Hand Operated Injection Moulding Machine for Manufacturing Recycled Plastic Products

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Based on the draft report of Indy Vester, intern at WASTE, April 2020
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1. Introduction
This report shows a summary of the research conducted by Integrated Product Design student Indy Vester during an internship at WASTE for 4 months during Spring 2020. The internship assignment consisted of supporting research and establishing a possible product portfolio by product conceptualization and embodiment design for the EJOM project using the hand operated injection moulding machine. EJOM stands for L’emploi des jeunes crée des opportunités, ici au Mali and aims to creates employment opportunities for the youth of Mali. This manual injection machine, widely used in India and Bangladesh, has potential to be introduced in Mali to start a recycling business. Unfortunately Indy Vester had to break off her internship due to the Corona pandemic.

2. Description of the hand operated injection moulding machine

The principle of injection moulding
Injection moulding is a manufacturing process for producing parts by injecting molten material into a mould. An injection moulding machine consists of an injection unit and a mould clamping unit. The injection unit must convey, melt, mix and homogenise the melt. It must also be able to inject a fixed weight into the mould. This is called the shot weight and will vary depending on the shape and size of the component to be moulded. Most of these injection moulding machines use screws to efficiently heat, mix and inject plastic into the mould.

Hand operated vertical injection moulding machine
Injection moulding in hand operated machines is also possible. In a vertical injection moulding machine the material is fed from the tops side of the machine. These machines consist of a heating cylinder and a clamping unit to hold the mould. The heating cylinder with a chamber is mounted on a base and has a discharge nozzle to inject the melted plastic material in the mould. There is a plunger being movable into the chamber toward the discharge nozzle to force the melted plastic into the mould under pressure. After completing the process, the final product is obtained from the mould. Temperature of the heating chamber can be regulated through the controller (see figure 1). These machines are commonly used in India and Bangladesh and a variety of sizes and capacity is available.

Figure 1: The vertical manual operated moulding machine
These hand operated machines are mainly used in small scale industries as they require low manufacturing cost, low maintenance cost and no skilled workers. It enables one person to produce simple and small plastic products.

**The moulds**
The moulds are made from hardened steel or aluminium. A proper vent in the mould cavity is required for the removal of gasses and easy flow of molten plastic equally in all the directions. The mould can be single cavity or multi-cavity. In multi cavity moulds, each cavity is identical and forms the same parts and in single cavity moulds the entire part cavity is made on one side. A part line, sprue, gate marks and ejector pin marks are generally present on the mould.

![Figure 2: Example of a mould made out of Aluminium](image)

**The products**
Table 1 shows some examples of products that can be manufactured by the vertical injection moulding machine with the possibility to use recycled plastic.

**Possibilities to use recycled plastic**
The proper flow of molten plastic inside the mould cavity depends on the viscosity of the plastic. The input material used can be granules, pellets or powder. Usually, the temperature of the heating chamber is slightly lower than the softening temperature of the plastic injected.

The usage of recycled plastic depends on the quality of the recycled granules and/or pellets. Contaminants will complicate the production process as they might block the system.

**The market**
To know the products that can be sold it is important to explore the market by building relationships with industry partners. They will place orders when they are in need of a product, for example an item they need to complement their product: handles for brushes or bags, electrical switch box appliances. This will also give guidance on the type of moulds to buy.
Door handles  Screwdriver handle  Chair leg caps/covers
Wheels for toy cars  Gardening products  Connector for tubing
Hang tags for clothes (Bangladesh)  Alphabet blocks for learning centres in refugee camps (Bangladesh)  Y-pipes for sewage systems

Table 1: examples of products manufactured with the manual injection mould machine

3. Working process

The machine has been tested on usability by the research team. For this, a hand-operated moulding injection machine was purchased from India and was used to manufacture products out of recycled plastics. The operating procedure of the machine is as follows:

1. Turn on the heater, wait until the required temperature, preferably a few degrees under the melting temperature of the plastic.
2. Clean the nozzle hole from any blockage.
3. Feed the plastic waste material (flakes, pellets) on top into the cylinder and wait 1 or 2 minutes until you conform its ready to operate.
4. Fix the mould in the machine vice in such a way that the filling hole (runner) is exactly under the nozzle.
5. By rotating the lever, you can produce the product by filling the mould with melted plastic.
6. Remove the mould and let it cool down in a bucket of water.
7. Open the mould and remove the product.

The following table shows the specification of the hand operated moulding machine:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Shot Capacity</td>
<td>60 ml, 120 grams</td>
</tr>
<tr>
<td>Min Power</td>
<td>220v</td>
</tr>
<tr>
<td>Max Temperature</td>
<td>300 Celsius 900W</td>
</tr>
<tr>
<td>Max Clamping Force</td>
<td>12 tons</td>
</tr>
<tr>
<td>Machine Dimensions</td>
<td>1250x550x400mm</td>
</tr>
<tr>
<td>Machine Weight</td>
<td>100kg</td>
</tr>
</tbody>
</table>

4. Testing

From the different product design ideas, a selection was made to develop into a concept so that moulds could be made. The most promising option was the modular component. With the mould of the modular component some experiments were executed by Indy, Sethu and Sophie to gain experience with working with the hand operated injection moulding machine. Unfortunately we were not able to test other moulds at this moment.

4.1 Modular component

The modular component is a flat puzzle piece with the dimensions of 98 x 98 x 8 mm. The component can be connected with copies of itself in a flat connection (for instance to use as flooring in a refugee tent) or with a 90 degrees angle. This makes it possible to use the piece to build cubicles (for instance to use as a flower pot, a compost barrel or a storage crate), which can be seen on the lower right of figure 3.

*Figure 3: The mould of the modular component, the product and image of a storage crate*
4.2 Results

On the lower left of figure 3, modular components are seen produced with the injection mould machine. The material used was recycled PP in pellets. The pieces connect very well together and have similar forms and thickness.

5. Case study from India

Rajni is the owner of Ragavandra Plastic’s in Pudicherry in India. He worked for a plastic injection company before and got inspired and learned the technics from my previous work. After his marriage he decided that he wanted to be an entrepreneur and started his own company. He has two employees.

He owns two manual injection mould machines (two sizes) to produce industrial plastic components. The materials that he uses are PP, HIPS, NYLON, ABS, EVA and PVC. He uses 50% virgin and 50% recycled material to manufacture the products. He chooses the raw materials according to the product quality and grade.

The business case

When producing smaller products (5-20 grams per product) he can produce 10 products per hour, when looking at bigger products (20-40 grams) the production capacity is 5-6 products per hour. He pays approx. Rs. 35 to Rs. 60 per kilogram (0.40 to 0.69 euro cent) depending on the market price and he sells the products for Rs.100 to Rs. 150 per kilogram (1.15 to 2 euro).

With the manual injection mould machine Rajni earns Approximately Rs 1500 to Rs 2000 per day (20 to 30 euro per day).

Investment

Ranji has two of these machines: one capable to produce products of a half-ounce (up to 20 grams) and 1 capable to produce products of 1 ounce (up to 50 grams).

The investment costs are:
- Half ounce machine cost – Rs.40000 (450 euro)
- One-ounce machine cost – Rs 60000 (650 euro)

Normally 1 mould is included but depending on the product that the entrepreneur want to make other moulds can be ordered for extra costs.
Challenges and advantages
There are no real challenges, some rarely heater problems. Furthermore it is easy to handle, it saves electricity, money, time and space to manufacture the products in this machine. Investment for the machine and the mould is cheaper compared to injection machine.

6. Conclusions, recommendations and follow up
Experiences from Bangladesh, India combined with the first test experiments executed in The Netherlands show promising results to use the manual injection mould machine to produce specific products. Advantages of the machine are:

- The investment is lower than an extruder based injection mould machine which makes it an interesting machine for starting enterprises.
- The machine uses less electricity than the extruder based injection mould machine and are less vulnerable to power cuts.
- The machine can be operated by one person.

Challenges of the machine are:

- PP pellets were used which have a high viscosity. The machine can handle these plastics very well. Whether more low viscosity plastics can be used need to be tested.

Unfortunately, it was not possible to test the machine with lower quality recycled materials with a percentage contaminants or MLP (Multi-Layer Packaging).

Some additional research and testing is recommended to answer the following questions:

- Can the machine be adapted to manufacture products with low viscosity plastics and/or Multi-Layer Packaging. If so, what products would be the most interesting ones with a local market?
- What are niche products that can me produced out of recycled plastic with the manual injection mould machine in the different locations?