Automatic Segregation Of Plastic Waste For Recycling Industries

Sureshkumar R, Suji Prasad S.J, Annas T, Aruna L, Iniya D G

Abstract: Plastic waste has been a primary environmental concern nowadays due to the increase in its consumption. It is a chemical compound manufactured by adding various chemicals and toxic agents. It is a known fact and at the same time, hard truth that plastic is non-biodegradable, and it causes multiple hazards to the environment and the living beings. Improper disposal of plastic leads to soil pollution, clogging of water on the surface of the earth, death of aquatic species and even more severe impacts on the environment. In our project, segregate the plastic waste without any human intervention. It helps in reducing the man's work, and it also makes the segregation process easier. The only way to eliminate the adverse effects of plastic waste is to recycle it properly such that the amount of waste is reduced and recycled material can be remade as useful plastic products. The plastic products are recycled based on its physical parameters such as size and colour. The process of segregation of plastic based on size and colour is at present is done by labourers at recycling units, which is a prolonged process and also leads to long term health hazards. The slow rates of reuse and recycling, most of them end up in landfills, beaches, oceans and remain there for hundreds of thousands of years.

Index Terms : Arduino, Colour sensor, IR Sensor, Plastic waste, Proximity sensor, Segregation System.

1. INTRODUCTION

Plastic is a material that consists of a wide range of synthetic or semi-synthetic organic compounds. The physical properties of plastic, such as malleability, allow it to be melt and moulded into any desired shape [1]. The constituents of plastic are usually synthetic and are derived from petrochemicals. However, a lineup of variants is manufactured from renewable materials such as polylactic acid from corn or cellulosic from cotton linters. Plastics are used in almost every product manufactured, starting from small clips to components of an aircraft. It is due to their ease of manufacture, meager cost, versatility, imperviousness to water and mainly the fact that they can be melt and moulded into any desired shape needed. In developed countries, almost one-third of plastic is used to pack items, and approximately the same is used in buildings in places such as piping, plumbing, or vinyl siding. Other significant uses include automobiles, storage containers, furniture, toys, and other daily use products. As the usage of plastic increased over the years, the plastic waste generated too increased [2]. Almost no customer product these days is made using zero plastic components. Plastic is everywhere; thus, plastic waste is also. Due to the sudden increase in plastic waste all over the world, it was difficult to find proper ways to dispose of the plastic, and thus, the amount of trash keeps increasing over time.

The primary outcome of this project is to provide a solution to and efficiently automate the process of segregation of plastics based on their size and colour which currently is done using manpower and efficiently automate the process.

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2 PLASTIC RECYCLING PROCESS

2.1 Waste Management

Plastic waste management is the process of recovering scrap plastic and reprocessing the material into useful products [3]. Since almost all plastics are non-biodegradable, recycling is a part of global efforts to reduce plastics in the waste stream, especially the approximately eight million tonnes of plastic that enters the ocean every year. Compared with the low value of glass recycling, plastic polymers recycling is often more challenging because of low density and low cost. Also, there were numerous technical difficulties to overcome when recycling plastic [4]. Materials recovery facilities are responsible for sorting and processing plastics but have struggled to do so economically as of 2019. The steps involved in plastic recycling are as follows: Plastic waste collection, Waste transportation, Plastic waste segregation, Crushing, grinding of plastic waste and Chemical treatment. The plastic waste is first to be collected from various source points of plastic waste for example industries, waste collection joints, households, etc. and it is done keeping hygiene in the first place and the persons collecting plastic waste cover their hands and face properly in order to decrease the risk of the adverse health effects of plastics. The collected plastics need to be transported to the recycling plants in covered vehicles, and it must be made sure that no waste particle is dropped anywhere. Plastic recycling plants are set up by the government and also by other companies, and the number of plants has seen an increase in the past decade as the amount of plastic waste generated too has increased [5]. As the collected plastics reach the recycling plant, it has to first segregate based on various physical and chemical properties before crushing and grinding them for chemical treatment. Plastics are recycled separately based on their size, colour, and chemical composition. The plastic waste is sent on a conveyor to the segregation area where there is personnel with gloves ready to pick and separate different plastics. Each worker segregates either a particular sized plastic or a coloured plastic. Plastic large in size are to be recycled separately, plastics that are of different colours are to be recycled separately. Hence, the segregation process is very crucial in recycling plants. There are height barriers that allow only objects lesser than a certain height, and it is placed over the conveyor carrying plastics, and thus, the plastic wastes

that are bigger are rejected. The workers pick and separate plastics of different colours (red, blue, green, etc.), and they are sent to recycling separately as the chemical composition of different coloured plastics are different and doing so increases the efficiency of the recycling process. The segregated plastics are then ground into fine pieces or sometimes into powder and are mixed with certain chemicals that make the plastics to be melt and moulded again to form products of any shape. The chemical treatment and melting processes are very complex and in the end, lead to reformed plastics that are manufactured from waste plastics. Almost all of the above processes are done using manpower, and they can be automated thus increasing the efficiency of recycling and decreasing the time taken. The segregation process can be automated using different sensors that can identify plastics of different sizes and colours. Proximity and colour sensors can be used to segregate plastic wastes that are of a certain size and specific colours. This reduces human intervention and also the risks of health hazards due to the handling of plastic wastes in hands.

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2.2 LITERATURE SURVEY

The ImpEE project on Recycling of Plastics [6] done by the University of Cambridge, UK, tells the amount of plastic waste generated in the UK, which is around 3 million tonnes per year and that 20,000 plastic bottles make one ton of plastic waste. But only 7% of the total plastic waste in the UK was recycled in 2005, and 200,000 tonnes of plastic waste was sent every year to China for recycling. The research paper also conveys the effect of plastic on the environment and also the consequences of landfilling of plastics instead of recycling. In the landfill, both synthetic and naturally getting polymers don't get the necessary exposure to UV and microbes to degrade. Here they are taking up space, and none of the energy put into making them is being reclaimed. Reclaiming the energy stored in the polymers can be done through incineration, but this can cause environmental damage by the release of toxic gases into the atmosphere. Recycling is a viable alternative in [6]getting back some of this energy in the case of some polymers. Thus, it is important to recycle plastic waste instead of filling them in the ground in a landfill and trying to incinerate them, which will only cause damage to the environment and not be the perfect solution. Jefferson Hopewell and his team in their research paper Plastic Recycling: Challenges and Opportunities explain the physical quality of plastic and that is inexpensive[7], lightweight and durable and can be moulded to form various products and also the amount of plastic waste generated and the challenges involved in recycling waste plastic. They convey the importance of recycling plastic as it is hard to destroy the hard polymers and also reuse them without any modification. Recycling is the most efficient actions currently available to reduce the impacts of plastic. Vishal Kumar Alok and his team in their article To study the different industrial applications of PLC through ladder diagrams give the different circumstances and processes in different industries where the automation is done using PLC [8] as the controller. There are different types of processes, such as linear, batch, etc. The ladder logic programming for various processes are unique and from the method used in a process similar to plastic segregation is used as a base to develop the ladder logic program for this project and the paper also deals with the how program control instructions are to be used in various industrial processes in order to increase safety, decrease process time and bring out efficient output. Mahmudul Hasan Russel et al. [9] explained about challenges about smart waste management system development, effective management, and recycling of waste materials based on their properties. This article detailed the separation of waste material based on metal and non-metal example paper, glass, and ceramics. Here waste material identified various categories by using microcontrollers separated for further process. Merits of the smart system are improved environmental safety and healthier. Bhagyashri and his team developed the Automatic Material Segregation System using PLC [10] to describe a scrap material segregation using the automation system. They suggest that scrap segregation and disposal can minimize manufacturing costs and also minimize raw material wastage. Their system comprises of separation of metal and nonmetal waste into respective bins; different sensors are incorporated for detecting the material along the conveyor belt. The only objective of this system is to segregate waste based on whether it is a metal or a non-metal. The controller used is a Programmable Logic Controller (PLC). They also suggest to use PLC as an automation gadget due to the fact it's far value-powerful, very bendy, lessen complexity, area green. The PLC represents one of these regular controllers, and it can be used for special applications and, through an application, is mounted in its reminiscence. They say, automation method is quicker, cleaner and does not affect the ecosystem. The largest benefit of automation is that it saves exertions; it is also used to save power and materials and to improve accuracy and precision. In this article, Michele Rosano proposed the methods of Recycling Plastic, properties, and applications of recycled thermoplastic polymers [11], where different methods can be used to recycle plastic waste. Numerous processes and steps have to be followed before the recycling of plastic waste materials. The plastic wastes have to be first segregated based on their different physical properties as the recycling processes are based on the different physical properties. The various physical properties include colour, size, etc. Plastics of different sizes (large, small) are to be segregated and sent to recycling separately as the steps involved in recycling them are different. The most important property to be considered is the colour of the waste plastic. The chemical composition of different coloured plastics are different and thus have to be segregated and recycled separately. For example, all red coloured plastics are to be sent for recycling separately, and this applies to every different colour. Thus, this paper briefly explains the need for the segregation of plastic wastes to be sent for recycling.

3 HARDWARE REQUIREMENTS

3.1 Arduino

The microcontroller used here is MicrochipATmega328P. It operates at a voltage of 5 Volts. The input voltage ranges between 7 and 20 Volt. There are 14 digital I/O pins in which 6 provides PWM output. There are 6 Analog input pins. The DC current required for the I/O pin is 20mA. The DC current required for 3.3V pin is 50 mA. Flash memory is 32 KB, of which 0.5 KB is used by the boot loader. The clock speed is about 16MHz.

3.2 Communication systems

The Arduino Uno has several facilities for communicating with

a computer, another Arduino board. The ATmega328 provides UART TTL serial communication, which is available on digital pins 0 and 1. An ATmega on the board channels this serial communication over USB and appears as a virtual com port to the software. The firmware uses the standard USB COM drivers, and no external driver is needed. Arduino Software includes a monitor that allows simple text communication to the board. The receiver and transmitter LEDs on the board will flash when data is being transmitted. A Serial library allows serial communication on any of the Uno's digital pins.

3.3 IR Sensor

Operating Voltage Range ranges between 3V and 5V. It detects the object at a distance of 2 to 30 cm. It has a digital output signal. The range can be adjusted by using a potentiometer. It consumes the current 23mA at 3V and 43mA at 5V. The low-level logic output will be activated when an obstacle is detected. When power is applied power LED will be illuminated. When an obstacle is detected, the LED is illuminated. It has a reciever and an emitter. It has Vcc, gnd, and out pins.

3.3 Proximity Sensor

The operating voltage ranges between 6V and 36V DC. It can detect the object at a distance upto 12mm. It is PNP normally open three-line output type. It detects the metal object when passes through it. When an obstacle is detected, it illuminates LED. The output current draws 300mA. It has a high switching frequency. The cable length of this sensor is about 110cm. It has generated reverse power and protects itself from a short circuit. It is made up of metal and plastic.

3.3 Colour Sensor

The colour sensor detects the colour of the surface, usually on the RGB scale. Emission of color by creating communication between light source, object, and observer. In the case of reflected light, light falling on an object will be reflected depending on surface characteristics, such as reflectance and transmittance. For example, green paper will. Colour sensors have a variety of applications, including detection of the environment, choosing the right product and sorting. The detection of colour compared to the vision sensor is much faster and cheaper.The most popular and easy operational colour sensor is the TCS-3200 RGB colour sensor. There are four LEDs that emit white light on the object whose colour is to be sensed. A part of the light is absorbed by the coloured surface, and the remaining light is reflected back to the sensor where a photodiode receives the light and creates a voltage output in accordance with the amount of light reflected back. The wavelength of the colour on the object's surface can also be retrieved from the colour sensor.

4 METHODOLOGY

Figure 1. shows the block diagram, which represents the various ports used for interfacing various components with arduino.

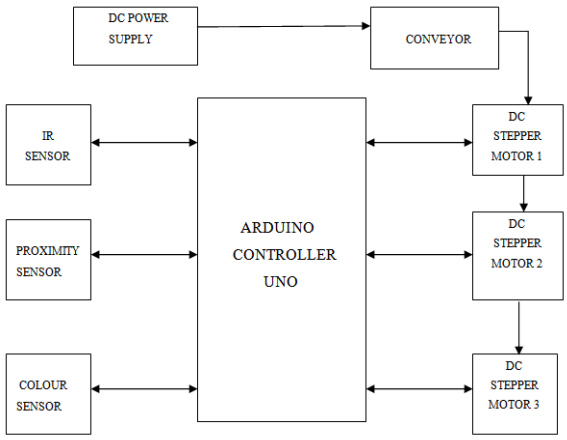

Fig 1. *Block diagram of the waste segregation system*

The waste materials are placed on the conveyor. If the waste is large in size, then it is sensed by the Infrared sensor, and the respective slider one will activate, and that will push out the waste from the conveyor. If the Infrared sensor doesn't sense that is if the size is below the position of Infrared, the waste is sensed whether it is metal or non-metal by the proximity sensor. The proximity senses if the waste is metal, then the respective slider two will activate that will push out the metal from the conveyor. The waste remaining in the belt will reach the RGB sensor the waste, which is red, will be sensed by the sensor, and that will activate the slider three that will push out the red coloured waste. The remaining waste will be left in conveyor, and it will drop into another bin.

S.No	Sensor Input	Corresponding Action
1.	IR sensor S1 = 1	Rejection Slider 1 activates Bigger size object is separated and Stored in Bin 1
2.	Proximity S2 = 1	Rejection Slider 2 activates Any metal object is removed Sent to Bin 2
3.	Color sensor S3 = 1	Rejection Slider 3 activates The red coloured object is separated and Stored in Bin 3

TABLE 1
SENSOR ACTUATION

5 RESULTS

Plastic waste objects of bigger in size and red in colour are segregated separately, and any metal objects are removed in the first stage. Thus, the project provides a system to segregate waste plastic based on its size and colour before recycling in waste recycling plants. Hardware setup with conveyor and arduino controller are shown in Figure 2 and 3.

Fig 2. *Conveyor setup*

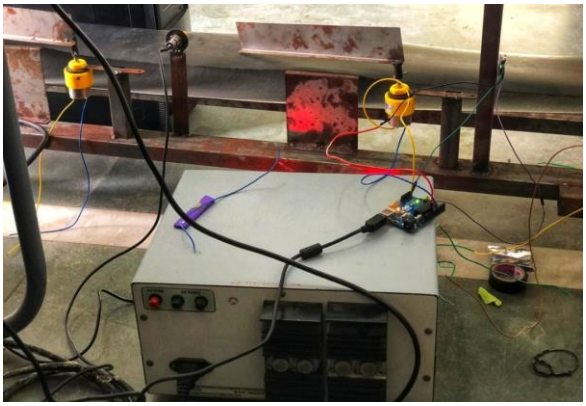

Fig 3. *Hardware implemented with Arduino*

As proposed, size, colour, and metallic property are sensed using sensors, and required action is taken through the project. The developed system is non-complex and provides high accuracy. The various output actions for different types of objects are shown in Table 1.

6 CONCLUSION

The developed prototype model reduces the manual work in the waste recycling industry. The proposed methodology helps to improve automation in the segregation process. Compared with the existing system, the proposed arrangement is compact and is possible to implement in all recycling industries. This system helps in segregating plastic waste based on size and colour.

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