Development of sorting system for plastic bottle waste management

N Maulidati¹, A D N Cahyo¹, D W Djamari¹, M R Fikri² and F Triawan¹,*

¹Department of Mechanical Engineering, Faculty of Engineering and Technology, Sampoerna University, Jakarta, Indonesia
²Information system, Faculty of Engineering and Technology, Sampoerna University, Jakarta, Indonesia

*farid.triawan@sampoernauniversity.ac.id

Abstract. This work studies the method of sorting plastic bottles waste. Currently, the recycling treatment for a different type of plastic bottle wastes is similar although they are made of different plastic material. The disadvantage of the current method is that the produced plastic is an unknown type of plastics. To perform recycling treatment of similar types of plastic bottle waste, the plastic-bottle waste needs to be sorted based on their material characteristics. We propose a sorting method of the plastic-bottle waste by using a barcode scanner. A database on plastic-bottle waste based on their barcode number, which then categorized their material characteristics, is first created. In this paper, the diagram of the sorting process is given.

1. Introduction

Plastics are constituted from a long series of carbon. The materials used to produce plastic are typically cellulose, coal, natural gas, salt and crude oil [1]. Around 4% of the worldwide oil and gas are used to manufacture plastic. Plastics are commonly used in the daily activities of humans. Around 300 million tons plastics are produced to support the daily activities of humans [2].

There are various plastic-based products that support human daily activities such as plastic cups, plastic bags, bottles, lunch boxes, and many other plastic-based products. In daily activities, those plastics are typically used once and then it turns into plastic wastes. Since plastics cannot degrade in a short amount of time, plastic waste management is important to save the environment [3-5].

The plastics waste has polluted land and ocean over decades. In 2010, it was found that around 12.7 metric tons of plastics waste entered the ocean [6]. When the plastics are intensively used to support human activities, the plastic waste will gradually increase and make the world become more polluted. Around 11% of plastics waste comes from plastic bottles [7] which people are strongly dependent on using a plastic-based product, for example, drinking water containers - water bottles.

Plastic waste management is the solution to save the environment as well as for the educational purpose [3-8]. One of the plastics waste management is the recycling of a by-product of plastic-based products that allow the plastics to be reusable. There are different types of plastic available in the market such as the PET (Polyethylene Terephthalate), HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene), PP (Polypolypropylene), and others. Each type of plastic has a different chemical composition and it requires different treatments when recycling it. The sorting of different types of plastic before recycling them in the correct treatment is needed to make the recycling process to be more
effective. To address the aforementioned needs, the present work is aimed at developing a sorting system for plastic bottle wastes management.

2. Methodology and problem definition

2.1. Plastic recycles characteristic
Before the plastics are recycled, there are several issues about the characteristics of the plastic itself. Not all plastics are recyclable. There are non-recyclable plastics such as plastic bags and straw. Not all plastics are created equal. This means that plastics have different types such as the PET, HDPE, and PP. When the plastics are recycled, the quality of the plastic typically has lower quality than the original plastics. In addition, when the plastic is recycled for the first time it can be categorized as a different type of plastic from the original plastic. Thus, the type of the recycled plastic cannot be determined and may be directed into the wrong treatment while recycling the plastics for the second time [9].

2.2. Sorting of plastics waste for effective recycling
Plastics need a different technique to recycle it; thus, the sorting techniques are really important. This section summarizes some techniques to differentiate plastics based on its type. Initially, sorting plastics are done manually by humans. However, due to the big amount of plastic waste, the manual sorting method is considered to be not efficient. Automatic sorting technique was developed, and several sensors are introduced based on the plastic waste characteristic condition such as the dry sorting, wet sorting, mechanical sorting, chemical sorting, etc. These sorting techniques are used on a site commercial scale because there is no global parameter that can differentiate the plastics in any condition [10].

The existing sorting techniques are used in the site in which the plastics are already grouped by their condition; however, that technique cannot be used directly by the user. The user in this context is people who produce the plastic waste.

This paper proposes a sorting system that can be done by the user directly. The proposed system aims to reduce the recycling process into a more compact system. The system will combine the collecting and sorting at the same time. While the site in the commercial scale will recycle a big amount of plastics which the plastics collection process needed before. The new system will make the recycling factory can directly do the recycling process based on the sorted plastic bottle waste.

3. Results
Sorting plastic bottle waste based on plastic-type is difficult because every plastic type has different characteristics such as the PET is more transparent than the HDPE. However, most of the sensors that can detect HDPE cannot detect the PET because of that characteristic. The simplest way to sort the plastic bottle is based on the product itself. Based on this fact, this paper introduces a new system of sorting plastics-waste using a barcode scanner. Each product has its own barcode which represents that product. However, the database is needed before using a barcode scanner as the sorting system sensor. This system can be used in any plastic bottles. The system also can cut off some processes while doing the recycling process. This system will make the collecting and sorting process in a single process.

A barcode scanner can differentiate a product by a barcode that sticks on its product. Therefore, a database becomes very important. The database is input manually by scanning a barcode of each product. Before we install the barcode scanner, we should install a controller. Controller will play a role as a device that will record data from the barcode scanner and utilize the storage to keep the database inside. The diagram shown in Fig. 1 represents the flow to create a database for a barcode scanner.

The data source in the diagram can be defined as picking up a barcode data from the online cloud or by manual input. After the raw data is obtained, the data will be extracted. The data is then structured and it will be stored in the plastic data storage. To optimize the retrieving of desired data while doing the sorting, data reduction and data indexing is needed and it will be saved in the indexed plastic data storage. The indexed plastic data storage can retrieve plastic data by giving a query to the storage and
the query will give a signal to the actuator and sort the plastic bottle based on the desired sorting characteristic.

![Database Flowchart](image)

**Figure 1.** Database flowchart.

A barcode scanner that is filled with a database can be used in any plastic bottle recycling machine. This system is also capable of installing another plastic recycling machine as long as the product that will be recycled is available in the database of the barcode scanner. This system is one of the simple sorting system techniques that are useful for the micro or macro recycling process. The Diagram shown in Fig. 2 represents the flow of the sorting system using a barcode scanner.

4. **Discussion**

A plastic bottle sorting system using a barcode scanner is a new system that is simple and meaningful. The data obtained will be more accurate because the plastic bottle waste can be sorted directly. The process to use a barcode scanner as a sorting device needs adjustment, especially for the controller part. The controller needs to communicate freely to the barcode scanner and the database being used. The barcode database can be obtained by some method as inputting the barcode manually in the system or taking the online database. Each of them has their own advantages and disadvantages.

While choosing the inputting the barcode manually into the system, it is easy for the system because it only uses a local database. Besides that, this option has an advantage in maintaining cost. The cost to access the database is free and it can be opened anywhere and anytime. However, by using this system, the database for the barcode is taking more time to be built and to be used readily. Moreover, this system needs more time while updating the database. It is possible that a new product that exists in the market may have not been included yet. On the other hand, the data given or obtained is not in the real time, this one is due to the online ability.
Figure 2. Sorting system flowchart.

The second option that can be used to identify the barcode is by accessing the online barcode database. There are a lot of websites that give access to the online database for barcode [11]. In this online database, the data growth will be extremely faster than the manual one. This extreme growth is due to there being a lot of people that input the barcode data every second. But from all of the easy ways, there are some considerations needed to get the maximum performance and minimum cost. If we look at the purpose used in the market scope used in this case, the manual input and use of a local database is preferred than the online database. If it is needed, upgrading the local database into an online database can be done. In order to get a database in an easy way, the input is not always done manually. Another way is using a selection from the existing database.

5. Conclusion
The existing sorting technique used in the site which the plastics already grouped by their condition, however, that technique cannot be used directly by the user. By developing a sorting system that can be directly used by the consumer, it will improve the bottle plastic waste recycling system’s effectiveness due to the collecting process and sorting system at the same time. The system used to identify and sort the plastic bottle is by identifying the product barcode and retrieving the data in the database to sort the plastic bottle waste based on its material characteristics.

References
[1] How plastics are made, Retrieved from https://www.plasticseurope.org/en/about-plastics/what-are-plastics/how-plastics-are-made. Accessed on 2020 April 5.
[2] Lewis C 2019 Crude Oil Price Forecast – Crude continues to chop in range,” Yahoo! News, 05-Mar-2019. [Online]. Available:https://news.yahoo.com/crude-oil-price-forecast-crude-171118006.html. [Accessed: 06-Jan-2020]
[3] Nurprasetio I P, Budiman B A and Triawan F 2017 Failure investigation of plastic shredding machine’s flange coupling based on mechanical analysis Indonesian Journal of Science and Technology 2 124-133

[4] Prawisudha P, Namioka T, Liang L and Yoshikawa K 2011 Dechlorination behavior of mixed plastic waste by employing hydrothermal process and limestone additive Journal of Environmental Science and Engineering 5 432-439

[5] Biddinika M K, Syamsiro M, Hadiyanto A N, Mufrodi Z and Takahashi F 2017 Technology for public outreach of fuel oil production from municipal plastic wastes Energy Procedia 142 2797-2801

[6] Jambeck J R, Geyer R, Wilcox C, Siegler T R, Perryman M, Andrady A, Narayan R and Law K L 2015 Plastic waste inputs from land into the ocean Science 347 768-771

[7] Maneeth PD, Pramod K, Kumar K, Shetty S 2014 Utilization of waste plastic in manufacturing of plastic–soil bricks International Journal of Engineering Research & Technology (IJERT) 3 530-536

[8] Cross J S, Ekawati E, Fukahori S, Obi S, Saito Y, Tandian N P and Triawan F 2017 Development of a Mechanical Engineering Test Item Bank to promote learning outcomes-based education in Japanese and Indonesian higher education institutions Tuning Journal for Higher Education 5 41-73

[9] Sedaghat L 2018 7 Things You Didn't Know About Plastic (and Recycling) National Geographic 7

[10] Ruj B, Pandey V, Jash P and Srivastava V K 2015 Sorting of plastic waste for effective recycling International Journal of Applied Science and Engineering Research 4 564-571

[11] Shahrir S, Rahaman I, bin Karim A, Hasan M M, Chowdhury F and Sarker M 2020 Bridging Internet of Things and Wireless Sensor Networks: Applications and Challenges Indonesian Journal of Computing, Engineering and Design (IJoCED) 2 13-23