Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 5 Issue 10, October - 2018

Hydraulics and Pneumatics: A Brief Summary of their Operational Characteristics

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Abstract— **The technology, in particular the engineering and automation industry, has developed to a great extent and has been particularly intense over the last few decades. The pneumatic and hydraulic automation systems have entered our lives, taking an active role, even if at times, the largest proportion of the population is unable to understand and understand it. In this document, a review is made of the properties, characteristics and functions of pneumatic and hydraulic control automation systems.**

Keywords— hydraulic systems; pneumatic systems; positioning systems

I. INTRODUCTION

The concept, which is widely known as pneumatic systems, is applied to analyze and describe the various motion automation systems, which use as their energy tool the compressed air and at the same time present as their natural output the reciprocating movement of pistons or partial times the rotation of the engines [1].

The basic features that govern the pneumatic automation systems are the following [4]:

- They deliver very fast and easy energy transfer and storage, of course, with a high production cost.
- They apply elements of automation that are described as explosion-proof. In particular, they do not present the risk of overloading and are capable of being implemented under adverse environmental conditions.
- They create a linear movement that is very simple and is accompanied by very low cost, at a speed of 1 to 2 m / sec, with a distance of 2 m and a power around 3,000 kp.
- They can instantly adapt both their speed and their strength.
- They can be maintained through easy and easy-to-use procedures.

Also, the main elements that influence the structure and the composition of the pneumatic automation systems are categorized in the following sections [8]:

- The air supply signal valves (also known as Signal).
- Piping and processing of compressed air (Power Unit).
- The valves designed to process the signal (also known as Processing).
- The air pistons that they give and the corresponding form of motion of the system (also known as Drive Control).
- The central valves that control the direction (also known as the Control Valve).

Fig. 1. Logical diagram of a mental system [10]

The basic principles of the pneumatic system are as follows [4]:

- The control valve of each piston necessarily needs a signal to perform its initiation. This signal is passed through the signal valves, the start-start valves and the shut-off valves.
- As an essential element of the individual pneumatic system of automation, the piston is considered to be air.
- A vital element of the system is the piston control valve which is located a short distance from the piston.
- The set of individual tools in the system combine with the aid of pneumatic conveyance tubes designed to correctly signal this function and function.
- Place the regulating valves between the piston and the control valve.
- The creation and design of the overall components of the automation system takes place before the start of the movement cycle.

Moreover, according to Routoula (2008), the three (3) stages, in order to perform the pneumatic systems supply with compressed air, are as follows:

- The air treatment, aiming at the air to be correct for its participation in the pneumatic system of automation.

- Air flow through a pipeline.
- The generation of air from its respective compressors.

Finally, the ways to create the appropriate air transport lines in these systems are the following [1]:

- The central transport line and the production of horizontal branches in the "H" format.
- Applying the branching of the main air line.
- The central circular transport line and the downward path of the branches to the respective pipelines.

Hydraulic systems are called those systems that carry power and consist of a plurality of hydraulic pumps, pipelines, motors and pistons that are applied and aimed at generating power or torque [13]. Also, in terms of fluid flow, it is called the motion activity of the various particles contained in the fluids because they flow [13].

The basic features that make up a simple hydraulic system are the following [12]:

- The high precision that characterizes the position.
- The potential toxicity of the hydraulic fluid present in the system.
- Has the ability to be highly sensitive to temperature changes.
- The intrusion of strong forces.

In addition, the properties of the fluid components that assist in the proper operation of the hydraulic systems are the following [11]:

- Hydraulic inertia: It is the inertia manifested by the changes in fluid velocity. It is also the result that results from the ratio of the pressure difference to the velocity change of the flow of the fluid element.
- The special pressure: It is the result that results from the ratio of the force that the fluid performs on a surface to its corresponding area.
- Specific weight: Indicates the weight of the fluid element per unit of its volume.
- Fluid density: Shows the mass of the fluid element expressed per unit volume at a constant position of the fluid.
- Hydraulic Capacity: This is the result of the ratio of the change in volume of the fluid element in a hydraulic device to the corresponding change in pressure.
- Hydraulic Resistance: It is the degree of resistance that fluid manifests in the phase of its mobility. It is the consequence that results from the ratio of the pressure difference to the delivered volume.

Finally, the components that make up a hydraulic automation system are the following [15]:

- Hydraulic pumps.
- Hydraulic cylinders.
- Hydraulic valves.
- Hydraulic actuators.

II. METHODOLOGY

The characteristics of the movement of pneumatic automation systems are the cylinders. They have the ability to translate the pneumatic power of compressed air into rectilinear motion [4]. The cylinders are the integral tool for the following movements [2]:

- The push.
- Traction.
- Raising weight.
- Powering the devices.
- Activating the levers.
- The displacement of the pieces.
- Automating other individual systems.

The pneumatic cylinders consist of a large chamber containing the following elements [3]:

- A piston.
- Sealing elements in order to achieve gas safety.
- An action bar to make the alignment of the movement.
- The gas inlet ports.
- The exhaust ports of the gas element.

In general, the construction and structure of the pneumatic cylinders is simple and is characterized by increased levels of resistance to overdrafts [3]. According to Kagawa et al. (2000), on the basis of their construction, the pneumatic, these cylinders are divided into the following categories:

- The single-acting cylinders: The single-acting cylinders are the simplest form of roller construction and are separated into single-energy rolls without a buy-back and single-return roller bearings. In particular, the compressed air therein is supplied solely to one side of the piston and thus moves only to one side of the direction. The input or output of the shaft is effected via compressed air. The opposite direction of the stroke is performed by means of a spring loaded system or by an external force that takes place. The force fed to the spring is chosen having as its point of departure the return of the piston to its original position from where it started with an increased return speed. Of course, on the cylinders that have a built-in spring, this path of movement is delimited in relation to the natural length of the spring, resulting in cylinders with a stroke length of about 100 mm [5].

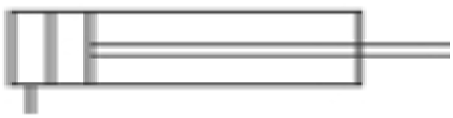

Fig. 2. Cylinder of simple energy without spring return [5]

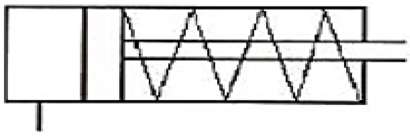

Fig. 3. Cylinder of simple energy with spring return [5]

- The dual-action cylinders: The double-acting cylinders are another class of cylinders for their construction. In particular, in this type of cylinders, the force exerted by the compressed air moves the corresponding piston sharply, not only in one direction but in all directions (2 directions). Usually, they apply to those cases in which the piston needs to produce work - motion and during the retraction process. As far as the extent of its course is concerned, it must always be taken into account the appropriate prediction and assessment for the displacement of the rod in bending and bending [10]. The categories of cylinders in this category are double-acting single cylinder cylinders, twin-roller double-rollers, double-acting cylinders with telescopic rollers and double-acting rollers with a deceleration device [5].

Fig. 4. Symbolization of a cylinder with a simple rod [5].

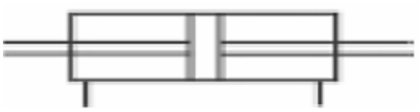

Fig. 5. Roll symbol with double rod [5].

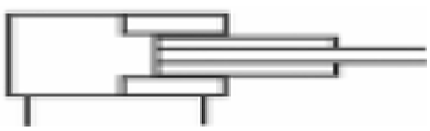

Fig. 6. Telescopic cylinder symbolism [5].

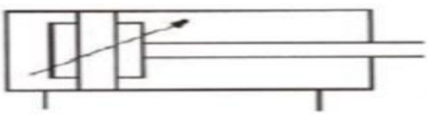

Fig. 7. Roller symbolization with deceleration [5].

The special application rollers: Special Application Rollers are a very rare category of cylinders. The most well-known form of these cylinders is the Tandem roller, which consists of two (2) individual double-acting compressed air cylinders inside a cylinder-tube, aligned in series.

The two forces created by this interaction are summed up and then the total force exerted by the piston is doubled. The most well-known special application cylinders are the rotary cylinder, the multi-position cylinder and the impact cylinder due to the large and [10].

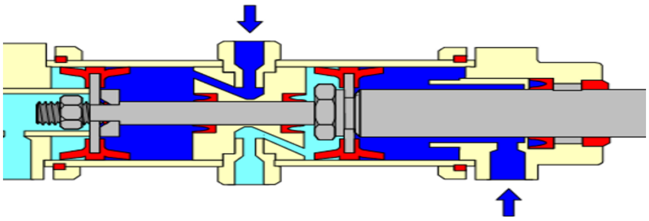

Fig. 8. Double Tandem roller cross section [10]

Among other things, the most important control of the pneumatic systems is the valves. These are responsible for the start / stop function of the piston as well as for the direction of the compressed air flow. Valves can be classified as control valves, signal valves, non-return valves, pressure control valves and valves [1].

Finally, as far as pneumatic automation control systems are concerned, the most important controllers used for the cost are the following [4]:

- An analogue controller.
- Analogue - differential controller.
- Analogue - integral - differential controller.

With regard to hydraulic automation systems, they are made up of hydraulic cylinders, hydraulic pumps, hydraulic valves and hydraulic actuators.

The hydraulic cylinders are known to the general public as hydraulic plungers. Hydraulic cylinders are called hydraulic machines which deliver linear motion to system components. The consequence that results from this hydraulic activity is reflected in its piston through the rectilinear movement that occurs [16]. The criteria for selecting the appropriate cylinder in these systems are pressure, velocity and force (Akers et al., 2006). The categories of hydraulic cylinders are the following [13]:

- The single-acting hydraulic cylinders: the piston they have, drives two (2) cavities with a liquid element. The first cavity contains hydraulic oil while the second cavity encloses the air. Then, with the movement of the cylinder, the air is withdrawn and repositioned through the venting outlet [11]. The underlying categories of single-acting cylinders are the plunger rod piston and the telescopic rod piston [12].

- The two-energy hydraulic cylinders: They have two (2) independent flow directions [5]. Thus, in the dual energy cylinder, in the case where a hydraulic fluid element is fed to one circuit inlet, the liquid element is replaced from the other inlet of the circuit. In order to prevent leakage, sealing rings are applied in both the piston area and the rotor area [11]. Dual energy rollers are non-satellite pistons and satellite-type pistons.

The hydraulic valves in hydraulic automation systems are for regulating and controlling the flow of the fluid element which makes the connection to the valve outlet [15]. According to Kostopoulos [5], the hydraulic valves are always composed of a mobile and a fixed part. Depending on how the flow of the fluid element is determined, the hydraulic valves are divided into the following categories [17]:

- Acoustic flap valves: The flow of the fluid element, in this case, is carried out with the help of a wing.
- Piston-type valves: In this type of hydraulic valves, the flow adjustment is effected by the movement that takes place in a piston that leaves the passage of the fluid element free of the valve openings.

While, based on their general function, the hydraulic valves are divided into the following categories [16]:

- Pressure control valves: They are capable of downwardly defining hydraulic pressure values within hydraulic automation systems that define a passageway to decongest the fluid element to the corresponding tank.
- Flow control valves: These valves are applied to hydraulic systems to adjust the flow rate. In general, hydraulic valves have stable pressure levels and do not exhibit varying flow. The flow control valves are adjustable throttling, single line throttling, adjustable throttling and pressure compensation [5].
- Directional valves: They are responsible, defining the direction towards the corresponding piston [5]. Such valves are the hydraulic valve 3/2, the hydraulic valve 2/2 and the hydraulic valve 4/2 [11].
- Adjustment valves: Inside, a spout that is capable of being modified with a spindle that is responsible for the control of the valve [16].

The hydraulic pumps are the basic component of hydraulic automation control systems. Their main objective is to convert mechanical and electrical power into hydraulic energy which is subject to compression of the fluid element to the overall system [7]. The categories of hydraulic pumps are [10]:

- Hydraulic Piston Pumps: They have as a basic feature of their operation, the process of suction of the fluid element and simultaneous reciprocating movement performed by a piston in a piston [6]. They are separated into hydraulic piston piston pumps of axial pistons and in piston plunger piston pumps [1].
- Hydraulic toothed pumps: Their purpose is to transport the fluid through the gears they have [11]. The two individual wheels that make up a gear pump are similar in pitch, diameter and number of toothed gaps in their perimeter. One of the two wheels is always in direct connection with the shaft and this results in the movement of all the wheels. Also, the depression spaces develop between the toothed gaps while surrounded by the main body of the pump, as well as two (2) plates called friction plates. In the time phase where the wheels make circular movements, the fluid element flows between them, and in the event that their toothed gaps come in contact, the fluid element is displaced to the nearest outlet. Finally, it should be noted that the toothed pump usually consists of small supplies [5].
- Hydraulic Friction Pumps: they have as their basic function the activity carried out by assisting a spring that affects a piston, holding the ring that is responsible for the route, in its initial placement [6].
- Hydraulic vane pumps: They have as their basic feature the rotational movement of their vanes which are placed on the inner side of a ring while at the same time developing suitable spaces during the time phase of the fluid element transfer. These spaces are placed between the friction plates. The blades equipped with this type of pump make free movements in the gaps of a rotating part of the mechanism and maintain constant contact with the ring by centrifugal force and pressure [6].

Finally, hydraulic actuators are known to the general public and as hydraulic sensors. They have the ability to interact with both the microcontroller and the external environment. Hydraulic actuators, essentially, are machines that are able to recognize a physical size within a hydraulic system. Hydraulic sensors are integrated into the hydraulic systems to receive information derived from the programmable logic controllers and then clearly delimit the position, velocity and acceleration of the piston [9]. According to Scarpeti & Koumbouli [10], the main characteristics of hydraulic actuators are strength, range, precision, error, repeatability, delay, stability and operating time. Hydraulic actuators - sensors are divided into force actuators, optical actuators, sensing actuators and displacement and drive actuators [6].

III. Conclusions

The conclusions drawn from this bibliographic review are as follows:

- Pneumatic systems are applied to analyze and describe the various automation systems that use their compressed air as their energy tool and at the same time present as their natural result the reciprocating piston movement or sometimes the rotation of the motors.
- The main elements that influence the structure and the composition of the pneumatic automation systems are the air supply signal valves, the flow and the processing of compressed air, the valves aimed at the processing of the signal, the various pistons of air also give the corresponding form of motion of the system and the central valves that control the direction.
- The 3 stages, which must be performed in order to perform the pneumatic systems with compressed air, are the air treatment, in order for the air to be correct for its participation in the pneumatic system of automation, the supply of air through of a pipeline and the generation of air from its respective compressors.
- The cylinders are the integral tool for pushing, traction, weight lifting, device feeding, lever actuation, displacement of individual parts and automation of other individual systems.
- The most important control of pneumatic systems is the valves.
- The hydraulic systems are systems that carry power and consist of a plurality of hydraulic pumps, piping, motors and pistons that are applied and aimed at generating fluid force or torque.

- The basic features that make up a simple hydraulic system are the high precision of the position, the potential toxicity of the hydraulic fluid present in the system, the ability to have a great sensitivity to temperature changes and the penetration of intense forces.

IV. ACKNOWLEDGEMENTS

Authors would like to acknowledge the University of West Attica postgraduate program of studies “MSc in Industrial Automation” for supporting this research project.

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