PLASTIC RECYLING IN INDONESIA BY CONVERTING PLASTIC WASTES (PET, HDPE, LDPE, and PP) INTO PLASTIC PELLETS

Hin Chandara[1], Sunjoto[2], Sarto[3]

[1]National Polytechnic Institute of Cambodia
[2]Jurusan Teknik Sipil dan Lingkungan, Fakultas Teknik, Universitas Gadjah Mada
[3]Jurusan Teknik Kimia, Fakultas Teknik, Universitas Gadjah Mada
*Corresspondence : chandara.kec@gmail.com

Abstract

Due to the population growth, economic development, increasing the consumption of products patterns in Indonesia and activities of citizen, MSW has generated by 384 Indonesia cities was about 80,235 ton per day (or 320,940m^3 per day). The plastics solid waste (PSW) become to the major concern after organic waste and significantly impact to in environment. In order to solve the problem this research is conducted to identify the potential raw material from plastics, in order to replaces the pure material of plastics pellets that is made from crude oil and minimize the effect bring to environment. This compendium is presented the concept of the appropriation technology for plastics recycling, it emphasize the typical method by converting plastics waste of thermoplastic type Polyethylene terephthalate (PET), High density polyethylene (HDPE), Low density polyethylene (LDPE) and Polypropylene (PP) into plastics pellets. Whereas thermoplastics chemical structure possible for recyclable , the mechanical recycling method is played as the best technology and common used in recycling of conventional plastic waste material into new raw material without changing basic structure. The quality of pellets that reprocess from the plastics waste is based on the effective factors of sorting, washing, drying and temperature of melting in each zones of extruder machine

History:

Received: August 19, 2015
Accepted: November 25, 2015
First published online:
December 21, 2015

Keywords:

recycling
plastics waste
plastics pellets
thermoplastics

1. Introduction

Indonesia is an archipelago with a population of 237,56 million by the year 2010, according to central statistical agency. The population is increasing year by year with the growth rate 1.2 % per year (World Bank, 2009). The growth of population is uneven, but concentrated in urban area. By 2020, the estimated urban population in Indonesia will reach 50% of the total population. It means that activities carried out by citizen such as waste will increase too. Besides increasing population, economic development and urbanization also led the increase of waste. With economic development, the level of social welfare also improves and it affects the pattern of consumption that can lead to the increase waste of produced by community. The average production of MSW in Indonesia metropolitan and big city was estimated between 2.48 and 3.27 liter per capita. The total MSW generated by 384 Indonesia cities was about 80,235 tons per day (or 320,940 m^3 per day). It is predicted to increase five times by 2020.

Table 1. List of MSW generation in several cities of Indonesia

No	City	Number of Population	Population Growth Rate (%)	Population Density (Person/Ha)	Waste Generation (l/capita/d)	Total Waste Generation (m^3/d)
1	Bandung	2,232,624	0.20	133	3.95	8,826
2	Denpasar	542,553	4.05	35	0.73	330
3	Jakarta	7,471,866	0.20	112	3.55	26,521
4	Makassar	1,173,107	1.27	67	3.02	3,546
5	Medan	2,006,014	1.50	76	2.71	5,436
6	Palembang	1,338,793	2.65	33	6.50	8,700
7	Semarang	1,389,421	1.43	37	2.52	3,500
8	Surabaya	2,740,490	2.38	84	3.17	8,700
9	Balikpapan	500,406	1.02	10	2.26	1,128
10	Lampung	800,490	2.66	41	1.25	1,000
11	Banjarmasin	574,259	0.34	80	1.65	947
12	Bekasi	2,005,899	4.10	95	2.39	4,800
13	Bogor	750,250	2.40	63	2.83	2,124
14	Depok	1,204,687	3.70	59	0.64	766
15	Yogyakarta	519,936	1.74	160	3.02	1,571
16	Surakarta	552,542	0.48	125	1.83	1,009

Due to the increase in generation, plastic waste are becoming a major stream in solid waste. After organic waste, plastic waste is the major constitute of municipal and industrial waste in cities. Economic growth have started producing more plastic waste due to plastic packaging, plastic shopping bags, PET bottles and other goods/appliances using plastic as the major component (UNEP,2009).

This increase has turned into a major challenge for most of the plastic waste is neither collected properly nor disposed of in appropriate manner to avoid its negative impacts on environment and public health and waste plastics are causing littering and chocking of sewerage system. On the other hand, plastic waste recycling can provide an opportunity to converted into the plastic pellets. In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which are in high demand. Plastic waste recycling also has a great potential for resource conservation and GHG emissions reduction, such as producing plastic pellets from plastic waste. This resource conservation goal is very important for most of the national and local governments, where rapid industrialization and economic development is putting a lot of pressure on natural resources. Some of the developed countries have already established commercial level of resources conversion from waste plastics.

The plastic waste generated throughout the world to the table how to effectively manage these plastic wastes to save the environment from its already existing problems. However, plastic waste poses a big problem since the plastic waste can stay in the environment for a quiet period of time causing all sorts of problems. The most common methods of solid waste disposal through the combustion and land filling. In the case of Plastic waste disposal, burning of the plastic waste does not only get rid of it but produces carbon dioxide (CO_2), carbon monoxide (CO), dioxin, methane (CH4) and higher hydrocarbons etc., which

is the major contributor of global warming. The non-biodegradable nature of the plastic waste, burying them in the ground is the appropriate environmental and economical way to dispose plastic waste. The way forward for plastic waste disposal is through recycling. Recycling of plastic Waste will bring numerous benefits. Recycling of plastic waste is environmental friendly as compared to the other ways to dispose plastic waste.

The plastic waste One of the environmental issues faced by Indonesia, therefore, is the problem of waste. We need to recognize what is waste, then what is waste management, how the waste is produced, also about the condition of waste in Indonesia, in order to handle the waste problems. The plastic wastes affect the environment in three ways; air, land and water pollutions.

2. Methodology

This research is conducted by means of plastic recycling by using method converting plastic waste to plastic pellet as the materials for plastics products in environment field. The research methodology was undertaken in order to provide a framework of available information regarding to the topic. In gathering information, primary and secondary data research methods were used to gather information and data when writing this research. The data of this research is obtained from different sources, as following:

a. The primary data research are collected from the plastics waste recycling industries in Indonesia. The data focuses on the processing, parameters of melting temperatures, speed of screw, characteristics of waste plastics and information from the experts who relate with this research.
b. The secondary data research method was also focused additional information data such as literature reviews observations, case study, internet sources and journal article and the result of previous study that related with this research.

In order to achieve the research objective, research plan need to be taken into account for which it can indicate clearly the procedure of the research. Accordingly, four main steps as show in the figure were chronologically conducted to accomplish the research; those are research preparation, research area, implementation, and discussion base on obtained result.

2.1. Research Preparation

Beginning with desk study, two tasks were determined and done simultaneously. First literature review was main step for understanding general features relating to research topic and study area. Subsequently, previous study provided the basic knowledge corresponding to what had been done in the research concerning to the topic. Likewise, background theories were mentioned in detail referring to objectives and scope of study. Second, secondary data were collected from various relevant in plastic recycling industry in Indonesia and from some referent research.

2.2. Research Area and Duration

After conducting desk study, the following step was research places. On 26th August, 2012, was done for 5 days to visit the real processing in the plastic recycling industries and collected data which related with the research. KEMBAR PLASTIC industry is located in JL. Cisangkan Hilir 137 Cimahi, Bandung City, west Jawa Indonesia, concerned on the plastic waste recycling, shredding, pelletizing and also the plastic waste supplier.

2.3. Flow Chart of Research Methodology

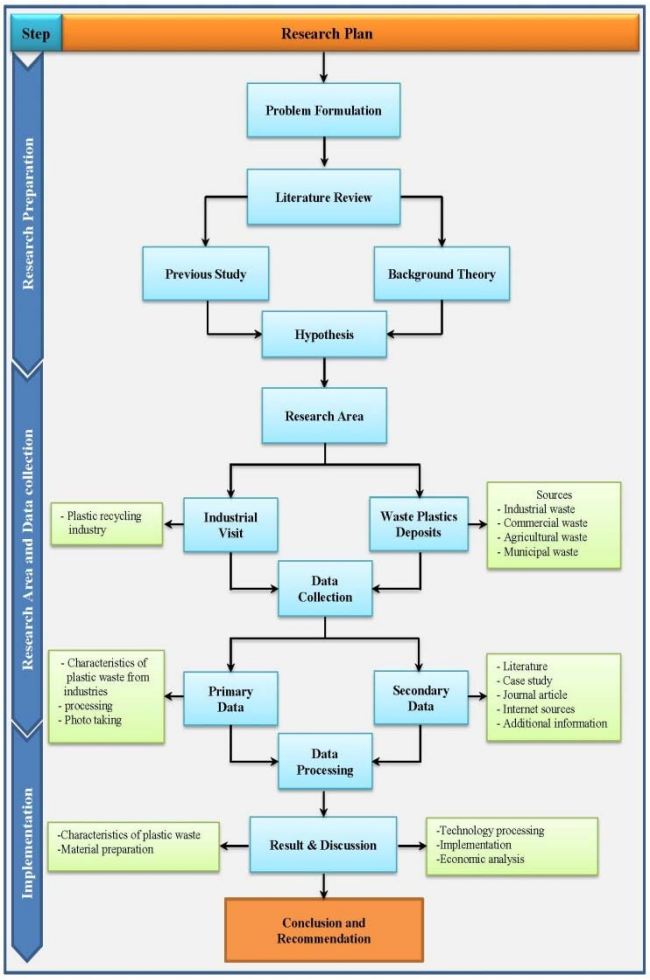

Figure 1. Flow chart of research methodology

3. Results and Discussion

3.1. Characteristics of Plastic Waste

There are different types of plastics; each can be used in various applications. The coding of different types of plastics is developed by the Society of the Plastics Industry (SPI) and it is used globally as a standard. The coding system is developed to allow for an efficient separation of different types of plastics for recycling. The symbols used in the code consist of arrows that cycle clockwise to form a rounded triangle and enclosing a number, each representing a major type of plastic. The numbers are often misunderstood as indicators of the difficulty in recycling or how often the plastic is recycled. They are actually

arbitrarily assigned numbers that have no other meaning aside from identifying the specific plastic.

However, based on the chemical properties, there are different types of plastics. In plastic recycling the segregation of the waste plastics into both of these categories are important. The reactions for different chemicals such as acids and physical conditions such as temperature and impact vary with the type of plastic.

These monomers are then chemically polymerized into different categories of plastics. The plastic waste which can be recycled is thermoplastics: PET, HDPE, LDPE, and PP (Boadrd, 2012).

Figure 2. Waste plastics before sorting

Figure 3. Waste plastics

3.2. Identify the Potential of Plastic Waste Recycling in Indonesia

Waste is predicted to increase year by year. This situation will lead TPA/TPS to no longer accommodate with the amount of waste and also cause environmental problems. As a result, there will arise the need for municipalities to look for other more environmental friendly treatments. This needs to be considerated for the Municipality to looking for other treatment which is more environmental friendly.

3.3. Technology for Converting Waste Plastics into Pellets/Granules

3.3.1. Process Overview

The research concerned in plastics recycling by converting plastics waste into plastic pellets, the parameters that most concerned were characteristics of plastic and the technology for processing. Mechanical recycling is regarded as the best technology for recycling of conventional plastic waste materials into new raw materials without the basic structure been changed. The mechanical recycling involves crushing, washing and sorting operations and it is use for all types of plastic waste materials. This process involves the assembly of mechanical products which includes driven electrical motor, pulley, cutter and others. The collected, sorted and clean plastic waste materials are put in the shredder or chipper to grind into the smaller pieces called flakes. The flakes are then feed to the extruder machine through the hopper. The extruder is incorporated with rotating single or double screw in heating barrel. When flakes are melted in the heated barrel and force out through a die by the rotation of the screw. The melted flakes come out as hot strands and passes through water to cool, which then are cut into pellets or granules by cutter. The finished products (recycled granules) are put into bags for prospective buyers or plastics manufacturing companies.

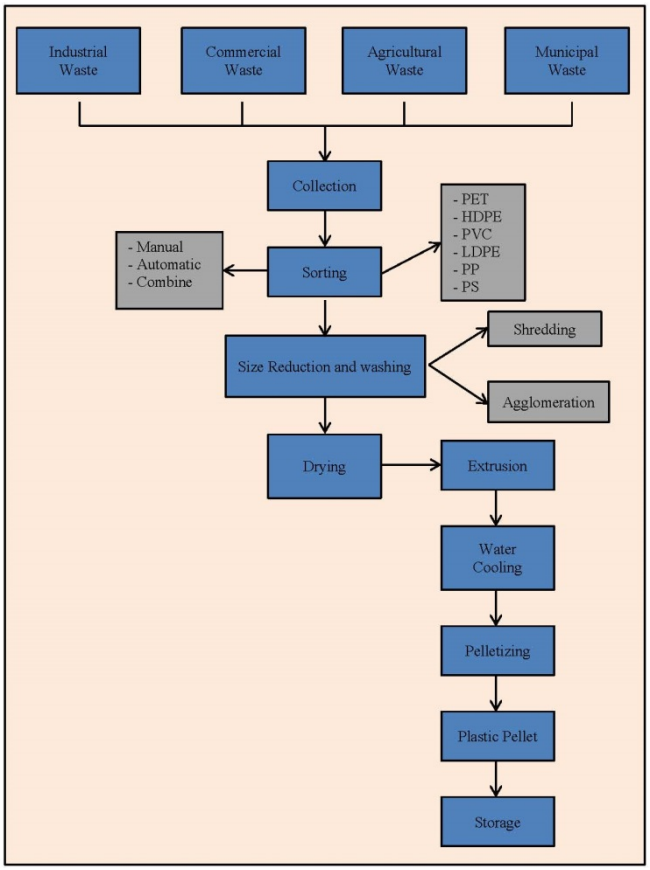

Figure 4. Flow Chart of Processing

3.3.2. Material Preparation

Material for using in this recycling method is the waste plastics which from the kind of thermoplastic such as Polyethylene (PET), High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), and Polypropylene.

a. Equipment

1. Gloves
2. Ear plugs
3. Goggles
4. Masks with gas filter
5. Sorting machine
6. Shredding or chipping machine with Washing
7. Drying machine
8. Extruder machine

b. Safety equipment

Safety should be a prime concern in plastic recycling as in any other industry. The workers in the factory should have adequate protection in handling material and operating machines. Gloves should use in handling material all the time. Heat resistant gloves are required for the handling of agglomerated film plastics and extruded plastics. Ear plugs and ear protectors should be used in crushing and agglomeration areas to protect ears from high noise levels. Goggles should use when feeding material into crushers, the agglometator and the extruder. Masks with gas filters should be worn when working at the agglomerator, extruder and when cleaning waste plastics. It is recommended that all the workers should wear protective boots when working in the factory.

c. Collection of waste plastics

Effective collection of plastic waste can be done by identifying the sources of plastics wastes, the contributors of the plastic wastes, industrial wastes, commercial waste, agricultural wastes and municipal wastes. The plastic wastes can be collected for recycling from people in residential areas by putting recycling plastic waste bins in vantage places for easy collection later and also collecting from the roadside. In Indonesia usually plastic waste are collected by informal sector that can be divided into 2 categories,

1. Waste picking in streets, communal bins, transfer points and disposal sites
2. Waste separation at the household stage.

Figure 5. Sources of plastics wastes

d. Sorting

After collecting the plastic wastes from the various collections points and brought to the recycling site, the next action is sorting. Sorting needs to be done based on the physical and chemical properties of the plastics. The plastic wastes are put on conveyor and here the plastics are separated from other wastes such as metals, wood. And plastic wastes are sorted into different types of plastic by using recycling. This can be done by training the workers to identify the different type by using the code, texture and appearance. Sorting of plastic waste can be done in either manual sorting or mechanical sorting. In manual sorting, it involves the use of hands to separate the plastics waste into different plastics or separate the metals, wood etc from the in the case of mixed waste recycling. With the mechanical or compressed air sorting, the sorting is done by automatic separation by using magnet to attract metals and also blow air across the falling plastics to separate wastes into different compartments depending on their weight.

We should be aware of feeling competence, that consumption waste contains just these kinds of plastics. Many other plastics can appear there because of various reasons. We would like to continue with detailed description of various methods used for plastic sorting in modern society. There is no enterprise, using automatic sorting separately without following manual control. Different combinations of methods are used in the world. Manual sorting is still rather common. Even though its productivity and efficiency may be questioned, it has a great advantage in price since it is a relatively cheap method. Due to efficiency issues, large attention is nowadays drawn to automatic technologies. The following scheme (Sorting methods' scheme) includes all the results of our findings, grouped in the order of technologies used.

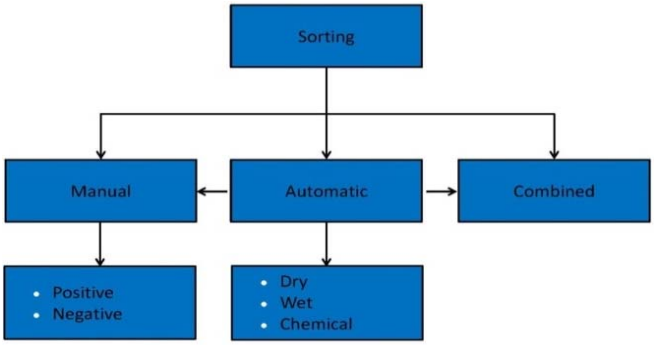

Figure 6. Sorting method's scheme

e. Cleaning

This is the most important stage in the mechanical waste plastic recycling process. The value of the recycled plastic relies greatly on its purity. Even small dust particles can reduce the quality of the material drastically as it will disturb the polymer arrangement and later the quality of the final product. Therefore, thorough washing of the plastic material and drying should be done prior to processing. In washing, a diluted detergent can be used and precautions should be taken to remove the detergent from the material on completion of the process. Oil contaminants should be removed using an appropriate solvent, followed by a detergent and water.

Maintaining a clean working environment is an important aspect of the process. Maximum care should be taken to prevent sand and dust coming into the processing

plant. Dust and sand particles can easily come in contact with the recycled plastic pellets which reduces the quality of plastic products. The behaviour of the workers in the recycling plant should be adjusted accordingly such as to maintain a clean work area, for example be wearing clean shoes, etc. A considerable quantity of water will be required for the washing of raw material (waste plastics). Therefore, water treatment and reusing is important to reduce the cost of production and environmental pollution. Moisture in the raw material should be removed prior to the processing of plastics and therefore, reserving area for drying is equally important.

f. Shredding

This is the most important stage in the mechanical waste plastic recycling process. After collection waste plastics is then sent to the shredder to be cut into small sizes it is called plastic flakes, this process is known as the size reduction. The shredder is incorporated with water and rotating cutting blade or cutter in a cylinder. From the figure 24,25,26 below, the plastic wastes are feed into the shredder and the rotary blade inside the shredder then cut the plastic into the required small pieces (flakes) and these go through a passage with small holes into flakes collector(collection bin). The rotary blade of the shredder can be powered by electric motor or mechanical engine. The rotary blade is connected to the electric motor or the mechanical engine by pulley belt with the pulleys of both rotary blade and electric motor or engine. Through the transmission of power between the two, the blade of the chipper rotates then initiates the cutting the process. The small pieces of plastic that comes out during the process are collected. The product is either washed if not washed prior to the cutting and pack into bags for selling the plastic plant or the flakes then go into another process of extrusion into granules.

The value of the recycled plastic relies greatly on its purity. Even small dust particles can reduce the quality of the material drastically as it will disturb the polymer arrangement and later the quality of the final product. Therefore, thorough washing of the plastic material and drying should be done prior to processing. In washing, a diluted detergent can be used and precautions should be taken to remove the detergent from the material on completion of the process. Oil contaminants should be removed using an appropriate solvent, followed by a detergent and water. Maintaining a clean working environment is an important aspect of the process. Maximum care should be taken to prevent sand and dust coming into the processing plant. Dust and sand particles can easily come in contact with the recycled plastic pellets which reduces the quality of plastic products.

The behaviour of the workers in the recycling plant should be adjusted accordingly such as to maintain a clean work area, for example be wearing clean shoes, etc. A considerable quantity of water will be required for the washing of raw material (waste plastics). Therefore, water treatment and reusing is important to reduce the cost of production and environmental pollution. Moisture in the raw material should be removed prior to the processing of plastics and therefore, reserving area for drying is equally important.

The large particles of plastic need to be broken down into small pieces to reduce storage and transportation space requirement. Such broken down HDPE, PP, and LDPE plastics can be sold as raw material for plastic production without any further processing. On the other hand, it can be re-extruded (the process is explained below) to produce pellets for plastic manufacturing. For PETE crushing can also be done to reduce the storage space requirement and easy transportation for further processing. A crusher should be used for this purpose and the resultant broken pieces of plastics should be the size of 0.5 - 2 cm. It is important to prevent mixing of plastic types to maintain the quality and value of the plastic. Mixed crushed plastics can be used only for low value and low quality products such as junction boxes used in electrical work or plastic lumbers. The crusher should comprise of a rotating set of blades, feeding hopper, and motor. The size of the feeder depends on the maximum size of plastic that needs to be crushed. Operating a crusher is easy and the sorted and cleaned plastics can be fed into the feeding hopper manually and the crushed material should be collected and stored to prevent contamination with sand, dust, and moisture. The operator of the crusher and helpers should wear ear plugs to protect their ears as the crusher creates a high noise level. Exposure to such noise levels over a long period can create hearing impairments. It is also advisable to use gloves when handling plastics.

g. Agglomeration

The term 'agglomeration' itself provides an idea of forming a crumb out of smaller material. Agglomeration is done for film plastics (polythene) instead of crushing. Film plastics cannot be crushed due to its properties. Agglomeration can be performed on LDPE and PP type film plastics. An equipment call the "Agglomerator" is used for agglomeration. The Agglomerator is simply a metal drum in which a set of blades are rotating at high rpm (rotations per minute). When the film plastics are fed into the agglomerator it cuts into small pieces by the blades inside. Consequently the heat generated due to the high rotation speed, it makes the pieces of film partially melt and bind into a small crumb. This crumb can be fed to the extruder, easily to ensure smooth functioning in extrusion. Operating of an agglomerator should be done with caution. First, a small quantity of film plastics (about 3 kg) needs to be put in and machine switched on. Then feeding should be done gradually until the drum filled up to 2/3rds of its capacity. The first batch needs more time to get agglomerated as the drum gets heated slowly. In a 100Kg capacity agglomerate the first batch takes 45 minutes for processing, while the following batches take only 25 minutes. The agglomerated film plastics (polythene) should be taken out quickly and allowed cool. The optimum time of agglomeration is when approximately 50% of the particles are in crumbs with 0.5 – 1cm diameter. Over agglomeration (long time in agglomerator) can melt the films too much and can result in pieces of film binding into larger particles. In addition, the rotation of the blades can be disrupted due to overmolten polythene blocking the rotating shafts. Over

melting will also make manual handling of the material difficult due to high heat and stickiness of the material.

Agglomeration can be performed only with LDPE and PP films. To agglomerate HDPE films, higher temperatures should be achieved within the agglomerator if not the films may block the rotating blades. Under high temperatures LDPE and PP film cannot be agglomerated as the melting points of these plastics are lower than that of HDPE. Therefore, a special agglomerator should be designed to agglomerate HDPE with heat elements and insulators.

Figure 7. Agglomeration

h. Washing

In recycling of plastic wastes, one critical thing that must be done is washing of the recycled plastic flakes or plastic waste materials before or after the process. The washing of the plastic wastes can be done either manually or mechanically operated mechanism in a well-constructed washing tank , where by the dirty water can be drain out easily. Since the plastic wastes are already contaminated with a lot of dirty such as grease, oil, dust etc, it is important to use the required surfactants (detergents) and water (cold or hot) to loosen and remove the contaminates from the plastic materials. Usually shredding and washing waste plastics are tend to be carried out within the same unit.

i. Drying

Plastics waste can be dried either manually or mechanically. With the manual method the plastics are spread out in the sun to dry, and turned regularly. Plastic films can be hung on lines and thus require only half the area normally used when plastics are spread out to dry. At Blowplast, the drying process is carried out mechanically. A water drier, which in principle is a thermal drying machine at 70^0C, is used to dry the washed shredded plastic waste.

3.3.3 Implementation

a. Extrusion

Extruding is a mechanism used to obtain plastic material in a required shape and size. In recycling, the plastic pellets are the most common final product obtained through extruding. An extruder is used in this process. An Extruder is simply a screw rotating in a zone which is heated under controlled conditions. The Thermoplastics (includes HDPE, LDPE and PP) will melt under specific temperatures and can be remoulded into a required shape. Extruding can be done either to produce plastic pellets. In the recycling process of waste plastics the final product in extruding is plastic pellets. An Extruder machine contains following components:

- Motor,
- Screw,
- Heating elements (1500W),
- Feeding hopper,
- Control panel,
- Die head with sieving net,

Generally the motor used in the extruding machine is 7.5 HP x 1440 rpm motor. The motor rotates the screw inside the extruder which is mounted on a horizontal barrel. There are three main areas in the extruder feeding zone, compression zone and metering zone as depicted in the diagrams below. A feeding hopper is fixed in the feeding zone through which the crushed plastics or polythene crumb is fed. In the compression zone the plastic material is melted and compressed. In the metering zone the compressed melted plastics is pressed through a sieving mesh and die head. A 0.5mm^2 Sieving mesh is fixed before the die head to extract any sand, dust and other particles from the recycled pellets. The number of strands extruded is equal to the number of holes on the die head. Within the extruder there are six 1000W bend heating elements. Five of them are mounted around the screw and one is located on the die head. Based on the heating pattern there are four heating zones. Zone 1 is located at the starting point of compression zone and the 4th zone is the die head. With the control panel the temperatures at different zones are maintained at required levels by coarse and fine adjustments.

The required levels of temperatures in each zone vary with the type of plastics. The temperature of each zone can be read in digital screens. When the extruder machine is operated melted plastic strands will come out from the die head and pass through a cooling tank and then through the pelletizer. The extruded plastic strands are in semi-liquid form. They should be cooled to make them hard. Therefore, the extruded stands are sent through a water tank to stabilize them. The length of the water tank should be about 10 feet. The plastic flakes are feed into an extruder when then melt the flakes. The melted flakes are extruded out of the extruder through a die of small holes. The plastic flakes in the hopper of the extruder travels by the gravity into the feed rod and drops onto the rotating screw. The rotation of the screw conveys the plastic forward through the heating barrel. As the plastic is convey forward along the screw the channel depth decreases forcing the plastic to a smaller area. The plastic is melted by heat generated from the friction by the combination of compression and screw rotation and the heat from the barrel system.

The plastic is well mixed when the melted plastic reaches the end of the screw. At this point the screw acts as pump to force the melted plastic out of the screw through the die and the melted plastic comes out as strands. The hot plastic strands pass through a water tank to cool and solidify the strands. As the plastic strands are cooled and solidifies, strands are conveyed towards a

pelletiser which then cut the plastic strands into pellets with in-built cutting blade.

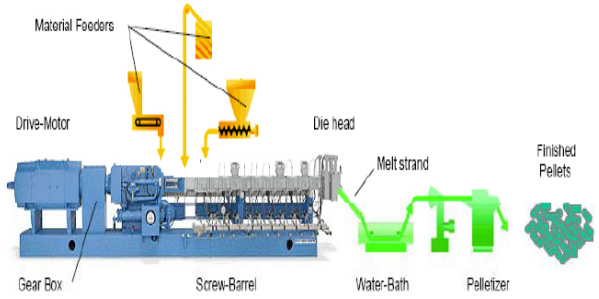

Figure 8. Extrusion process

Figure 9. Pelletizing processing
(Photo taking 31/07/2013)

b. Pelletizer

This is done by melting the chops and extruding them out first through a fine grill to remove any solid dirt or metal particles that have made it through the treatment thus far and then through a die of small holes. If the plastic was simply allowed to extrude from these holes it would come out spaghetti like strings and quickly tangles together. However, it is sprayed with water as it comes out (to prevent the plastic from sticking together) and cut off by rotating knives to give small, oval pellets. The Pelletizer is a rotating blade by which the stands are cut into small pieces (pellets). The length of the pellets can be changed by adjusting the speed of the motor which is done by changing the pulleys.

Figure 10. Plastics pellets from recycling

c. Water Cooling

Water cooling for the extruder machine parts and cooling the extruded plastic strands, the water used in cooling the tank and as coolant in the extruder machine needs to cool. It can then be reused. A simplified cooling tower can be used to reuse this water. A simple water treatment unit can be used to reuse water using in cleaning.

Figure 11. Water Cooling

d. Technical specification of extrusion

Plastic Recycling Granulator is suitable for the granule remaking of thermoplastic plastics. Mainly applied to processing old and useless plastic sheeting, braided bags, convenient bags, boxes, barrels, beverage bottles, furniture, items in everyday use, and so on.

Table 2. Specification of extrusion machine

N^0	Type	Dia of screw (mm)	L/D Ration of screw	Main power (kw)	Exhaust mode	Weight overrate (T)	D (LxWxH) (mm)	Productivity (T/M)
1	PET	178	13.5:1	30	single	2	3400x1100x1300	70-100
2	HDPE	178	13.5:1	30	single	2	3400x1100x1300	70-100
3	LDPE	178	13.5:1	30	single	2	3400x1100x1300	70-100
4	PP	178	13.5:1	30	Single	2	3400x1100x1300	70-100

Table 3. Temperature of each Zone

Code	Type	Zone 1 ^{0}C	Zone 2 ^{0}C	Zone 3 ^{0}C	Zone 4 (Die head) ^{0}C	Screw Speed (Rpm)
1	PET	200-220	220-240	250-270	225-229	280
2	HDPE	220-240	240-260	260-280	210-230	280
3	LDPE	170-190	190-210	210-230	180-200	280
4	PP	140-160	160-180	180-200	170-180	280

e. Storage Facilities

Storage facilities are required to store waste plastics and plastic pellets, cleaned plastics and recycled plastics. Storage space should be available in order to store different types of waste plastics in adequate quantities.

During rainy periods the drying of washed waste plastic will be a problem. Therefore, storage facilities should be available to store standby stocks of cleaned and dried waste plastic material. After produce the pellets also need to be stored before marketing. In this case, special containers are required to store recycled plastics pellets to protect them from contamination and moisture.

Figure 12. Storage facility for plastics pellets
(Photo taking 31/07/2013)

4. Conclusion

According to the result above it can be determined that the plastics recycling by converting plastic waste into plastics pellets have to be carried out in plastics types are PET, HDPE, LDPE and PP with best technology, effective and economic, known as mechanical recycling. Using mechanical recycling to manage plastic wastes would be created job opportunity for the people in Indonesia and provide a good potential to convert plastic wastes into new raw material to replace pure plastics pellets and can be applied with small and large scale industries as well as home industries. A plastic recycling by converting plastics waste into pellets is regarded as mechanical recycling and extruder machine with the appropriated temperature of melting to produce pellets, the quality of pellets involves in collection, sorting, shredding, washing or cleaning, and drying. The quality of pellets from plastic waste is acceptable to produce the plastic products but not for drinking or foods container products.

Converting plastics waste into pellets is an activity that provided appropriate manner to avoid its negative impacts on environment and it is environment friendly as compared to other ways to dispose plastic waste and burning.

References

Belaji, J. S. (2013, Match Tuesday). *Jai Shree Belaji Plasic*, from www.plasticgranules.co.in. Retrieved Match 1, 2013

Boadrd, C. P. (2012). *Material on Plastic Waste Management.* East Arjun Nagar: Delhi.

H.K karapanagioti, I. K. (2007). Investigating The Properties Of Plastic Resin Pellets Found In The Coastal Areas Of Lesvos Island. *Global NEST Journal, Vol 9*, 71-76.

UNEP. (2009). *Converting Waste Plastics into a Resource Compendium of Technologies.* Japan: United Nations Environmental Programme, Division of Technology, Industry and Economics, International Environmental Technology Centre, Osaka/Shiga.

UNEP. (2009). Converting Waste Plastics into a Resources Assessment Guidlines. 1-63.

Wong, C. (2010). *A Study of Plastic Recycling Supply Chain.* UK: The Chartered Institute of Logistics and Transport UK.