DESIGN AND FABRICATION OF A COMPRESSED AIR ENGINE

A Project
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Department of Mechanical Engineering

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In partial fulfillment of the requirement for award of the degree

Of

Bachelor of Science in Mechanical Engineering

May, 2025

DECLARATION

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We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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ABSTRACT

A Compressed Air Engine (CAE) is an eco-friendly alternative to conventional internal combustion engines, utilizing compressed air as its primary energy source. Unlike fossil fuels, compressed air is clean, non-toxic, and abundantly available, making it a sustainable solution for reducing carbon emissions. The engine operates by releasing high-pressure air stored in tanks, which drives pistons or turbines to generate mechanical power. This mechanism eliminates the need for fuel combustion, significantly reducing air pollution and greenhouse gases. CAEs are particularly suitable for short-distance travel, urban transport, and material handling applications. Key advantages include low operational costs, minimal maintenance, and zero exhaust emissions. However, challenges such as energy losses during compression, limited energy density, and storage capacity need to be addressed for widespread adoption. Future advancements in energy storage, compression technologies, and hybrid integration may enhance its efficiency, making CAE a promising candidate for sustainable mobility solutions.

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CHAPTER 1
INTRODUCTION

1.1 Overview

Material handling is necessary in a day to day operation to increase the productivity in industries. The existing systems are manual and mechanical systems but these have disadvantages like time consuming, high labor cost, more space is required and complicated operation and high initial cost also. A large part of the indirect labor employed in manufacturing plant the in the handling of materials. It has been estimated that average material. handling cost is roughly 20 to 25% of the total production cost. It thus becomes clear that the cost of production of an item can be lowered considerably by making a saving in the material handling cost. To overcome these points one can go for 'Pneumatic Control System'. Particularly known as Low Cost Automation' which is the introduction of pneumatic control. To reduce idle time and labor effort and increases the productivity. The technology of pneumatics deals with the study of the behaviors and application of compressed air. Due to ease of availability and non-hazardous nature of air pneumatics is found increasingly in industrial automation. It is the best solution to low cost automation in industries. As the name implies, pneumatic system typically use air as the fluid medium because air is safe, low cost and readily available fluid.

About 100 years ago, the major source of energy shifted from recent solar to fossil fuel (hydrocarbons). Technology has generally led to a greater use of hydrocarbon fuels, making civilization vulnerable to decreases in supply. The current study made in the year 2004, predicts that if the oil is consumed at the current rates, then by 2020, we will be consuming 80% of the entire available resource. This necessitates the search for alternative of oil as energy source or preserving it by tapping some other alternatives such as Non-conventional energy like battery operated vehicles, wind mills, photocells etc. and to convert their output into mechanical energy, which may alternatively preserve oil source.

From the last two decade lot of researches are being made to tap down air freely available in atmosphere at high compression, which can easily be stored in cylinders with little modified design. This compressed air can be used to run combustion engine with mixture of gas which gets fire at compression stroke at TDC. Compressed air helps for fire stroke when ignition is

given. Thus efficiency of IC engine gets improved and without all running four stroke cycle it runs two stroke cycles.

The main objective of our project is to reduce dependency of vehicle on conventional fuel. These conventional fuels are available in very small amount & perish after some time. These fuels also produce a pollutants such as CO, CO2, NOX, SOX which are harmful to human being & produce effects such as cancer, headache etc. So for these fuels alternatives are used for ex.CNG, Compressed air, biogas etc. Here development of pneumatic vehicle using compressed air (prototype) is main objective project.

1.2 Problem Statement

The primary challenge in conventional material handling and transportation systems lies in high energy consumption, pollution, and dependency on fossil fuels, which are depleting rapidly and contribute to environmental damage. Traditional mechanical systems are often expensive, require significant maintenance, and involve complex operations. To address these issues, the development of a Pneumatic System powered by compressed air offers a sustainable, low-cost, and eco-friendly solution. This system aims to reduce emissions, lower operational costs, and simplify automation processes, making it an ideal choice for industrial applications while supporting global efforts toward cleaner and greener technologies.

1.3 Objectives

The objectives of this project are

- To design and implement a Compressed Air Engine
- To understand the working principles of pneumatic components such as compressors, valves, actuators.
- To develop an eco-friendly engine powered by compressed air instead of fossil fuels.
- To achieve efficient mechanical power generation with reduced environmental impact.
- To design a compact and efficient system for converting compressed air energy into mechanical motion.
- To enhance safety and reduce maintenance through a simplified engine structure.

1.4 Methodology

Our used methodology for the project:

- Design and construction of an Pneumatic System. Block diagram and Circuit Diagram to know which components need to construct it.
- Then, to design & fabrication Pneumatic System. Then, collecting the proper components.
- Then, assembling the all components to a proper shape.
- Here we use an air compressor which is measure the air pressure.
- It will be control as we need. Finally, Completion the process to make a proper pneumatic System.

1.5 Work Flow Diagram

A Compressed Air Engine project progresses through five key stages. It starts with Study, focusing on the principles of compressed air propulsion and engine design. Next is Design, where schematics and system layouts are planned. In the Components Collection phase, essential parts like air tanks, valves, and pistons are gathered. Assembling follows, integrating all components into a functional engine. Finally, Complete Project involves testing the engine for performance, making necessary adjustments to ensure optimal efficiency and reliability for clean, sustainable operation.

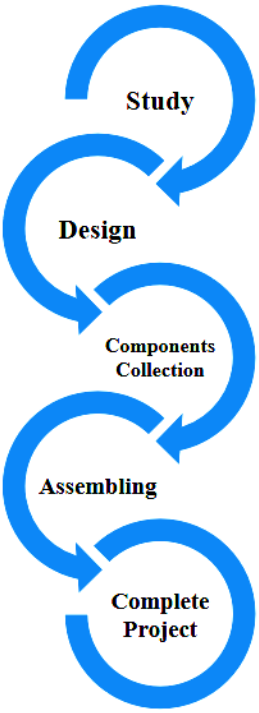


Figure 1.1 : Work Flow Diagram

1.6 Report Overview

This project book consists of Six chapter. The first chapter contains the statement of the Introduction, Overview, Problem Statement, Work Flow Diagram, objectives of the study and Methodology. Chapter two contains system Literature Review details. Chapter three System Architecture, Discussed in Block Diagram, Circuit Diagram, Working principle and Cost analysis. Chapter Four describes the hardware implementation with component details and the software which we have used for our work. Chapter Five deals with the result Analysis, shows the complete prototype, Advantage, Application and Limitation of the project that we have built. In the final chapter, we have discussed the , Future Scope, conclusion of the project.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this chapter we discuss our system overview. In this paper we are also work about **Compressed Air Engine**. In below section we will describe some previous literature review. From previous literature we gather more knowledge to build this project and we successfully made it .

2.2 Literature Review

Anthony Esposito [1] This book (Fluid Power with Applications) presents the details of pneumatics such as properties of air, compressors, air control valves, pneumatic actuators etc. and many more. It describes the preparation of compressed air with compressors. Different parts of the compressors along with their functions have also been discussed.The book also describes the pneumatic circuit design considerations and their applications. The selected portions of the book were studied and understood. The basic ideas for the system were developed after studying the book. The review of the book formed the basis for the pneumatic based materials handling system.

EurIng Ian C. Thrner [2] This book (Engineering Applications of Pneumatics and Hydraulics) presents the detail concepts of control valves, their types and principles of operation; pneumatic actuators, pneumatic circuits and arrangement of components. Theimportant portions of the book were reviewed. The understanding of the concepts of pneumatics was developed. The review of the book also helped in selecting suitable control valves such as directional control valves required in the pneumatic system. It also provided the information about the pneumatic circuits and arrangement of the components

S. Premkumar, K. Surya Varman, R. Balamurugan [3] This paper mainly focuses on the design and implementation of multi handling pick and place robotic arm. Robotic arm consists of revolute joints that allowed angular movement between adjacent joint. Three double acting cylinders were used to actuate the arm of the robot. Robot manipulators are designed to execute required movements. By using this collaborated mechanism the success

rate of pick and place robots are increased. The rack and pinion is welded with piston of the double cylinder, by actuating the hand lever valve the vertical arm will attain its 360 degrees rotary moment. While the angular moment of the horizontal arm is actuated by the double acting cylinder and 3/2 hand lever valve. The material handling equipments such as gripper and vacuum suction cup are mounted over the arm. The to and fro movement of the gripper is actuated by a separate double acting cylinder and gripper is operated by using BO motor. The robots contain two vacuum suction cups which generate vacuum with the help of vacuum generator. Compressor continuously delivers the air to the cylinder with help of the cylinders all the parts of the robot were operated. By using gripper and vacuum suction cup both the flat and irregular shaped materials were handled.

[4] (Carducci et al., 2006). validated a complete mathematical model of a pneumatic actuator driven by two on/off two ways valves (with Pulse Width Modulation technique) by tuning a number of geometric and functional characteristics and parameters by means of non-linear optimization algorithms. The experimental data were obtained driving the on/off valves with five different duty cycles: 10, 25, 50, 75 and 90% over a period of 20 ms and measuring the actuator position with a potentiometer. In particular experimental apparatus was realized in order to measure valve coefficients in all operative conditions.

[5] (Xue et al., 2007). presented a dynamic model and a design method for an accurate self-tuning pressure regulator for pneumatic pressure load systems that have some special characteristics such as being nonlinear and time varying. A mathematical model was derived, which consists of a chamber continuity equation, an orifice flow equation and a force balance equation of the spool. Based on a theoretical analysis of the system dynamics, a three order controlled auto regressive moving average (CARMA) model was used to describe the practical pressure load systems. Then a linear quadratic Gaussian self-tuning pressure regulator was designed to realize an adaptive control of pressure in the chamber. The Kalman filtering method and the recursive forgetting factor least squares were adopted to estimate the system parameters and the system states. Experimental results show that the proposed self tuning pressure regulator can be adopted to parameters which vary with such factors as the volume of the chamber and the setting pressure and that better dynamic and static performances can be obtained.

[6] (Nieto et al., 2008). presented an analytical model of pneumatic (air spring) suspensions that is based on an experimental characterization. The suspension consists of three principal parts: the air spring, an auxiliary tank, and a pipe connecting the two. The solution of both the nonlinear model and its linearized version are well in agreement with our experimental measurements of the stiffness, damping factor, and transmissibility for a reasonable operation range of this suspension. It was shown that the dynamic behavior of the air suspension can be made more versatile by a convenient choice of the sizes of the elements, in particular of the air spring and reservoir volumes. On the other hand, reducing the air spring volume increases the stiffness and hence also the highest eigen frequency. And on the other hand, increasing the reservoir volume reduces the stiffness and hence also the lowest eigen frequency. The analysis allowed us to propose a practical strategy for the operation of the suspension.

Burrows et al., 1970) [7]. presented a comparison between experimental and theoretical transient and frequency response results for a low-pressure on-off pneumatic servomechanism comprising a polarized relay with dead zone and hysteresis operating a four-way flapper nozzle valve via a torque motor. The effect of dynamic conditions on the valve characteristics was discussed. Position, velocity, and quasi-transient pressure feedback are provided. The effect of dynamic conditions on the valve characteristics is discussed.

Aguilera-Gomez and Lara-López (1999) [8] conducted a comprehensive study on the dynamic behavior of pneumatic actuators. The research focused on developing a mathematical model to predict the motion characteristics of actuators under varying loads and pressures. Using thermodynamic equations and kinetic principles, they simulated the performance of pneumatic cylinders with high accuracy. Their results validated the model through experimental tests, highlighting its application in optimizing actuator design and control.

[9] Demetgul et al. (2009) explored innovative fault detection techniques for pneumatic systems using Artificial Neural Networks (ANNs). Their work demonstrated how ANN algorithms could accurately diagnose system faults, enhancing reliability and reducing downtime. The study employed sensor data analysis under various operational states to train the ANN, achieving high accuracy in fault detection and predictive maintenance.

[10] Khusainov et al. (2016) focused on enhancing energy efficiency in pneumatic systems through intelligent valve control and air consumption optimization. Their research highlighted the importance of minimizing air losses during operation to boost efficiency. Using simulation and experimental validation, they demonstrated that smart valve designs could significantly reduce energy consumption without affecting performance.

Mei et al. (2013) [11] introduced a model-based control strategy aimed at improving the precision of pneumatic actuators. Their research focused on reducing issues like hysteresis and overshooting by employing real-time feedback control mechanisms. The results indicated enhanced motion control and reliability under varying load conditions.

[12] Wang and Li (2017) studied hybrid electro-pneumatic systems designed to integrate electrical control with pneumatic operation. Their work demonstrated how combining these technologies could achieve greater precision and energy savings. The hybrid system allowed for smoother operation and real-time control adjustments.

Rodriguez and Green (2021) [13] explored the use of pneumatic logic circuits for process automation. Their study illustrated how pneumatic logic gates, controlled by air pressure, could efficiently manage sequential operations in manufacturing environments.

2.3 Summary

From the literature discussed above, we gained a lot of knowledge and we inspired to do this project. We were able to do it with everyone tireless work.

CHAPTER 3

SYSTEM ARCHITECTURE

3.1 Introduction

The project objectives, methods, literature evaluation, and other details were all clarified in the preceding chapter. The block diagram, circuit diagram, Working principle,Project final Image and cost analysis will all be covered in this chapter.

3.2 Block Diagram

Here is the block diagram of the **Compressed Air Engine** with all the essential components. All of the components are shown in below as a block in this diagram. Here we use SMPS, Air Compressor, Air Cylinder, Pneumatic valve, Arduino Nano, Relay of our project and work together for perform as our desire outcome.

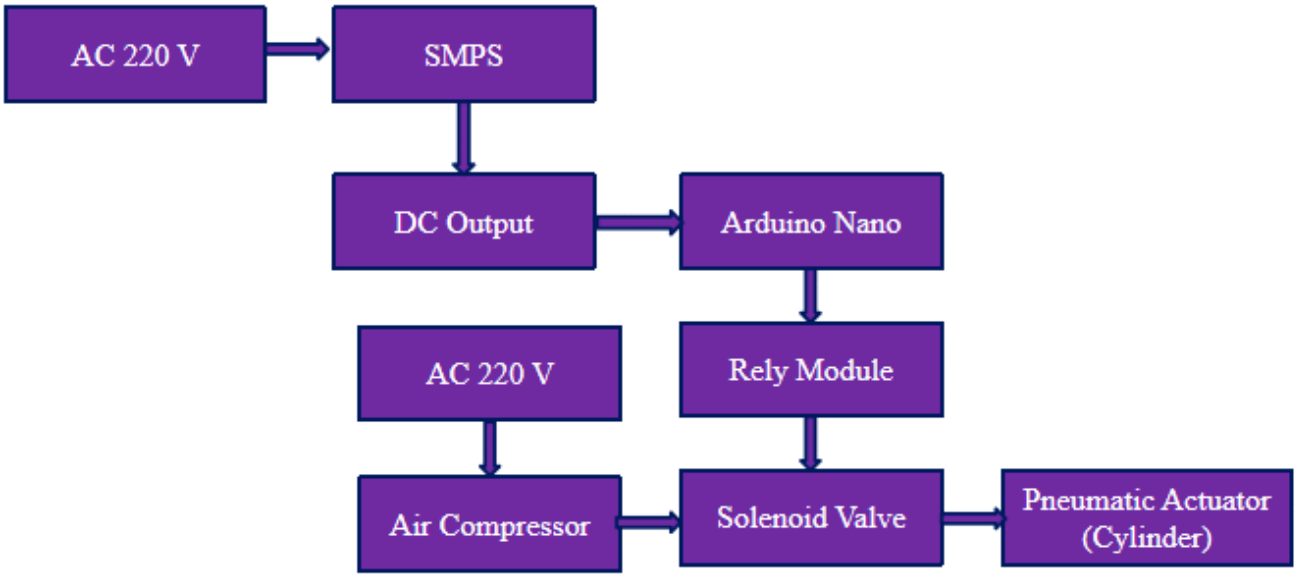


Figure 3.1: Block Diagram of Our Project

3.3 Circuit Diagram

In this part we show our project circuit design and connect out instrument through standard wire.

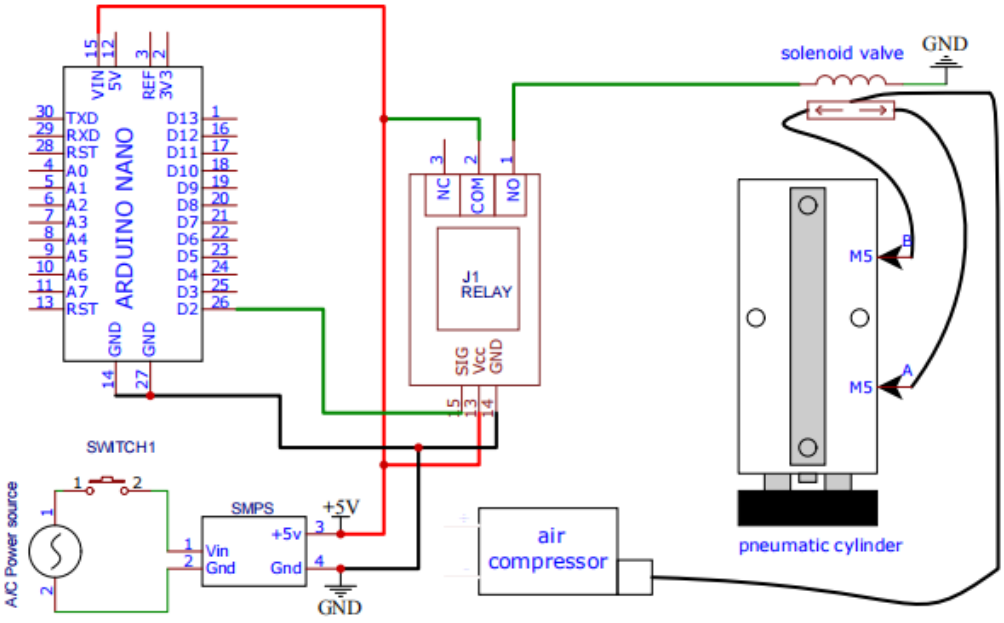


Figure 3.2 : Schematic Design of our Project

3.4 Working principle

A compressed air engine operates by converting the energy of compressed air into mechanical motion. An air compressor pressurizes ambient air, storing it in a tank. This compressed air is directed through pneumatic valves, which control the airflow into a double-acting air cylinder. The cylinder's piston moves linearly in response to the air pressure. An Arduino Nano microcontroller, powered by an SMPS (Switched-Mode Power Supply), manages a relay module that actuates the pneumatic valves. By toggling the relays, the Arduino controls the direction of the piston's movement, enabling forward and backward strokes. This setup allows precise control over the engine's operation, making it suitable for various applications requiring controlled linear motion.

3.5 Proposed Design







3.6 Final Project

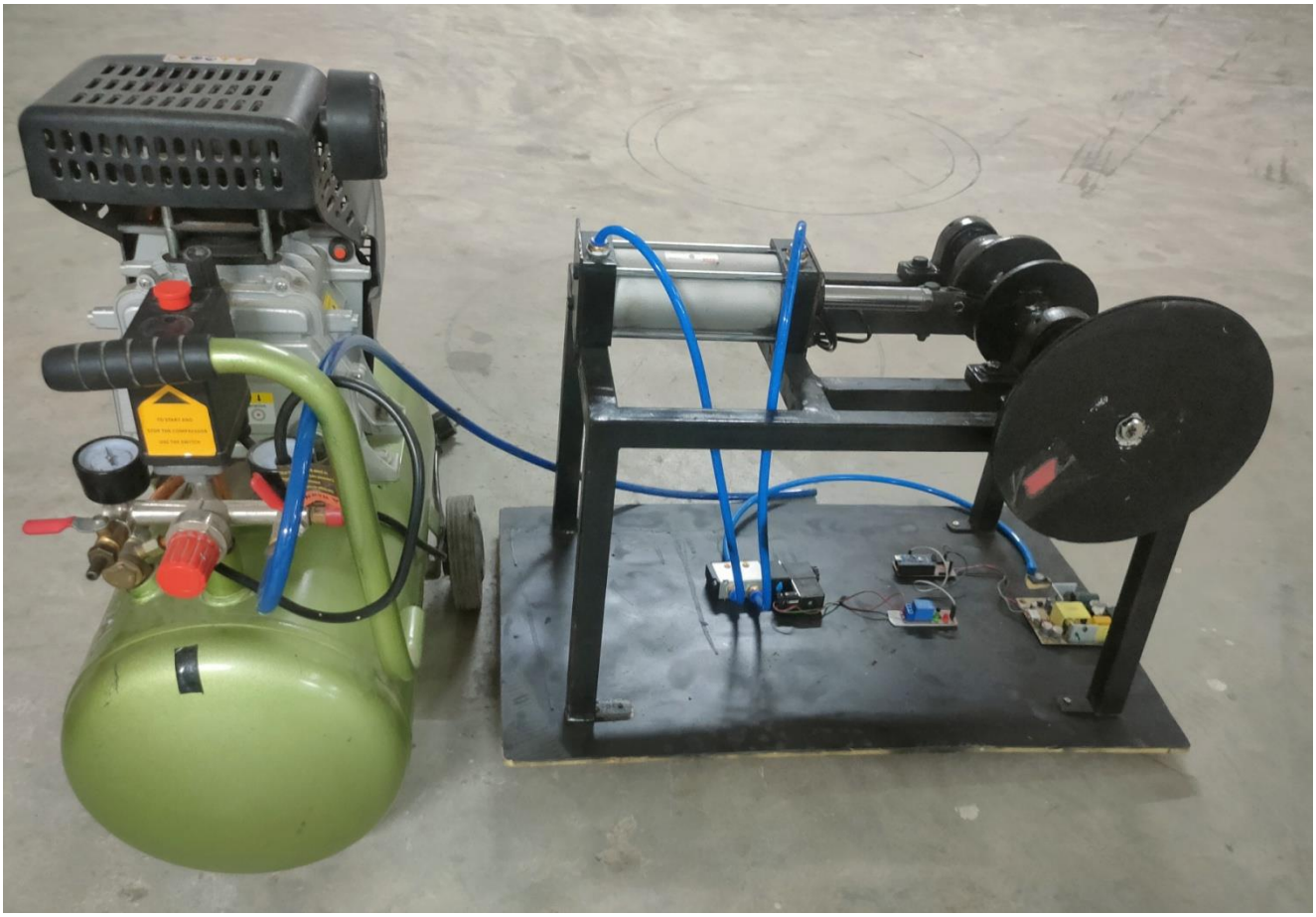


Figure 3.3 Complete Project Prototype

3.7 Cost Analysis

Table 1:List of Component with Price

Sl.no	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	SMPS	12V 10A	1	600	600
2	Air Compressor		1	12000	12000
3	Air Cylinder	SC 32 x 100 32mm Bore 100mm	1	2000	2000
4	Arduino Nano	AT mega328p	1	600	600
5	Relay			200	200
6	Bearing		5	150	750
7	Frame			2000	2000
8	Others				1000
				Total	19150/=

CHAPTER 4
HARDWARE & SOFTWARE ANALYSIS

4.1 Introduction

In this section, we will discuss elaborately about "**Compressed Air Engine**" and the component description, features, working procedure of our all equipment. The system hardware fabricates composed of micro-controller unit, power unit, source unit, power store unite, sensor unit and many more related components.

4.2 Hardware & Software

Hardware

- Air Compressor
- SMPS
- Pneumatic Valve
- Pneumatic Air regulator Valve
- Air Cylinder
- Bearing
- Arduino Nano
- Relay

Software

- Easy EDA

4.3 SMPS (Switch Mode Power Supply)

A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state. Switching power supplies have high efficiency and are widely used in a variety of electronic equipment, including computers and other sensitive equipment requiring stable and efficient power supply. A switched-mode power supply is also known as a switch-mode power supply or switching-mode power supply.



Figure 4.1: SMPS (Switch Mode Power Supply)

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.



Figure 4.2: SMPS Internal Part

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

12V 20A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non-Waterproof with Aluminum casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz
- Output Voltage: 12V DC, 0-20A
- Output voltage: Adjustment Range: ±20%
- Protections: Overload / Over Voltage / Short Circuit
- Auto-Recovery After Protection
- Universal AC input / Full range
- 100% Full Load Burn-in Test
- Cooling by Free Air Convection
- High Quality and High Performance
- LED power supply with a metal body for hidden installation for LED lighting
- Design with Built-in EMI Filter, improve signal precision.
- Certifications: CE & ROMs
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliability & low energy consumption
- Category – Switch Mode Power Adaptor (SMPS)

4.4 Pneumatic Air Regulator Valve

The air pressure regulator is also known as pressure-reducing valves. It maintains a constant output pressure regardless of variations in input pressure or output flow. In pneumatic instrumentation systems, instrument air is required to power valve actuators and other instruments like transmitters, controllers, control valves etc.



Figure 4.3: Pneumatic Air Regulator Valve

The figure shown above is fisher air regulator. As the pressure rises, it pushes the diaphragm closing the inlet valve and preventing the instrument air from entering regulator. As the air is drawn out through the outlet side, the pressure inside the regulator falls.

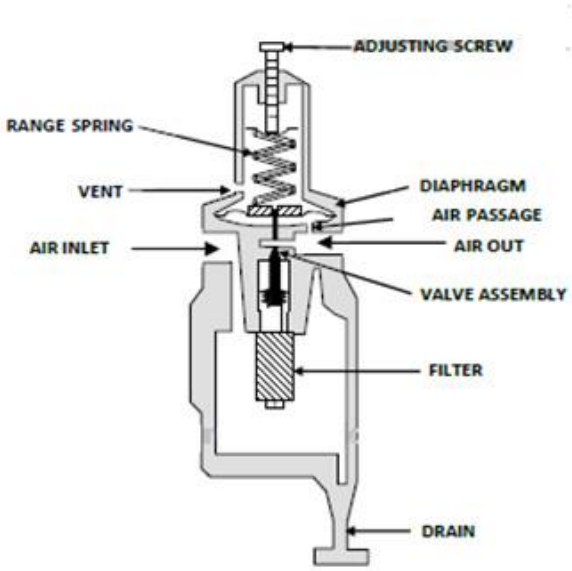


Figure 4.4: Construction of Pneumatic Air Regulator Valve

The working principle of the air pressure regulator

- The main air supply which is connected to the air inlet port passes through the filtering chamber.
- The filter removes the dirt particles from the air which may block nozzles etc. The air then goes into the valve assembly.
- The valve assembly is moved by the range spring pressing on the diaphragm.
- The range spring holds the valve assembly until the output pressure is high enough to lift the diaphragm. At this point the small spring in the valve assembly closes the valve.
- The air now passes through a hole at the center of the diaphragm and out of the vent. This is how the pressure is balanced across the diaphragm.
- When the output pressure becomes more than the pressure set by the range spring, the air will go out through the vent. When the outlet pressure becomes less, the valve assembly opens up to reach the set pressure. This pressure will exit the regulator through the outlet air port.
- If the outlet pressure is below the pressure set by the range spring the valve assembly will stay open until the set pressure is reached.

4.5 Bearing

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts. Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.



Figure 4.5: Ball Bearing

The purpose of Bearing is to reduce rotational friction and support radial and axial loads Types of bearings There are at least 6 common types of bearing, each of which operates on different principles:- Plain bearing, consisting of a shaft rotating in a hole. There are several specific styles: bushing, journal bearing, sleeve bearing, rifle bearing, and composite bearing. Rolling-element bearing, in which rolling elements placed between the turning and stationary races prevent sliding friction. There are two main types Ball bearing, in which the rolling elements are spherical balls Roller bearing, in which the rolling elements are cylindrical, taper and spherical rollers Jewel bearing, a plain bearing in which one of the bearing surfaces is made of an ultra hard glassy jewel material such as sapphire to reduce friction and wear Fluid bearing, a noncontact bearing in which the load is supported by a gas or liquid, Magnetic bearing, in which the load is supported by a magnetic field Flexure bearing, in which the motion is supported by a load element which bends.

4.6 Air Cylinder

Pneumatic actuators enable considerable forces to be produced from relatively small pressure changes. Pneumatic energy is desirable for main engine controls because it can quickly respond in starting and stopping as the power source does not need to be stored in reserve for operation. Moreover, pneumatic actuators are cheaper, and often more powerful than other actuators. These forces are often used with valves to move diaphragms to affect the flow of air through the valve.



Figure 4.6: Pneumatic Air Cylinder

The advantage of pneumatic actuators consists exactly in the high level of force available in a relatively small volume. While the main drawback of the technology consists in the need for a compressed air network composed of several components such as compressors, reservoirs, filters, dryers, air treatment subsystems, valves, tubes, etc. which makes the technology energy inefficient with energy losses that can sum up to 95% .

Specifications

- Manufacturer: Fest
- Model: DNU-80-50-PPV-A
- Type of Operation: Double Acting
- Piston Diameter: 80mm
- Stroke: 50mm
- Pneumatic Connection: G3/8
- Operating Pressure Range (Bar) 0-12

Pneumatic System Work

A Pneumatic actuator mainly consists of a piston or a diaphragm which develops the motive power. It keeps the air in the upper portion of the cylinder, allowing air pressure to force the diaphragm or piston to move the valve stem or rotate the valve control element.

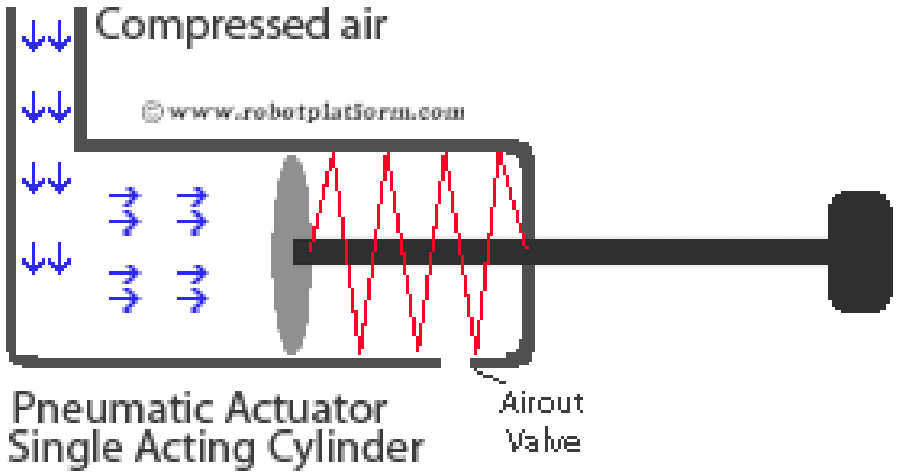


Figure 4.7: Pneumatic working System

4.7 Arduino Nano

Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

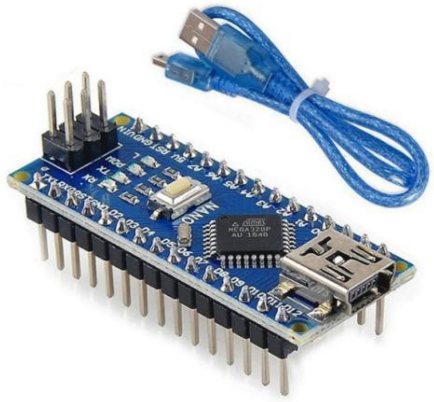


Figure 4.8: Arduino Nano

The micro-controller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, Maxims'). Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a small, complete, and breadboard friendly component. It has everything that Decimal/ Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano can automatically sense and switch to the higher potential source of power.

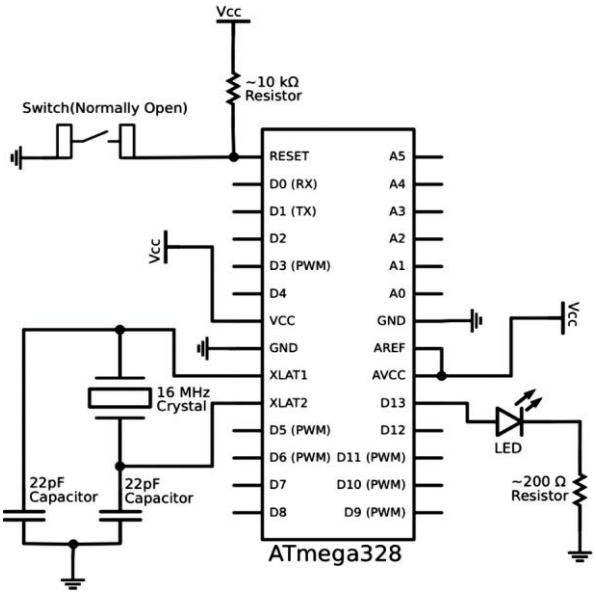


Figure 4.9: Arduino Nano Schematic Diagram

Nano's got the breadboard-ability of the Boarding and the Minibus with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, and GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It has two layers. That make it easier to hack and more affordable. One of the best features of Arduino Nano is, it's easy to use, compact and also small.

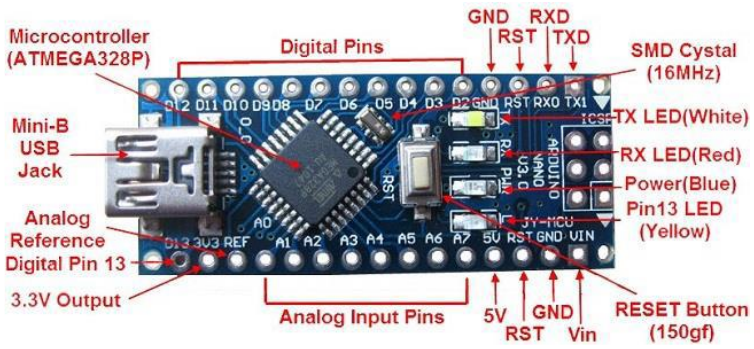


Figure 4.10: How Arduino Nano looks like

Specifications

- Micro-controller: Atmel ATmega328
- Operating Voltage (logic level): 5 V
- Input Voltage (recommended): 7-12 V
- Input Voltage (limits): 6-20 V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 am
- Flash Memory: 32 KB (of which 2KB used by boot loader)
- SRAM : 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Dimensions: 0.70” x 1.70”

Features

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input
- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download
- Manual reset switch

Micro-controller IC ATmega328p

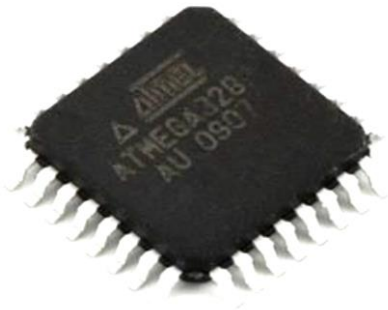


Figure 4.11: Micro-controller IC AT mega 328p

The high-performance Microchip Pico Power 8-bit AVR RISC-based micro-controller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughput's approaching 1 MIPS per MHz, balancing power consumption and processing speed.

4.8 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

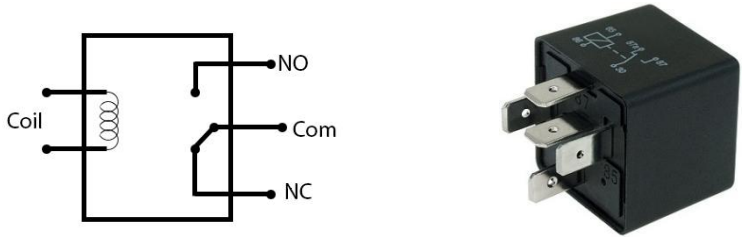


Figure 4.12: Relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts. Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands. The relay module is the one in the figure below.

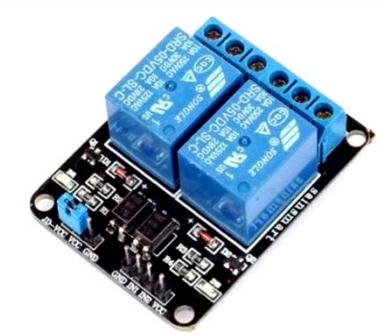


Figure 4.13: Relay Module.

This module has two channels (those blue cubes). There are other varieties with one, four and eight channels.

Main's voltage connections.

In relation to mains voltage, relays have 3 possible connections:

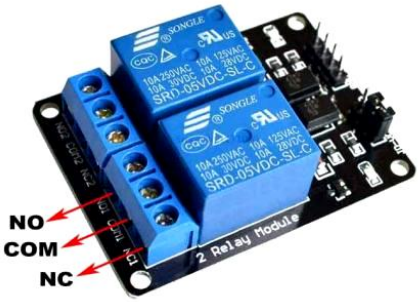


Figure 4.14: Main's voltage connections.

COM: Common pin

NO (Normally Open): There is no contact between the common pin and the normally open pin. So, when you trigger the relay, it connects to the COM pin and supply is provided to a load

NC (Normally Closed): There is contact between the common pin and the normally closed pin. There is always connection between the COM and NC pins, even when the relay is turned off. When you trigger the relay, the circuit is opened and there is no supply provided to a load.



Figure 4.15: Voltage Connections

Pin wiring

The connections between the relay module and the Arduino are really simple:

GND: Goes to ground

IN: Controls the first relay (it will be connected to an Arduino digital pin)

IN2: Controls the second relay (it should be connected to an Arduino digital pin if you are using this second relay. Otherwise, you don't need to connect it)

VCC: Goes to 5V

4.9 Air Compressor

The Mega Air Compressor is engineered for optimal performance in small to medium-scale pneumatic operations. With its 24-liter air storage tank, it can deliver a steady flow of compressed air, ideal for powering air tools, inflating tires, and spray painting. The compressor is equipped with a powerful motor, ensuring rapid air compression and minimal downtime. The unit's robust design includes a reinforced tank for durability, along with user-friendly controls for safe and efficient operation.



Figure 4.16 : Air Compressor

Features :

- **24-Liter Steel Tank:** Durable, rust-resistant, and ideal for medium-duty tasks.
- **Powerful Motor**: Provides efficient air compression with low noise.
- **Pressure Regulator & Gauge:** Allows precise control and real-time monitoring.
- **Safety Valve:** Prevents over-pressurization for safe operation.
- **Air Filter:** Protects from dust and debris, extending lifespan.
- **Drain Valve:** Easy removal of moisture buildup.
- **Portable Design:** Lightweight with handle and rubber feet.
- **Thermal Overload Protection:** Auto shut-off during overheating.

Specification

Table 2: Specification of Air Compressor

Parameter	Details
Model Name	Mega Air Compressor
Tank Capacity	24 Liters
Compressor type	Reciprocating Piston
Power Source	Electric (220V AC)
Motor Power	2 HP (1.5 kW)
Max Pressure Output	8 Bar (110 PSI)
Flow Rate	100–120 L/min
Weight	Approximately 15–20 kg

4.10 Pneumatic valve

Pneumatic valves play an important role in any pneumatic system. These valves not only regulate the quantity and direction of airflow, serving as control valves, but they also function as safety valves, capable of shutting off the air supply during hazardous situations or depressurizing the system for safety purposes.

Consisting of three essential elements, pneumatic valves are equipped with ports, a housing, and a controller. Ports, or connections, serve as openings for coupling, facilitating the passage of compressed air. The housing accommodates the switching mechanism, directing the air to the designated working port. The controller, operated manually, mechanically, pneumatically, or electrically, ensures precise timing in valve switching.

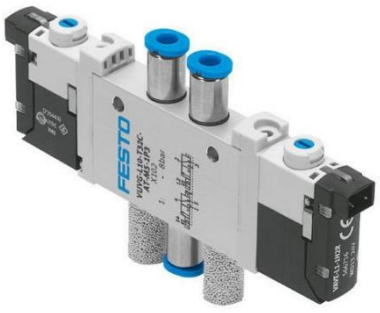


Figure 4.17 : Pneumatic Valve

In recent decades, pneumatic valves have undergone significant advancements, evolving from mechanical, manual, or pneumatic operation to the introduction of electrically operated valves. These valves utilize a magnetic coil and a control signal for switching, and they have become the predominant choice due to the widespread adoption of PLC technology in modern machines.

The innovation continued with the introduction of valve islands, a revolutionary concept consolidating multiple valves into a single, more efficient component that is quicker to install and more compact. The latest trend in valve technology, the Motion Terminal, represents a breakthrough in Digital Pneumatics. This development allows for dynamic functionality by assigning various functions to valve positions through software apps, offering a broad spectrum of new possibilities.

4.11 Easy EDA

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share-publicly and privately-and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

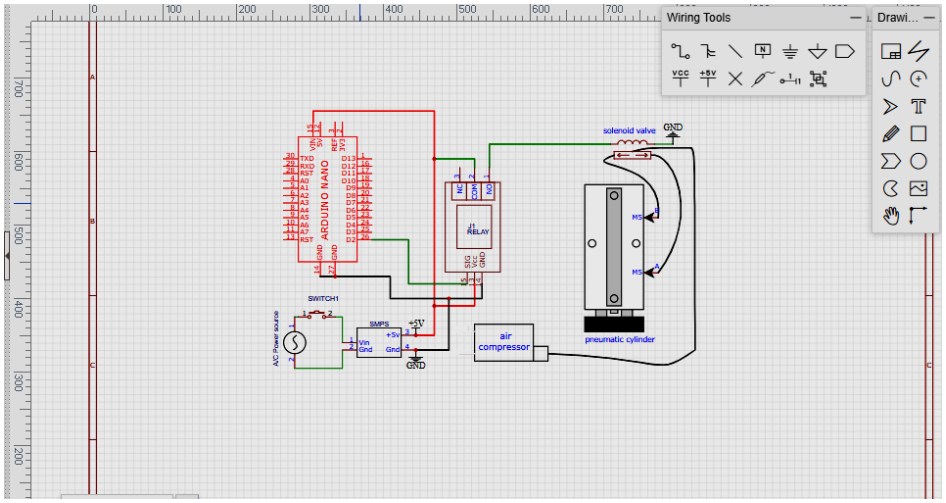


Figure4.18:Easy EDA Software Interface

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

CHAPTER 5

RESULTS & DISCUSSION

5.1 Project Output

After finally completing this project, we ran it & we observed the output of this project. We can see that it is working well as expected. After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- At first, we start our system.
- Efficient conversion of compressed air energy into mechanical motion.
- Smooth forward and backward movement of the air cylinder controlled by Arduino.
- Reliable switching mechanism using the relay module for directional control.
- Eco-friendly operation with zero emissions and reduced carbon footprint.
- Suitable for lightweight automation tasks and sustainable energy applications.
- Demonstrated effective pneumatic actuation with precise control.

- **Compressed Air Hold : 110 /115 PSI**
- **Compressor Capacity : 24 Liter**
- **Compressor Motor Power : 2HP**

Data table

Rotation	Time (Sec)	RPM
5	4	75
10	8.1	74
15	12	75
20	16.12	74
25	19.83	76
30	23.52	77
35	28.56	74
40	32.72	73

- **Compressed Air Hold : 90 PSI**
- **Compressor Capacity : 24 Liter**
- **Compressor Motor Power : 2HP**

Data table

Rotation	Time (Sec)	RPM
5	4	75
10	8.2	72
15	12.5	72

- **Compressed Air Hold : 70 PSI**
- **Compressor Capacity : 24 Liter**
- **Compressor Motor Power : 2HP**

Data table

Rotation	Time (Sec)	RPM
4	3.5	69
8	7	68
12	10.7	67

The data shows that there is a stable RPM from 67 to 77, with the time increasing linearly as the rotation increases. Minor RPM fluctuations may occur due to mechanical resistance or torque changes. However, the best RPM is obtained at 110/100 PSI pressure. Then the crankshaft rotates more in less time, resulting in higher RPM. Similarly, when the compressor pressure decreases, the crankshaft takes more time to rotate, resulting in lower RPM. Overall, the mechanism operates efficiently with consistent speed, suggesting good alignment and minimal mechanical losses.

5.2 Advantages

There are certainly many advantages of our project and some of the major ones have been given below -

- No consumption of any fossil fuel.
- Eco-friendly.
- Low installation cost.
- Low maintenance cost.
- Simple in construction.
- Simple operation
- High reliability
- Safety in operation
- Cost-effectiveness
- Fast response
- Flexible applications

5.3 Limitation

It is a demo project so we found some limitation. In future we will work for reduce this kind of limitation. These limitations are -

- This project can now be only used for small scale purposes
- No energy backup.
- Operation can be noisy without proper silencers.
- Air leakage can reduce system efficiency.
- 115 PSI ,Rotation, Uniform,
- RPM Fluctuate Around Number 67-77.

5.4 Application

Some of the application areas of the project has been pointed out below-

- Industrial automation
- Material handling systems
- Packaging industries
- Automotive systems
- Pneumatic tools

5.5 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

The Compressed Air Engine project successfully showcases the potential of compressed air as an eco-friendly alternative to traditional energy sources. By utilizing pneumatic systems controlled by an Arduino Nano, the project enables precise and efficient movement of the Air Cylinder. The integration of a Relay Module ensures seamless direction control, while the SMPS provides consistent power to maintain stability. Though promising for eco-friendly applications, challenges such as optimizing air storage capacity and pressure management remain. Future improvements could involve enhancing system efficiency, exploring higher-pressure compressors, and scaling the design for more complex automation tasks or transportation solutions.

CHAPTER 6
CONCLUSION

6.1 Conclusion

The Compressed Air Engine project presents a viable solution for sustainable and eco-friendly mechanical motion using compressed air as an energy source. By leveraging components like an Air Compressor, Pneumatic Valve, Air Cylinder, Arduino Nano, Relay Module, and SMPS, the system successfully converts compressed air into controlled mechanical movement, enabling forward and backward motion. The Arduino Nano serves as the central controller, orchestrating the system's operation, while the Relay Module allows for precise directional control of the pneumatic valve. The SMPS ensures a stable and reliable power supply to the system, enhancing performance and efficiency.

This project highlights the potential of compressed air as a clean and renewable energy source, promoting a shift toward more environmentally friendly technologies. The system operates without emissions, offering a sustainable alternative for applications such as material handling, light automation, and transportation. However, challenges such as optimizing air storage capacity and managing pressure fluctuations remain, which could affect system performance in long-term applications.

Overall, the Compressed Air Engine project lays the groundwork for further exploration into pneumatic-based systems, with opportunities for improving efficiency, scalability, and broader applications in green technologies. With continued refinement, this technology could play a significant role in reducing dependence on traditional fossil fuels, contributing to a more sustainable future.

6.2 Future Scope

We are thinking about adding many features to our project in the future to get more desirable outcomes.

- In future, this project can be developed by Microcontroller Unit.
- Additional power systems can be added.
- Advanced control on IoT System can be developed.

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APPENDIX

```
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```