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Design and Fabrication of Reciprocating Air Compressor for Electro Pneumatic Trainer Kit

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***Abstract*: An air compressor is a device that converts power using an electric motor into potential energy stored in pressurized air. By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its engineered upper limit, the air compressor shuts off. The compressed air, then is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of application, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, air compressor turns on again and re-pressurizes the tank. An air compressor must be differentiated from a pump because it works for any air, while pumps works on a liquid.**

***Keywords*: potential-air source, storage tank-air reserve**

1. Introduction

A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor.

Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids.

2. Literature survey

Gyberg and Stent Nissen [1] have developed a model for fixed vane refrigerant rotary compressors which is based on a control volume for suction and pressure. The first law of thermodynamics and the law of continuity in dynamic form are used on these control volumes. The thermodynamic properties, mass flow, heat effect and compression power are calculated as a function of time or angle of rotation instead of a static average value. The developed model describes suction mass flow, pressure drop and temperature rise in suction pipe, gas leakage from pressure volume to suction volume, oil leakage from shell and shaft to suction and pressure volume, shaft torque arising from gas forces and pressure, temperature, internal energy and enthalpy from the refrigerant equations. The differential equations for the first law of thermodynamics and the law of continuity are solved numerically by a simple Euler integration. The calculated values of volumetric efficiency are validated with measurements. It was observed that the measured values are closer to the experimental values.

Chi and Didion [2] presented a simulation model of a heat pump. The heat pump utilised a hermetic reciprocating compressor. The model equations were developed using a polytropic approach. Simulation of a 4-ton residential air-to-air heat pump operating in the cooling mode was performed with R-22 as the working fluid. The simulated start-up transients were compared to experimental data.

Davis and Scott [3] outlined a hermetic compressor model for use in a system simulation. The steady-state compressor model included heat transfer within the compressor shell and pressure drop in the suction and discharge passages. In addition, the model included the electric motor dynamics and allowed for the modeling of different compressor sizes and speeds. The model required that the mechanical and volumetric efficienciesare specified as input parameters. These parameters were to be determined from experimental data. No experimental verification or simulation results were presented.

Cecchini and Marchal [4] developed a general steady-state system simulation model based on experimental data. An attempt was made to develop component models in which the component could be characterized by a small number of parameters estimated from a few experimental data points. The compressor model utilized a polytropic-based expression for predicting the discharge refrigerant state similar in form to the reversible polytropic work of compression. The polytropic exponent was defined as an input parameter to the model. The steady-state refrigerant mass flow rate was estimated using an equation based on the pressure ratio and polytropic exponent with the compressor displacement and the clearance fraction as equation parameters. Although the model accounted for different compressor geometries, none of the model equations contained a reference to the compressor speed. It was unclear what assumptions were made about heat loss from the compressor and how the compressor power was determined. The details concerning the development of the compressor model equations were not provided. The system model was verified through the use of experimental data. For an air-to-air system, the model was able to predict the compressor power within ± 10 %. Furthermore, when the model was used to simulate an air-to-water heat pump, the compressor power was

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predicted to within ± 7 %.

Seshaiah et. al. [5] have developed a mathematical model of a rotary twin screw compressor. Mathematical analysis was carried out on the basis of the laws of perfect gas and standard thermodynamic relations. Heat transfer coefficient required for computer simulation was experimentally obtained and used in performance prediction. The behaviour of control mechanism has been theoretically investigated by a simulation model of control mechanism of variable displacement swash plate compressor of automotive air conditioning system developed by Changqing Tian et. al. (2007).

3. Block diagram

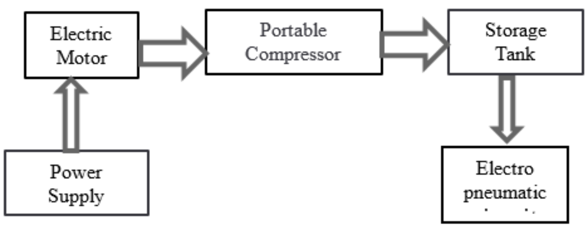

Fig. 1. Block diagram

A. Electric Motor

An electric motor is a device converting electrical energy into mechanical energy (usually a torque). This conversion is usually obtained through the generation of a magnetic field by means of a current flowing into one or more coils.

DC motor:

A dc motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields.

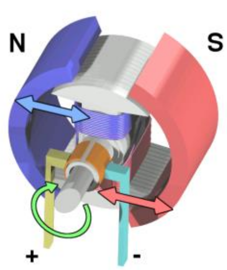

Fig. 2. DC motor

B. Storage tanks

Storage tanks are containers that hold liquids, compressed gases (gas tank; or in U.S.A "pressure vessel", which is not typically labeled or regulated as a storage tank) or mediums used for the short- or long-term storage of heat or cold. In the USA, storage tanks operate under no (or very little) pressure, distinguishing them from *pressure vessels*. Storage tanks are often cylindrical in shape, perpendicular to the ground with flat bottoms, and a fixed flangible or floating roof. These tanks may be called *cylinders* and, being pressure vessels, are sometimes excluded from the class of "tanks".

Fig. 3. Storage tanks

C. Piston

A piston is a component of reciprocation engines, reciprocating pumps, gas compressors and and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder.

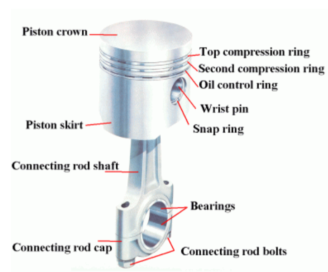

Fig. 4. Piston

D. Pressure gauges

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of force per unit of surface area. Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure meters or pressure gauges or vacuum gauges. A manometer is a good example, as it uses the surface area and weight of a column of liquid to both measure and indicate pressure. Likewise, the widely used Bourdon gauge is a mechanical device, which both measures and indicates and is probably the best known type of gauge.

Fig. 5. Pressure gauges

E. Double acting cylinder

A double-acting cylinder is a cylinder in which the working fluid acts alternately on both sides of the piston. In order to connect the piston in a double-acting cylinder to an external mechanism, such as a crank shaft, a hole must be provided in one end of the cylinder for the piston rod, and this is fitted with a gland or "stuffing box" to prevent escape of the working fluid. Double-acting cylinders are common in steam engines but unusual in other engine types. Many hydraulic and pneumatic cylinders use them where it is needed to produce a force in both directions. A double-acting hydraulic cylinder has a port at each end, supplied with hydraulic fluid for both the retraction and extension of the piston. A double-acting cylinder is used where an external force is not available to retract the piston or it can be used where high force is required in both directions of travel.

Fig. 6. Double acting cylinder

F. Connecting rod

A connecting rod, also called a con rod, is the part of a piston engine which connects the piston to the crankshaft. Together with the crank, the connecting rod converts the reciprocating motion of the piston into the rotation of the crankshaft. The connecting rod is required to transmit the compressive and tensile forces from the piston, and rotate at both ends.

The predecessor to the connecting rod is a mechanic linkage used by water mills to convert rotating motion of the water wheel into reciprocating motion.

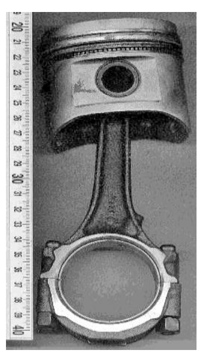

Fig. 7. Connecting rod

G. Compressor hoses

A durable air compressor hose is an essential accessory for many industries, ranging from automotive repair to roofing. It's important to know that these products are reliable, especially if you plan to use them every day. At Compressed Air Systems, we have an assortment of hoses available for purchase, all of which are designed for use in even the toughest environments. We have hoses in a wide variety of lengths, diameters, working pressure ratings, and types of connections, so you'll be able to find a hose to suit your needs. In fact, we offer retractable air hoses that are easier to store than regular hoses because they stay coiled and out of the way when they're not in use. If you'd rather purchase a regular air hose, you can also buy one of our hose reels to make it easier to keep your hoses organize.

4. Conclusion

This paper presented the implementation of reciprocating air compressor for electro pneumatic trainer kit.

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