air compressors are very critical machines with reference to the energy consumption. Therefore, energy conditioning is inevitable by keeping focus on compressed air systems. In this connection, twelve different industries were selected from Pakistan to observe the energy extravagant use through air leakages and improper housekeeping of the compressed air system. Through comprehensive surveys, it was observed that our industrial sector have rare information and awareness about these critical machines and air leakages. Therefore, some remedial approach should be adopted to save this extravagant energy utilization. On the basis of the collected data and analysis, air auditing of compressed air systems is highly recommended to save energy for our industrial and commercial sector in Pakistan.

LITERATURE REVIEW

It has been stated by Abdelaziz *et al.* that currently the 37% of the world energy is being used by the industrial sectors. Different practices and state-of-the-arts have been adopted for minimizing the energy utilization employed in the industrial sector. Variable speed drive motors (VSD), high efficiency motors (HEMS) and energy auditing techniques are used to decrease the additional load of the energy. [1,2]. Saidu *et al.* stated the rubber industry to be very critical pertaining to energy utilization because of using huge amount of electricity; the electric motors bearing the major source of extravagant energy utilization for compressed air production. Saidu *et al.* also suggested various energy saving methodologies, such as the use of variable speed drive motors (VSD), high efficiency motors (HEMS), air leakage detection, waste heat recovery , efficient nozzles minimized the energy consumption. [3]. It was stated by Seslija *et al* that in Serbia, 8% of the total electricity is used by the compressed air systems and an amount of € 8.07 million can be saved by effective energy audits of compressed air systems and general awareness of the employees [4]. Curtner *et al* stated that specialized software, capable of providing textual, graphical and mathematical information regarding air compressor systems, can be used for operational and financial calculations of the air compressors [5]. In china, 9.4% of the electricity is used by compressed air systems audit is observed that energy efficient air audits of the air compressors is indispensable [7]. In Sweden, industrial energy audits were introduced to counter the issues regarding electricity prices hiking. [8] In Palestine, the need of electricity has been increasing at the rate of 10-12% since last decade, and it is anticipated that up to 15% of the energy can be saved from residential, commercial and utilities sector by adopting energy audits techniques [6].

PROBLEM STATEMENT

Compressed air is essential for operations and utilities of the growing industrial sector in Pakistan. It has been observed with grave concern that our textile, chemical, automobiles and rubber sector is using high rating air compressors in terms of KWh. Usually an air compressor produces 1 cubic meter / min of compressed air by utilizing 6 to 6.5 KWh of the electricity. Thus, ample amount of electricity is required to meet the industrial requirements of the compressed air. In this perspective the air compressors become critical machines. The problem of compressed air leakage has become the one of the core issues of our industrial sector, keeping this in view, the data collection regarding air compressor ratings, operation, maintenance, environmental effects and types of leakages has become critical to conduct comprehensive air audits to conserve the energy. Surely these findings will develop specific air audit technique and will be useful to evaluate compressed air leakages. This data collection of targeted industries will be helpful for raising the awareness of compressed air audits. This

research will be very lucrative for our industrial sector and save excessive utilization of electricity. As a matter of fact, driving new horizon of energy conservation in our industrial sector, the compressed air audit will also be very supportive parameter for minimizing the current shortfall of electricity in Pakistan.

METHODOLOGY

The numerous air compressors have been installed in the industrial sector of Pakistan. The air compressors require a significant amount of electricity to produce the specific amount of compressed air. Therefore, cautious and vigilant strategy is required to prevent air leakages to reduce the running cost of the compressors. After prolific deliberation and consideration of operation and maintenance procedures of the air compressors a comprehensive questionnaire was designed to investigate the air compressor power ratings, leakage areas, maintenance techniques, leakages detection program, leakages cost, and annual maintenance cost.

In this perspective twelve industries were selected in the vicinity of the Lahore to probe out the facts about the air leakages of the air compressors. The questionnaire consisted of five parts, the first part is related to introduction questions, the second part of the questionnaire determines the rating capacity of air compressors, area of leakages, leakages cost and leakages detection program. The third part of the questionnaire deals with the operational parameters of the air compressors. The fourth part of questionnaire is about the utilization of compressed air. The fifth part of the questionnaire deals with treatment devices and inspection of the air compressors. The questionnaire was composed on the basis of aforementioned parameters. Twelve different industries were selected to develop an optimum strategy to build up general awareness about the operating cost sensitivity of the air compressors.

RESULTS AND DISCUSSIONS

These industries includes Mehroz Textiles, Sultan Rubber, Main Textiles, Sahtaj Textiles, Servis Industries, Ittehad Chemicals, Shahraj Fabric, Nishat Chunian, Packages Limited, Coke Lahore, Riaz Bottlers and Atlas Honda.

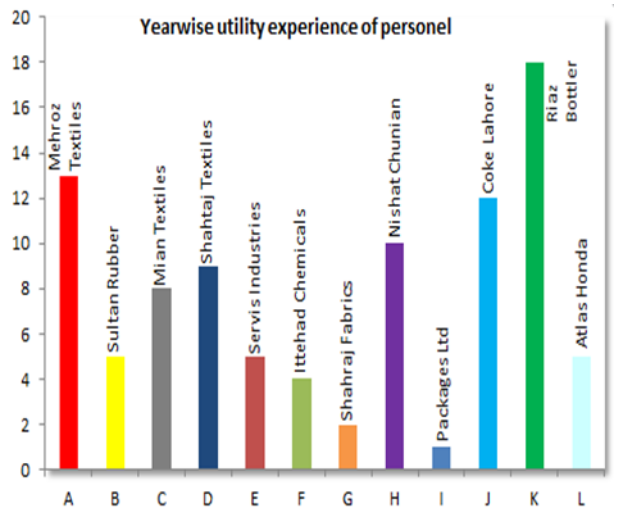

Figure 1: Year wise Utility Experience of Personnel in the Selected Industries

The Figure 1 shows the comparisons of personnel working in these organizations. The experience of the compressor room in charge ranges from 1 year (I- Packages Limited) to 18 years (K-Riaz Botlers). Figure 2, explains the power ratings of the air compressors installed at the facility of the targeted industries in the form of Kilo Watts Hours (KWh). The Nishat Chunian have comparatively maximum power ratings (3065 KWh), while Packages Limited has minimum consumption (23 KWh). The majority of the targeted industries have air compressors of power ratings were between 190 KWh to 800 KWh except Mian Textile (1250 KWh), Shahraj Textiles (1600 KWh) and Atlas Honda (1200 KWh).

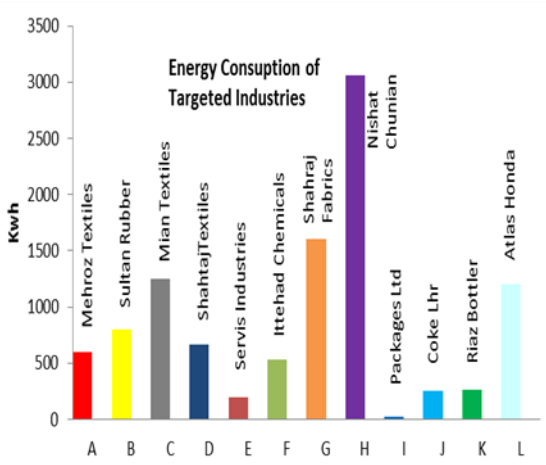

Figure 2: Energy Consumption of Targeted Industries

Figure 3 determines the area of leakages of the targeted industries. The most common areas of leakages were couplings, pipes, pipes joints, pressure regulators, hoses tubes, fittings etc. The analytical study shows that 50% of the compressed air leakages were through the couplings and pipes etc. The 25% leakages of the compressed air were observed in hose tube and fittings, while leakages through the hoses tubes, pipe joints and pressure regulators were 9%, 8% and 8% respectively.

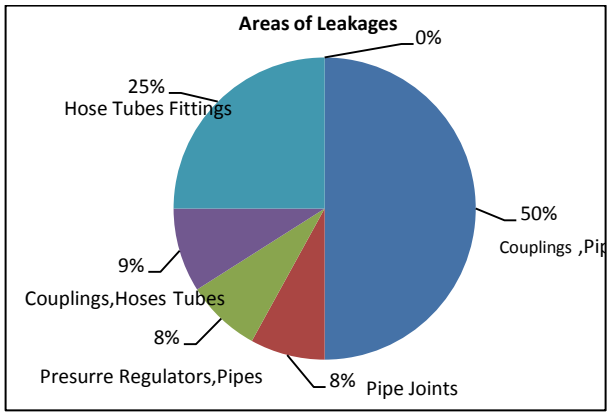

Figure 3: Areas of Leakages of the Targeted Industries

When the air is compressed in the compression chamber of an air compressor, it has normally 120 C° temperature. Therefore, this hot air is cooled through the cooler. In this way, the heat is rejected into the surroundings.

This rejected heat recovery is necessary for the quality of the compressed air. The survey shows that only 42% of targeted industries have a mechanism for compressor heat recovery, while 58% of the industries have not recovered this heat. It shows clearly about the loss of power which strengthens the novelty of the problem statement of this research. It is observed that 92% of the targeted industries have formal air leakages detection program. It shows the high concern and awareness of the targeted industry about the sensitivity of the problem. The most critical parameter of the air compressor is its total annual operational cost. The operational cost is the sum of maintenance cost and power consumption cost of the equipment.

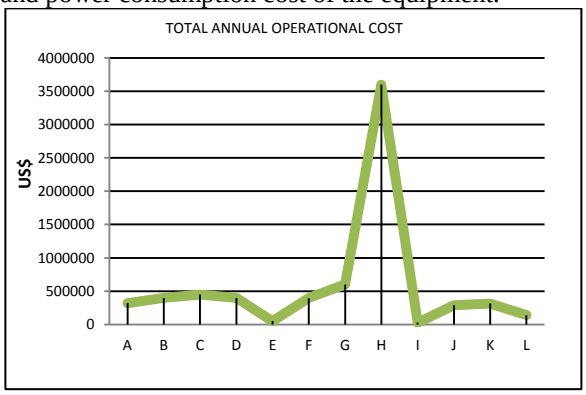

Figure 4: Total Annual Operational Cost

The Figure 4 explains the graph of the total annual operating cost of the air compressors working at a facility of the targeted industries. Nishat Chunian have maximum operational cost, i.e. $ 3600,000 (3.6 million US Dollars), whereas, the majority of the targeted industries has total annual operational cost between 0.13 million US Dollars to 0.6 million US Dollars. The commercial average unit (1 KWh) is of 14 rupees i.e. 0.14 US Dollars, and average annual maintenance cost excluding major overhauling and accidents is 3200 rupees (320 US Dollars). As per study, it is meaningful that the majority of targeted industries have no sufficient record in perspective of annual operational costs. If otherwise they have maintained such records, yet their concern personnel have no clear idea about these expenditures. This finding supports the research idea that there should be a comprehensive study about the compressed air power consumption and power savings.

It was the information of the annual cost of compressed air leakages which compelled the idea of comprehensive air audits of the compressed air machines to save energy.

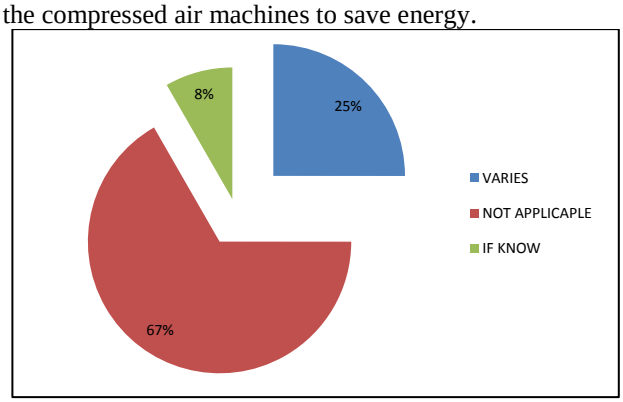

Figure 5: Annual Cost of Compressed Air Leakages Information

Figure 5 provides the information about the annual cost of the compressed air leakages. This clearly shows that 67% of the targeted industries have never calculated any estimated cost of the compressed air leakages. While 25 % percent of the targeted industries were concerned about this very factor of energy saving, but they have also no numeric clarity about the cost of the leakages as they reported that this cost varies over the period of time. Only 8% of the targeted industries claimed $ 10,000 as a cost of compressed air leakages. This industry has machines of capacity of 532 KWh., supposedly, the compressed air leakages cost was properly calculated, then $ 612864 was the total annual operational cost and 1.65 % of the annual operational cost was just due to air leakages.

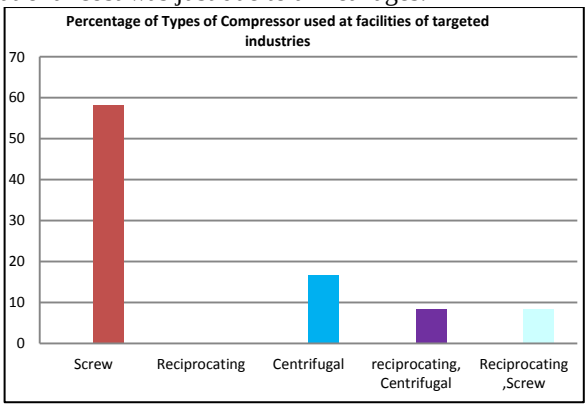

Figure 6: Percentages of Types of Compressor Used at Facilities of Targeted Industries

Figure 6 explains the different types of compressors used at the facility of the targeted industries. The 58% of the targeted industries used screw compressors; 18-20% of the targeted industries were using centrifugal compressors.

The combination of screw and reciprocating compressors was below 10 %, similarly the processor arrangement of centrifugal and reciprocating compressors were also below 10%. The critical analysis shows that the majority of the targeted industries are producing compressed air by using screw compressors which is costly as compared to centrifugal compressors. Industries can save much power if screw compressors are replaced by the centrifugal compressors. Generally, The screw compressors produces one cubic meter per minute using 6.5 KWh, while centrifugal compressors produce the same flow rate of compressed air using 4.8-5.2 KWh.

The control type of air compressors is very critical to save the energy. Variable frequency drive control is power efficient.

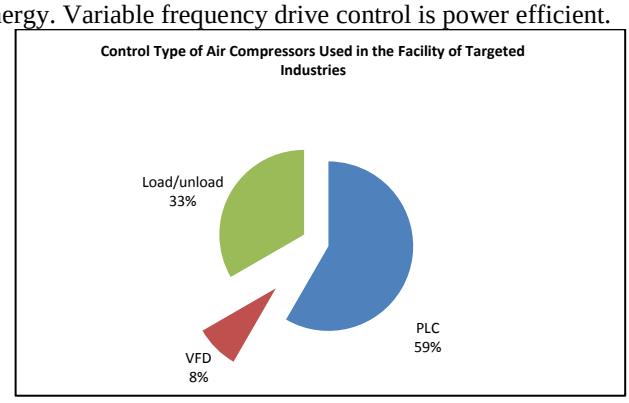

Figure 7: Control Type of Air Compressors Used in the facility of targeted industries

The Figure 7 shows that 33 % of the air compressors of the targeted Industries are using load/unload control, 59% PLC control and 8% VFD control type. Sometimes the compressors are running at zero capacity for a long time for fitness testing. This frequent practice increases the overall annual operational costs of the air compressors. However The industries are very concern about running of compressors at zero capacity during overhauling. 67 % of the industries usually do not operate compressors at zero capacity, while 33 % of the industries run compressors at zero capacity. The majority of the air compressors installed at the facility of the targeted industries use a combination of air dryers and filters (67%), on the other side some of the targeted industries use only air dryers for air treatment (33%).

Critical analysis shows the ratio of the temperature of the air controlled before compression. The methodology opted for the compressed air leakage inspection is very critical. The results show that leakage detection program adopted in the targeted industries were not appropriate. The data collected from targeted industries explains that 33% of the targeted industries used instruments while the rest were inspecting the compressed air leakages through experience. It means 67% of the targeted industries were unaware about the quantity of the compressed air leakages the research illustrates that only 25% of the targeted industries have proper leakages measuring program, while 75% of the targeted industries have no means to gauge the air leakages. The 75% of the industries commit that condition monitoring is carried out to check leakage detection. However, most of them were unaware of equipment/tools used for condition monitoring.

Figure 8 shows the questionnaire comparison of the targeted industries regarding inspection routine of the air compressors such that 50% of the targeted industries inspect the operation of air compressors on daily basis, while 34% observe aroutine inspection in every shift(after every 8 hrs), 8% of the targeted industries inspect these critical machines on weekly and monthly basis. 58% of the target industries are well cautious about the pressure drop monitoring of the air compressors. Whereas, 42 % of the targeted industries have no idea about the pressure drop monitoring of the air compressors. This pressure drop becomes more sensitive in case of frequent use of bend, elbows and tees in the compressed air main pipe line

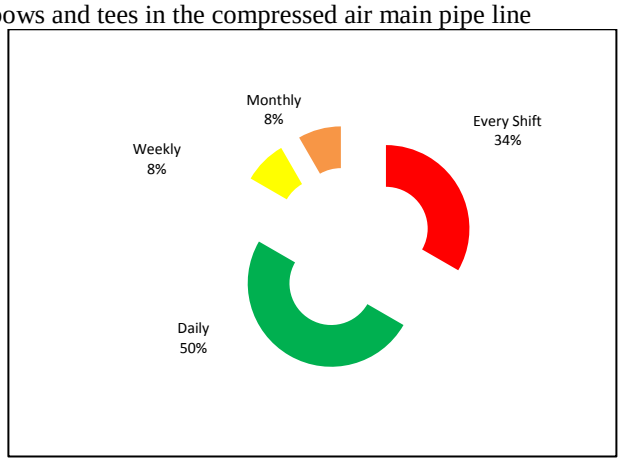

Figure 8: Inspection Routine

CONCLUSION

The air compressors are very critical machines in perspective of electricity utilization. Pressure drop, leakages, piping selection and environmental conditions are the major causes for the extravagant energy used by the air compressors. The management and the employee are mostly unaware about the sensitivity of these issues. The workers are not trained enough to maintain/operate the air compressors. The majority of the industries rely on the services of the air compressors service companies. This research probed out about the consensus and awareness of the workers employed at the facility of the different industries. This research will be helpful to determine the main causes of the air leakages and the technical approach for the remedial or corrective action.

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