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Production of S45C Steel Pneumatic Pistons, MS, Cylinder E235

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Abstract. *In the industrial world, production continues to grow rapidly, especially in the press industry. Press machines have 2 types of hydraulic and pneumatic. One of the commonly found press systems is the pneumatic system. Pneumatic is a system that gets compressed air sprayed on a certain object so that the object will move linearly. The piston has types including: single-acting cylinder system and double-acting cylinder system, many types of use, one of which is used as a press media. The purpose of this writing is to find out the production process of a pneumatic piston that uses 3 materials, namely Steel S45C, MS, Cylinder E235. This writing is based on field studies and literature studies conducted by the author. The production process of the pneumatic piston includes several processes namely; Drilling, Lathe, Assembly, and QC. In the drilling process, flanked 1 and 2 are given holes with diameters of 11 and 13, in the lathe process the parts on the tube and piston are turned to the adjusted size. In the assembly process all parts are combined into one component starting from the hydraulic tube, flanked, tube and piston. After completing the combination into 1, it will enter the last process, namely the quality control process, in this process it can be seen whether the pneumatic piston is feasible or not if the piston is not feasible then do the assembly process again but if the piston is deemed feasible then the piston can be used.*

Keywords *Pneumatics, Production, Press, Pneumatic Piston.*

INTRODUCTION

The rapid advancement of industrial technology has significantly increased the demand for efficiency and effectiveness across various stages of the production process. Among the many challenges industries face is the necessity of generating large compressive forces for diverse operations such as stamping, molding, compacting, or assembling components. Traditionally, these force-intensive tasks have been carried out manually, relying heavily on human labor. However, manual methods come with inherent limitations, such as inconsistent force application, reduced productivity, and increased risk of operator fatigue or injury over prolonged use. These constraints have prompted the exploration of more reliable, consistent, and automated alternatives.

In this context, pneumatic press machines present a promising solution. These machines utilize compressed air as a power source to produce high pressing forces in a controlled and repeatable manner. The use of pneumatic systems not only increases productivity but also enhances operational safety and precision. By eliminating the dependency on human strength, pneumatic presses contribute to more ergonomic and efficient workplaces, particularly in high-volume manufacturing environments.

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The term "pneumatic" is derived from the Greek word “pneuma,” meaning air or breath, and is generally used to describe systems that operate using pressurized air or gas. The core principle behind pneumatic systems is the conversion of energy stored in compressed air into mechanical motion. This is typically achieved through the use of a piston within a cylinder, where the air pressure exerts force on the piston surface, causing linear motion. The compressed air required to drive the system is generated by an air compressor, which draws in atmospheric air, compresses it, and stores it in a reservoir for distribution to various pneumatic components.

Modern pneumatic systems are equipped with advanced control mechanisms, often involving solenoid valves, pressure regulators, and programmable logic controllers (PLCs) to regulate the timing, direction, and intensity of the motion. These systems are designed not only to perform repetitive tasks efficiently but also to ensure that safety and energy consumption are optimized.

From a fluid dynamics perspective, pneumatic systems operate based on the principles of aeromechanics, which includes both aerostatics (the behavior of stationary air under pressure) and aerodynamics (the study of air flow and motion). These principles govern the way air behaves within the system, allowing engineers to design components that maximize force output while minimizing energy loss.

Overall, the adoption of pneumatic press machines in industrial applications represents a strategic move towards automation and sustainability. They offer a cleaner, safer, and more adaptable alternative to hydraulic or manual systems, especially in operations that demand speed, precision, and reliability. As industries continue to evolve, the role of pneumatics will remain integral in supporting modern manufacturing goals and enhancing the overall quality of production processes.

LITERATURE REVIEW

Production plays a vital role in building a nation's wealth. In developed countries like the United States, the manufacturing industry contributes about 15% to the Gross Domestic Product (GDP). In contrast, natural resource sectors such as agriculture, mining, and oil reserves contribute less than 5%—with agriculture alone accounting for only around 1%. Construction and public facilities contribute approximately 5%, while the service industry, including retail, transportation, banking, communication, education, and government, dominates with over 75% of GDP contributions (Budiyanto, Eko, and Lukito Dwi Yuono, 2021).

Given its contribution to economic development, the manufacturing sector is considered highly strategic. In 2020, the World Economic Forum (WEF) released the “Readiness for the Future of Production Report,” ranking the top 100 countries based on their competitiveness in production. The report evaluates two major indicators: the current production structure and the supporting factors, highlighting the need for countries to invest in technologies that enhance production capacity.

One such technology is the pneumatic system. Pneumatics operates by converting compressed air energy into mechanical motion, typically used to move or control a workpiece. It serves as a control system where pressurized air is directed into pneumatic actuators to perform tasks like opening or closing valves. Due to its simplicity and efficiency, pneumatic systems are ideal for repetitive and straightforward automation tasks (Tuapetel, Victor, and Narwalutama, 2022).

Pneumatics, derived from the Greek word meaning "air" or "wind," uses compressed air as a medium for energy transfer. This system is widely applied due to its ease of use, low cost, and high safety standards. Compressed air pressures typically range between 4–8 atm in laboratory settings and higher in industrial use cases (Ferdian and Denny, 2016). Pneumatic systems are commonly employed in both linear and rotary applications in automation.

The main components of a pneumatic system include the energy supply unit (e.g., compressors), input elements (e.g., push-button valves), processing elements (e.g., pressure regulators), control elements (e.g., directional control valves), and actuators (e.g., pneumatic cylinders or motors). Due to the relatively low pressure of the air used, components can be manufactured from cost-effective materials such as molded plastic, zinc, or aluminum. However, component shapes and sizes may vary between manufacturers (Ferdian and Denny, 2016).

METHODS

This study employs a qualitative descriptive method aimed at systematically documenting and analyzing the production process of a pneumatic piston, starting from material selection to the final stages of quality control. Data collection was carried out through direct observation, technical document analysis, and interviews with production operators and engineers involved in the manufacturing process. This approach allows for a comprehensive understanding of each step in the process, particularly regarding the function and suitability of each material used.

To support the technical validity of the observations, machining parameters, including feed rate and cutting speed, were calculated using standard formulas in manufacturing engineering. A key focus was placed on the turning process applied to the Cylinder E235 tube, which involved a spindle speed of 20 RPM and a feed rate of 0.05 mm/rev. Based on the calculations, the feed rate was determined to be approximately 6.3 ft/min, which aligns with industry norms for processing chromoly steel tubes. These calculations were essential in evaluating the precision and efficiency of the machining process, especially for threaded components that require tight tolerances.

Additionally, a process analysis framework was utilized, employing a process flow diagram to map the sequence and interrelation of each manufacturing stage. This visualization method highlights the material flow, identifies potential bottlenecks, and emphasizes critical control points such as machining, assembly, and quality assurance. The flowchart also serves as a reference to determine the logical sequence and operational dependencies among the different parts and processes, ensuring that the production system is both coherent and repeatable.The following are several flow process diagrams involved in the production steps of a Pneumatic Piston made of S45C Steel, MS, and Cylinder E235:

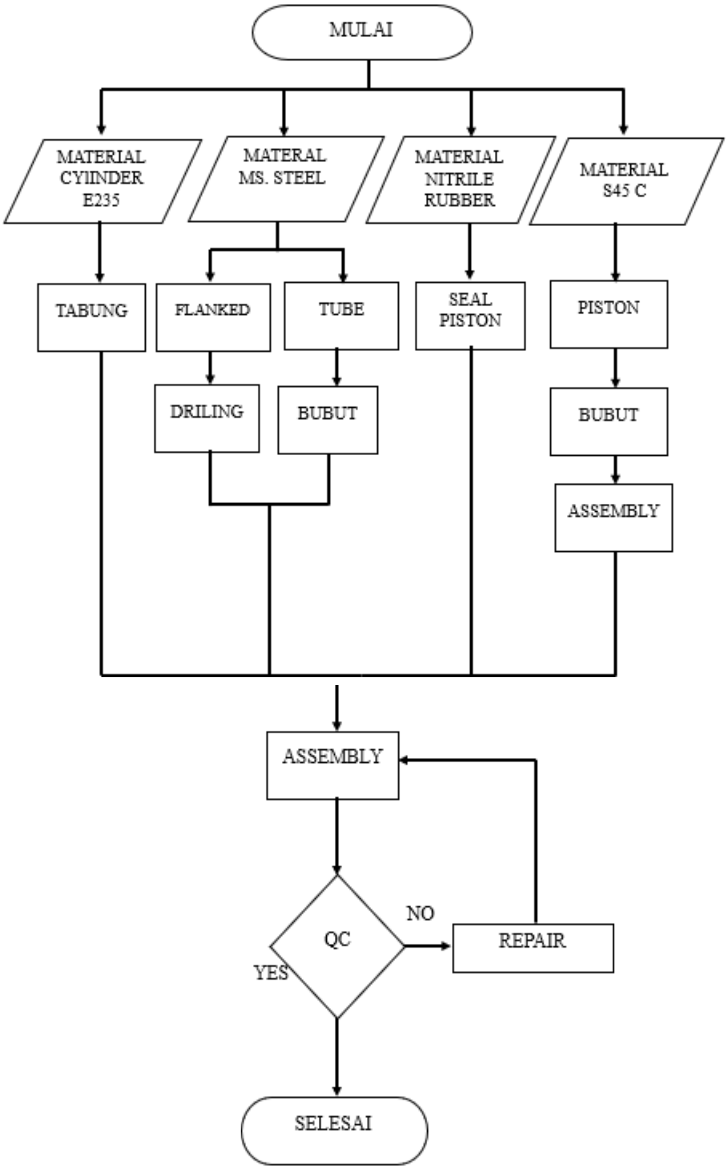

Figure 1. Process in a production step of Steel S45C Pneumatic Piston, MS, Cylinder E235

In the fabrication of this device, three different materials are used: Mild Steel (MS), S45C, and Cylinder E235. The use of each material in the respective parts is described as follows:

1. For the pneumatic piston assembly, Mild Steel (MS) is used for the flanked and tube parts. Mild steel, also known as low carbon steel or plain carbon steel, contains a relatively low amount of carbon. It is the most commonly

used form of steel due to its affordability, versatility, and ease of fabrication. Mild steel has good mechanical properties such as strength and ductility, making it suitable for a wide range of applications.

2. In the same assembly, S45C steel is used for the piston part. S45C is a medium-carbon steel widely used in various applications due to its good balance between strength and workability. This makes it ideal for manufacturing piston rods intended for medium to heavy-duty loads.
3. For the cylinder housing, Cylinder E235 is the material used. E235 refers to a type of steel tube made from chromoly alloy steel (chromium-molybdenum). Chromoly steel is known for its high strength and excellent weldability. The designation "E235" indicates that the steel has a minimum yield strength of 235 MPa.
4. As for the piston seal, Nitrile Rubber (NBR) is the material used. Nitrile rubber is a synthetic elastomer commonly applied in piston sealing due to its excellent resistance to oil, fuel, and temperature. It is wear-resistant, flexible, and effective in mechanical environments where the seal is exposed to direct motion and pressure.

RESULTS

The manufacturing process of the pneumatic piston integrates four main materials—Cylinder E235, Mild Steel (MS), S45C Steel, and Nitrile Rubber—each selected for their specific mechanical properties and roles in the assembly. These materials contribute to distinct components within the piston system, and their processing steps are tailored accordingly. Cylinder E235 is utilized to fabricate the piston housing (cylinder tube). This material, a type of chromoly alloy steel, is known for its high strength, machinability, and weldability. The tube undergoes a turning operation to form threads at both ends, enabling the cylinder to be opened and closed during maintenance. The machining process is carried out using parameters optimized for chromoly steel, ensuring durability and dimensional accuracy of the threaded features.

Mild Steel (MS Steel) is used to produce the flanked and tube components. The flanked part is processed through drilling, providing holes for fasteners or alignment pins, while the tube undergoes turning to achieve a smooth finish and precise external geometry. Mild steel is selected for its ductility, cost-effectiveness, and suitability for general-purpose structural components, particularly where heavy loads are not a primary concern. S45C Steel, a medium-carbon steel with balanced strength and machinability, is applied in the production of the piston rod. This component is critical in converting air pressure into mechanical force, and thus it undergoes turning operations to ensure surface finish and dimensional tolerances meet the required standards for dynamic sealing and linear movement. The choice of S45C is appropriate due to its toughness, which supports moderate to heavy loads typically encountered in industrial pneumatic systems.

Nitrile Rubber (NBR) is used to manufacture the piston seal, which plays a vital role in maintaining air pressure within the cylinder during operation. NBR is chosen for its excellent resistance to oils, fuels, abrasion, and temperature extremes. The seal must perform effectively in dynamic conditions, offering high flexibility and wear resistance to prevent leakage and maintain efficiency. Once all components have been fabricated, they are brought together in the assembly stage. This step involves precise fitting of the piston, cylinder tube, flanked parts, and seals to ensure airtight functionality and structural integrity. The assembled unit is then subjected to a Quality Control (QC) inspection, where it is tested for dimensional accuracy, sealing capability, and operational smoothness. If the unit passes the inspection, it is approved as a finished product. If it fails, it is directed to a repair or rework stage, where necessary adjustments are made, after which it is reassembled and re-tested.

This closed-loop production and quality control process ensures that only components meeting the desired performance standards are released. It reflects an industry best practice in ensuring reliability, safety, and repeatability of pneumatic systems. The integration of appropriate material selection, calculated machining parameters, and structured production flow contributes to a robust manufacturing system for pneumatic pistons.

CONCLUSION

The pneumatic piston production process involves the use of three different materials, each selected according to its specific function. These materials include Mild Steel, S45C Carbon Steel, and Cylinder E235. Mild Steel is used for the flanked and tube parts due to its good machinability and structural adequacy. S45C, a medium carbon steel, is applied to the piston component owing to its balance between strength and formability. Cylinder E235, a chromoly alloy steel, is used for the cylinder housing, with the designation "E235" indicating a minimum yield strength of 235 MPa. This material provides the necessary durability and resistance for cylindrical pressure components. The manufacturing sequence for the pneumatic piston starts with the threading of the cylinder tube. The tube is turned to a length of 25 mm and threaded using M12 × 1.75 threads. The next step is drilling the flanked part, which includes holes with diameters of 11 mm and 13 mm. This is followed by turning the tube, also threaded with M12 × 1.75. The piston undergoes turning in three separate areas: the upper head includes an M12 × 1.75 thread, the lower head has no threading, and the piston rod is threaded using a cutting tool to M12 × 1.75, with a thread length of 35 mm. Based on machining parameters, the feed rate during the turning process of the cylinder tube was calculated using $\pi = 3.14$, $d = 101$ mm, and $n = 20$ RPM, resulting in a feed speed of 6.3 ft/min. The cutting feed rate (VF) was determined to be 1 mm/min. In the welding process, the weld length was measured at 155 mm, corresponding to a full circular weld, with a material thickness of 7 mm. The weld surface area was calculated to be 542.5 mm^2.

The assembly process serves as the final stage of the pneumatic piston production. Assembly involves both welding and mechanical fastening using bolts. The initial step includes welding the flanked part to the cylinder tube. Once this is completed, the three piston components are assembled into a complete piston, which is then inserted into the cylinder tube. Following that, Flanked 1 and Flanked 2 are connected using nuts of the corresponding size. These two flanked components function to limit and guide the linear motion of the piston during operation. Lastly, the tube is threaded into the cylinder housing using the pre-machined M12 × 1.75 thread. Once all components are connected into a single assembly, the entire manufacturing process is complete.

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