Electro-Pneumatic Servo System

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Abstract

A predictive pneumatic circuit, able to harness to provide power to a variety of mechanisms or machines depending upon their application, has been proposed. With the emergence of the pneumatic-servo system, pneumatic system control is extended from logical control to servo control area. The model can be used as a tool to assess a-priori the operations of turbines, manufacturing and other related industries and can be easily coupled to kinetic models for process simulation. The input parameters to the model include the air pressure inside the compressor and the type and magnitude of voltage provided to the double solenoid servo valve. The model has been successfully verified and tested with satisfactory results. The model output, to successfully provide the actuating force to a piston, is assessed critically. The proposed circuit, if used, can be pivotal in transforming typical hydraulic circuits into their pneumatic counterparts. Pneumatic systems can be connected with hoses, pipes or tubing without difficulty, producing a large amount of linear energy. Using pneumatic systems is economical and environmental friendly, as air is inexpensive, plentiful and easily compressed and stored in tanks.

Keywords: Pneumatic, Servo System, Electro Pneumatic

1 Introduction

The use of servo mechanisms to provide actuating forces and to correct the performance of a mechanism has been intensively exercised. Since the circuit of the servo mechanism involves a feedback loop, it is hence called an "*electro-servo system*". Servos are commonly electrical or partially electronic in nature, using an electric motor as the primary means of creating mechanical force. Other types of servos use hydraulics, pneumatics, or magnetic principles. A servo mechanism is unique from all other control system as it controls a parameter by controlling the time based derivative of that parameter. For example, if the servo mechanism is meant for controlling position, it uses a feedback loop to command the velocity (which is the time-based derivative of position) of the mechanism.

The dynamics involved in the use of servo valves helping to regulate the fluid flow through the valve in a proportional manner are inherently very complex. Several modeling efforts making various assumptions regarding the flow structure and employing very different mathematical formulations have been known to have appeared in the recent literature. In many cases it found that it is difficult for pneumatic-servo system to track the position continuously because of the substantial nonlinearities of air compressibility valve dead zone and saturation and cylinder friction [1], [2]. Servo-electrical drive systems have been dominated up presently in the continuous position tracking. More recently, nonlinear control law have been developed using the full nonlinear dynamics of pneumatic system using feedback linearization techniques [3]. The model proposed, however, aims at simplifying these efforts by projecting a circuit that not only makes the use of a double solenoid valve as a servo valve but this valve provides a basic actuating force to the piston. The main objective of this work consisted in the development of a fully predictive and dynamically tractable model which could typify an electro pneumatic servo system.

2 Motivation

Servo Mechanisms were first used in military fire-control and marine navigation equipment. Electro hydraulic actuator can apply high forces and have a high-power-to-volume ratio partly because, next to actuating, they can also be used as construction elements. In case of steam turbine, these are used for rapid closing of valves between the turbine and boiler by opening a drainage valve. The use of servo systems in various fields is phenomenal, but one such use of these in the active suspension system in automobiles provided the impetus required to model the circuit. The objective of the work is to provide a pneumatic equivalent of any hydraulic circuit which can be used for any application.

3 Working Principle

The circuit diagram, along with the components used and their assembly, is shown in Fig (1). It also shows symbols for some typical components found in a hydraulic/pneumatic circuit diagram. Here, the valve is being used to actuate the cylinder. Atmospheric air is compressed to 100 psi using the air compressor. This compressed air now passes through the Filter-Regulator-Lubricating (FRL) Unit that, apart from controlling the flow rate, also checks the pressure at which air enters the double solenoid valve using the pressure gauge. The movement of the spool (or the actuation of the cylinder) depends upon the solenoid that is being energized. Thus, 3 cases arise:

Case I: When solenoid A is energized (Left Hand square):

Pressure port P is connected to port A. As a result, air under pressure enters the rod-side of the cylinder, causing the rod to retract. Air in the blind-side of the cylinder is pressed out and returns to the atmosphere.

Case II: When solenoid B is energized (Right Hand square):

Pressure port P is connected to port B. So, air under pressure enters the blind-side of the cylinder, causing the rod to extend. Air in the rod-side of the cylinder is pressed out and is provided a path to return to the ambient atmosphere.

Case III: When neither solenoid A nor solenoid B is energized (Center square):
Spring pressure moves the spool to the center position. Thus, pressure port P is opened to the atmosphere and both ports A and B are blocked. Hence, the cylinder rod does not extend or retract.

The above 3 cases have been described for actuating a cylinder using an electro pneumatic servo system.

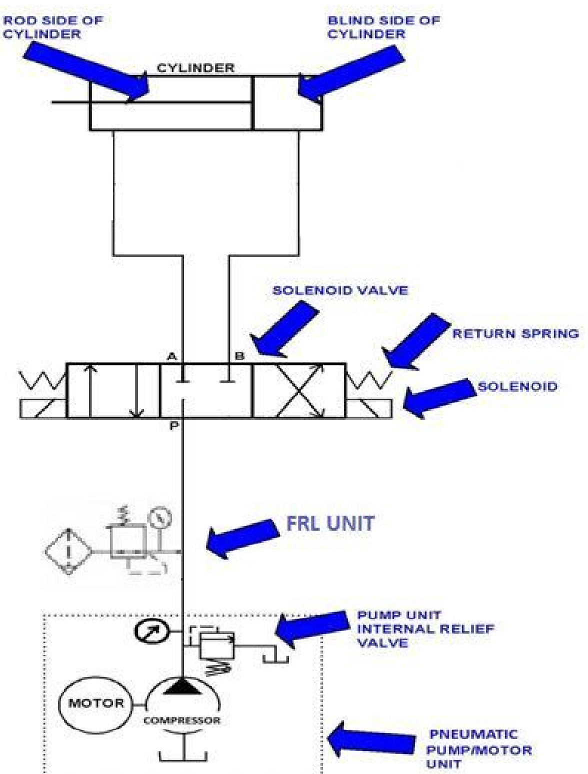

Figure 1: Circuit Diagram of the Model.

The symbols used are typical hydraulic symbols for components. The various components used have been labeled.

4 Advantages

As a result, the model may be confidently utilized as a design and scale-up tool. Apart from this a pneumatic model holds many other advantages that have been discussed below.

4.1 Renewable Source

Air is widely popular as a renewable source of energy which when harnessed could provide a solution to the increased demand of energy sources. The preference of air to water can be accounted for due to the easy availability of air compared to water.

4.2 Cost Effective

Pneumatic systems have proven to be more cost effective than their hydraulic counterparts because of the obvious fact that air is found in abundance on earth. In order to run a hydraulic system it is necessary to have an external source of water supply within the system itself (a reservoir, tank etc) whereas in case of a pneumatic system, supply of air need not be from an external source. Thus the effective cost of a pneumatic system would be lesser.

4.3 Power Output

The density of water being much higher than that of air, the weight of a hydraulic system is much more than that of a pneumatic system. The above argument regarding the requirement of a reservoir in a hydraulic system also adds to the weight of the hydraulic system, thereby increasing its weight to power ratio compared to that of a pneumatic system.

4.4 Control

The pneumatic system being light in weight, forces the control over the system or mechanism, whatever the case may be, to be simpler.

5 Final Achievements of the Model

The key objective in the development of the predictive pneumatic model was to limit the dependence on conventional sources of energy that are generally applicable over a wide range of conditions. In the predictive hydrodynamic model developed in this work, the only two parameters which may be altered are the air pressure inside the compressor and the type and magnitude of voltage provided to the double solenoid servo valve. The actuation of the piston can be harnessed to provide power to a variety of mechanisms or machines depending upon its application. It may be used to push, pull, lift and open or close doors in material handling and processing. It may also be used for the governing of hydraulic turbine by opening/closing the inlet flow valve or even to remove or position materials or pieces for manufacturing. Pneumatic systems can be connected with hoses, pipe or tubing without difficulty, producing a large amount of linear energy. Using pneumatic systems is economical and environmentally friendly, as air is inexpensive, plentiful and easily compressed and stored in tanks. Exhaust air can also be returned back to the atmosphere.

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