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DESIGN AND FABRICATION OF METAL AND NON-METAL SEPARATION SYSTEMS FOR WASTE SEGREGATOR

Dr.S.Vetrivel, Assistant Professor, Department of Mechanical Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India
M. Godwin Bernish, S.S. Nikhil, S. Deenadhayalan, R. Santhosh, UG Student Department of Mechanical Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

ABSTRACT
Our project deals with the design and fabrication of the automatic waste segregator. The main aim of our project is to separate metal and non-metal waste by using a conveyor. The nation and world are facing a huge problem today of disposal, segregation, and recycling of solid waste, and improper management of these wastes is hazardous to human health and ecological system. There is a rapid increase in capacity and categories of solid waste as a result of urbanization, constant economic growth, and industrialization. Global Waste Management Market reported that the amount of waste generated worldwide produced is 2.02 billion tonnes. “Wastes are not always waste if it is segregated as they were”.
The economic value of waste is best comprehended when it is segregated. Currently, there is no such system employed for the segregation of glass, plastic, and metallic wastes at the industrial level. Here we propose an Automation of Waste Material Segregation in the scrap industry.
This method is an easy and simple solution for the segregation of two types of wastes metal and non-metal (like plastic, and wood). It is designed to sort the trash into metallic waste, and plastic waste ready to be processed separately for the next process of operation. The method uses inductive sensors for metallic items and proximity sensors for plastic and wood waste. Experimental results show that the segregation of waste into metallic, and non-metallic waste has been successfully implemented using the Automation of material segregation (AMS) method
Keywords: Metal, Non-Metal, Waste, Segregator

I. Introduction
A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which makes them very popular in the material handling and packaging industries. Many kinds of conveying systems are available and are used according to the various needs of different industries.
The various departments involved in an industry are design, production, assembly, and quality. The major portion of the industry’s success depends upon the quality department. They inspect the machined products and separate them based on the acceptable level and rejection. Quality Control and Inspection are the most important things in the factory design. Automation plays a vital role in the mass production of a product; the machining operations decide the sequence of machining. The machines designed for producing a particular product are called transfer machines. Conveyor Automation is a specialized activity for a modern manufacturing concern. It has been estimated that about 60-70% of the cost of production is spent on material-transferring activities.
Conveyors are durable and reliable components used in automated distribution and warehousing. In combination with computer-controlled pallet handling equipment, this allows for more efficient retail, wholesale, and manufacturing distribution. It is considered a labor-saving system that allows large volumes to move rapidly through a process, allowing companies to ship or receive higher volumes with smaller storage space and with less labor expense.

This project combines the usage of conveyor systems and sensors for inspecting the products that are manufactured in an industry. The sensors sense the dimension of the workpiece and send signals to the control unit which in turn actuates the pneumatic cylinder through the solenoid valve. The control unit controls the actuation mechanism based on the signals received from the sensors. This project is a semi-automated system where partial human effort is also involved. The project can be made fully automated where the construction of the project and the fabrication becomes more complicated.

1.1 Need for Conveyor Automation

We chose the belt conveyor system in this project because of its various advantages such as,

- Reduction of labor and material costs.
- Reduction of overall cost.
- Increased production.
- Increased safety.
- To reduce the inspection time.
- Reduction in fatigue.

II. Literature

In recent times, garbage disposal has become a huge cause for concern in the world. A voluminous amount of waste that is generated is disposed of by means which harm the environment. The common method of disposal of waste is by unplanned and uncontrolled open dumping at landfill sites. This method is injurious to human health, and plant and animal life. This harmful method of waste disposal can generate liquid leachate which contaminates surface and ground waters; can harbor disease vectors that spread harmful diseases; can degrade the aesthetic value of the natural environment and it is an unavailing use of land resources.

In India, rag pickers play an important role in the recycling of urban solid waste. Rag pickers and conservancy staff have higher morbidity due to infections of the skin, respiratory, gastrointestinal tract, and multisystem allergic disorders, in addition to a high prevalence of bites of rodents, dogs, and other vermin. Dependency on the rag-pickers can be diminished if segregation takes place at the source of municipal waste generation. The economic value of the waste generated is not realized unless it is recycled completely.

Several advancements in technology have also allowed the refuse to be processed into useful entities such as Waste to Energy, where the waste can be used to generate synthetic gas (syngas) made up of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam; Waste to Fuel, where the waste can be utilized to generate biofuels. When the waste is segregated into basic streams such as wet, dry, and metallic, the waste has a higher potential for recovery, and consequently, is recycled and reused. The wet waste fraction is often converted either into compost methane gas or both.

Compost can replace the demand for chemical fertilizers, and biogas can be used as a source of energy. The metallic waste could be reused or recycled.

Even though there are large-scale industrial waste segregators present, it is always much better to segregate the waste at the source itself. The benefits of doing so are that a higher quality of the material is retained for recycling which means that more value could be recovered from the waste. The occupational hazard for waste workers is reduced. Also, the segregated waste could be directly sent to the recycling and processing plant instead of sending it to the segregation plant and then to the recycling plant. Currently, there is no system of segregation of glass, plastic, and metallic wastes in an industry.

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III. Materials and Methods

3.1 D.C. Motor (Permanent Magnet)

3.1.1 Description of DC Motor

An electric motor is a machine that converts electrical energy to mechanical energy. Its action is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a magnetic force whose direction is given by Fleming's left-hand rule.

When a motor is in operation, it develops torque. This torque can produce mechanical rotation. DC motors are also like generators classified into shunt wound series wound or compound wound motors.

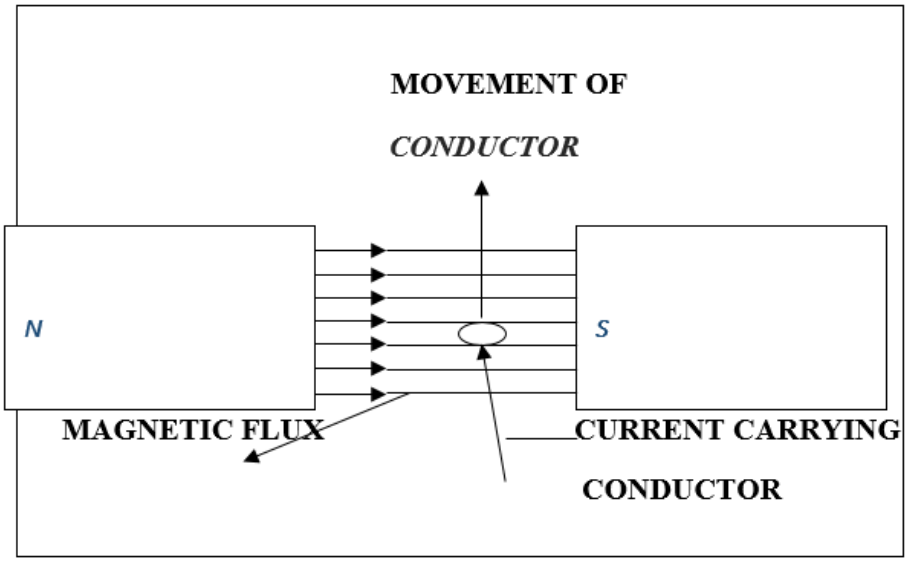
3.2 Fleming's Left-Hand Rule

Keep the force finger, middle finger, and thumb of the left hand mutually perpendicular to one another. If the forefinger indicates the direction of the magnetic field and the middle finger indicates the direction of current in the conductor, then the thumb indicates the direction of the motion of the conductor.

3.3 Principle of Operation of DC Motor

The figure shows a uniform magnetic field in which a straight conductor carrying no current is placed. The conductor is perpendicular to the direction of the magnetic field.

The conductor is carrying a current away from the viewer, but the field due to the N and S poles has been removed. There is no movement of the conductor during the above two conditions. The current-carrying conductor is placed in the magnetic field. The field due to the current in the conductor supports the main field above the conductor but opposes the main field below the conductor.



The result is to increase the flux density in the region directly above the conductor and to reduce the flux density in the region directly below the conductor. It is found that a force acts on the conductor, trying to push the conductor downwards as shown by the arrow. If the current in the conductor is reversed, the strengthening of flux lines occurs below the conductor, and the conductor will be pushed upwards.

Now consider a single-turn coil carrying a current as shown in the above figure. given the reasons given above, coil side A will be forced to move downwards, whereas the coil side B will be forced to move upwards. The forces acting on the coil sides A and B will be of the same magnitude.

But their direction is opposite to one another. As the coil is wound on the armature core which is supported by the bearings, the armature will now rotate. The commutator periodically reverses the direction of current flow through the armature. Therefore, the armature will have a continuous rotation.

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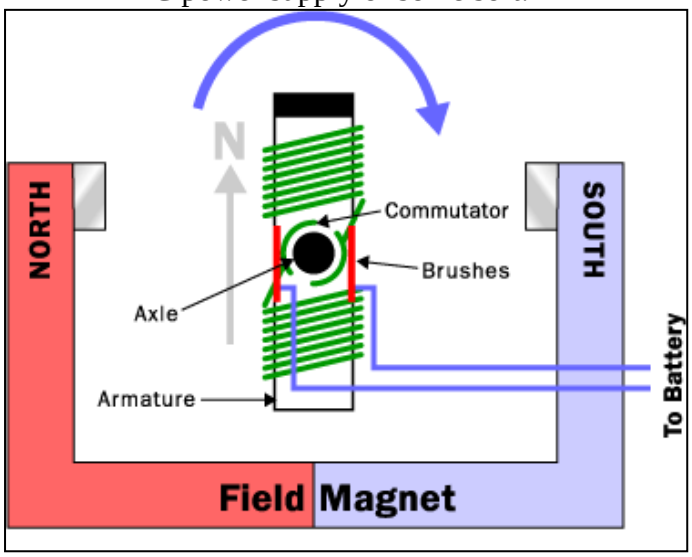
The conductors are wound over a soft iron core. DC supply is given to the field poles for producing flux. The conductors are connected to the DC supply through brushes. Let's start by looking at the overall plan of a simple 2-pole DC electric motor. A simple motor has 6 parts, as shown in the diagram below.

- An armature or rotor,
- A commutator,
- Brushes,
- An axle,
- A field magnet,
- A DC power supply of some sort.



An electric motor is all about magnets and magnetism: a motor uses magnets to create motion. If you have ever played with magnets you know about the fundamental law of all magnets: Opposites attract and likes repel.

So, if you have 2 bar magnets with their ends marked north and south, then the North end of one magnet will attract the South end of the other. On the other hand, the North end of one magnet will repel the North end of the other (and similarly south will repel south). Inside an electric motor these attracting and repelling forces create rotational motion.

In the diagram above and below you can see two magnets in the motor, the armature (or rotor) is an electromagnet, while the field magnet is a permanent magnet (the field magnet could be an electromagnet as well, but in most small motors it is not to save power).

3.4 Electromagnets and Motors

To understand how an electric motor works, the key is to understand how the electromagnet works. An electromagnet is the basis of an electric motor. You can understand how things work in the motor by imagining the following scenario. Say that you created a simple electromagnet by wrapping 100 loops of wire around a nail and connecting it to a battery. The nail would become a magnet and have a North and South Pole while the battery is connected.

Now say that you take your nail electromagnet, run an axle through the middle of it, and suspend it in the middle of a horseshoe magnet as shown in the figure below.

If you were to attach a battery to the electromagnet so that the North end of the nail appeared as shown, the basic law of magnetism tells you what would happen: The North end of the electromagnet would be repelled from the north end of the horseshoe magnet and attracted to the south end of the horseshoe magnet.

The South end of the electromagnet would be repelled similarly. The nail would move about half a turn and then stop in the position shown.

You can see that this half-turn of motion is simple and obvious because of the way magnets naturally attract and repel one another. The key to an electric motor is to then go one step further so that, at the moment that this half-turn of motion completes, the field of the electromagnet flips. The flip causes the electromagnet to complete another half-turn of motion.
You flip the magnetic field simply by changing the direction of the electrons flowing in the wire (you do that by flipping the battery over). If the field of the electromagnet flipped at just the right moment at the end of each half-turn of motion, the electric motor would spin freely.

3.5 The Armature

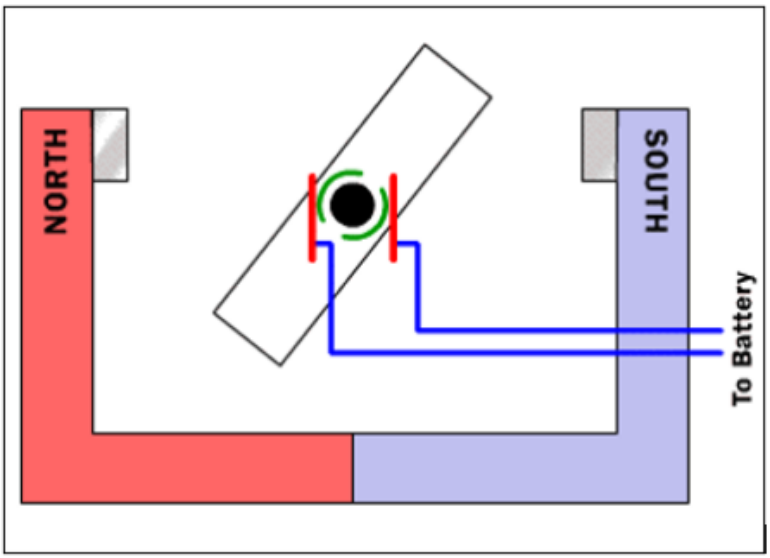
The armature takes the place of the nail in an electric motor. The armature is an electromagnet made by coiling thin wire around two or more poles of a metal core. The armature has an axle, and the commutator is attached to the axle. In the diagram above you can see three different views of the same armature: front, side, and end-on. In the end-on view, the winding is eliminated to make the commutator more obvious. You can see that the commutator is simply a pair of plates attached to the axle. These plates provide the two connections for the coil of the electromagnet.

3.6 The Commutator and Brushes

The "flipping the electric field" part of an electric motor is accomplished by two parts: the commutator and the brushes. The diagram at the right shows how the commutator and brushes work together to let current flow to the electromagnet, and also to flip the direction that the electrons are flowing at just the right moment. The contacts of the commutator are attached to the axle of the electromagnet, so they spin with the magnet. The brushes are just two pieces of springy metal or carbon that make contact with the contacts of the commutator.

3.7 Putting it All Together

When you put all of these parts together, what you have is a complete electric motor:



In this figure, the armature winding has been left out so that it is easier to see the commutator in action. The key thing to notice is that as the armature passes through the horizontal position, the poles of the electromagnet flip. Because of the flip, the North Pole of the electromagnet is always above the axle so it can repel the field magnet's North Pole and attract the field magnet's South Pole. If you ever take apart an electric motor you will find that it contains the same pieces described above: two small permanent magnets, a commutator, two brushes, and an electromagnet made by winding wire around a piece of metal. Almost always, however, the rotor will have three poles rather than the two poles as shown in this article. There are two good reasons for a motor to have three poles:

It causes the motor to have better dynamics. In a two-pole motor, if the electromagnet is at the balance point, perfectly horizontal between the two poles of the field magnet when the motor starts; you can imagine the armature getting "stuck" there. That never happens in a three-pole motor.
Each time the commutator hits the point where it flips the field in a two-pole motor, the commutator shorts out the battery (directly connects the positive and negative terminals) for a moment. This shorting wastes energy and drains the battery needlessly. A three-pole motor solves this problem as well.
It is possible to have any number of poles, depending on the size of the motor and the specific application it is being used in.

3.8 Electronic Control Unit

The control unit (CU) is a component of a computer's central processing unit (CPU) that directs the operation of the processor. It tells the computer's memory, arithmetic/logic unit, and input and output devices how to respond to a program's instructions.

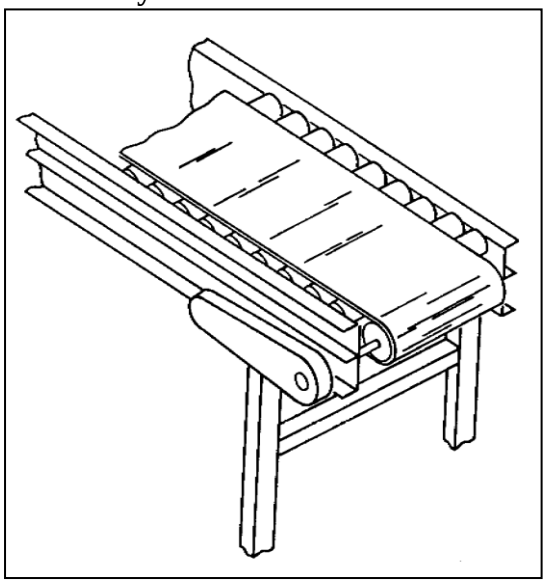
3.8.1 At Normal Condition:

At normal conditions, the IR transmitter and IR receiver, the resistance across the Transmitter and receiver is high due to the non-conductivity of the IR waves. So the output of transistor T5 goes from ON condition to OFF stage. At that time the relay is OFF position so that the motor is OFF.

3.8.2 At Obstacle Condition:

The IR transmitter sensor is transmitting the infrared rays with the help of a 555 IC timer circuit. These infrared rays are received by the IR receiver sensor. The Transistors T1, T2, and T3 are used as an amplifier section. At normal conditions, Transistor T5 is ON condition. At that time relay is ON. The MOTOR is on so that non-metallic will be separated by this motor.

3.9 Conveyor Belt and Rollers



A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which makes them very popular in the material handling and packaging industries. Many kinds of conveying systems are available and are used according to the various needs of different industries. There are chain conveyors (floor and overhead) as well. Chain conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand-pushed trolleys.

3.10 Battery

In isolated systems away from the grid, batteries are used for storage of excess solar energy converted into electrical energy. The only exceptions are isolated sunshine loads such as irrigation pumps or drinking water supplies for storage. In fact for small units with output less than one

kilowatt. Batteries seem to be the only technically and economically available storage means. Since both the photo-voltaic system and batteries are high in capital costs. The overall system must be optimized concerning available energy and local demand patterns. To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties:

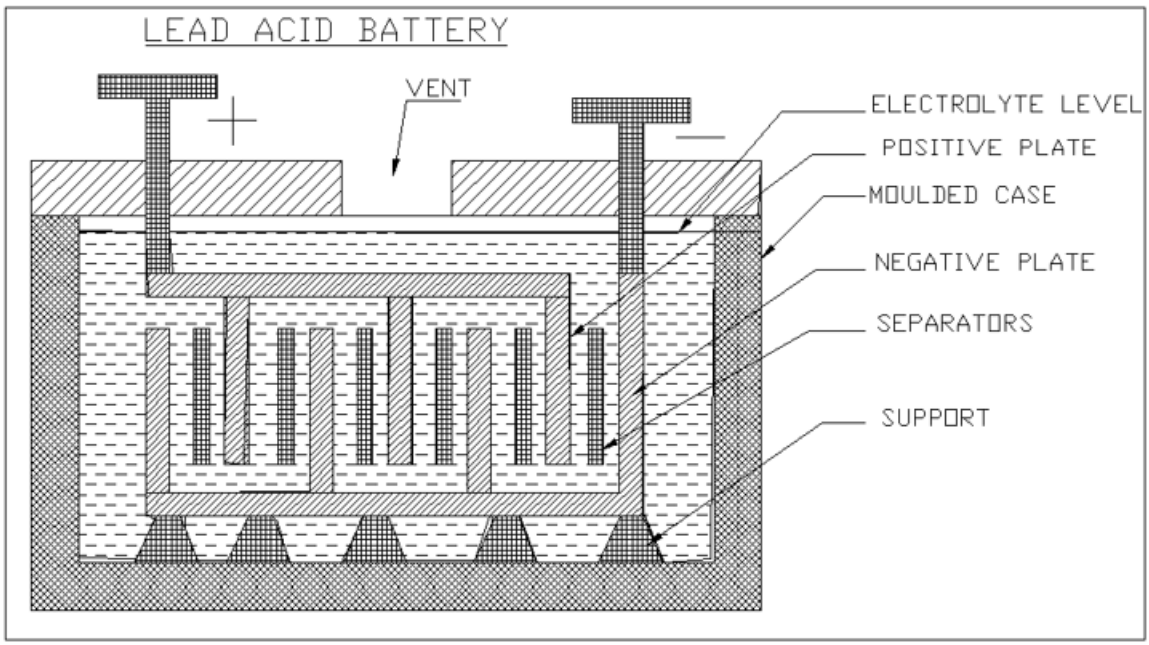
- Low cost
- Long life
- High reliability
- High overall efficiency
- Low discharge
- Minimum maintenance
- Ampere hour efficiency
- Watt-hour efficiency

We use lead acid batteries for storing the electrical energy from the solar panel for lighting the street and so about the lead acid cells are explained below.

3.11 Lead-Acid Wet Cell

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an automobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery.

The lead-acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortens the useful life to about 3 to 5 years for an automobile battery. Of the different types of secondary cells, the lead-acid type has the highest output voltage, which allows fewer cells for a specified battery voltage.



3.12 Spur Gear

The spur gears, which are designed to transmit motion and power between parallel shafts, are the most economical in the power transmission industry.

3.12.1 Internal Spur Gear

The internal gears are spur gears turned "inside out." In other words, the teeth are cut into the inside diameter while the outside diameter is kept smooth. This design allows for the driving pinion to

rotate internally to the gear, which, in turn, allows for clean operation. Intended for light-duty applications, these gears are available only in brass. When choosing a mating spur gear, always remember that the difference in the number of teeth between the internal gear and pinion should not be less than 15 or 12.

3.12.2 External Spur Gear:

Perhaps the most often used and simplest gear system, external spur gears are cylindrical gears with straight teeth parallel to the axis. They are used to transmit rotary motion between parallel shafts and the shafts rotate in opposite directions.

They tend to be noisy at high speed as the two gear surfaces come into contact at once. Internal spur gears: The internal spur gear works similarly to the external spur gears except that the pinion is inside the spur gear. They are used to transmit rotary motion between parallel shafts but the shafts rotate in the same direction with this arrangement.

3.13 Bearing with Bearing Cap

The bearings are pressed smoothly to fit into the shafts because if hammered the bearing may develop cracks. The bearing is made up of steel material and the bearing cap is mild steel.

Ball and roller bearings are used widely in instruments and machines to minimize friction and power loss. While the concept of the ball bearing dates back at least to Leonardo da Vinci, their design and manufacture has become remarkably sophisticated. This technology was brought to its present state of perfection only after a long period of research and development. The benefits of such specialized research can be obtained when it is possible to use a standardized bearing of the proper size and type. However, such bearings cannot be used indiscriminately without a careful study of the loads and operating conditions. In addition, the bearing must be provided with adequate mounting, lubrication, and sealing. Design engineers have usually two possible sources for obtaining information that they can use to select a bearing for their particular application:

a) Textbooks

b) Manufacturers'

Catalogs Textbooks are excellent sources; however, they tend to be overly detailed and aimed at the student of the subject matter rather than the practicing designer. They, in most cases, contain information on how to design rather than how to select a bearing for a particular application. Manufacturers' catalogs, in turn, are also excellent and contain a wealth of information that relates to the products of the particular manufacturer. These catalogs, however, fail to provide alternatives – which may divert the designer's interest to products not manufactured by them. Our Company, however, provides the broadest selection of many types of bearings made by different manufacturers. For this reason, we are interested in providing a condensed overview of the subject matter objectively, using data obtained from different texts, handbooks, and manufacturers' literature. This information will enable the reader to select the proper bearing expeditiously. If the designer's interest exceeds the scope of the presented material, a list of references is provided at the end of the Technical Section. At the same time, we are expressing our thanks and are providing credit to the sources that supplied the material presented here.

3.14 Frame Stand

This is made up of M.S L-Angle material. This is used as the body of the vehicle. The front and rear wheels are fitted below this bottom frame with the help of end bearings.

3.14.1 Working Principle

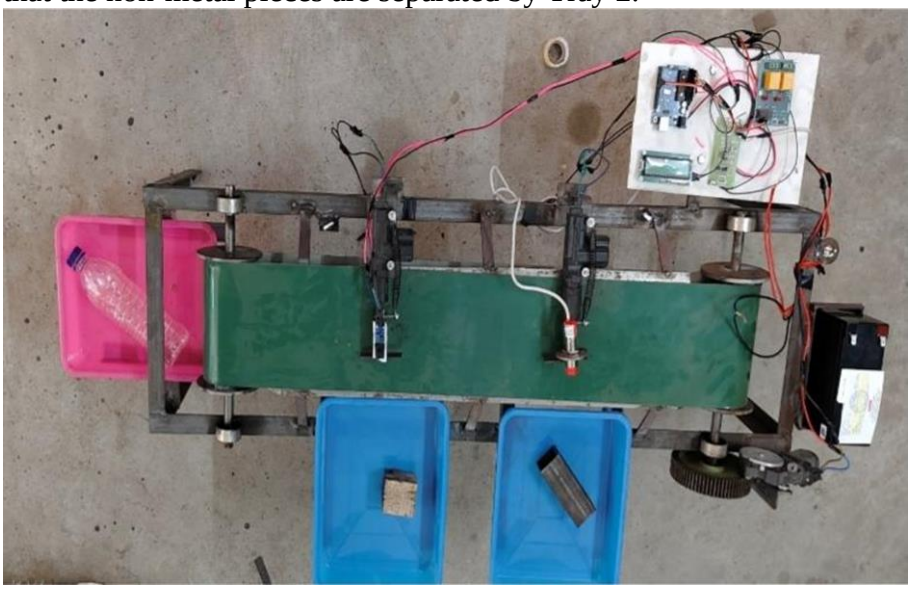
The project automatic waste segregator which we fabricate is easy to construct and simple to operate. The 12-volt power supply is used to drive the permanent magnet D.C motor. The two conveyor rollers are fixed to the two ends of the frame stand with the help of an end bearing (6202) with a bearing cap. The conveyor roller shaft is coupled to the D.C. permanent magnet motor with the help of a spur gear mechanism. This total arrangement is used to transfer the material from one place to another place with the help of a conveyor.

The Proximity sensor is vertically fixed on the frame stand using a round washer arrangement. This sensor is used to check whether the incoming material is metal or non-metal. The workpiece in this conveyor is metal at that time relay is ON so that the Rejecter DC Motor 1 is ON and it will be separated by tray 1.

The IR transmitter and IR receiver circuit are used to sense the non-metal material. It is fixed to the frame stand with a suitable arrangement. This mechanism is also adjustable with the help of a bolt and nut.

The IR transmitter sensor is transmitting the infrared rays with the help of a 555 IC timer circuit. These infrared rays are received by the IR receiver sensor. At normal conditions, the Transistor is at OFF condition. At that time relay is OFF, so the D.C motor is in OFF condition.

At obstacle conditions the IR transmitter and IR receiver, the resistance across the Transmitter and receiver is high due to the non-conductivity of the IR waves. The relay is ON to the D.C Motor 2 so that the non-metal pieces are separated by Tray 2.



3.14.2 Advantages

The Automatic waste segregator is more efficient in the technical field.
Quick response is achieved.
Simple in construction.
Easy to maintain and repair.
The cost of the unit is less when compared to the other equipment.
There are chances of fire hazard problems due to overloading.
Comparatively, the operation cost is less.
Continuous operation is possible without stopping.

3.14.3 Disadvantages

Only Metal and Non-Metal separations.
Small components only to separate.

IV. Conclusions

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling, and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries.

We are proud that we have completed the work within the limited time successfully. The "DESIGN AND FABRICATION OF METAL AND NON-METAL SEPARATION SYSTEM FOR WASTE SEGREGATOR" system is working with satisfactory conditions. We can able to understand the difficulties in maintaining the tolerances and also the quality. We have done to our ability and skill making maximum use of available facilities.

Thus, we have developed an "AUTOMATIC WASTE SEGREGATOR" which helps to easily identify the products with defects. In the olden days, it was done by various analysis methods which consumed more time and human power. This is eliminated with the implementation of our project. By using more techniques, they can be modified and developed according to the applications.

References

[1] Joice Johny et.al., (2013), "Automatic Plastic Separating Technology for Solid Waste Disposal", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)ISSN 2249-6866Vol. 3, Issue 2, Jun 2013, 99-108 © TJPRC Pvt. Ltd.

[2] Prof. Mr. P. Balramdu et.al., (2014), "Remote Monitoring and Sorting System for Waste Material Management Using RFID", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 3 Issue 10, October 2014.

[3] Y V Aruna et.al., (2015), "Automatic convey or System with In–Process Sorting Mechanism using PLC and HMI System", Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 11, (Part - 3) November 2015, pp.37-42.

[4] S.M. Dudhal et.al., (2014), "Waste segregation using programmable logic controller", ijtre, Volume 1, Issue 8, April 2014.

[5] Nidhi Mishra et.al.,(2014), "Plc Based Scrap Management System", Rani B. Phulpagar et al Int. Journal of Engineering Research and Applications ISSN: 2248- 9622, Vol. 4, Issue 3 (Version 1), March 2014, pp.26-2.

[6] M.K. Pushpa et al., (2015), "Microcontroller Based Automatic Waste Segregator", International Journal of Innovative Research in Electrical, Electronics, Instrumentation, and Control Engineering, Vol. 3, Issue 5, May 2015.

[7] Subhasini Dwivedi et al., (2016), "A Review on PLC-based Automatic Waste Segregator", International Journal of Advanced Research in Computer Engineering and Technology, Volume 5, Issue 2, February 2016.

[8] Athira J et al., (2016), "An Economic Automatic Waste Segregator using Arduino", International Journal of Research in Advent Technology, Vol.4, No.7, July 2016.
[9] Aishwarya Bhojkar et al., (2017), "Waste Management Using PLC", International Journal of Electrical, Electronics and Computer Systems, ISSN 2347-2820, Volume -5, Issue-2, November 2017.
[10] M. Arun Kumar et al., (2018), "Programmable Logic Controller based Metal Segregation in Steel Industry", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 7, Issue 2, February 2018.
[11] Rahul Deshmukh et al (2018), "Material Segregation & Waste Management using PLC", International Journal of Engineering Technology Science and Research, Volume 5, Issue 3 March 2018.
[12] K.G.Suhirdham et al (2018), "Automatic Material Segregation using PLC", International Journal of Engineering Technology, Vol7, Issue 2, April 2018.