DESIGN & CONSTRUCTION OF METAL, NON-METAL & COLOR-WISE PRODUCT SORTING SYSTEM WITH CONVEYOR BELT & PNEUMATIC TECHNOLOGY

A Thesis
By

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Supervised By

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Abstract

This project presents the design and development of a conveyor belt system integrated with color sorting and metal/non-metal detection capabilities, powered by a pneumatic system. The conveyor belt facilitates the movement of materials through a series of sensors—an color sensor and ESP32 cam for color differentiation and an inductive proximity sensor for metal detection. Upon identification, the pneumatic actuators are triggered to sort objects into designated bins based on their properties. The system ensures precise and efficient sorting, reducing manual labor and minimizing errors. Its application is particularly useful in manufacturing, recycling, and material handling industries, where speed and accuracy are critical. The integration of pneumatic mechanisms enhances system reliability and cost-effectiveness, providing a sustainable solution for automated sorting processes. The project emphasizes optimization of throughput, energy efficiency, and scalability, making it a viable choice for modern industrial automation.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The sorting of materials in garbage industries square measure created manually at this time days. There could also be a likelihood of errors in sorting. We've enforced an answer for substitution human by automatic management while not manual power. The project detects the objects completely different of various} materials and segregate them into 4 different boxes. By using sensors, it decreases the errors in sorting and reduces the person's power. The projected system involves detector, IR sensor, mini limit switch for sensing weight and for sorting purpose linear motion electrical actuators square measure used [1]. The motor shaft is connected to the roller and also the conveyor belt is placed on the roller. These provide sensible tension over the belt. The conveyor motors input gets from electrical devices.

The negative feedback circuit consists of ARDUINO board, relay interfacing board, transformer, input interfacing board, DC motors [2]. The logic used for sensors for characteristic materials is finished in program by weight and inductive means that it's sorted as metal. By weight and reflection, it's sorted as glass and if solely reflection it's known as plastic. The material sorter has been designed in such the simplest way it will fulfill all the wants of the packaging industries wherever merchandise of various materials square measure factory-made. It has innumerous applications like garbage industries, packaging fields. The project is intended in such the simplest way that may manufacture high productivity and may type materials while not smashup. By this packaging system becomes easier.

1.2 Literature Review

The concept of automatic sorting arose due to the difficulties faced by the packaging industries. The idea of sorting has existed for quite a while after there have been advancements in technology. Shen and Hassan [1] states that an approach for continuous recognition and the sorting of objects into their respective and desired location can be implemented as an image of color processing that can attract an enormous

attention leading to a possible widening scope of application in a different field in a modern technology. A color-sorting robot is designed and developed using an Arduino Uno micro-controller, SG90 Tower Pro Servo Motor, TCS3200D color sensor and several other electronic components. The system has the potential to sort the objects according to their colors into their relevant color station in a less time. A distinct code for this system is developed. According to Yunardi et al. [2],

A 3D volume of the packed box is well quantified from the 2D images using the techniques of image processing. The 2D image consists of two images captured on the camera with a horizontal view and a vertical view. With the parameters, that is, the length, width and the height, a multiplication program is used to obtain the result of the volume. Consequently, contour-based object detection can be appertained to the automatic sorting system to measure the volume of an object in a computer-based vision. According to Babita [3], sensors are embedded at several places that detects and senses the materials of various sizes that gets sorted at different stations based on their sizes. For sensing, the material used is an infrared sensor that is so sensitive. All the process is controlled and handled by a PLC. Kulkarni et al. [4] has implemented the sorting of the boxes using a barcode, which is decoded by raspberry pi.

This raspberry pi sends a signal to the motor driver to start and stop the motor accordingly. Proximity switches are implanted on every cylinder to sense the box position, which again sends back the signal to raspberry pi. Relay is used as an interface for the motor driver and motor. The relay used is solid relay type. Raspberry pi uses cameras of five megapixels to capture the image, which will then be decoded. The sorting process is controlled and handled by Arduino Microcontroller. Automating every sector of industry is an important step towards increasing efficiency and reducing human related errors, here we try to automate the sorting process by using Controller. The program feed in the Arduino controls the entire process. [5]

1.3 Objectives

The objectives of this project are:

- To design and construct a conveyer belt for metal, non-metal & color-wise product sorting system
- To test the performance of our constructed project

CHAPTER 2
THEORY & WORKING PRINCIPLE

2.1 History

This metal non-metal sorting system is so effective and safe process. It is mainly used in the factory and industrial area. After it used, we reduce the manpower and time. That's why we get good efficiency. Where very difficult to move company products from here to another location perfectly at that moment we can easily use this machine. This machine is very easy to use, and it works very effectively. A relevant picture is added below –

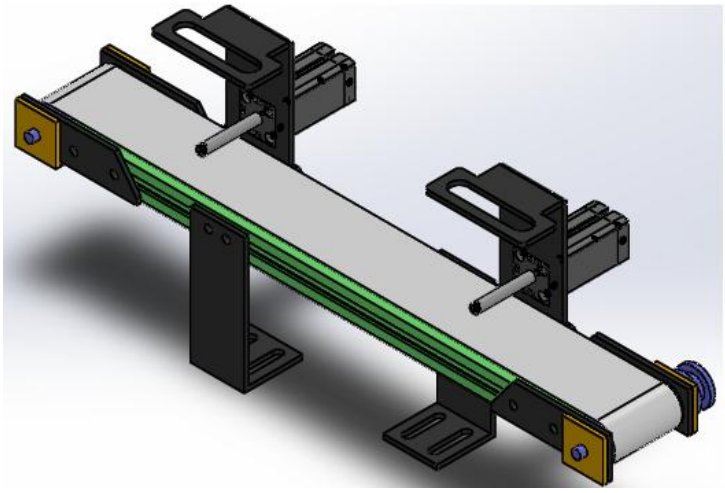


Fig 2.1: Color and Metal Non-metal sorting system with conveyor belt 3d image.

2.2 Methodology

- Creating an idea for designing and construction of an **Conveyor Belt for color sorting and Metal non-metal sorting using pneumatic system**. And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the micro controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

2.3 Block Diagram

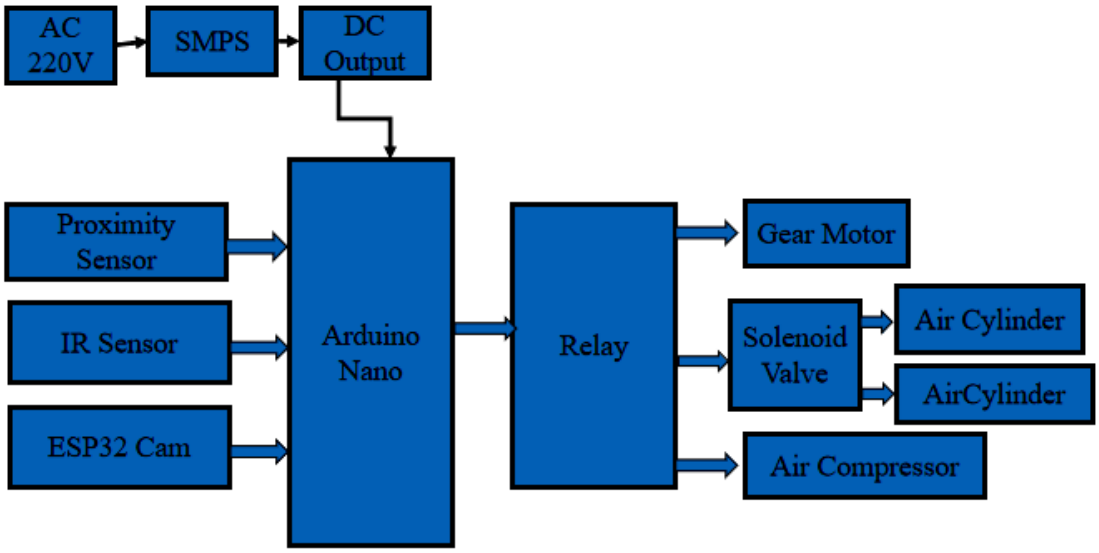


Figure 2.2: Block Diagram of color and metal non-metal product sorting system with conveyor belt & Pneumatic Technology.

This block diagram illustrates a microcontroller-based pneumatic control system. The system is powered by an AC 220V source, which is converted to a suitable DC voltage via an SMPS (Switched-Mode Power Supply). An Arduino Nano microcontroller unit serves as the central control unit, interfacing with various input sensors, including a Proximity Sensor, an IR Sensor, and an ESP32-CAM for visual monitoring.

The Arduino processes input signals and transmits control outputs to a relay module, which actuates external devices. These devices include a gear motor, a solenoid valve, and an air compressor. The solenoid valve directs compressed air to actuate air cylinders, thereby facilitating mechanical movement. This configuration enables automated control of pneumatic operations based on sensor inputs and programmed logic.

2.4 Circuit Diagram

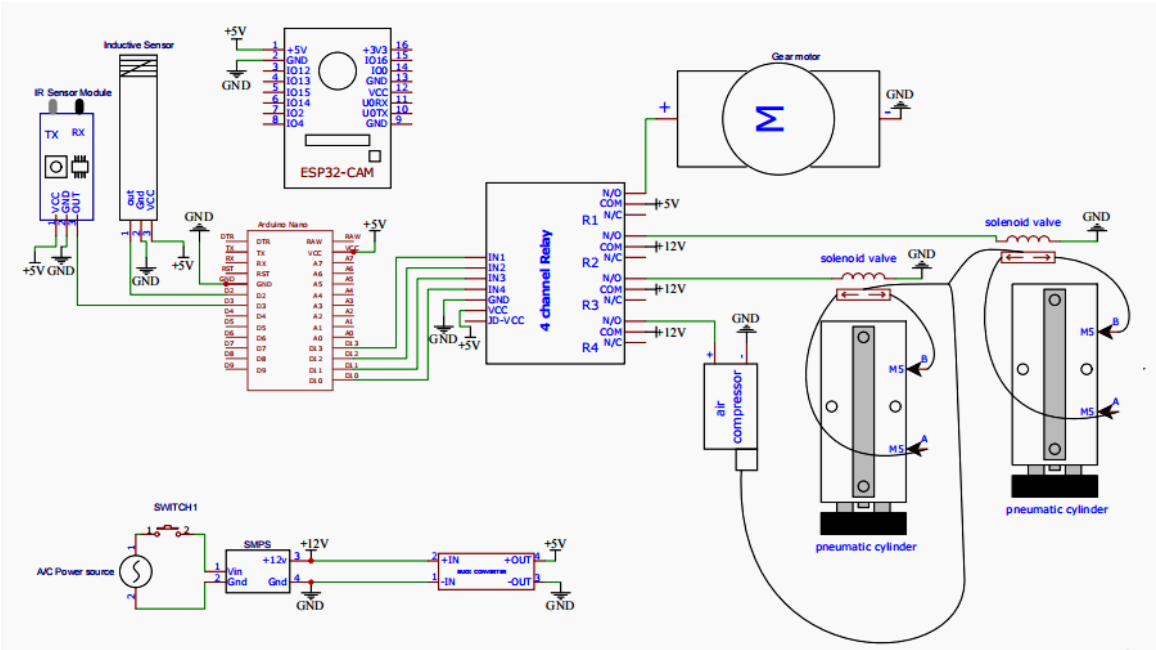


Figure 2.3: Circuit Diagram of color and metal non-metal product sorting system with conveyor belt & Pneumatic Technology.

2.5 Working Principle

The conveyor belt system efficiently sorts objects based on color and material type (metal or non-metal) using an ESP32-CAM and a pneumatic mechanism. As objects move along the conveyor, an IR sensor detects their presence, temporarily stopping the belt. The ESP32-CAM captures the object's image and analyzes its color in real-time. Identified colors are then processed by the controller for sorting. After color detection, the object is checked by a proximity sensor to determine if it is metallic. The sorting process is managed through pneumatic cylinders where color sorting directs objects into their respective bins, while metal and non-metal items are separated accordingly. An Arduino Nano controls the entire system, managing sensor inputs, conveyor belt movement, and pneumatic actions, ensuring smooth and precise operation. This automated solution enhances sorting speed, accuracy, and efficiency in industrial environments.

2.6 Hardware Implementation



Figure 2.4: Project Progress Image.

2.7 Components List:

1. DC Gear Motor.
2. IR Sensor.
3. Proximity Sensor.
4. Air Cylinder.
5. Air Compressor.
6. SMPS
7. Relay
8. Pneumatic Solenoid Valve.
9. Arduino Nano.
10. ESP32 Camera
11. Buck Converter

2.8 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.

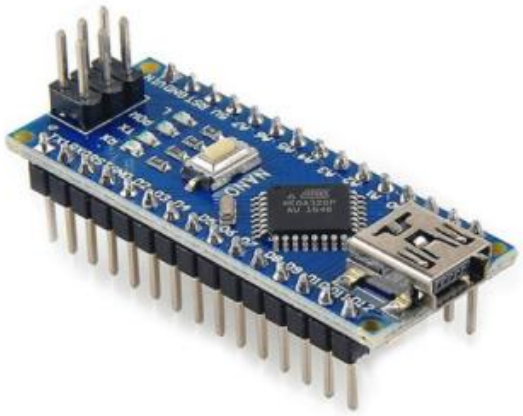


Figure 2.5: Arduino Nano

The microcontroller 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, Max MSP).

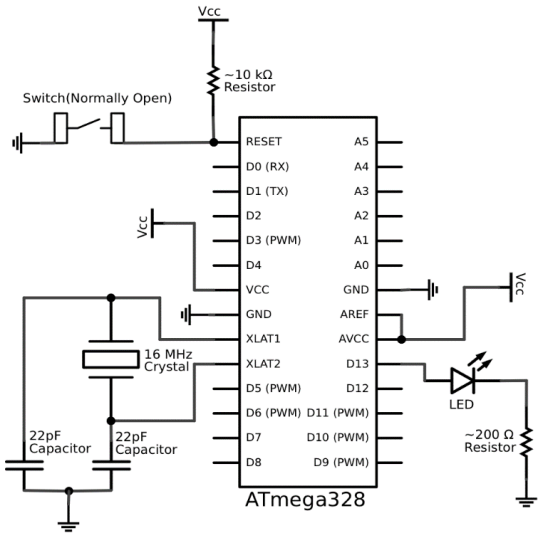


Figure 2.6: Arduino schematic diagram

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is the smallest, complete, and breadboard friendly. It has everything that Diecimila / Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power. Nano's got the breadboard-ability of the Boarduino and the Mini+USB 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, 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 is two layers. That makes it easier to hack and more affordable.

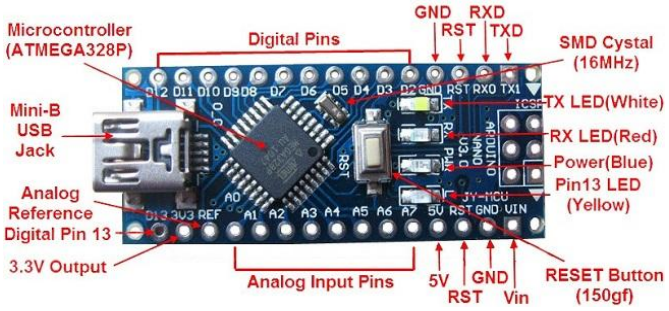


Figure 2.7: Section of Arduino Nano.

Specifications

- Microcontroller: 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 mA
- 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.
- Standard 0.1 spacing DIP (breadboard friendly).
- Manual reset switch.

Microcontroller IC ATmega328p:



Figure 2.8: Micro-controller IC AT mega 328p.

The high-performance Microchip Pico Power 8-bit AVR RISC-based microcontroller 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 throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

2.10 Switch Mode Power Supply (SMPS)

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. 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 2.9: SMPS

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 5A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non-Waterproof with Aluminium casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz.
- Output Voltage: 12V DC, 0-5A.
- 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 & RoHs.
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliability & low energy consumption.
- Category – Switch Mode Power Adaptor (SMPS).

Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC.
- DC to DC.
- DC to AC.
- AC to AC.

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter.
- Inverter consisting of switching devices such as MOSFETS.
- Transformer.
- Output rectifier and filter.
- Feedback and control circuit.

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

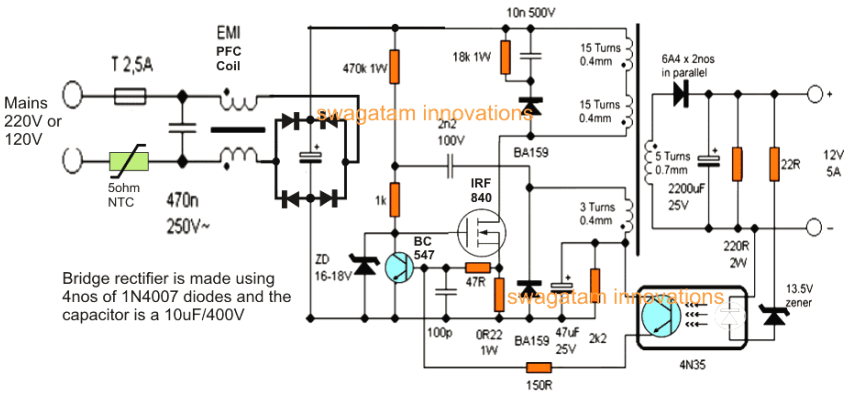


Figure 2.10: SMPS Circuit Design

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electro technical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up o the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as flyback, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies

- Higher efficiency of 68% to 90%.
- Regulated and reliable outputs regardless of variations in input supply voltage.
- Small size and lighter.

- Flexible technology.
- High power density.

Disadvantages

- Generates electromagnetic interference.
- Complex circuit design.
- Expensive compared to linear supplies.

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency.

Switch Mode Power Supply

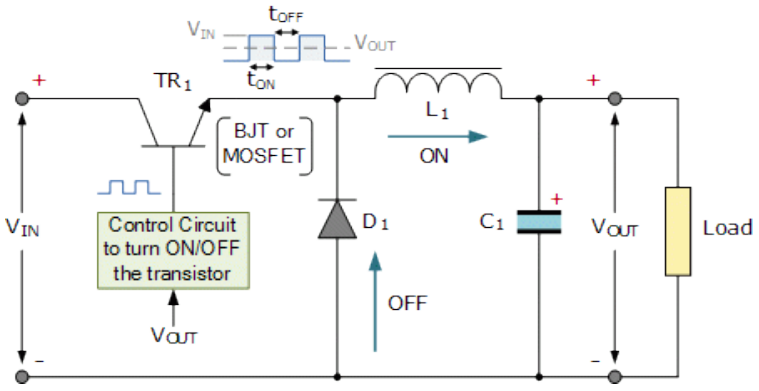


Figure 2.11: Power Supply Connection

Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps.

The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79… negative output voltage series. These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits.

There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Most D.C. power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified d.c. producing a suitably smooth d.c. voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical D.C. power supply would look something like this:

Typical DC Power Supply:

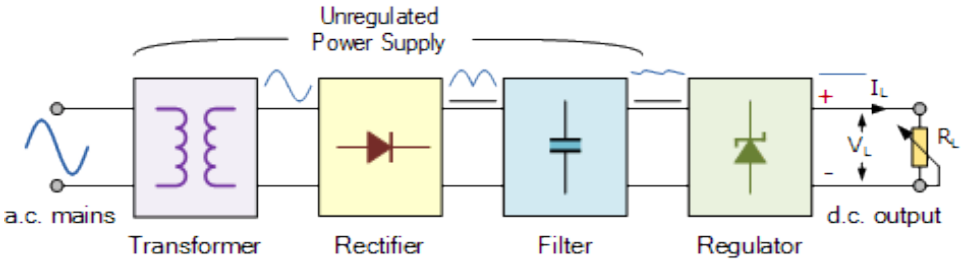


Figure 2.12: DC Power Supply Step

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

2.10 IR Sensor

An infrared sensor is an electronics device that emits certain features around it and / or detects infrared radiation. Infrared sensors are capable of measuring the heat emitted by an object and detecting motion. In this project we will control the fan and light automatically through the closed loop system so the IR sensor for the system is definitely needed as a

response. Here the fan will turn on and the light will turn on when the IR sensor detects an object and the fan and light will switch off automatically when an object leaves the house.



Figure 2.13: IR Sensor

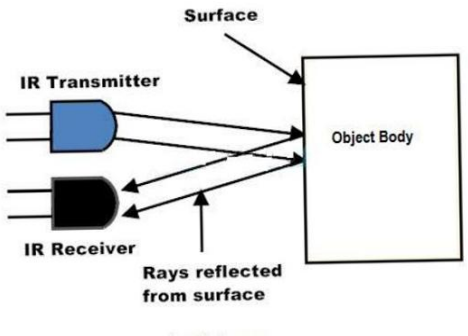


Figure 2.14: IR sensor reflection System.

Principles of operation:

Sensor works with sense. When an object intersects the sensor light then the sensor detects something. Some infrared ray is deflected from the object and scene the length of this distance. In this sensor we can make a fixed length light and detect our exact object. If some object comes in front of this sensor, then the sensor detects it and sends a signal in LED.

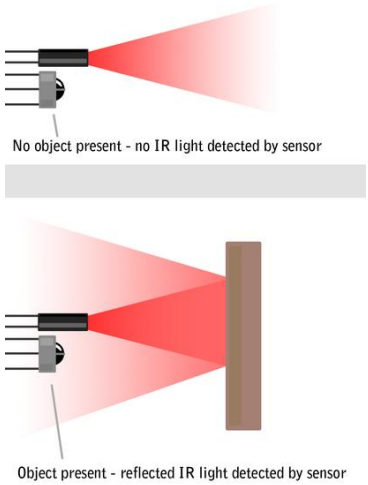


Figure 2.15: IR sensor Detection System.

2.11 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.

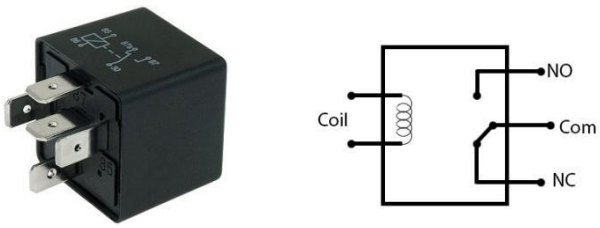


Figure 2.16: Relay

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.

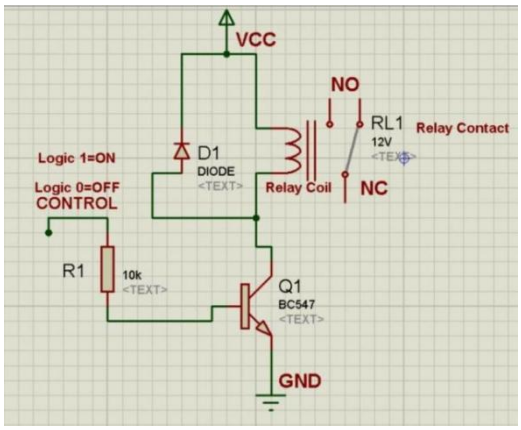


Figure 2.17: Transistor Switching Circuit.

The circuit above is called a low-side switch, because the switch – our transistor – is on the low (ground) side of the circuit. Alternatively, we can use a PNP transistor to create a high-side switch: Similar to the NPN circuit, the base is our input, and the emitter is tied to a constant voltage. A relay is an electrically operated switch of mains voltage. It means that it can be turned on or off, letting the current go through or not. Controlling a relay with the Arduino is as simple as controlling an output such as an LED. The relay module is the one in the figure below.



Figure 2.18: Relay Module.

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

Mains voltage connections:

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

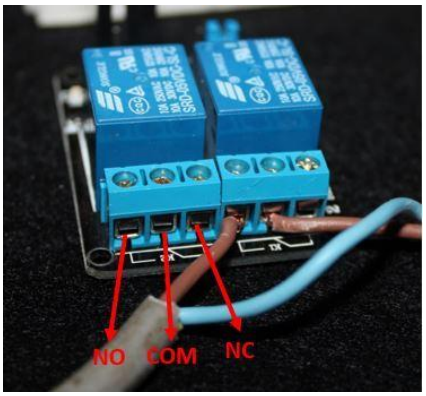


Figure 2.19: Pin diagram of Relay Module

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 a 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. If you want to control a lamp for example, it is better to use a normally-open circuit, because we just want to light up the lamp occasionally.

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



Figure 2.20: Main Voltage Connection

GND: goes to ground.

IN1: 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.

2.12 DC Gear Motor:

Description

A DC motor is any motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. ... A 12v DC motor is small and inexpensive, yet powerful enough to be used for many applications.

Specification:

- Voltage: 12V DC.
- Gear ratio: 1/31.
- No-load speed: 200RPM.
- Rated Speed: 140RPM.
- Rated torque: 10kg.cm.
- Rated current: 2.5Amp.
- Length of Motor(including spindle): 106mm/4.17″..
- Diameter: 37mm/1.45″.
- Shaft length: 21mm/0.82″.
- Shaft diameter: 6mm/0.24″.



Figure: 2.21: DC Gear Motor

2.13 Proximity Sensor:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object. Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

Types of Proximity Sensor

- Inductive Proximity Sensor.
- Optical Proximity Sensor.
- Capacitive Proximity Sensor.
- Magnetic Proximity Sensor.
- Ultrasonic proximity Sensor.



Fig 2.22: Proximity Sensor

Proximity sensors are suitable for damp conditions and wide temperature range usage, unlike your traditional optical detection. Proximity sensors are also applicable in phones as

well, be it your Andriod or IOS devices. It consists of simple IR technology that switches on and off display accordingly to your usage. Proximity sensors are used in phones, recycling plants, self-driving cars, anti-aircraft systems, and assembly lines. There are many types of proximity sensors, and they each sense targets in distinct ways.

- Model: LJ12A3-4-Z/BY .
- Wire Type - Cylindrical DC 3 Wire Type.
- Switch Appearance Type - Cylinder Type.
- Theory - Inductive Sensor.
- Output Type - PNP NO(Normal Open)..
- Diameter of Head - 12mm .
- Detecting Distance - 4mm .
- Supply Voltage - DC 6-36V .
- Current Output - 300mA .
- Response Frequency - 0.5KHz .
- Detect Object - Iron.
- Operating Temperature -25°C to +55°C (Non-freezing Condition) .
- Size 6.2 x 2cm/2.4" x 0.8" (L*Max. Dia).
- Cable Length 110cm/43.3".
- External Material Plastic, Alloy .
- Net Weight 46g.

2.14 Solenoid Valve

A solenoid valve, also known as an electrically operated valve, is a valve that uses electromagnetic force to operate. When an electrical current is passed through the solenoid coil, a magnetic field is generated which causes a ferrous metal rod to move. Solenoid valves are controlled by the action of the solenoid and typically control the flow of water or air as a switch. If the solenoid is active (current is applied), it opens the valve. If the solenoid is inactive (current does not exist), the valve stays closed.

Product Specification:

- Port Size 1/8" 1/4" 3/8" 1/2" M5
- Material Aluminum Alloy
- Brand Festo
- Response Time 0.05Second
- Protection Class IP65
- Voltage Range -10%~+10%

Description:

- Pneumatic Solenoid valves are shut-off, divert, reverse-acting, valves, having unique sealing design for total hygienic operations.
- It's ball shaped valve body is designed for optimum flow and CIP cleaning.
- These valves can be supplied with control head for operation with solenoid valve and micro switches.



Fig: 2.23: Pneumatic solenoid valve

2.15 Air Cylinder

Pneumatic cylinder(s) (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved.] :85 Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Because the operating

fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets of the Disney Tiki Room, pneumatics are used to prevent fluid from dripping onto people below the puppets.

Different types of hydraulic cylinder:

- Single – Acting Cylinder. This type of cylinder is named due to the fluid only having one access point or port into the cylinder.
- Double-Acting Cylinder.
- Non-differential Cylinder.
- Telescoping, Ram-type, actuating Cylinder.
- Balanced, Double-acting, Piston-type Cylinder.
- Cushioned Cylinder.
- Single Acting, Spring Loaded.



Figure: 2.24: Air Cylinder

Pneumatic Cylinder Specifications

Model	ATO-CP-MSA
Bore Size	20mm, 25mm, 32mm, 40mm
Stroke	25mm, 50mm, 75mm, 100mm, 200mm, 350mm, 500mm
Acting Type	Single Acting
Working Medium	Air
Max Pressure	0.1-0.9 Mpa
Working Temperature	-5~+70℃
Speed Range	50-800 mm/s
Cushion Type	Rubber Buffer
Port Size	M5 X 0.8", G 1/8"

Cylinder Works:

Pneumatic actuators are mechanical devices that use compressed air acting on a piston inside a cylinder to move a load along a linear path. ... Double-acting cylinders have an airport at each end and move the piston forward and back by alternating the port that receives the high-pressure air.

2.16 Air Compressor

An air compressor is a pneumatic device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When the tank's pressure reaches its engineered upper limit, the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released, and the tank depressurizes.

Air Compressor can also be classified according to the design and principle of operation:

1. Single-stage reciprocating compressor.
2. Two-stage reciprocating compressors.

3. Compound compressor.
4. Rotary-screw compressor.
5. Rotary vane pump.
6. Scroll compressor.
7. Turbo compressor.
8. Centrifugal compressor.

Function of Air Compressor

An air compressor is a pneumatic device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure.

Product Specification

Horsepower	5 HP
Brand	ESYEXPRESS ELECTRIC AIR PUMP
Maximum Flow Rate	0-20 cfm
Power Source	Electric DC
Voltage	12V
Minimum Order Quantity	1 Piece

Product Description

Your Brand Electric Portable DC12V Tire Inflator Mini Car Compressor Pump.

Description:

- This portable air compressor has a small electric motor that compresses the air in a small, attached tank.
- It can be plugged into a 12V car system for on-the-go repairs or inflation.
- It's ideal for cars and bicycle tyres, sports balls etc.
- It can be powered through a cigarette lighter in your vehicle and is very versatile.

Specification

- Maximum Pressure - 260 PSI.
- Brand new and high quality.
- Material: ABS.
- Color: Black.
- Compact and portable.
- easy to use.
- Provide pressure gauge and 3 nozzle adapters.
- Ideal for inflating tires, balls, rubber floater, hovercraft and so on.
- Can also inflate Bicycle/Scooter/Moped tyres and also allows inflation of many other inflatable.
- leisure items using Flow rate: 35 L /Min.
- Voltage: DC 12 V.



Figure 2.25: Air Compressor

2.17 ESP32- CAM

The ESP32-CAM is a full-featured micro controller that also has an integrated video camera and micro SD card socket. It's inexpensive and easy to use, and is perfect for IoT devices requiring a camera with advanced functions like image tracking and recognition.



Figure 2.26: ESP-32 CAM

ESP32-CAM Specifications

The ESP32-CAM is based upon the ESP32-S module, so it shares the same specifications. It has the following features:

- 802.11b/g/n Wi-Fi
- Bluetooth 4.2 with BLE
- UART, SPI, I2C and PWM interfaces
- Clock speed up to 160 MHz
- Computing power up to 600 DMIPS
- 520 KB SRAM plus 4 MB PSRAM
- Supports WiFi Image Upload
- Multiple Sleep modes
- Firmware Over the Air (FOTA) upgrades possible
- 9 GPIO ports
- Built-in Flash LED

2.18 Buck Converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while drawing less average current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element, a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side

filter). It is called a buck converter because the voltage across the inductor “bucks” or opposes the supply voltage.



Figure 2.27: DC -DC Buck Converter

DC-DC Buck Converter Step Down Module LM2596 Power Supply is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. The LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

Specifications of DC-DC Buck Converter Step Down Module LM2596 Power Supply:

- Conversion efficiency: 92%(highest)
- Switching frequency: 150KHz
- Output ripple: 30mA9maximum)
- Load Regulation: ± 0.5%
- Voltage Regulation: ± 0.5%
- Dynamic Response speed: 5% 200uS
- Input voltage:4.75-35V
- Output voltage:1.25-26V(Adjustable)
- Output current: Rated current is 2A, maximum 3A (Additional heat sink is required)
- Conversion Efficiency: Up to 92% (output voltage higher, the higher the efficiency)
- Switching Frequency: 150KHz
- Rectifier: Non-Synchronous Rectification
- Module Properties: Non-isolated step-down module (buck)

- Short Circuit Protection: Current limiting, since the recovery
- Operating Temperature: Industrial grade (-40 to +85) (output power 10W or less)

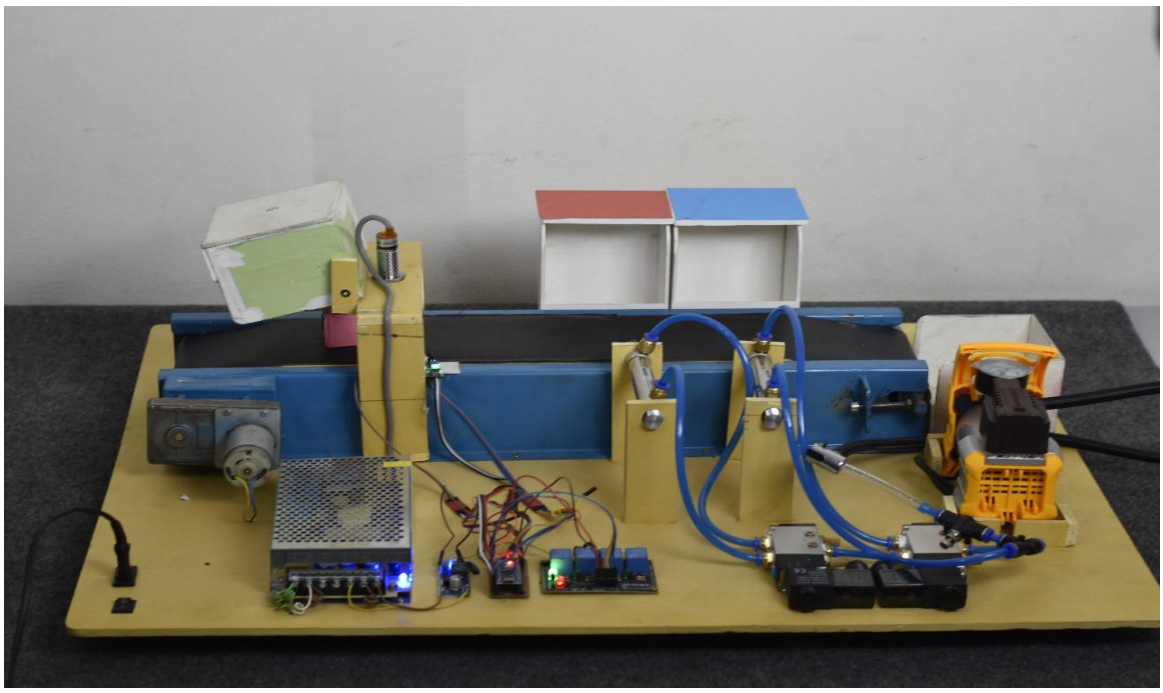


Figure 2.28: Constructed project

CHAPTER 3
RESULTS & DISCUSSION

3.1 Result

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 doing our project we observed it very careful. It works as we desire. Our project gives output perfectly and all equipment 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.
- Efficiently distinguishes between metal and non-metal objects with high accuracy.
- Real-time color detection using ESP32-CAM ensures quick and reliable sorting.
- Pneumatic actuators provide fast and precise separation into designated bins.
- Arduino Nano effectively synchronizes conveyor movement, sensor data, and actuator control.
- Reduced manual intervention enhances productivity and minimizes errors.
- Suitable for industrial applications where rapid and automated sorting is required.

Table 1: Metal Performance Test

Sl	Color (Metal)	Dimensions(mm)	Weight (gm)	Time(s)
1	Red	26*26*26	21.60	5.1
2	Green	26*26*26	22.10	6.3
3	Blue	26*26*26	22.70	8.7
4	Black	26*26*26	23.30	4.2

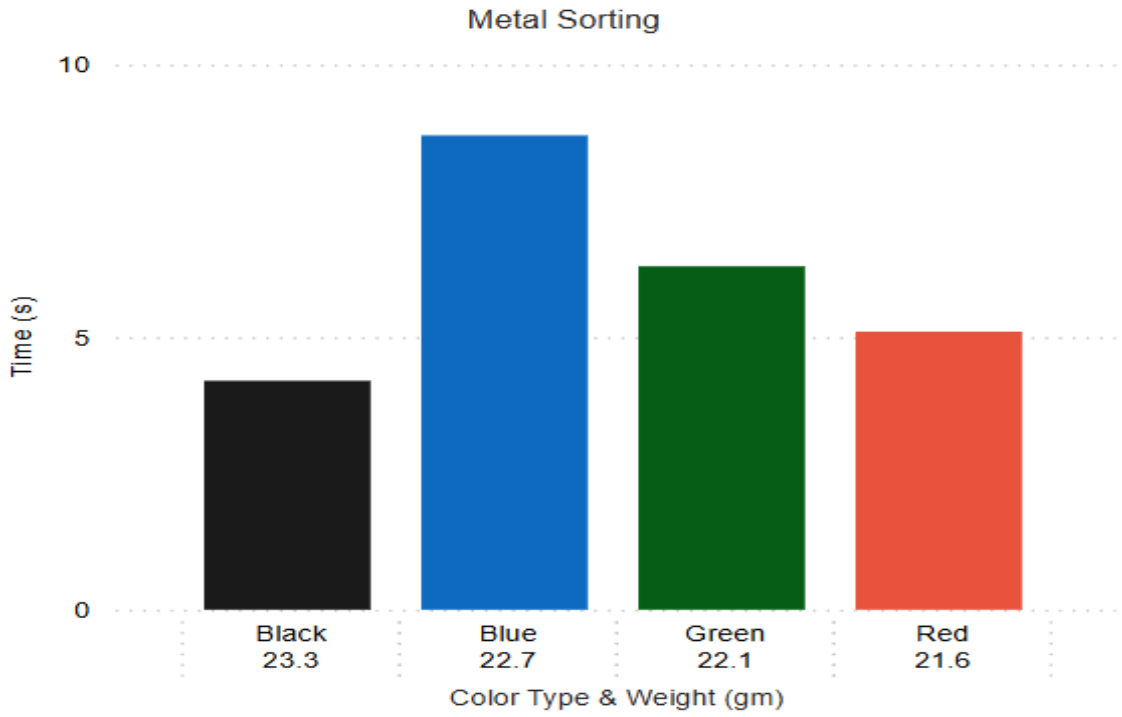


Figure 3.1: Metal Performance Graph

Describe:

The graph titled "Metal Sorting" shows the relationship between the weight of different metal sheets (in grams) and the time required (in seconds) for sorting. The color include:

- Black (23.3 gm, 4.2 sec).
- Blue (22.7 gm, 8.7 sec).
- Green (22.1 gm, 6.3 sec).
- Red (21.6 gm, 5.1 sec).

The time increases and decreases depending on the metal type and weight.

Table 2: Non-Metal Performance Test

Sl	Color (Non-Metal)	Dimension (mm)	Weight (gm)	Time (s)
1	Red	25*25*25	11.5	5.2
2	Green	25*25*25	13.5	6.4
3	Blue	25*25*25	10.5	7.8
4	Black	25*25*25	12.5	4.3

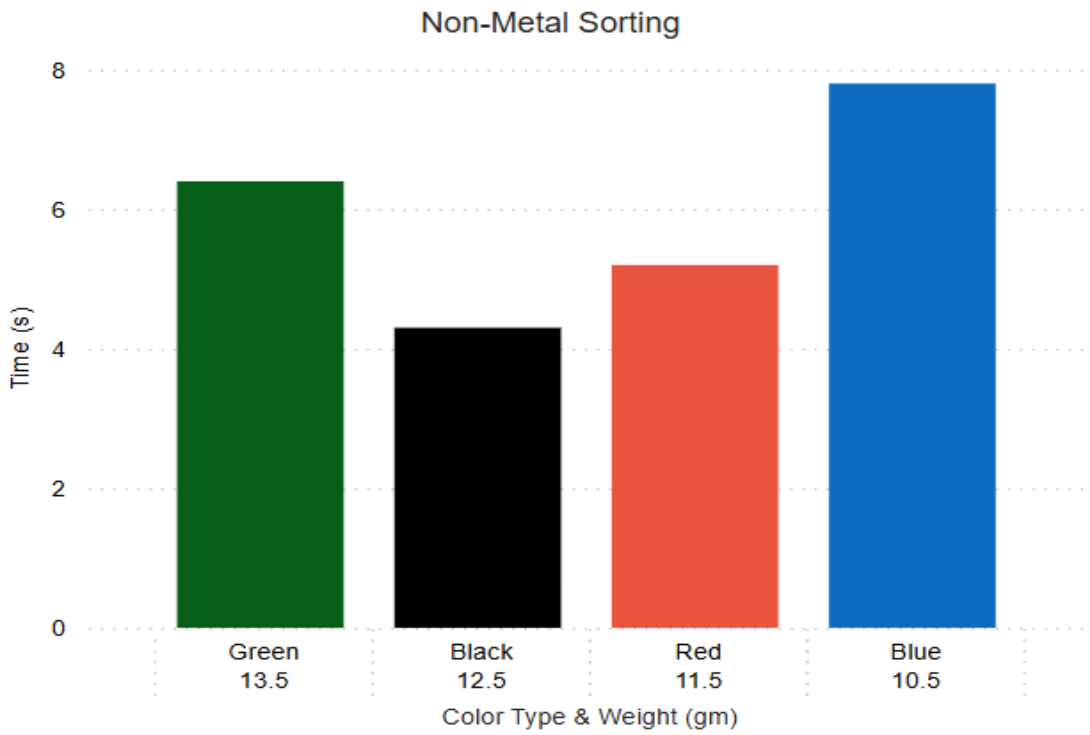


Figure 3.2: Non-Metal Performance Graph

Describe:

This graph titled "Non-metal Sorting" shows the relationship between the weight (in grams) of non-metal materials and the time (in seconds) taken for sorting.

- Black (12.5 gm, 4.3 sec).
- Blue (10.5 gm, 7.8 sec).
- Green (13.5 gm, 6.4 sec).
- Red (11.5 gm, 5.2 sec).

3.2 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 involve improvement in system design and wiring, adding features for more efficiency.

The conveyor belt sorting system demonstrates an efficient approach to automated object classification based on color and material type. Integrating ESP32-CAM for color detection and a proximity sensor for metal identification ensures accurate and real-time sorting. The use of pneumatic cylinders provides rapid and reliable separation, reducing human effort and enhancing productivity. Arduino Nano's control over sensors, actuators, and conveyor movement synchronizes the entire process smoothly. This system is ideal for industrial applications, optimizing sorting speed and reducing manual errors. Future enhancements could include multi-color detection and advanced material classification for broader industrial use.

3.3 Advantages

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

- Good accuracy to find metal and non-metal object.
- Time saving machine for industrial work.
- Very effectively work for product peak and place.
- Reduce energy waste.
- No Oil consumption.
- Less skill technicians is sufficient to operate.
- Installation is simplified very much.
- Less time and more profit.
- Simple construction
- Reduced the weight of the system.
- Ease of operation.

3.4 Applications

The project has major applications in the following areas

- It can be used in industrial automation.
- It can be applied in waste management and recycling.
- It is useful in logistics and warehousing.
- It can be implemented in pharmaceutical and chemical industries.
- It can be used for construction material handling.

3.5 Limitations

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

- It is a demo project, so its accuracy is 85%.
- This compressor has no extra air chamber.
- Our project may delay in work.

CHAPTER 4

CONCLUSION

4.1 Conclusion

The conveyor belt sorting system utilizing an ESP32-CAM for color detection and a proximity sensor for metal/non-metal identification represents an effective solution for automated object sorting. The system is designed to operate seamlessly, beginning with object detection by an IR sensor as items travel along the conveyor. Upon detection, the belt halts momentarily, allowing the ESP32-CAM to capture the object's image and perform real-time color analysis. Identified colors are processed by Arduino Nano, which acts as the primary controller, synchronizing the entire sorting operation. Following color detection, the object is analyzed by the proximity sensor to determine if it is metallic. Based on this analysis, the Arduino Nano triggers pneumatic cylinders to push the object into designated bins: one set for color sorting and another for metal/non-metal separation. This precise and rapid action reduces manual intervention, enhances sorting accuracy, and boosts productivity in industrial environments. The system’s integration of real-time sensing, automated control, and pneumatic actuation showcases significant advancements in material handling and industrial automation. Its low power consumption, powered by a 12V SMPS, further highlights its energy efficiency. Future upgrades could include enhanced image processing, multi-color detection, and advanced material classification to expand its application scope.

4.2 Future Scope:

The model can be improved by making some changes in the program and components. Some suggestions are given below-

- We can add monitoring-based control to automate control.
- We will increase its working accuracy level.
- We will add an air reserve tank.
- We can also add a counter for counting the number of products.
- We will add a Counting Sensor.

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APPENDIX

```
// Define pins for metal detector sensor and servo motor
const int metalDetectorPin = 2;  // Pin connected to metal detector sensor output
int ir_sensor = 3;
int ir;
int motor = 4;
int compressor = 5;
int metal =6;
int nonmetal=7;
void setup() {
  pinMode(metalDetectorPin, INPUT);
  pinMode(ir_sensor, INPUT);
  pinMode(motor, OUTPUT);
  pinMode(compressor, OUTPUT);
  pinMode(metal, OUTPUT);
  pinMode(nonmetal, OUTPUT);

  Serial.begin(9600);  // Initialize serial communication for debugging
}

void loop() {
  // Read metal detector sensor input
  int metalDetected = digitalRead(metalDetectorPin);
  ir=digitalRead(ir_sensor);
  digitalWrite(motor,HIGH);
  Serial.print(metalDetected);
  Serial.println(ir);

//  delay(100);  // Adjust delay as needed to control loop timing
  if(metalDetected==0 && ir==0){
  delay(1500);
  digitalWrite(motor,LOW);
  digitalWrite(compressor,HIGH);
   delay(1000);
//     digitalWrite(compressor,LOW);
     digitalWrite(metal,HIGH);
     delay(1000);
     digitalWrite(metal,LOW);
     delay(1000);
//   digitalWrite(compressor,HIGH);
//    delay(1000);
     digitalWrite(compressor,LOW);

  }
 if(metalDetected==1 && ir==0){
  delay(2400);
  digitalWrite(motor,LOW);
   digitalWrite(compressor,HIGH);
```

```
   delay(1000);
//   digitalWrite(compressor,LOW);
  digitalWrite(nonmetal,HIGH);
   delay(1000);
     digitalWrite(nonmetal,LOW);
 delay(1000);
//   digitalWrite(compressor,HIGH);
//    delay(1000);
     digitalWrite(compressor,LOW);

  }


}
```