The Advantages of Pneumatic System over hydraulic system: Review

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***Abstract*—Having navigated through numerous successful enterprises, they have gained insights into the essentials of efficient production. The answer lies in a combination of factors such as low machining costs, high-quality output, material availability, eco- friendliness, affordability, and economic efficiency. Due to its numerous benefits, the pneumatic system meets all the criteria for leading technological advancements. Moreover, the future is leaning towards sustainable technology. This document will delve into a bibliographic study on the widespread use of pneumatic systems in various global applications. It will also uncover why companies invest heavily in pneumatics over other technologies. Additionally, this article explores potential future applications of pneumatic systems that are currently under investigation.**

KEYWORDS: Double Acting Cylinder, Expansion, Pneumatic System, Single Acting Cylinder.

I. INTRODUCTION

Pneumatic System: The Pneumatic System converts inert or compressed air into mechanical energy for various operations (see Figure 1). An air compressor generates the pressure needed by the system, providing high-pressure air that is stored in an atmospheric reservoir [1]. This pressurized air is then distributed through pipes and various valves to the system as needed. Pneumatic systems are widely employed across numerous industries, including automation for air brakes, construction site drilling machinery, clamping machines in workshops, and other applications [2].

Fundamental Components of a Pneumatic System:

Figure 1: Schematic diagram of Pneumatic system

Compressor: This component facilitates the transfer of high-pressure air to an external storage tank. It includes an air suction pump, a pump, and a motor that drives the tank to store the suctioned air (see Figure 2) [3].

Actuator: This consists of a piston rod and cylinder that generate external force when there is a pressure differential within the cylinder. Various types of pneumatic actuators exist, such as diaphragm cylinders, rodless cylinders, telescopic cylinders, and rod cylinders [4].

Filter: This component is responsible for removing dust and unwanted particles from the ambient air before it enters the compressor [5].

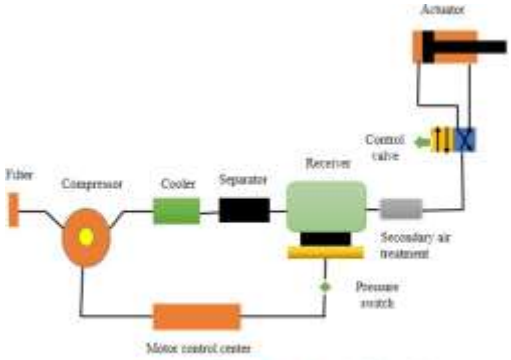

Figure 2: Basic components of Pneumatic system

II. PROCEDURE FOR PAPER SUBMISSION

Coolers and Separators: These components are responsible for dissipating the heat generated from compressed air. They transfer this heat to a separator, which removes water impurities from the air before sending it to the receivers [6].

Receiver: This component stores air for various mechanisms. It maintains the pressurized air at the correct pressure level to control the valve through a connected pipe, with a pressure gauge attached to the receiver for monitoring [7].

Valve Control: This component is essential for regulating and maintaining the direction and pressure of the air flow.

Types of Pneumatic Systems:

Among the most commonly used actuators are single- acting and double-acting cylinders:

Single-Acting Cylinder: This type of cylinder generates thrust in only one direction [8]. It features a spring attached to the piston for retraction or relies on an external force to reverse the piston (see Figure 3). These cylinders are typically used in applications such as clamping, marking, or assembling objects [9].

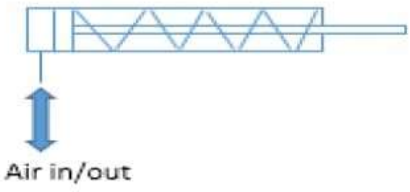

Figure 3: Symbol used for single acting cylinder

Advantages of Single acting cylinder:

a. Their design is simpler.
b. The compactness in size is greater.
c. The valves and pipelines must be utilized with less no.
d. Cheaper

e. Less air intake.
f. It's made up of only one port.
g. Small housing is also available

Single acting cylinder disadvantages:

a. The spring utilized to return the rod of the piston, may allow the entry into a system of undesirable particles that diminish cylinder life.
b. Boron and stroke is restricted in size.
c. At the moment of the outstroke there will be a decrease in thrust.
d. (d) The spring employed there shall take up a big area and leave for the piston in a cylinder a modest working surface[10].

Application of single acting cylinder:

It is widely used in various applications such as: -

a) Clamping
b) Hydraulic rams
c) Pumps in reciprocating engines
d) Punching applications
e) Positioning applications

Double-Acting Cylinder: Unlike the single-acting cylinder, this type does not utilize a spring to retract the piston rod. Instead, it requires two separate air supplies to generate thrust force for both the outstroke and instroke movements (see Figure 4).

Figure 4: Symbol used for double acting cylinder

Advantages of Double acting cylinder:

a) They are generally designed on ISO standards.
b) It can be widely used for different sizes of bores and strokes.
c) They are widely used in various applications.
d) They are faster and stronger than single acting cylinder.

Double acting cylinder disadvantages:

a. Cannot retain the cylinder in the intermediate position.
b. More expensive than a single acting cylinder.
c. More housing is needed.
d. The piston rod is a long stroke cylinder that requires guiding.

Application of the Double acting cylinder

It is widely used in various applications such as: -

a) Wide ranges engine
b) Industrial furnace
c) Digging machine
d) Lift shaft.

II. LITERATURE REVIEW

H. Sick et al. conducted a study and published a research article that allows us to explore the technology used in pneumatic systems, automation, and robotics. Their paper, titled "A Review of Pneumatic Bumper for Two-Wheeler Cylinders," delves into these technologies [11].

S. G. T. Studies presented arguments and reasons for choosing pneumatic systems across various sectors in the study "Pneumatic Systems." In their online article, "5 Applications of Pneumatic Systems," the authors discuss the widespread industrial applications of pneumatic systems. They also provide detailed information about a smaller cylinder without a piston

that still functions mechanically on their webpage, "The Basic Components of a Pneumatic System" [12].

Papoutsidakis et al. researched the long-standing use of pneumatic systems, highlighting their continuous expansion with innovative ideas [13]. In the online article "Pneumatic Basics and Pneumatic Systems," Satyendra discusses the use of compressed air in pneumatic systems, which can be easily transported over long distances through pipes. On their webpage, "Benefits and Advantages of Pneumatic Systems," the authors note that while pneumatic systems are simple in design, they are sensitive to rapid and severe changes. In "Know Your Pneumatics: Single or Dual Action," the authors mention that a spring in a single-action cylinder might allow unwanted particles into the system, reducing the cylinder's lifespan.

C. Mano explores the applications of pneumatic systems in artificial muscles and fluid logic in his web article "Principles of Pneumatic Systems." In the thesis "99 Pneumatic Application Examples," S. Hesse discusses how numerous successful companies have led to efficient production. The authors also examine various applications of single-acting and double-acting cylinders in their online paper, "What Are the Differences?"

III. DISCUSSION

When several successful companies conducted an analysis, they discovered the key to effective manufacturing. The answer lay in integrating several factors, such as low processing costs, high-quality products, material availability, eco-friendly options, affordable labor, and cost-efficient products. These goals can be achieved through automated equipment and processes. Industrial pneumatics play a crucial role in enhancing production efficiency. Thanks to the numerous advantages mentioned, pneumatic systems meet all the requirements for technological growth at a very affordable rate. In our daily lives, we encounter various

examples of pneumatic systems. However, precautions should be taken when using compressed air pneumatically to avoid direct skin contact, as it can cause harm. Despite some drawbacks, pneumatic technology remains enduring and indispensable.Pneumatic systems have a rich history that showcases their continuous evolution and the expansion of their applications through innovative ideas. The journey began with the development of the earliest air compressors around 3000 B.C. In the 1600s, a German scientist further advanced pneumatic science by inventing the vacuum cleaner, transitioning from generating power in pneumatic systems. Pneumatic systems are widely used in various applications, from producing pneumatic trains to delivering letters, reducing workforce requirements in industries, and automating machines and equipment. They are now advancing to the level of controlling production units.

In the future, pneumatic systems are expected to be applied in artificial muscles and fluid logic. The creation of "artificial muscles" by physicist McKibben was initially designed for individuals with polio. These artificial muscles are significantly superior to previously used artificial and robotic limbs. They function similarly to human muscles, contracting when the tube expands and elongating when it flattens. This technology is being used to power robotic arms and legs. A current focus in research centers is "pneumatic logic," which aims to replace electronic circuits with pneumatic or hydraulic systems. The primary advantage of these systems is their immunity to sunlight interference.
NASA scientists are currently employing this technology to control the separation of rocket stages.

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IV. CONCLUSION

According to extensive research on pneumatic systems, they offer an affordable solution for generating high pressure. The components of pneumatic systems work in harmony to achieve this high pressure, as previously mentioned. While pneumatic technology continues to advance, the generation of heat within pneumatic power systems remains a notable challenge. Pneumatic systems utilize fluid to transmit energy from one location to another without relying on mechanical or electronic

devices. This brief overview explains why companies invest substantial amounts in pneumatics rather than other technologies: the air in the atmosphere is abundant and inexhaustible, unlike other natural resources. The emphasis is on adopting sustainable technologies now and in the future. Despite some drawbacks, such as limited use in simple control devices, low torque, and slow operational speeds, the benefits of pneumatic systems—such as ease of installation and maintenance, simple design, and cost-effectiveness—faroutweighthese disadvantages. Looking ahead, pneumatic systems are expected to find applications in artificial muscles and fluid logic.

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