No Cost – Low Cost Compressed Air System Optimization in Industry

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Abstract. Energy conservation is a systematic, integrated of effort, in order to preserve energy sources and improve energy utilization efficiency. Utilization of energy in efficient manner without reducing the energy usage it must. Energy conservation efforts are applied at all stages of utilization, from utilization of energy resources to final, using efficient technology, and cultivating an energy-efficient lifestyle. The most common way is to promote energy efficiency in the industry on end use and overcome barriers to achieve such efficiency by using system energy optimization programs. The facts show that energy saving efforts in the process usually only focus on replacing tools and not an overall system improvement effort. In this research, a framework of sustainable energy reduction work in companies that have or have not implemented energy management system (EnMS) will be conducted a systematic technical approach in evaluating accurately a compressed-air system and potential optimization through observation, measurement and verification environmental conditions and processes, then processing the physical quantities of systems such as air flow, pressure and electrical power energy at any given time measured using comparative analysis methods in this industry, to provide the potential savings of energy saving is greater than the component approach, with no cost to the lowest cost (no cost - low cost). The process of evaluating energy utilization and energy saving opportunities will provide recommendations for increasing efficiency in the industry and reducing CO\textsubscript{2} emissions and improving environmental quality.

1. Introduction

Energy conservation is the use of energy efficiently and rationally without reducing the energy usage that is really necessary. Energy conservation efforts are implemented at all stages of utilization, from utilization of energy resources to ultimate utilization, using efficient technology, and cultivating an energy-efficient lifestyle. There are three basic principles in the first energy conservation: eliminating energy waste (prevention); secondly, reducing energy losses (recovery) and the last is increasing the efficiency of energy utilization (innovation).

Industrial growth contributes vital to Indonesia's economic growth, but on the other hand the industry is also the largest energy user and also makes the industry sector has a significant greenhouse gas emission. Increased greenhouse gas emissions from burning fossil fuels and rising world fuel prices pose a serious threat to the environmental sustainability and economic sustainability of Indonesia. The results of a survey conducted by the United Nations Industrial Organization (UNIDO) in 200 Industries in 2009 showed that in general the process involving compressors as well as other equipment such as boilers and pumps is a significant point of energy users. The facts show that energy...
saving efforts in the process usually only focus on replacing tools and not an overall system improvement effort. The potential of the team involved in this research has been through various stages of education and training conducted by the Ministry of ESDM through the Directorate General of EBTKE, so it is expected that the research can run smoothly.

In this research a systematic technical approach in evaluating accurately a compressed-air system and its optimization potential through observation of environmental conditions and processes, then processing the physical quantities of systems such as flow (air flow), air pressure (pressure) and electric power unity work time (energy) measured using the comparative analysis method in the beverage industry as a case study, in the hope that it can provide greater energy saving potential compared to the component approach in no-cost to low cost cost). This study can also provide a more comprehensive picture of the potential of compressed air system optimization (CASO) as a basis for better action planning steps, as well as to provide better performance and reliability. Energy conservation in addition to the savings gained from energy efficiency the most important thing is also to reduce CO\textsuperscript{2} emissions in industrial processes [1].

2. Compressed air system optimization in industry
The program of forming a compressed air system in a country outside Indonesia is a best practice program and is a key component of one of the energy efficiency programs in the industry, initially supported by New Zealand government ministries and agencies. But in this global context it is not a new initiative because the program already exists and works in Europe and the United States, but in each case it affects after ten years and subsequently has been done with limited long-term improvements in overall energy efficiency [2].

Compressed air system installed almost 70% in all plants and not infrequently these systems pay between 20-30% of the total electricity consumption of the company. A review of the system and operational conditions will often result in one or more compressors that are closed or replaced with a more economical type of operation, as it will increase the overall efficiency of the system. To optimize the compressed air system, it is important to thoroughly investigate all equipment systems as well as their respective components. This means that in addition to examining the individual parts of the system, it is also necessary to analyze the inlet system side and discharge and interaction between them [3].

For this research, relevant data must be measured and then combined to yield an analysis of the energy-consumption patterns, under normal operational conditions, of the plant concerned, a sample of Compressed air system optimisation (CASO) in industry was taken in Bali Island. It represented the system that used in industry to produce product that can be finally distribute to the consumer. The type of this system was beverage industry with the following data that related to compressed air system and system operating costs consecutively. It has shown at table 1 and table 2 respectively.

**Table 1. The compressed air systems on site**

| System description | No of compressors | No of Running Compressors | Total rated output, SCFM | Total rated power, kW | Treatment system/dew point |
|--------------------|-------------------|---------------------------|--------------------------|----------------------|---------------------------|
| Compressor Room for Production Plant | 3 | 2 | 661.32 | 130 | Refrigerant |

Note: Compressor number 2 and 3 (35 kW) were not used due to out of service.

**Table 2. Systems operating costs**

|                              |                  |                  |
|------------------------------|------------------|------------------|
| Annual generating cost       | 12,429.72 USD    | 164,010.155 IDR  |
| Mean demand used to calculate cost | 230 SCFM         |                  |
| Mean power consumption       | 43 kW            |                  |
Specific power consumption 18.87 kW/100cfm
Annual energy consumption 162,480 kWh
CO₂ equivalent 128,360 kgCO₂eq
Unit cost 0.187 $/kWh
Operating hours per annum 3,744 12x6x52

3. Finding, discussion and recommendation

The plant air system

The sample plant of this research actually has 1 compressor GA-55 which was in good condition and 2 compressors GA-22 were out of service and need to be repaired. The compressor used as on/off load compressor has no VSD system. The single stage, oil injected, air cooled, GA-55 rotary screw machine distributed air in series to 2000 l air receiver tank, then it entered it refrigerant air dryer (FD-220 and FD-60) with pre and after filtration and finally is distributed to the production line. Both dryers were piped in 2” galvanised pipework. The capacity of compressors were 55 kW and 22 kW respectively. The measurement has been done in Compressor GA-55, then we get some data like: system pressure, air flow and electrical power consumption.

Figure 3.1. Shows a simplified layout of equipment in compressor house. The equipment installed in compressor room, such as: Compressors, Air Receiver Tank, Air Dryers.

(a) System Demand

Some measurements was taken during this research such as, pressure system along in wet and dry pipe at a certain point in the compressed air system, air flow, voltage and current being used by motor when load or unload. All of those data’s is store to data logger. System demand curve performance of air flow and pressure drop during full load and no load condition as shown in figure 3.2. In this case the factory runs over a 12 hours period from around 06.30 am to 22.30 pm. The first and last 2 hours of this period are devoted into cleaning period. The average production demand is 230scfm, this drops to around 75scfm when cleaning. Out of production/cleaning times the system is depressurized and the compressors do not run at all.
The compressor was set to load or unload on their internal pressure switches, there was no group controller. The individual settings are shown below:

| Unit | #1 | #2 | #3 |
|------|----|----|----|
| Unload Pressure | Barg | 7 | - |
| Load Pressure | Barg | 6.8 | - |

Figure 3.3 shows the characteristics of the pressure in the wet dry pressure under load and unload pressure. There was a pressure drop of 0.1 which was considered accepted.
A Curve performance of Pressure drop during full load and no load condition is shown in figure 3.4. We can see the individual pressure traces and the moving averages. The pressure drop is around 0.15barg during production periods, dropping to around 0.5barg when cleaning takes place due to the lessened flowing velocity through the treatment period. This level of pressure drop is acceptable within the best practice figure of 0.2barg from wet to dry.

![Compressor pressure drop](image)

**Figure 3.4.** Compressor pressure drop.

(c) Air generation costs

Based on the measured data and conversation with the sample plant, the annual generation cost can be calculated.

Parameters used:

| Unit Electricity Cost: | 5p/kWh = 7.65c/kWh = IDR 1009.418/kWh |
|-----------------------|-----------------------------------------|
| Annual Run Hours      | (24/6/50)                                |
|                       | Production: 12hrs/6days/52weeks          |
|                       | Cleaning: 4hrs/6days/52weeks             |
| Mean Demand           | 230scfm                                  |
|                       | Production: 230scfm                      |
|                       | Cleaning: 75scfm                         |

Figure 3.5 depicts the relationship between estimated generation costs with online capacity in cubic feet meter (cfm). There are differences the use of each compressor. The currently installed compressor, that operates GA-55, has the highest generation cost compare to others. It was found that the use of two GA-22 is more cost efficient.
(d) Leakage

A limited leak detection survey was carried out in the compressor and production house, using ultrasonic leak detectors. The total leak flow which can be saved is around 71cfm, it is about 15.62 kW. Total Cost of Leakage was £3,899, it converted to dollars became $5,965.47 or 78,714,376.65 IDR. From the survey, the biggest leakage was from junction pipe at Compressor house which was 41cfm, PI and UnCaser were 15cfm. The action of repairing of this leak is a low-cost action which has big result in the reduction of energy consumption, so that the implementation needs to be taken seriously.

As we can see from figure 3.6a the blue chart refers to Compressor House, the purple one refers to PI site and cream colour one refers to UnCaser site. The biggest leakage among others was from Compressor House with the cost of leakage around £2,251 and both of PI and UnCaser site with the cost of leakage around £824. The frequency of occurrences of leaks is presented in figure 3.6b above. The number of occurrence of leaks frequency at Scale 5 and 8 are the same that is 3 times. These occurrences contribute big release air being produced.

No cost - low cost recommendations for improvements and savings

Some recommendation to no cost-low cost for improvement and saving:

- Detail calculation has been given to the cost saving was 78,714,377 IDR/yr. with CO₂ savings was 46,200 Tonnes/yr. when site leakage is reduce. Reducing site leakage will reduce compressed air usage, reducing compressor power consumption is about 58,481 kWh/yr. The
locations which we focus to identify the leak are: Compressor House, PI, and Un Caser site. There are no risks to implementing leak reduction. For the next step, do site setup leak detection campaign.

- Repair two compressor type GA-22 and replace the Compressor GA-55 in term of applicable in use as production and cleaning. Cost of saving during a year was 141,500,145 IDR/yr. with CO₂ being release was 110,737 Tonnes/yr. and electrical power consumption was 140,174 kWh/yr. The currently installed compressor, that operates GA-55, where it has the highest generation cost compare to others. The use of two GA-22 are more cost efficient compare with GA-55 and no Risk. Find the appropriate selection of compressor base on requirement process.

4. Conclusion

- It can be conclude that the total compressed air generating cost was related to total identified savings was 220,214,522 IDR/yr. with CO₂ savings was 156,937 Tonnes/yr. and power consumption was 198,655 kWh.

- No cost – Low cost action plan should be taken into account base on recommendation given with the 1st priority is leak reduction and 2nd is repair and running compressor GA-22 as soon as possible either for production or cleaning process.

5. References

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