

CONSTRUCTIVE AND DIMENSIONAL CONSIDERATIONS ON THE REALIZATION OF A VERTICAL PISTON INJECTION STAND.

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ABSTRACT: The study undertaken addresses the possibility of making a device for analyzing the way in which the plasticization parameters of the materials in the injection process. The analysis is carried out both from a dimensional point of view, but also from the point of view of the deformations that may appear in the injection assembly during its production process. The geometrical change of the dimensions of the active elements in the analyzed process is also analyzed. It can be seen that the active elements undergo a slight ovalization process along the directions of the X-Y plane at the piston of the order of microns, and at the compression cylinder also of the order of microns.
KEYWORDS: injection molding stand, dimension consideration, deformation, injection, manufacturing

1. INTRODUCTION

The plastics industry began in the year 1872. When Hyatt and his brother Isaiah [1-2] built the first constructive solution of the injection machine. It was built like a large hypodermic needle which used a piston to inject the plastic material through a cylinder, which would then be heated, then into the mold. Plastic materials are considered an alternative solution to replace metal materials. The chemical industry played an important role in the discovery of new types of plastics and synthetic fibers.

In the past 15 years, injection molding parts have been successful, starting from plastic dishes, toys, medical instruments, to products used in the manufacture of automobiles. Thermoplastic materials such as polystyrene, polyethylene obtained at high and low pressure, polyamide, polymethyl methacrylate can be used. The choice of material is made according to the mechanical and chemical resistance, the temperature, and the desired appearance of the finished product [1, 2]. Plastic injection machines are composed of two constructive parts. First from the point of constructive importance is the injection part and the second is the closing part.

1.1 The injection parts.

The injection part includes material feeding device (made by piston solution or screw construction), thermoplastic equipment (made from steel and two or more heating elements), and injection system (linear or rotary solution).

1.2 The closing unit.

The closing and opening systems of the mold include, the ejector of the injected part, the protection systems, etc. The actuation of the injection and closing parts can be done pneumatic, hydraulic, hydromechanical, or mechanical. Pneumatic actuation is only used on machines with reduced injection capacity. For the injection of large parts, the most suitable are machines with hydraulic actuation. The pressure required to actuate the mold closing system and the injection system is achieved with the help of linear hydraulic motors [3-4].

1.3 The piston builds solution.

The piston build solution is often used in the production of small, complex parts with much higher precision. The way the machine works involves preheating the granules which are then pushed inside the cylinder with the help of a piston. When the material reaches the required temperature and pressure, the piston pushes the material into a cavity made in the mold's parts. When the mold is filled, the piston does not change its initial position, thus providing the necessary pressure for the cooling and solidification process of the finished product. After which the mold structure is opened, and the injected material automatically removed, and the process is repeated [3, 4].

There is a difference between the piston and screw solution though. The piston is replaced by a screw that mixes and melts the material before injecting it into the mold. Screw injection molding is more common and widely used, but has some disadvantages, such as: higher material waste, higher stress on the plastic, and reduced precision in part manufacturing. After positioning the entire assembly, they can be vertical or horizontal machines. The horizontal solutions have the mounting axis but also the mode of horizontal opening of the mold, facilitating the falling of the part simultaneously with the opening of the mold [2].

The piston assembly has a few advantages, including:

- The resulting parts are of superior quality;
- Allows good control over plastic placement and pressure;
- The need for less plastic improves the strength and durability of the finished product;
- Excess plastic can be reused or recycled;
- It is cost effective for small and medium volume production.

Like any technological process, in addition to the advantages, the following disadvantages can also be deduced:

- It requires high temperatures and pressures, which can lead to increased energy consumption and maintenance costs;
- It has a longer cycle time than screw injection molding, which can affect production efficiency;
- It has a limited range of materials that can be used, as some plastics may not flow smoothly through the plunger and nozzle;

2. CONSTRUCTION CONSIDERATIONS REGARDING INJECTION ASSEMBLY

The elements that make up the assembly are further analyzed from a constructive point of view according to their assembly order on the part of the piston injection assembly and vertical injection position.

2.1 Nozzle/ Injection head.

The energy of the dog is presented in equation (1) and the speed of the quick fox in (2). Please use the TAB character in between the equation and the equation number.

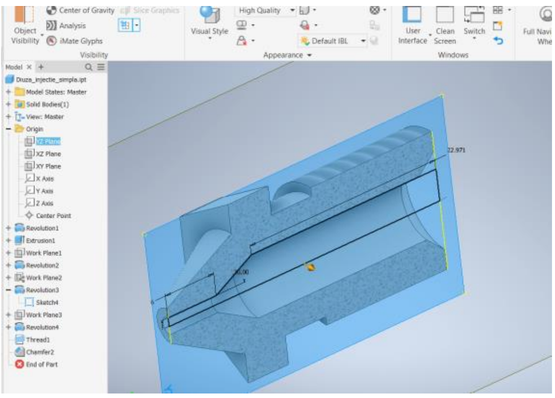

Figure 1. Injection nozzle

It is located at the head of the injection cylinder through which the processed thermoplastic material enters and is pressed into the mold. The conical part found on the face of the nozzle creates a connection with the mold through the pressure bushing, which gives us minimal pressure loss. The pressure bushing holds back the amount of material that is over-injected, helping to maintain a constant flow into the mold thus eliminating interruptions that can occur in the casting process. It is located at the head of the injection cylinder through which thermoplastic material passes. From a constructive point of view, a ceramic heating strip can be arranged on the peripheral part of the nozzle for a better flow of the material injected into the mold. This is called a nozzle heater and is controlled like the other heater strips on the injection cylinder.

2.2 Injection cylinder.

The second element as an assembly order is the injection cylinder, which is made of carbon steel or alloy steel, having the shape of a long tube. It contains two concentric parts Figure 2. The first is arranged on the outside with thick walls to provide resistance to the pressure during the injection and compression processes, thus distributing pressure and respectively temperature from the heating bodies uniformly in its structure. The second is the inner part of the tube which has a high chromium content in its structure, this when it is desired to reduce the material section to increase the resistance to the developed injection pressure, but also to reduce the material consumption in the manufacture of the cylinder. The assembly of the two components will be done by fretting with a tightening dependent on the internal pressure that develops inside the cylinder. This chrome surface also has the role of reducing friction with the piston surface that slides in relation to the cylindrical surface. The cylinder sizing must be equal to a capacity of (5÷10) times the capacity injected in a single cycle as recommended from a constructive point of view. Injection pressure is dependent on the type of material being injected.

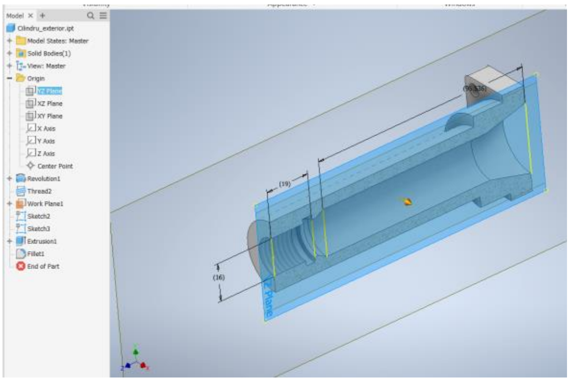

Figure 2. Injection cylinder

2.3 Injection plunger.

The role played by the cylindrical piston entering the cylinder in the injection process. is to push the thermoplastic material, which was previously heated through a nozzle, after this phase the material enters the cavity of the mold where it takes its shape. The pressure can be controlled by the speed with which the piston moves. From a constructive point of view, this is in the form of a cylindrical rod with a fixing and positioning shoulder at the top, being made of metal material of carbon steel type or medium alloy Figure 3. Its operation can be achieved by pressing on the top, both manually, but it is recommended for a better injection of the material to be done with the use of hydraulic or pneumatic pressure.

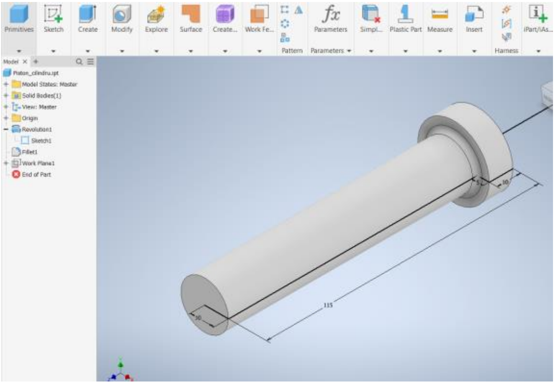

Figure 3. Injection plunger

2.4 Heater bands.

The heater bands are thermal activated and are placed along the entire length of the cylinder with minimal space between them. Each temperature control unit is controlled by a thermocouple mounted in or affixed to the wall of the heating cylinder in the area it controls Figure 4.

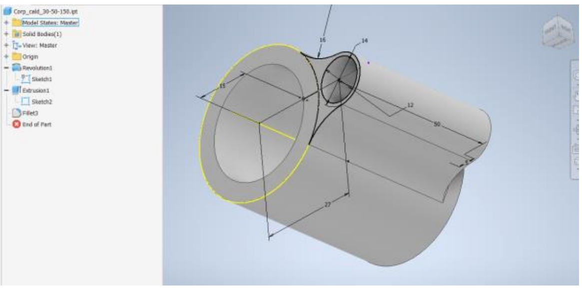

Figure 4. Heater bands

The programmable control unit then decides if more heat is needed and, if so, supplies the heating strips with electricity. The chosen method is closed-loop control where the preset temperature value is compared to the actual value and making the necessary corrections as previously / below. When the required temperature is reached, the thermocouple sends a signal to the control unit, which cuts off electricity to the heating strips until the temperature drops again, at which point the cycle repeats. Minimum and maximum temperature limits are set on the control unit and used by the unit to determine whether the heater strips should be energized or de-energized. Only one control unit and one thermocouple are assigned to one heating zone. Each of the command-and-control units are programmed independently and are not controlled from a programmable control unit. The electronic control part was not considered in the present study because the purpose of the assembly is to allow us to determine how the plasticized material flows through the injection nozzle.

When the required temperature is reached, the thermocouple sends a signal to the control unit, which cuts off electricity to the heating strips until the temperature drops again, at which point the cycle repeats. The minimum and maximum temperature limits are set on the control unit and used by the unit to determine whether the heating strips need to be energized or switched off. A single control unit and a thermocouple are assigned to a single heating zone.

The strip heating process is carried out with an electric resistance supplied at 220 Volts mounted inside the side hole constructively provided in the heating strip Figure 5.

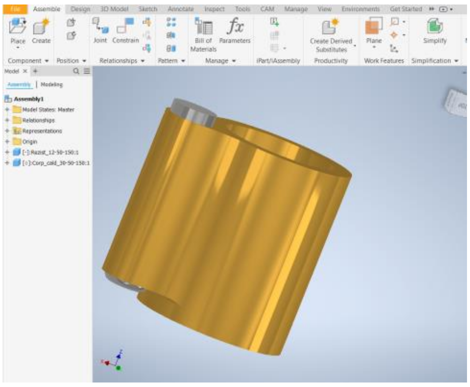

Figure 5. Built-in resistance heating bands

2.5 Bracket support for the injection machine.

To be able to provide support for the entire assembly in a fixed position during the injection process, I chose an extruded profile support made of aluminum on which the cylinder assembly with resistors will be mounted by means of a clamping and positioning system. Fastening will be done using channel nuts, accessories compatible with an aluminum profile ITEM Figure 6.

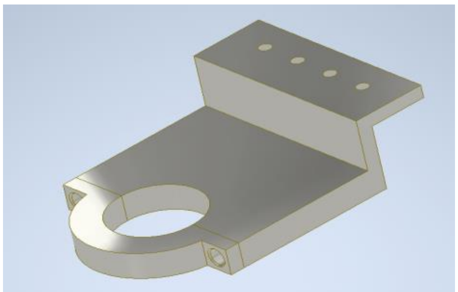

Figure 6. Bracket support.

2.6 Support structure of the whole assembly.

The supporting metal frame is constructed from ITEM aluminum profile with a dimension of 20 mm width and 20 mm heights. Fastening the joists to make the resistance pillars can be done using screw fastening (holes will be provided for the screw to pass through) Figure 7. As an alternative solution for stiffening the structure, corner elements can be used to fasten and fix two bars each adjacent. To create the assembly, the INVENTOR 2024 program was used with the positioning of the bars by rotation and translation, respectively the CONSTRAINE-type positioning constraint and respectively the parallelism or opposition of surfaces that we have in mind for assembly.

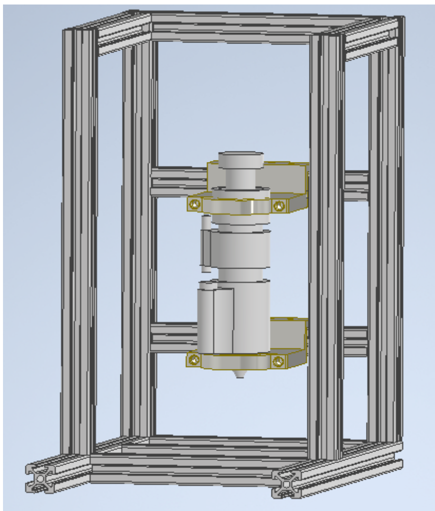

Figure 7. Metal structure with injection system

3. DIMENSIONAL CONSIDERATIONS REGARDING INJECTION ASSEMBLY

From the analysis of the constructive solution of the assembly to study the flow of the material to carry out the injection process in additively manufactured molds, it can be observed that the material passes in the pressure cylinder from the granular state to the plasticized state and is at this moment evacuated through a nozzle from the cylinder cavity as a result of a force developed by the piston pressing the plasticized material.

A second important aspect is related to the fact that the support supports of the cylinder are subjected to compressive forces and bending moment when developing the force of the piston on the material in the injection cylinder.

Therefore, to check whether the constructive solution satisfies the previously mentioned requests with the help of the INVENTOR 2024 educational version program and the finite element simulation module for the first two components, the loads were simulated and the deformations that appear because of these requests were determined.

3.1 Analysis of pressure piston deformations for injection force generation.

The first element that ensures the injection process as mentioned in the previous chapter is the material pressing piston Figure 3. The deformation analysis process is relatively simple in the INVENTOR 2024 program and it consists in the first phase in launching the program finite element analysis of the deformations, followed by the assignment of the material from which this piston is made and later by the realization of the loading phase of the stresses and respectively of the surface/surfaces that are fixed (not subject to deformation) as a result of the loads applied to the analyzed geometric element Figure 8.

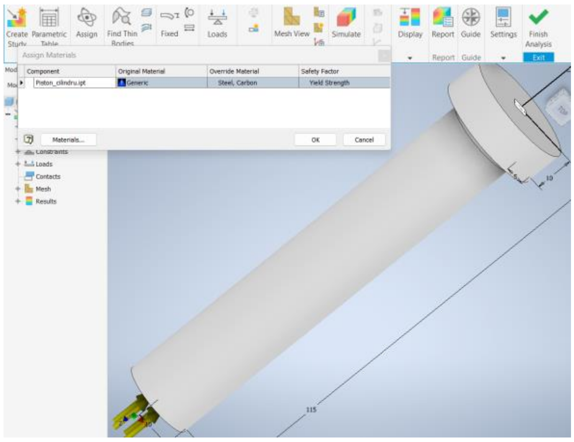

Figure 8. Piston with material assigned and loads positioned.

After carrying out the previously mentioned phase and checking the dimensions of the tetrahedron for calculating the demands (recommended as large as possible or keeping the program's default settings), it will proceed to running the program for calculating the tension Figure 9 and respectively the deformations by Z axis Figure 10 and from X axis Figure 11.

Along the Z axis we have an axial contraction of 38.67 microns Figure 9, which will translate along the X axis unevenly with zero deformation in the horizontal plane and of 1.016 microns in the plane perpendicular to the horizontal Figure 11. From the figure can see that the ovality is almost the entire length of the piston.

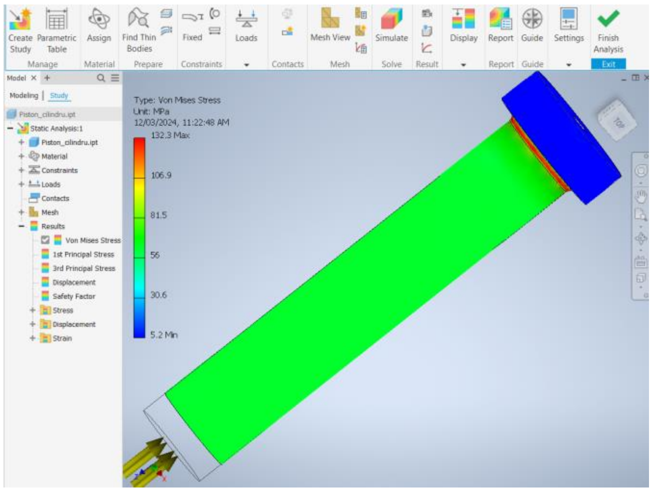

Figure 9. Piston with tension study.

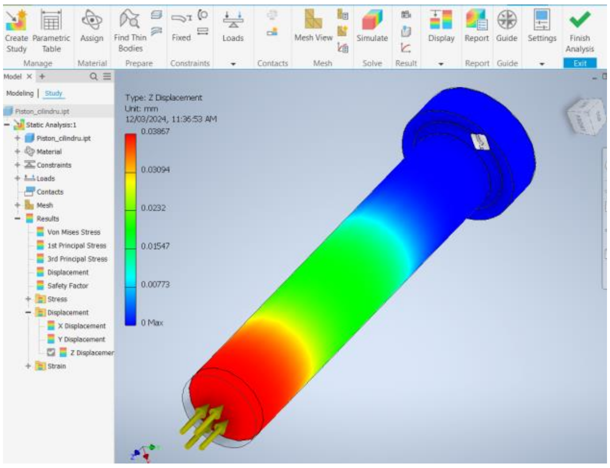

Figure 10. Piston with Z displacement analysis.

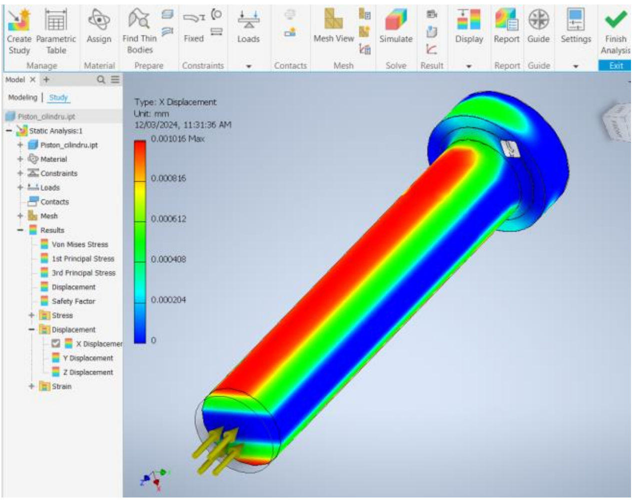

Figure 11. Piston with X displacement analysis.

3.2 Analysis of material plasticizing and material injection cylinder deformations.

The first element that ensures the injection After carrying out the previously mentioned.

The analysis was carried out on the same principle presented for the piston and from the point of view of the stresses it can be seen in Figure 12 that they are maximum with a value of 251 MPa. It can also be seen from Figure 13 that the deformation value is 0.0098 microns along the X direction and is maximum in the horizontal plane, respectively along the perpendicular direction it is of zero value, which can compensate for the ovality of the piston.

4. CONCLUSION

From the study, it can be seen that the constructive solution considered is feasible from a physical point of view. It should also be pointed out that the present device will be used both for carrying out further studies to analyze the flow of the material but also to determine the injection parameters depending on the different materials considered in the injection process, but also on the way the process parameters (force, respectively temperature) can influence the injection process.

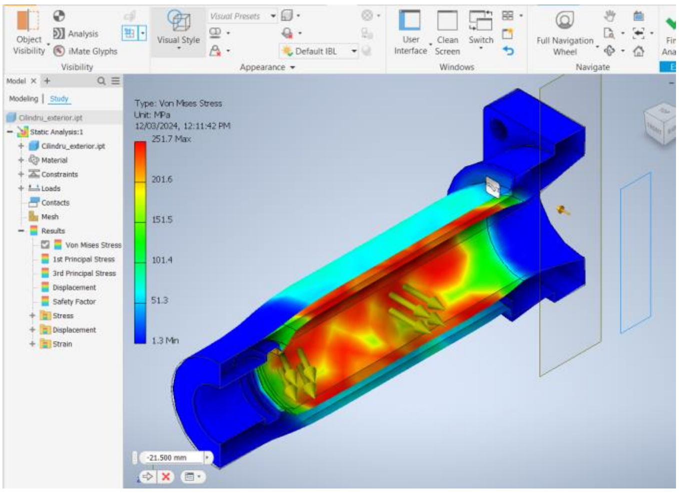

Figure 12. Injection cylinder with tension study.

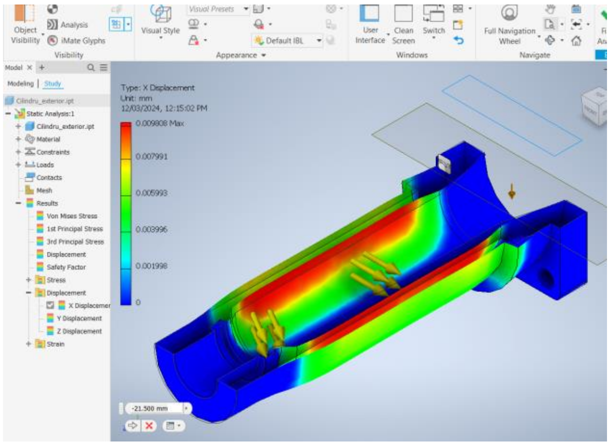

Figure 13. Injection cylinder with X displacement analysis.

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