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Development Of Waste Sorting Technology for Pet and HDPE Plastic Bottles For The Production Of Recycled Plastic Seeds

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Abstract

Plastic bottle waste is a problem that always arises. In Indonesia, the processing of plastic bottle waste still needs to be improved. Plastic bottle waste can be converted into plastic pellets with economic value. The type of plastic and the colour must be sorted to get quality plastic pellets. A machine is designed to sort out the types of plastic bottle waste, polyethene terephthalate (PET) and high-density polyethene (HDPE). The result is a prototype plastic biotol waste sorting machine with a 41 kg/hour capacity. The prototype of this machine can sort out plastic bottle waste and those not included in the plastic bottle waste category. The results show that the colour sensor and object sensor work optimally to sort plastic bottle waste according to the program.

Keywords: Plastic Bottle Waste Separator, Design, Conveyor, Arduino Uno

Abstrak

Sampah botol plastik merupakan permasalahan yang selalu muncul. Di Indonesia pengolahan sampah botol plastik masih belum optimal. Sampah botol plastik dapat dirubah menjadi biji plastik yang memiliki nilai ekonomi. Pemilahan jenis plastik dan juga warna perlu dilakukan untuk mendapatkan biji plastik yang berkualitas. Sebuah alat dirancang untuk dapat memilah jenis sampah botol plastik Polyethylene Terephthalate (PET) dan High Density Polyethylene (HDPE). Hasilnya sebuah prototipe mesin pemilah sampah biotol plastik dengan kapasitas 41 kg/jam. Prototipe mesin ini dapat memilah sampah botol plastik dan yangt tidak termasuk dalam kategori sampah botol plastik. Hasil menunjukan sensor warna dan sensor benda bekerja dengan optimal sehingga dapat memilah sampah botol plastik sesuai dengan programnya.

***Kata-kata kunci**: Pemilah Sampah Botol Plastic, Rancang Bangun, Conveyor, Arduino Uno*

1. Introduction

Plastic bottle waste is one of the environmental problems that is still unresolved [1] [2] [3]. This is exacerbated by increased packaged beverage products circulating in the community [4]. PET and HDPE are the most common types of plastic bottle waste [5]. PET is plastic drinking water bottle waste, and HDPE is plastic bottle waste from hygiene products [6]. PET and HDPE can be distinguished physically or visually by their color. PET tends to have a transparent color, while HDPE is solid [7]. The more packaged drinks and hygiene products are produced, the more plastic bottle waste will be produced [8]. Therefore, it is necessary to make an effort to reduce plastic bottle waste [9]. One way to reduce plastic bottle waste is by recycling plastic bottle waste into plastic pellets [10]. Besides being able to reduce plastic bottle waste, this can also provide more economic value than plastic bottle waste [11]. Plastic pellets have high economic value depending on the quality of the plastic pellets [4]. Quality recycled plastic pellets are plastic pellets that are made without any mixture of other types of polymers [12].

For this reason, sorting plastic bottle waste as a raw material for making plastic pellets needs to be done at the beginning before the recycling process is carried out into plastic pellets [13]. Sorting the types of plastic bottles based on the polymer manually will take quite a long time [14]. Therefore, an automatic plastic bottle waste sorting machine must be designed to distinguish several types based on the polymer [15]. In this study, a prototype plastic bottle waste sorting machine was designed that could distinguish Polyethylene Terephthalate (PET) and High-Density Polyethylene (HDPE) polymer types.

2. Method

2.1 Desain

The prototype design of the plastic bottle waste sorting machine was made after determining the concept used for the machine. The design process was carried out using Solidworks design software. The shape design is in the form of a conveyor, which has dimensions of 1100 mm in length and 200 mm in width, as shown in **Figure 1**.

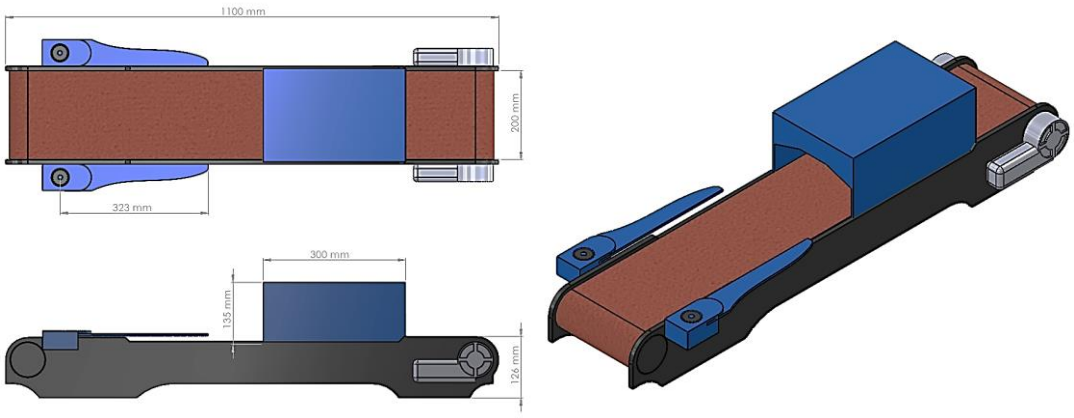

Figure 1. Design of a prototype plastic bottle waste sorting machine

2.2 Materials

Several tools and materials are needed to make a prototype of a plastic bottle waste sorting machine. The tools used are a hand grinder, hand drill, screwdriver set, tin solder, multimeter, pliers, and a PC/laptop. At the same time, the materials used are acrylic, Arduino Uno, proximity sensors, infrared sensors, AC motors, buzzers, relays, step-downs, nuts, bolts, and cables. The block diagram can be seen in **Figure 2** and the circuit diagram is in **Figure 3**.

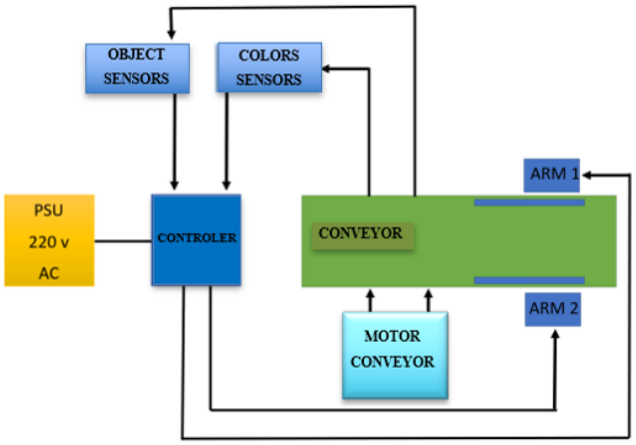

Figure 2. Block Diagrams

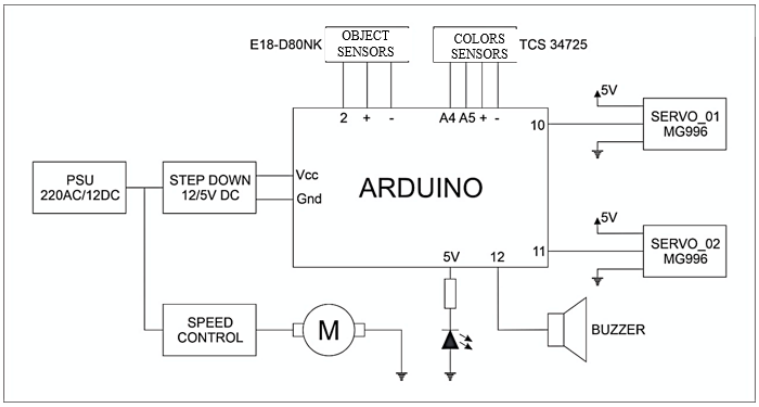

Figure 3. Circuit Diagram

The machine testing method is carried out in three stages. The first stage is to check the voltage of the machine's electrical components. This stage is carried out by measuring the voltage of each electrical component using a multi-tester. The second stage is to observe the performance of the engine components. At this stage, the function of each component is visually checked to see whether it is functioning as it should or not. The third stage is testing the machine with several types of plastic bottle waste and other waste or objects. This test is carried out by starting the machine and placing several types of rubbish to be read by the sensor.

3. Results and Discussion

The voltage measurement process is carried out in the first stage on each module. From the results of the measurements carried out, the voltage obtained is different from the theory; this occurs due to several factors; namely, in a multi-tester, several resistors can inhibit the current when the measurement process is carried out. Each module measured also has a resistance value different from the theory, as shown in **Table 1**.

Table 1. Voltage Checking Results

No	Test Type	Test Criteria	Measurement Results
1	Power Adapter Voltage	12,01 V	11,97 VDC
2	Capacity Proximity Sensor Voltage	12 V	11,98 VDC
3	Inductive Proximity Sensor Voltage	12 V	11,97 VDC
4	Infrared Proximity Sensor Voltage	5 V	4,97 VDC
5	Arduino voltage	5 V	4,97 VDC
6	AC Motor Voltage	220 V	220 VAC
7	Relay Voltage	5 V	4,98 VDC

The machine testing process is carried out at this stage, where each module and component functions as expected, as shown in **Table 2.**

Table 2. Machine Test Results

No	Machine Success Indicators	Trial Results	
		Yes	No
1	Proximity Sensor Detect	✓	
2	Arduino Sends a signal to the relay.	✓	
3	AC motor working	✓	
4	The buzzer makes a sound.	✓	
5	Relays work	✓	
6	Walking Conveyors	✓	
7	Speed control works	✓	
8	Stepdown works	✓	

The third stage was testing the type of waste and bottle waste on the machine prototype. The results of the test are shown in table 3. The waste that can be detected is PET type, and HDPE bottle waste, where the PET type will come out on the left side, and the HDPE type will come out on the right side of the machine. Undetected trash, such as paper, tissue, wood, and canned bottles, will come out at the end of the conveyor. The maximum load of waste that can be sorted or sorted at one time is 1 kg. Trash testing results is presented on Table 3.

Table 3. Trash Testing Results

No	Type of Trash	Criteria		Information
		PET polymer	HDPE polymer	
1	Mineral water bottles	∨		detected
2	Hygiene product bottles		∨	detected
3	Clear plastic	-	-	Not Detected
4	Colored plastic	-	-	Not Detected
5	Wood	-	-	Not Detected
6	Paper	-	-	Not Detected
7	tissue	-	-	Not Detected
8	Tin bottle	-	-	Not Detected

Before designing a sorting machine, conducting an in-depth analysis of the physical and chemical characteristics of PLA and HDPE plastic bottles is necessary. This involves understanding the differences in the density, colour, strength, and light reflectivity of these two types of plastics. This information is necessary to select the most suitable sensor type for detection and screening.

At the machine design stage, it is essential to understand the working principle of the optical sensor used to sort plastic bottles. The optical sensor will identify characteristic differences between PLA and HDPE, such as differences in reflected or absorbed light.

Furthermore, the signal from this optical sensor will be used to control the sorting system, such as activating a motor to divert the bottles to the appropriate path.

In designing the machine, conveyor belt integration becomes an essential element. The conveyor belt will carry the plastic bottles under the optical sensor for analysis. The sorting system must be carefully designed to ensure the plastic bottles can be moved to the appropriate lane based on signals from the optical sensors. The selection of the suitable motor and arrangement of the bottle transfer mechanism is crucial in designing this system.

The sorting machine must be tested to measure its accuracy and efficiency in sorting PLA and HDPE plastic bottles. The trial process involved testing several plastic bottles fed to the machine. Data on sorting time, success rate, and production speed should be collected and analyzed. The machine's ability to sort bottles with a high degree of accuracy is an essential parameter in assessing the quality of the machine.

4. Conclusion

In this research, a PLA and HDPE plastic bottle sorting machine has been successfully designed and developed. Based on the trials that have been carried out, this machine can sort plastic bottles with an adequate level of accuracy and in a more efficient time than manual sorting. Integrating optical sensors and conveyor belts is critical to achieving this result.

Automation technology in sorting plastic bottles has excellent potential to reduce the impact of plastic waste on the environment. By sorting bottles based on the type of plastic, the recycling process becomes more effective, and more bottles can be recycled. This positively impacts efforts to protect the environment and reduce pollution. However, remember that this sorting machine is still an early prototype and further development is needed to ensure reliability and efficiency in long-term use. In addition, cost, maintenance, and the possibility of using it on an industrial scale must also be considered in further development. By continuing to develop and improve this machine, it is hoped that it will significantly contribute to overcoming the problem of plastic waste and protecting the environment.

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