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Recycling and Manufacturing Plastics with an Injection Molder

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Abstract

The Precious Plastic initiative is an open-source project that shares information with anyone looking to begin plastic recycling efforts. It is the goal of many students in conjunction with Millersville University's Applied Engineering, Safety and Technology program (AEST), to bring a recycling program to Millersville University's campus. This project involves the collection, processing, and manufacturing of plastic into new items. The Precious Plastic initiative is supported by the Society of Manufacturing Engineers (SME) chapter at Millersville University. The various types of plastic collected around campus must be sorted by type and even color. The plastic then needs to be carefully prepared so it is able to be processed. The collected plastic goes through cleaning, shredding, extrusion, and injection, to reach its new form. The focused effort for this project was to go through the design and manufacturing process for an injection molder to supplement the overall Precious Plastic program. To design a functional injection molder research was done into current machines and compared to the design goals in mind. Making machines capable of processing recycled plastic is the first step to make Millersville more environmentally friendly.

What Is Precious Plastic

The precious plastics project was started by Dave Hakkens in 2012 as a part of his studies in the Design Academy in Eindhoven, Netherlands. His goal was to create a more sustainable lifestyle with the reduction of plastic waste. His first design was showcased at his graduation in 2013. This design consisted of an extruder, an injection molder, and a rotation molder, which are different types of plastic processing machines. A year later Hakkens noticed that a group of people replicated his design, showing him the potential that this project could have. Despite that, Hakkens continued and designed and updated more tools that will shred and inject recycled plastic. The precious plastics team created files and videos in order to make these tools, they also created articles and videos on plastic types for further information on the subject. The goal that their team wants to achieve is a "global alternative recycling system" (Precious Plastics, 2020) that can be

accessible to anyone, not only larger companies.

Preparing and Sorting Plastic

Collection efforts come directly from Millersville University's campus, students, faculty, and organizations working to collect the plastic. One main source of support comes from the Society of Manufacturing Engineers (SME) Millersville chapter. The plastic that is collected on campus is gathered to prepare for processing. The collected plastic goes through a cleaning process, removing residues, labels, and other impurities that could impact the processes like pulverization, extrusion, and injection. Once the plastics are clean, they are then sorted by plastic-type, which is the most confusing part of the process, as many manufacturers fail to properly identify the type used in their products. Nevertheless, there are different chemical tests that can be performed to ensure plastic-type, like testing plastic floating properties in different liquids and burning tests to examine smoke and smell. There are seven different types of plastic (Plastics for Change, 2021), but the types needed for the project are:

- #2-high-density polyethylene (HDPE)
- #4-low-density polyethylene (LDPE)
- #5 - polypropylene (PP)

The other standard plastic classifications are Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC), Polystyrene (PS). Any other type of plastic falls into the last category of, "other."

The next major part of the process is to sort the plastic types further into general colors. This is important solely for aesthetic purposes. The products which we plan to make vary, and their respective colors vary as well. Lastly, the process of shredding the plastic is what makes the following extrusion process so successful, as it greatly reduces the number of air pockets, the most common reason for melting and injection failure. This process is done with an industrial shredding machine, made by the students at Millersville University. Following the shredding, the shredded plastic bits are separated into their respective types, to be then directly put into the extruder.

Injection Molder

Injection molding is a major manufacturing technique in industry, allowing for complex parts to be made in high volume (Kauffer, 2011, p. 2). Injection molding involves heating the plastic to the point where it is molten and then by means of injection it is forced into a mold. The mold creates the form for the plastic to fill and once it cools the final product becomes a hard plastic item that matches the shape of the mold cavity. The main types of plastics that will be utilized are high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polypropylene (PP) all of which are found in everyday items such as bottles. Each type of plastic has different melting temperatures that must be reached for proper molding. HDPE, LDPE, and PP each need a different temperature anywhere from 300°F-570°F for injection molding due to their different properties (Plastic Injection Molding Processing Conditions, 2017). To adjust for this wide range of temperatures, a heat controller was used along with a temperature sensor. The controller can toggle three 500-watt heat clamps on and off to reach a set temperature. This is a similar concept to how a standard kitchen oven can be set to a desired temperature. Once the plastic is heated to the proper temperature a force is required to push the material into a mold.

There are multiple methods for producing the required force to inject the plastic into a mold, including mechanical screws, hydraulics, pneumatics, or manual levers. Industrial machines produced by companies such as Arburg, which is one of

the leading global manufacturers of injection molding machines for plastic processing, use mechanical injection screws. The screws allow for more continuous output while mixing the plastic to make it more homogenous. In the case of this project, a piston injection powered by two pneumatic cylinders was chosen. Pneumatic cylinders use pressurized air to push a piston which creates large amounts of force. The combined cylinders can output a theoretical 5600 newtons when extending. The design was heavily inspired by an injection molder created by the Youtube channel Action Box. Their design utilized many components that appear in all injection molders; however, they displayed the idea of combining two pistons for more force. The main changes made when building the design for this project were to the size and rigidity of the machine. By using larger pneumatic cylinders, the machine can output more plastic for bigger molds. Another problem that had to be considered was reducing stress on the pneumatic cylinders. Pneumatic cylinders aren't made to withstand horizontal loads which can cause severe wear. To remove horizontal force, linear guide rails were used along with bearings that are made to withstand any forces introduced. This will ensure the machine can withstand continued use and work with a wide range of molds. The injection molder will become another tool to add to the recycling effort on Millersville University's campus. Having these different machines will create a wide range of options for plastic to be recycled. The injection molder and extrusion machine will be able to create products that are not only useful, but the goal will be to create projects that can benefit Millersville University as a community.

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