

# International Journal of Innovative Research in Science, Engineering and Technology

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## Energy Saving In Glass Bottle Manufacturing Plant

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**ABSTRACT:** Energy saving is very essential in the present scenario for all types of industries. Global warming and higher carbon footprint is resulting in climatic changes across the world. In glass bottle manufacturing plant, energy consumption is very high as furnaces are used. Annual operating cost of compressed air system is also high in the glass bottles manufacturing plant. Leakages and pressure drop are the main cause for energy loss in compressed air system. Inefficient improper compressed air system and pressure drop may increase the percentage of defective bottles. The objective of the project is to reduce the operating costs and energy consumption by reducing the pressure drop and thus reducing the percentage of defective bottles manufactured due to insufficient pressure. The annual energy consumption leakage percentage and energy loss of the existing compressed air system is calculated with the collected data. The pressure drop in the system is reduced by modifying this system by adding a secondary air receiver. A set of pipes and valves are fitted to implement the modification without disturbing the existing layout. The annual energy consumption leakage percentage and energy loss are calculated for modified arrangement at the same operating pressure and increased operating pressure. On analysis, it is found that energy loss is reduced by 18.1 % in the modified compressed air system.

**KEYWORDS:** Global warming, manufacturing plant, pressure, valves, compressed air system.

### I. INTRODUCTION

In most industrial facilities, compressed air is necessary for manufacturing. Compressed-air generation is energy intensive, and for most industrial operations, energy cost for compressed air is significant compared with overall energy costs. The glass industry also consumes lot of energy. Fuels are burnt to create a high temperature inside the furnace, where the batch is reacted, vitrified, degassed, homogenized, and taken out as products (e.g. glass bottles). Compressed air is used for blowing the bottles and for pneumatic components of the machine. The conservation of energy is an essential step for overcoming the mounting problems of the worldwide energy crisis and environmental degradation. In particular, developing countries are interested to increase their awareness on the inefficient power generation and energy usage in their countries. Annual operating costs of air compressors, dryers, and supporting equipment's is high; so energy saving is important in increasing the efficiency of manufacturing companies. The two main types of glass container used in food packaging are bottles, which have narrow necks, and jars and pots, which have wide openings. Glass closures are not common today, but were once popular as screw action stoppers with rubber washers and sprung metal fittings for pressurized bottles, e.g. for carbonated beverages, and vacuumized jars, e.g. for heat preserved fruits and vegetables. Ground glass friction fitting stoppers were used for storage jars, e.g. for confectionery.

Glass bottles are widely used for beers, wines, spirits, liqueurs, soft drinks and mineral waters. Within these categories of food and drinks, the products range from dry powders and granules to liquids, some of which are carbonated and packed under pressure, and products which are heat sterilized. Glass containers continue to be the preferred package for a variety of foods and beverages. The reasons behind the long-standing preference are numerous and include that glass containers are made from raw materials that are abundant and inexpensive.

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## II. RELATED WORK

### *Energy Saving Methodologies for Compressed Air Systems*

Ryszard Dindorf (2012) has stated that compressed air is typically one of the most expensive utilities in an industrial facility. While designing energy saving compressed air systems various methods are applied to reduce energy losses and minimize energy consumption. The compressed air systems require the complex approach towards rational energy consumption by effective production, distribution and application equipment of the compressed air. As a first step towards identifying applicable energy savings an inventory of compressed air system and major system operating parameters should be established. On the basis of the data collected, the basic indicators of compressed air system performance can be calculated or estimated: specific power, annual energy cost, cost of compressed air, compressed air leaks, pressure drop in a system. From this review, as a result, potential savings opportunities are aggressively sought out and identified. Once identified, projected energy savings must be calculated in order to justify the cost of implementing the savings opportunity. It is important to calculate projected energy and cost savings as accurately as possible. There are three important reasons why it is worth investing time and effort in reducing compressed air costs: it will save energy and money by identifying and eliminating waste; it will improve the reliability and performance of the compressed air system; it will reduce environmental impact through reduced electricity consumption and consequent lower carbon dioxide (CO<sub>2</sub>) emissions.

R. Saidur et al (2010) has reviewed the compressed-air systems account for about 10% of total industrial-energy use for few selected countries as found in literatures. Compressed air is typically one of the most expensive utilities in an industrial facility. This paper describes a comprehensive review about compressed air energy use, savings, and payback period of energy efficient strategies. Payback periods for different energy savings measures have been identified and found to be economically viable in most cases. Methodology explains the energy audit, the data needed for energy analysis, in estimating energy savings and emission reductions by high-efficiency motor, variable speed drive, preventing leak, use of intake air temperature, reducing pressure drop, recovering waste heat and use of efficient nozzle. Durmus Kaya et al (2002) has evaluated and quantified the energy losses associated with compressed-air systems, and their costs to manufacturers. They also show how to reduce the cost of compressed air in existing facilities by making some modifications with attractive payback periods. Among the measures, we investigate to reduce the compressed air are: (1) repairing air leaks, (2) installing high-efficiency motors, (3) reducing the average air inlet temperature by using outside air (4) reducing compressor air pressure. From this review, a considerable energy and money can be saved in compressed-air systems in industrial facilities by attractive common sense measures. These measures are: repairing air leaks, installing high-efficiency motors, reducing the average air inlet temperature by using outside air, reducing compressor air pressure.

### *Glass Manufacturing and Environmental Impacts*

Miroslav Kovacec et al (2011) have investigated the glass production of glass containers requires large amounts of raw materials, such as: silica sand, soda, dolomite, etc., and substantial quantities of energy since the production cycle is extremely energy-demanding. The aim of this paper is to present how the usage of waste glass in the production of glass packaging saves the raw materials for the production of glass, reduces energy necessary for the exploitation and melting of raw materials, thus preserving also the un renewable sources of energy such as natural gas, fuel oil or electricity, which are mostly used as energy sources in the production of glass packaging. Besides, since fewer energy sources are used, the emission of harmful gases (CO<sub>2</sub>, NO<sub>x</sub>, particulates, etc.) into the environment is lower. By using glass cullet, which is obtained by waste glass recycling, the quantity of municipal waste is reduced, and in this way the environment is preserved as well. From this paper, The recycling of waste glass packaging is thus claimed to preserve the environment, since the raw materials are not exploited, energy is saved, the emission of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub> particles is reduced because less heat energy which is usually obtained from land gas and electrical energy is needed for the melting of glass cullet than for obtaining of glass melt from raw materials. It is also necessary to work on the

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development of new technologies such as electric boosting, better refractories, oxygen enriched by combustion air, chemical boosting, etc.

## III. THEORETICAL INVESTIGATIONS

### *Energy Saving and Its Factors*

Energy saving or energy conservation efforts in industrial activities are directly connected to the effect of controlling the increase in cost by reduction of unit energy consumption in industry, leading to intensified competition. At the same time, such efforts provide an essential means for the improvement of the global environment so that the human being will maintain its health for a long time to come. It is imperative for the industrialists to understand that the energy conservation is one of the most important policies for industry, the nation and the world. The factors that affect energy savings are valve systems, filters, hoses, check valves, relief valves, extensions, and the equipment connected to the compressed-air lines. The energy consumption can be calculated using parameters like specific energy consumption, free air delivery, energy cost, leakage rate and cost, energy loss and cost.

### *Glass Bottle Manufacturing Process*

The glass composition determines the physical and chemical properties of the glass, and varies therefore for each product/application. Of particular interest for most applications are the chemical durability, the transmission, the softening point and the thermal expansion of the glass. Depending on their function, glass-forming oxides can be grouped into network formers intermediate oxides (for example  $Al_2O_3$ ), and network modifiers (for example  $Na_2O$ ).

The use of 5 to 25 percentages by weight of clean cullet is not uncommon; in the case of colored container glass, sometimes more than 90 weight percent of cullet from post-consumer glass is used. Fig .1 shows the simplified overview of glass bottle manufacturing.

### *Melting & Refining*

With the exception of a few specialty glass manufacturing processes, continuously operated tank furnaces are commonly used for the melting of glass. Typical glass-melting furnace ("tank") consists of a batch charging area ("doghouse") attached to a refractory basin covered by a refractory superstructure ("crown"). Common heating methods are combustion-heating (oxy-fuel, air-fuel burners) and direct electrical heating ("Joule heating"), as well as combinations of both ("electric boosting"). The process of refining (also known as fining) takes place in the melting chamber. During this process, the batch of molten glass is freed of bubbles, homogenized, and heat conditioned before the glass is introduced into the fore hearth.

### *Conditioning*

After completion of the refining stage the fairly homogenous, bubble-free glass leaves the tank and enters the fore hearth, sometimes through a specifically designed pathway (channel, "throat"). Main function of the fore hearth is to condition the glass, i.e. to deliver glass with the desired temperature and temperature distribution to the forming process. Deviations from the desired thermal profile can cause undesirable differences in viscosity, and subsequently lead to visible defects in the finished product. Forehearths can be gas-fired or electrically heated.

### *Forming*

The conditioned glass is delivered from the fore hearth to the forming equipment at a constant rate ("pull rate"). Depending on the process, the viscous glass stream is either continuously shaped (float glass, fiber glass), or severed into portions of constant weight and shape ("gobs") which are delivered to a forming machine (container glass). There are currently two primary methods of making glass containers: the blow & blow method for narrow neck containers only, and the press & blow method used for jars and tapered narrow neck containers. In both methods, a stream of molten glass, at its plastic temperature (1,050–1,200 °C [1,920–2,190 °F]), is cut with a shearing blade to form a solid cylinder of glass, called a gob. The gob is of predetermined weight just sufficient to make a bottle. Both processes start

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with the gob falling, by gravity, and guided, through troughs and chutes, into the blank moulds, two halves of which are clamped shut and then sealed by the "baffle" from above.

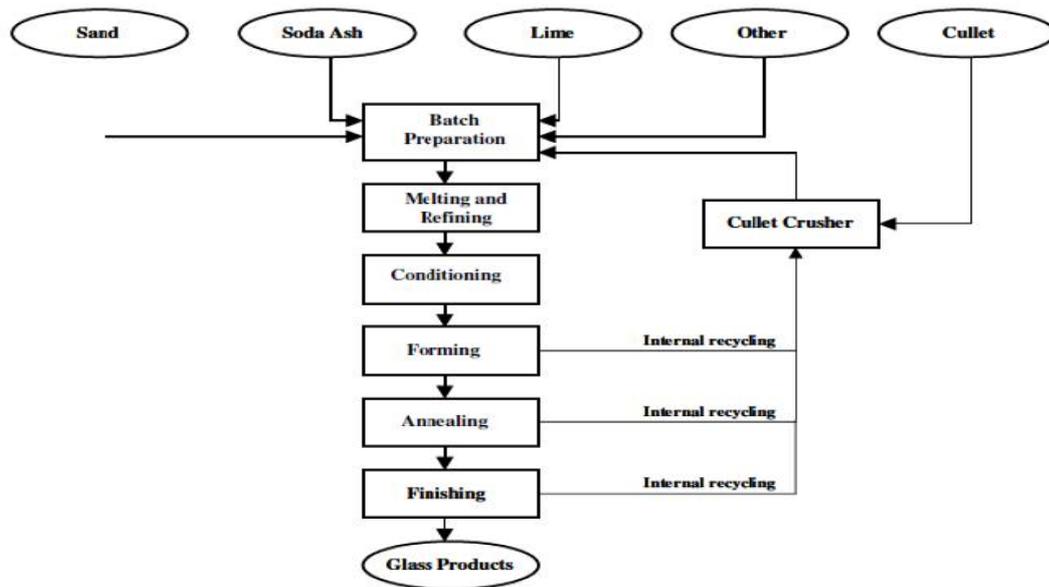


Fig 1: Schematic diagram of glass manufacturing process

## IV. DESIGN METHODOLOGY

The main objective of the project is to reduce the energy loss in the glass bottle manufacturing plant. The compressed air system of the plant is taken up for this project for energy savings as it is also a cause for defective bottles. The methodology used in this project work is shown in Fig 2.

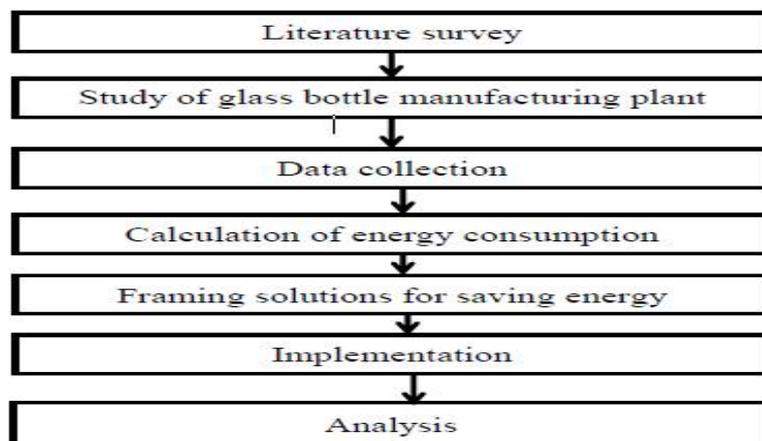


Fig 2: Methodological frame work for energy saving in glass bottle manufacturing process

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## V. PLANT LAYOUT AND ARRANGEMENT

The layout and workflow of the glass bottle manufacturing plant is described in the following sections.

### Batch house

Batches are processed in the batch house. It is one of the initial steps of the glassmaking process. The batch house simply houses the raw materials in large tanks and holds anywhere from 2 days of material. Some batch systems include material processing such as raw material screening, drying. The batch house measures, assembles, mixes, and delivers the glass raw material by conveyors, and scales to the furnace.

### Furnace

Furnace is located in centre of the plant. The batch is fed into the furnace at a slow, controlled rate by the batch processing system (batch house). The furnaces are LPG or fuel oil fired, and operates at temperatures up to 1,575 °C (2,867 °F) to 1600 °C. The temperature is limited only by the quality of the furnace's superstructure material and by the glass composition.

### Forming machines

Forming machines are placed in the way of fore hearth gob delivery. The forming machines hold and move the parts that form the container. The machine consists of basic 19 mechanisms in operation to form a bottle and generally powered by compressed air (high pressure 3.45 bar and low pressure 2.85 bar). They are electronically timed to coordinate all movements of the mechanisms. The most widely used forming machine arrangement is the individual section machine (or IS machine). This machine has a bank of 5 identical sections in the plant. Each section which contains one complete set of mechanism to make containers.

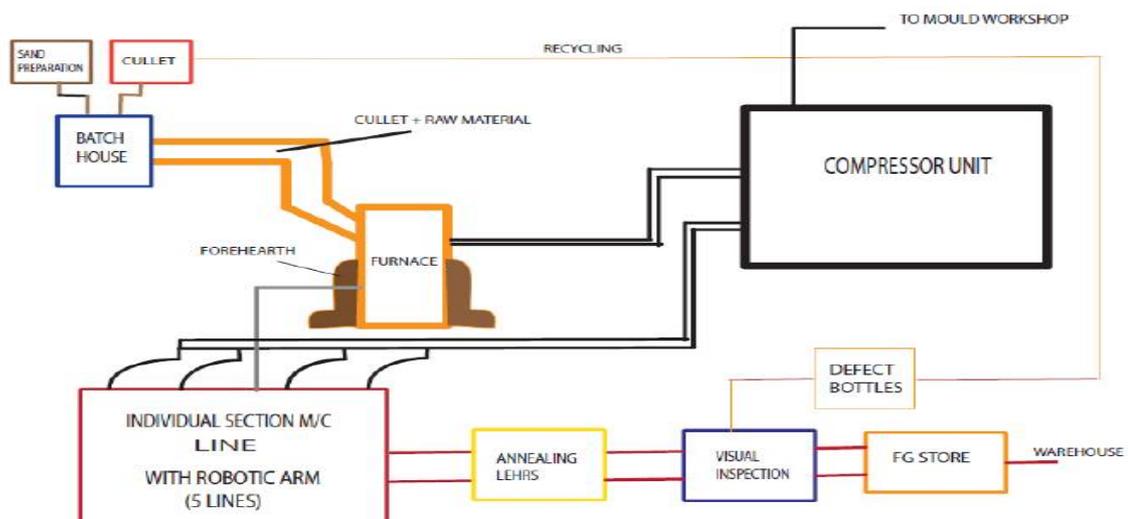


Fig 3: Glass bottle manufacturing process arrangement in the plant

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### Annealing

Annealing lehrs are located in the 5 individual section lines. As glass cools, it shrinks and solidifies. Uneven cooling causes weak glass due to stress. Even cooling is achieved by annealing. An annealing oven (known in the industry as a Lehr) heats the container to about 580 °C (1,076 °F), then cools it, depending on the glass thickness, over a 20 – 60 minute period.

### Cold end

The role of the cold end is to spray on a polyethylene coating for abrasion resistance and increased lubricity, inspect the containers for defects, package the containers for shipment, and label the containers.

### Visual Inspection

Visually inspection is done to find the glass bottles defects in the single line conveyor before packing. Defective bottles are to be collected for recycling.

### FG Store

Finished goods store is used to store the bottles before the shipment. The bottles are stacked in the corrugated box and covered with the help of shrink films.

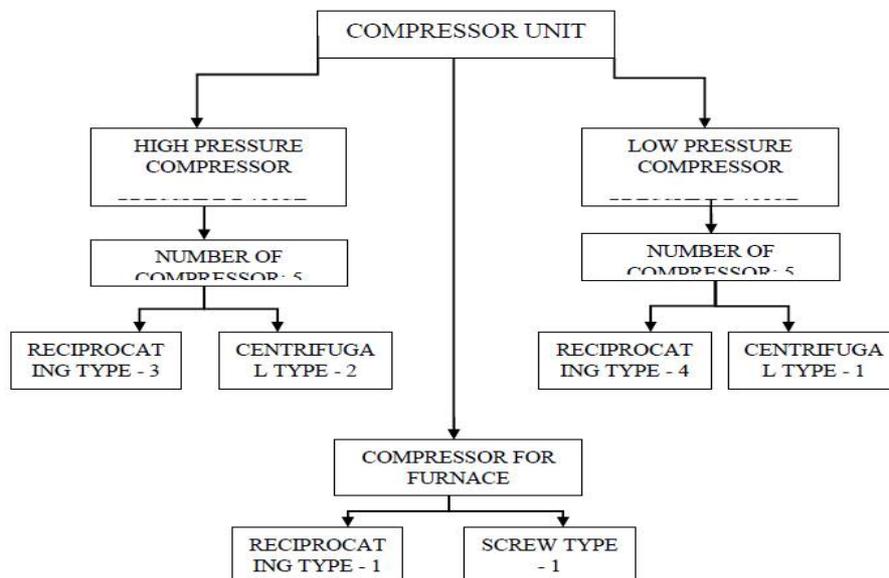


Fig 4: Compressor unit and compressor types

In this design, the PIC microcontroller is used as a gateway communicate to the various sensors such as temperature sensor, heartbeat sensor, ECG sensor, sensor for keeping a track of drip level (blood or saline).The microcontroller picks up the sensor data and sends it to the network through a Wi-Fi and hence provides real time monitoring of the health care parameters for doctors. The controller is also connected with buzzer to alert the caretaker about variation in sensor output. At the time of extremity situation alert message is sent to the doctor through the android application connected to the cloud server. Hence quick provisional medication can be easily done by this system. Also an additional subsystem is

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provided for prediction of heart disease for the patient based on his/her health parameters. This system is efficient with low power consumption capability, easy setup, high performance and time to time response.

## HIGH PRESSURE LINE

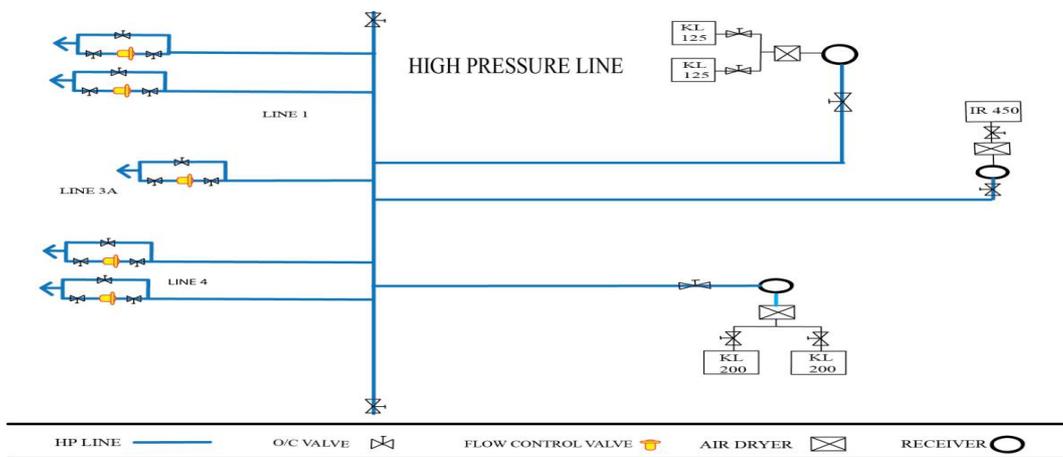


Fig 5: High pressure line arrangement in plant

## LOW PRESSURE LINE

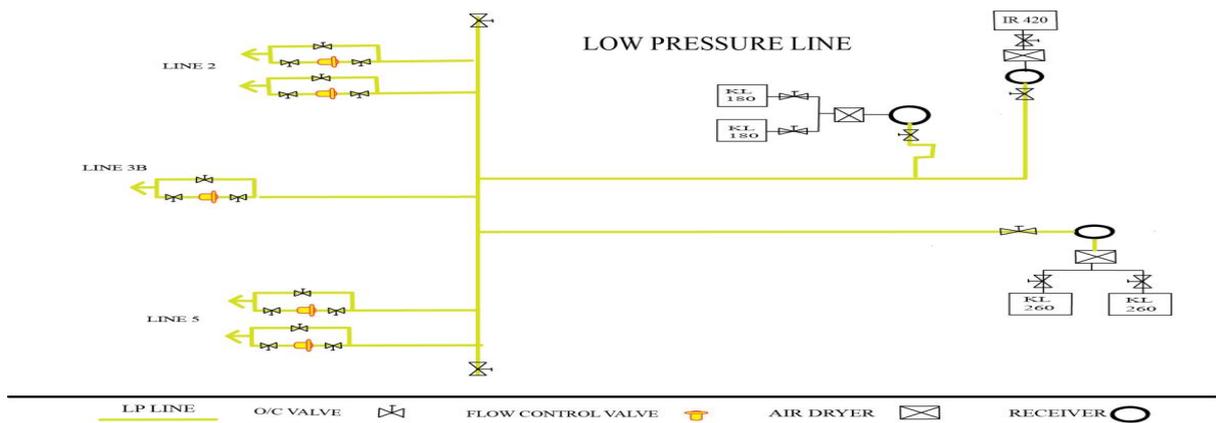


Fig 6: Low pressure line arrangement in plant

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## VI. RESULT ANALYSIS AND DISCUSSIONS

### *Average Power Draw*

Average power draw depends on energy consumed by the compressor to generate pressure in the compressed air pressure line. The average power draw for old arrangement and the modified compressed air system are given in the following table. Comparing the three results, 52.5 kW is saved. Annual energy consumption is reduced up to 60.2 %.

Average power draw Kw			
	OLD ARRANGEMENT	MODIFIED ARRANGEMENT	INCREASING OPERATING PRESSURE IN MODIFIED ARRANGEMENT
HIGH PRESSURE LINE 450 kW	8.71	14.34	6.20
LOW PRESSURE LINE 420 kW	10.16	14.98	7.29
LOW PRESSURE LINE 260 kW + 260 kW	24.74	27.31	13.71
HIGH PRESSURE LINE 200 kW + 200 kW	26.87	32.35	13.96
LOW PRESSURE LINE 180 kW + 180 kW	30.72	33.96	19.07
HIGH PRESSURE LINE 125 kW + 125 kW	30.69	40.17	19.16
<b>TOTAL</b>	<b>131.89</b>	<b>163.11</b>	<b>79.39</b>

Table 1: comparison of average power draw

### *Annual Energy Consumption*

Annual energy consumption depends on average power draw of the compressor to generate pressure in the compressed air pressure line. The annual energy consumption for old arrangement and the modified compressed air system are given in table 9.2. Comparing the three results, 459996.36 kWh/Yr is saved. Annual energy consumption is reduced up to 60.2 %.

Annual energy consumption kWh/ yr			
	OLD ARRANGEMENT	MODIFIED ARRANGEMENT	INCREASING OPERATING PRESSURE IN MODIFIED ARRANGEMENT
HIGH PRESSURE LINE 450 kW	76299.60	125662.20	54312.00
LOW PRESSURE LINE 420 kW	89,001.60	131224.80	63860.40
LOW PRESSURE LINE 260 kW + 260 kW	216801.24	239235.60	120160.92
HIGH PRESSURE LINE 200 kW + 200 kW	235381.20	283386.00	122289.60
LOW PRESSURE LINE 180 kW + 180 kW	269186.04	297489.60	167053.20
HIGH PRESSURE LINE 125 kW + 125 kW	268844.40	351889.20	167841.60
<b>TOTAL</b>	<b>1155514.08</b>	<b>1428887.40</b>	<b>695517.72</b>

Table 2: comparison of annual energy consumption

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## VII. CONCLUSION

The objective of the project work is to reduce the energy consumption in the compressed air system of glass bottle manufacturing plant. Energy savings by identifying and eliminating pressure drop. The working characteristics of the compressor used in the plant are studied. Compressed air requirement of the plant is found and the high pressure and low pressure compressed air line layout is drawn. Data is collected for all compressors by using receiver filling method. With the collected data, annual energy consumption for the compressed air system, the leakage percentage and the energy losses are calculated. Based on this data, corrective measures are found and modified for reducing the energy loss. Data is collected for new modified arrangement at same working pressure and increased operating pressure. All the energy consumption and energy loss results are calculated with the help of collected data.

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