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# Design of a Molding Machine for Elaborating Biodegradable Plates

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**Abstract:** ***In this article, we are going to show the design, process, and manufactures of a molding machine prototype that allows the production of biodegradable plates (made of oat grass, corn glass, waste of nopal and other natural products). Our objective is to make a mold prototype of simple fabrication, of accessible cost in order to produce quality biodegradable plates.We describe the process that started with de design. The base of molding machine was built with metal and guides made of steel. Regarding the mold, sweet iron is proposed, since the used mixture doesn't require a strong force compression. In the same way, it is pretended to replace a pneumatic actuator for endless screw, coupled to reducer-motor, to get the ideal torque the molding of the mixture and this getting as a result an efficient and effective design to produce biodegradable plates.The proposal of manufacturing low-cost molding machine is because it can be an easy acquisition for micro-entrepreneurs.***

**Keywords:** molding machine, plates, compression, motor

## 1. Introduction

In this project, it is pretended the design and manufacture of a prototype of a molding of a molding machine of biodegradable plates made a natural waste, in such a way that the construction of this machine can be low-cost, applying different engineering techniques that let us achieve our objective and produce the plates before mentioned. A principal problem today is the contamination of oceans and earth with long biodegradation products also the pollution causes damages in aquifers, rivers. And so on. The polluting materials are made of plastic. That's why this project comes up with the idea to realize a mold for plates of easy degradation.

They three most disposable products are polyethylene, propylene and cloture of polyvinyl. However, the polyethylene is the most popular polymer since more than 1/3 of the plastics produced and sold in the world to belong to this plastic family.

There is documentation than that in the XVIII century was produced the first type of plastic, which substituted the ivory used in the world. The plastic is a product derivate from the petroleum, it is so cheap because it is an inflate material and requires a little raw material for its production. Besides this, it is a light and bulky, and it takes approximately 150 years to degrade. That's why is so important to produce degradable plates.

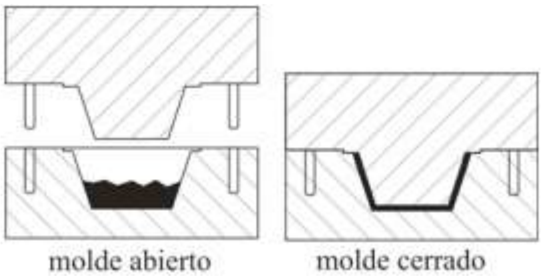
Some of the benefits of producing of degradable plates are: The product obtained from natural sources is cheaper, the production system profitable and attractive for the class.

## 2. Methods and Materials

The method used was compression molding is a process of conformation which put a material straight in a metal mold or another material depending of method to use, forced to mold with the mold form, in the closed mold. Then, is described the definition process.

## 3. Summary of Process

The molding by compression is started, with a determined quantity of mixture, putted in a mold. After that the press compress the mixture in the mold, giving how result a perfect piece molding that to keep the form of interior surface of mold. Then hydraulic press goes back, an ejector pin in the bottom of mold fastest send out the final piece out of mold and then, finished the process.




Scheme of the process

In the compress mold, the material, liquid, or dust form, grain o preform pills, to put in a mold, and this close slowly, until the two halves of mold exert oppression on the material. As the mold go closed, the material is forced to use all the parts of molding cavity. In some cases, is advantageous to make the molding closing first the mold almost by complete and after opening some seconds before to applicate definitive oppression. This form it leaves "to breathe" the material, for a to allow the evacuation of gasses Once that the mold was completely closed is applicate the maximum oppression, what provoke the final fill and complete of cavity.

The molding by compression might define of the next form:

1) Opening the mold
2) Removal of the molded parts in the previous cycle
3) Preparation of the mold, which includes cleaning the mold and lubrication to facilitate the extraction of the next piece and placement of the metal inserts, if any,

and the molding compound, either liquid, in powder or pellet form.

4) Hot mold closing and pressure application.
5) Opening the mold to let it "breathe" and allow the release of moisture and volatile materials
6) Application of all pressure to the mold and maintenance for the necessary time.
7) Removing the piece

## 4. Limitations

The molding by compression has some limitations, and is not very advisable when it comes to molding items in a very complicated way with projections, recesses or small side holes. It is also not advisable to mold articles with thick walls (1 cm or more).

The molds in compression molding tend to have very high areas, so the presses used must develop high closing forces. The following figure shows a typical press used in compression molding.

## 5. Closing Force

To verify if the closing force of the machine to be selected will be sufficient, the projected surface of the piece must be considered on the plane parallel to the surface of the plates by the injection pressure in the cavity, necessary to inject such piece. It is recommended that the maximum closing force of the machine to be selected is approximately 20% higher than that required for the injection of the piece in question. The conservative method is to multiply the projected surface of the cavity (in cm2 or in2, depending on the column used in the table), by the pressure in the cavity, which is different according to the resin, as shown in the following table, where the influence of thin walls and long flows of resin from the point of injection to the furthest point are also considered. (The data in the table are average values, which arise from practice) [2]

**Table 1:** The data in the table are average values

| Resina | tonnes/in2 | ton/cm2 |
|---|---|---|
| PS (GPPS) | 1.0 - 2.0 | 0.155 - 0.31 |
| PS (GPPS) (paredes delgadas) | 3.0 - 4.0 | 0.465 - 0.62 |
| HIPS | 1.0 - 2.0 | 0.155 - 0.31 |
| HIPS (paredes delgadas) | 2.5 - 3.5 | 0.388 - 0.543 |
| ABS | 2.5 - 4.0 | 0.388 - 0.62 |
| AS (SAN) | 2.5 - 3.0 | 0.388 - 0.465 |
| AS (SAN) (flujos largos) | 3.0 - 4.0 | 0.465 - 0.62 |
| LDPE | 1.0 - 2.0 | 0.155 - 0.31 |
| HDPE | 1.5 - 2.5 | 0.233 - 0.388 |
| HDPE (flujos largos) | 2.5 - 3.5 | 0.388 - 0.543 |
| PP (Homo/Copolymer) | 1.5 - 2.5 | 0.233 - 0.388 |
| PP (H/Co) (flujos largos) | 2.5 - 3.5 | 0.388 - 0.543 |
| PPVC | 1.5 - 2.5 | 0.233 - 0.388 |
| UPVC | 2.0 - 3.0 | 0.31 - 0.465 |
| PA6, PA66 | 4.0 - 5.0 | 0.62 - 0.775 |
| PMMA | 2.0 - 4.0 | 0.31 - 0.62 |
| PC | 3.0 - 5.0 | 0.465 - 0.775 |
| POM (Homo/Copolymer) | 3.0 - 5.0 | 0.465 - 0.775 |
| PET (Amorphous) | 2.0 - 2.5 | 0.31 - 0.388 |
| PET (Crystalline) | 4.0 - 6.0 | 0.62 - 0.93 |
| PBT | 3.0 - 4.0 | 0.465 - 0.62 |
| CA | 1.0 - 2.0 | 0.155 - 0.31 |
| PPO-M (unreinforced) | 2.0 - 3.0 | 0.31 - 0.465 |
| PPO-M (reinforced) | 4.0 - 5.0 | 0.62 - 0.775 |
| PPS | 2.0 - 3.0 | 0.31 - 0.465 |

If it is desired to calculate the necessary closing force with more accuracy, the influence of the thickness of the injected piece (the smallest thickness in the whole path of the resin) and the length of the flow of the resin should be considered with greater precision. From the point of injection to the furthest point. The ratio of the flow length / wall thickness will be taken into consideration. It is also advisable to use a correction factor for viscosity. In the following figure the flow of the resin in the piece is schematized, to visualize what we call the Flow Length.

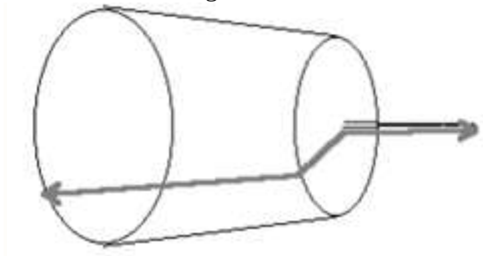
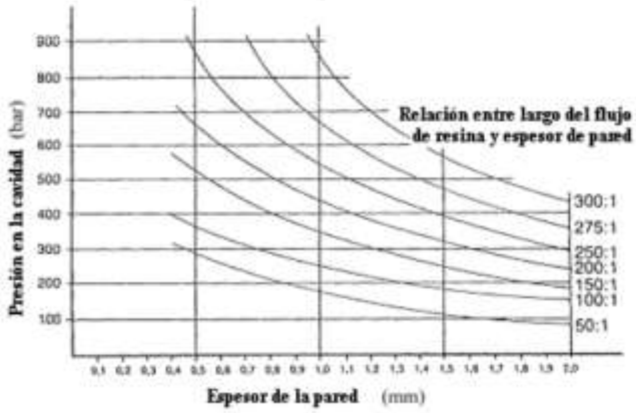


**Figure 2:** The flow is schematized

In the figure the flow of the resin in the piece is schematized, to visualize what we call the Flow Length. In the following curves it can be obtained for each long flow curve / wall thickness, entering with the thickness in the abscissa axis, the pressure in the cavity in the axis of the ordinates. In the following curves it can be obtained for each long flow curve / wall thickness, entering with the thickness in the abscissa axis, the pressure in the cavity in the axis of the ordinates.




The pressure in the cavity is expressed in bar (1 bar = 1.02 Kg / cm2). Therefore, the pressure obtained in the axis of the ordinates must be multiplied by 1.02 to obtain the pressure in Kg / cm2. Finally, in the following table, the correction factor is obtained, taking into account the viscosity of the resin.

**Table 2:** The correction factor is obtained, taking into account the viscosity of the resin

| Resina | Factor POR Viscosidad |
|---|---|
| GPPS (PS) | 1 |
| PP | 1 – 1.2 |
| PE | 1 – 1.3 |
| PA6 o PA66, POM | 1.2 – 1.4 |
| Celulósicos | 1.3 – 1.5 |
| ABS, ASA, SAN | 1.3 – 1.5 |
| PMMA | 1.5 – 1.7 |
| PC, PES, PSU | 1.7 – 2.0 |
| PVC | 2 |

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Then applying the following formula, you will obtain the necessary closing force, which must have the fuel transfer, expressed in Kg.
Fc = Ap. Pi
Where:
Fc: Closing force
Ap: Projected area
Pi: injection pressure

**Cálculo de la fuerza necesaria de cierre del molde**


$$F \geqq A \times P / 0.8$$

**F** : **Fuerza necesaria de cierre del molde** [kgf]
**A** : Total del área proyectada del producto moldeado [cm²]
**P** : Promedio de la presión interna de la cavidad [kgf/cm²]
0.8 : Coeficiente de seguridad

"Valor de referencia" de la presión interna de la cavidad de cada resina

| Resina | Temperatura de la resina°C | Presión de inyección kgf/cm² | Presion interna de la cavidad kgf/cm² |
|---|---|---|---|
| PE | 180~300 | 800~1400 | 230~320 |
| PS | 180~310 | 700~1700 | 260~320 |
| PP | 200~300 | 800~1500 | 270~300 |
| ABS | 200~280 | 800~1800 | 330~440 |

Steps to establish mold parameters [3]

To determine the proper closing force, the projected area of an individual piece must be calculated. Once the entire surface area is obtained, it must be multiplied by the number of cavities in the mold. If the mold has a cold channel, the projected area of the mold should also be added.

$$\textbf{Área de la cavidad} = largo\ x\ ancho$$

$$\textbf{Área de la cavidad} = 4.6in\ X\ 4.6in = 21.16\ in^2$$

$$\textbf{Área total} = área\ de\ la\ cavidad\ x\ número\ cavidades$$

$$\textbf{Área total} = 21.16in^2\ X\ 8 = 169.28in^2$$

$$\textbf{Tonelaje} = área\ total\ x\ factor\ tonelaje$$

$$\textbf{Tonelaje} = 169.28in^2\ X\ 3\frac{tons}{in^2}$$

$$\textbf{Tonelaje} = 507.84\ tons$$

Example of molding a lid of plastic container with hot channel and 8 cavities. [4]

**Mold opening**

Finally, it must be confirmed that the required Opening of the mold, which arises from adding the height of the mold on the side of the male plus the height of the molded piece

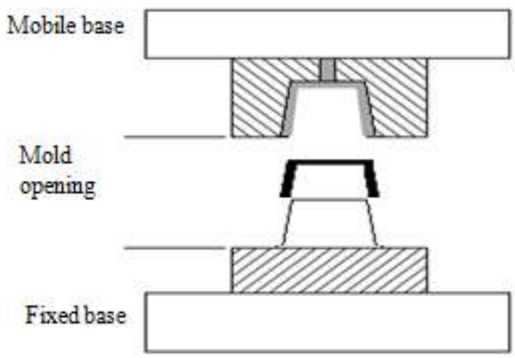


**Figure 3:** Mold opening scheme

In this case the rotation of the models is reversed (Male, Female) since there is no direct injection of the mixture, this will be manual in the upper part of the fixed base

**Method of construction**

For this molding process, an artisan molding machine was designed with materials that are easy to obtain on the market and at low cost, some materials are recycled, such as: braces, poles and VD engines with a resistance capable of supporting factors such as pressure, temperature and strength.

## 6. Materials

The steel plate is used in the manufacture of structures, tanks, industrial machinery, poles, bodies, etc. For our molders we use 1/8-inch steel plate.

**Figure 4:** Steel plate 1/8

- These bars are ideal for CNC equipment such as routers or plasma where the expense of a high pressure ball screw is justified for the proper functioning of the mechanism. The measurements are ½ (with 10 threads per inch) and 1 "(with 4 threads per inch) in bar and nut

**Figure 5:** Asparagus and nut acme of ½ by 25cm high

- The mechanism of a pneumatic or hydraulic actuator is a mechanical device which provides a force to exert a movement or mechanical work. The force exerted by an actuator comes from hydraulic pressure, pneumatic pressure and electric motive power (electric motors or solenoid). In this case the actuator was replaced by mechanisms made of 12 VD motors. These engines are found in cars for children


**Figure 6:** 12 volt electric motors original power wheels.

- 12-volt DC relay with 10-amp resistance and 12 pins. For the electrical circuit.
- Two bearings type 6701 2rs, have rubber contact seals, both inside and outside bearing ring; this prevents moisture and dust from damaging the bearing, were used in the fixed part of the base, to serve as a guide

## 7. Results and Discussion

In the following figure we present the first finished prototype, which has all the materials mentioned above. Here the molding machine is presented with only one acme asparagus and only one motor.

**Figure 7:** First molding machine made with a single motor

The result obtained from this is that it does not have enough torque and has a minimum speed, it also has faults in the molding of the material, because the pressure exerted on it is not uniform and only one side is molded and have deformations in the plate.

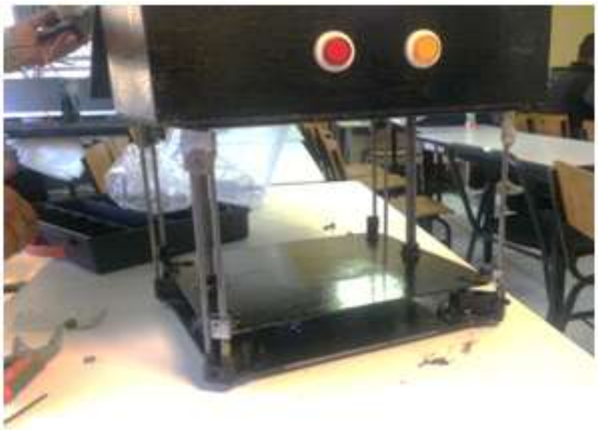

**Figure 8:** Molding machine finished

In this molding machine, better results were obtained than the previous ones, since it has two acmé studs and two independent 12VD motors with a reversible control, for the molding torque made of biodegradable materials, as well as the extraction of the mold.

**Figure 9:** Mixture of biodegradable products

**Figure 10:** Plate finished

The mixture presented in Figure 9 is made from biodegradable materials (made from ground oats, ground forage, nopal residues and other natural products). The process for the preparation of this mixture was calculated for a dish. The amount depends on the production you want to obtain.

**Projected area calculation**

Area of the piece

(Length x width x number of cavities) - (hole area x quantity)

(300 mm x 300 mm x 2) - (100 mm) 2 x 2)+ Laundry area

(Length x perimeter)

150 mm x 400 mm

Ap = 220,000 mm2 = 2,200 cm2

Calculation of the pressure

Pi = Engine pressure x correction factor

Pi = (30Kg) (9.81m / s2) x 1.4 (ABS)

Pi = 294kg.m / s2

Calculation of closing force

Fc = Projected area x Pressure

Fc = 22m x 294kg.m / s2

Fc = 6468kg.m / s2

## 8. Conclusion

Given the results, it was observed that compression was adequate, allowing the material to expand correctly in the mold. A machine with low cost materials was built to meet the requirements, reducing the cost of said machine.

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