Study and Fabrication of Plastic Recycling Machine – Extrusion Machine

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***Abstract*—This paper covers the topic of study and development of Plastic Recycling Machine i.e. Plastic Extrusion Machine. It is based on the open source project Precious Plastic. It was an initiation taken by Dave Hakkens to reduce plastic pollution. He has a series of machines which are shredder, injection, extrusion, moulding machine. The goal of this project is to make a plastic recycling machine at the minimum cost available which can be used at a personal level to fight plastic pollution. The machine is to be made from parts available at local junk or scrapyard. The machine is also to be made of different modular units which can be easily assembled or dismantled such as motor and gearbox unit can also be used for shredder machine.**

***Keywords*—Plastic Recycling, Plastic Extrusion Machine, Precious Plastic, Plastic Waste, Small Scale Plastic Recycling**

1. Introduction

As plastic is an inevitable need of today's world, after use it ends up in landfills and water resources such as lake, river and sea, endangering the ecosystem and forming pollution. So, it is necessary to manufacture less plastic and recycle the one which will form trash to reduce the plastic waste. It is deteriorating our planet and people's lives. It is a problem. A material made to last hundreds of years that is only used for minutes, a fraction of its possible lifespan, and quickly discarded.

All waste plastic around us is a valuable resource with great abilities. If used properly recycling waste plastic can help all living beings. Waste plastic is around us everywhere. We can use this resource and start earning.

1.1 Precious Plastic

Precious Plastic, an open-source project that was started by Dave Hakkens in 2013. The idea was to make a series of machines that were to decrease the problem of plastic waste throughout the world by reshaping it into new products on a local basis. Hakkens suggested that people all over the world could build their own production line and pay the local citizens a small fee according to the weight of the raw material they bring to the workshop.

Plastic recycling is a world with many complications and it is not available for the general public. It is very difficult for normal public to access this knowledge. The objective of precious plastic was to enable everyone to work with waste plastic and be able to recycle it.

All the machines in precious plastic are made from very basic, affordable, easily available parts. The machines are made in a way that it can be easily assembled and dismantled, and the power unit consisting of motor and gearbox to achieve optimum speeds can be used for different machine such as shredder. Precious plastic shows that there are numerus opportunities for waste plastic to eradicate the plastic pollution. Plastic recycling also helps in eradicating the request for novel plastic.

2. Problem Statement

Many times, it is seen that Indians blindly follow western techniques to dispose the trash i.e. is burning the trash. In India there are plants set up to take care of the trash by burning it. And the trash contains plastic too which when burned creates hazardous fumes which are very harmful and it does not suit our environment.

Instead, plastic should be melted and recycled. As new plastic is made or manufactured from oil and oil resources from earth are on the verge of depletion, we should use of resources wisely and should recycle the plastic instead of manufacturing new.

2.1 Objective

Dave Hakkens was clear in his instructions that the Precious Plastic machines are not perfect and so is under ongoing development by the community. Consequently, problems are expected to arise during construction and testing since variations in dimensions and tolerance will depend on the precision of the material supplier and manufacturing methods.

Since the blueprints only cover the actual extrusion machine part and a general framework, the actual setup would have to be modified to fit whatever power supply unit (PSU) that was finally used.

Following are the **objectives** of precious plastic

1. Make an easily detachable modular unit of power supply which can be utilized for shredder as well
2. Minimise building cost
3. Using waste plastic from industrial and household waste to produce new components
4. To enable plastic recycling at small scale (such as in societies etc.) and to earn
5. To reduce plastic pollution in waste stream to enable healthy eco-system.
6. Saving non-renewable resources such as oil.
7. To represent and promote plastic recycling.
8. Enabling carbon neutral energy production from waste.

2.2 Scope

The project consists of the complete building and testing of the plastic extrusion machine provided by Hakkens. Ultimately, the goal was to build a physical and functioning version of the plastic extrusion machine

We can produce different types of domestic and industrial products by recycling the west plastic example from pots for plants to 3D printing filament. Extruded plastic can be cut into beads to sell it to the industry to earn income.

No deeper analysis is made of the throughput of the machine other than a cursory examination if the desired functionality is fulfilled. To keep the costs to a minimum, the building of the machine is exclusively to be done in the college workshop

2.3 Methodology

The recycling of plastics is carried out in a five-step process:

Step 1- Plastics collection
This is done through roadside collections, special recycling bins and directly from industries that use a lot of plastic.
Step 2 - Manual sorting
At this stage nails and stones are removed, and the plastic is sorted into three types: PET, HDPE and 'other'.
Step 3 - Chipping
The sorted plastic is cut into small pieces ready to be melted down.
Step 4 - Washing
This stage removes contaminants such as paper labels, dirt and remnants of the product originally contained in the plastic.
Step 5 – Pelleting
The plastic is then melted down and extruded into small pellets ready for reuse [9].

3. Types of Thermosetting Plastic

a) PET (polyethylene terephthalate)
This is a very strong plastic that can be easily recognised for its transparent look. All beverage bottles containing your favourite sodas are PET. This plastic is also used in many other products like jars, combs, bags, tote bags, carpets and ropes. Items made from this plastic are commonly recycled. Most recently, PET is often recycled into yarns to make clothes. This plastic is a bit more complex to work with, we advise to start with other plastics.

b) HDPE (high-density polyethylene)
This plastic is often used for food or drink containers. Items made from this plastic include containers for milk, motor oil, shampoos, soap bottles, detergents, and bleaches. Many toys are also made from this plastic. This plastic works very well with Precious Plastic.

c) PVC (polyvinyl chloride)
This is toxic and we do not work with it. PVC is most commonly found in plumbing pipes and releases chloride when heated up. Do not use with Precious Plastic.

d) LDPE (low-density polyethylene)
Plastic wrap, sandwich bags, squeezable bottles, and plastic grocery bags all are made from LDPE. Usually, LDPE is not recycled from the industry but works rather good with Precious Plastic.

e) (polypropylene)
This is one of the most commonly available plastic on the market. This type of plastic is strong and can usually withstand higher temperatures. Among many other applications, it is consistently used for products that get in contact with food and drink (Tupperware, yoghurt boxes, syrup bottles etc..). PP works very well with Precious Plastic.

f) PS (polystyrene)
PS is most commonly known as Styrofoam. PS can be recycled, but not efficiently; recycling it takes a lot of energy, which means that few places accept it. Disposable coffee cups, plastic food boxes, plastic cutlery and packing foam are made from PS. Very good to work with Precious Plastic.

g) Other (Mix)

This code is used to identify other types of plastic that are not defined by the other six codes. ABS, Acrylic or Polycarbonate are included in this category and can me more difficult to recycle. Precious Plastic can work with some of this.

3.1 Plastic Extrusion Machine

The extrusion machine is a very powerful machine of the Precious Plastic arsenal as it can create unique products and can run continuously. Technically, if we have enough plastic and a well-streamlined process, we could be recycling 24/7. With the extrusion machine we can create filament, granulate or get creative working with moulds. This machine is also great for educational purposes as the process is very straightforward and easy to understand. This technique nicely blends differently coloured plastics together and outputs a homogeneous and smooth colour, for example, if we mix black and white plastic together, we will get a nice and smooth grey output. We can use this feature to our advantage in our designs.

Figure 1 Plastic Extrusion Machine [1]

3.2 Process

Plastic is inserted from the hopper, gets transported along the barrel by a big screw towards the end where heating bands are placed. The heating from the bands and the mounting pressure inside of the barrel bring the plastic to a melting state (liquid). Once sufficiently melted the plastic can eventually get out through the nozzle in the form of a continuous thread. The plastic thread is then treated differently depending on the wanted outcome.

Figure 2 Extruded Plastic [1]

The extruded thread can be used for following purposes –

1) As a 3D printing filament
2) Components using moulds
3) Pellets to sell as raw materials to industries
4) Application as per person's imagination

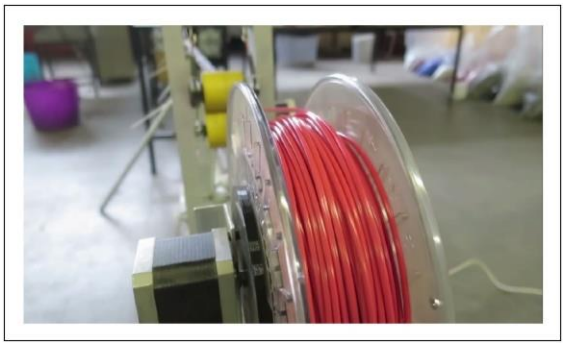

Figure 3 Extruded 3D Printing Filament [1]

Figure 4 Pallets as a Raw Material [1]

Figure 5 Safety Handle for Knife [1]

Figure 6 Creating Lamp Using Mould [1]

3.3 Operational Procedure for the Extrusion Machine

Start-up
Heat the machine to the desired temperature.
Wait 20 minutes.
Add desired plastic in the hopper.
Turn on the motor.
The material that comes out of the machine for the first 2 minutes is to clean the machine from old plastics from previous sessions.
The machine is now ready for production.

Production
A plastic string is now flowing out of the extruder, this cannot be easily stopped, so one should know what we want to make before we start extruding.
The flow and pressure of the extrusion can be adjusted by turning the screw at the nozzle (more flow equals less pressure).
It takes roughly 2 minutes for the plastic to reach the nozzle from the hopper.
Keeping enough plastic granulates in the hopper while extruding to reduce chances of bubbles in the extruded plastic.

Cooldown
When cooling down the machine let the machine turn until there is no more material coming from the nozzle.
First stop the motor than the heating.

4. Design screw, barrel and die

4.1 Screw Design

The design of screw is important for plastic processing. It has mainly three different functions: namely, feeding mechanism; uniform melting and mixing of plastic and finally it generates the pressure to push the molten material through die.
A screw length (L) is referenced to its diameter (D) as L/D ratio. Generally, L/D ratio is used as 24:1, but for more mixing and output, it may increase up to 32:1. There are three possible zones in a screw length i.e. feed zone, melting zone, and metering zone.
a. Feed zone: In this zone, the resin is inserted from hopper into the barrel, and the channel depth is constant.
b. Melting zone: The plastic material is melted and the channel depth gets progressively smaller. It is also called the transition or compression zone.
c. Metering zone: The molten plastic is mixed at uniform temperature and pressure and forwarded through the die. The channel depth is constant throughout this zone. [5]

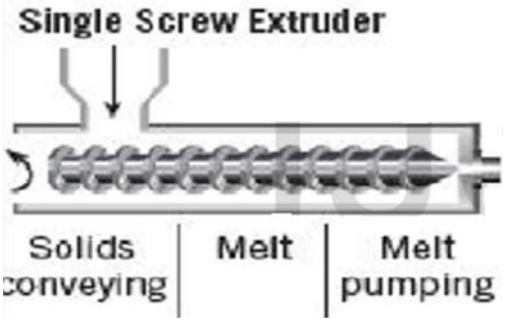

Figure 7 cross-section of Single Screw extruder [5]

4.2 Extruder barrel

Internal diameter of barrel typically ranges from 25 to 150 mm (1.0 to 6.0 in) and L/D ratio ranges from 10 to 30. Higher L/D is used for thermoplastics and lower for elastomers Feedstock fed by gravity onto screw whose rotation moves material through barrel. [5]

Electric heaters melt feedstock: subsequent mixing and mechanical working adds heat which maintains the melt

4.3 Die end of extruder

Progress of plastic melt through barrel leads ultimately to the die zone. Before reaching die, the melt passes through a screen pack – series of wire meshes supported by a stiff plate containing small axial holes.

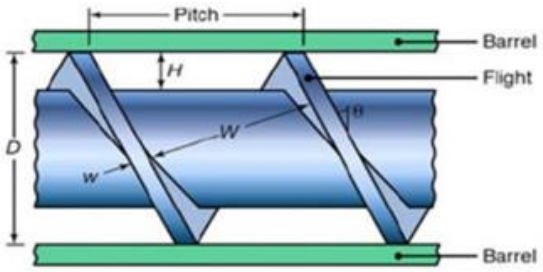

Figure 8 Details of an extruder screw inside the barrel [5]

4.4 Application and Material Used

The different types of plastic **materials** that can be used in extrusion process are Polyethylene, Polypropylene (PP), Acetal, Acrylic, Nylon (Polyamides), Polystyrene, Polyvinyl Chloride (PVC), Acrylonitrile Butadiene Styrene (ABS) and Polycarbonate.

• The extrusion process is used for manufacturing rods, plates and tubes, wire and cable coating, hose liners, hose mandrels, filaments, sheet, multilayer film, medical packaging and food packaging, sheathing, and jacketing 7
• Single conductor (wire) or multiple conductor (cable) covering
• Flat ribbon multi-conductor cables for appliance cords, TV antenna
• Decorative trim elements with polished brass, Al, or chrome plated substrates in a protective, transparent cover. (Plastic bag ties)

5. CONCLUSION

In this way a small-scale plastic extrusion machine can be fabricated. This machine could be used at societies, backward areas where plastic pollution is on a larger scale and by recycling people could earn money by selling recycled plastic as raw materials to the industry. If such short scale machines are adapted by a wide range of people, there will be significant amount of trash or plastic reduction. Plastic will not end up in landfills or water resources endangering the ecosystem.

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