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Injection Molding Hand-Press Design and Analysis Using Solidwork

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***Abstract*— Injection molding is a method of forming a thermoplastic/composites material that is melted by heating and then injected into a mold so that the thermoplastic material can harden. The use of plastics is not only caused by the need for efficiency, as well as technological advances in the field of material engineering or manufacturing technology from the material itself. In this study, a hand-press injection molding machine was planned with the working principle of the lever being applied so that the transmission would transform the force to the injector so that the molten thermoplastic and composite material would come out into the mold. When the force is applied to the hand-press injection molding is analysed using Solid works and the mold design used refers to the dimensions of the ASTM D 3039 standard. For the tensile test, ASTM D 6110 for the impact test and ASTM D 695 for the bending test. Construction components of hand-press injection molding machine using ST 60 material, mold for tensile testing specimens, bending testing and impact testing using Al 7075 material, heating cylinder tube using Al 7075 material, the force given to the 200kg suppressor lever transmitted on the suppressor shaft obtained 0.29MPa. The maximum voltage at construction is 332 N/mm2 with a safety factor of 2.12 and a deflection of 13.09 mm.**

Keywords— injection, molding, thermoplastics, composites.

I. INTRODUCTION

According to Ministry of Environment and Forestry (MoEF) and the Ministry of Industry in 2016, the number of waste generation in Indonesia has reached 65.2 million tons per year. Whereas from B3 waste, waste managed from industry in 2017 amounted to 60.31 million tons, and accumulated from 2015 reached less than 40 percent of the B3 waste management target of 755.6 million tons in 2019 [1]. According to [2,3] the process of plastic formation can be classified in outline including injection, extrusion, blow-molding, calendaring, coating, compression, powder, and others. From the formation process, the injection molding process is the most widely used process [3]. The company that has used injection molding machine one of them is located in Kiara Condong, in the company injection molding machine used with automatic control system using electric motor and manual injection molding machine with connecting rod mechanism that moves by given force on the lever. Based on the background of the problem there needs of modification in the research of plastic forming tools [4,5], therefore machine planning and analysis of injection molding hand-press are need to determines the speed of injectors on the system to know the limits of component part capabilities and holds the load statically by performing manual calculations and using Solid works software [6].

II. LITERATURE RESEARCH

Injection molding is a process of processing polymer material that is heated to a melting state and then the material is flowed by utilizing gravitational forces or other forces with high pressure into the mold cavity, so that it is obtained results according to the mold. In the casting process, the mold serves to form an object that begins by melting metal or plastic products that will be flowed into the mold cavity that has been formed first. As needed, the mold is divided into two sand molds and metal molds [2,3].

The design process that started with the discovery of human needs for a product until the complete of the drawings and documents of the design used as the basis of the manufacture of the product [7]. The design made into products will be produced products that can meet human needs [8].

In the process of designing, the designer will use [9]:

(1) experience and knowledge of the design process and

(2) all knowledge related to the product and manufacture of the products he is designing, such as: physics, solid object mechanics (static, kinematics, material strength, dynamics, vibration), fluid mechanics, thermodynamics, material science, production techniques, knowledge of equipment such as pumps, electric motors and others [10]..

III. METHODS

Research begins with project planning and definition, where in this phase is determined the project title, the formation of the team in question as well as the project schedule [10]. The next one performs the design criteria that are the basis of the design needs based on the discussion of fellow members of the designer, showed in Table 1.

TABLE 1 DESIGN CRITERIA

Requirement Specifications	Requirements Obtained
Geometry	1. Place-saving frame size 2. Cylinder-tube adjustment 3. Thermocouple box adapted to the frame
Kinematics	Easy-to-operate mechanism Transmission can increase injector speed
Energy	1. Electrical energy used 2. Energy savings
Material	1. Strong material 2. Easy to get 3. Corrosion resistant 4. Heating material below thermoplastic melting point temperature 5. Long service life
Production	1. Easy and fast production process

A. *Work Identification*

Work in the design process can be identified after technical specifications are successfully outlined. Planning of hand-press injection molding machine can be arranged as follows [11].

1. Compose the requirements/ technical specifications of hand-press injection molding machine.
2. Develop and select 4 product concepts.
3. Test and analyse 4 product concepts.
4. Assess and evaluate 4 product concepts.
5. Choose one product concept based on assessment.
6. Test the selected hand-press injection molding machine in the field.
7. Compile production documentation.
8. Develop a production plan.

B. *Block Function*

In manual injection molding machine design, input energy in the form of motion mechanical energy and electrical energy. Connected to a heating cylinder to melt thermoplastic products. When electrical energy turns into heat energy, the thermoplastic product will melt at an adjustable temperature using a thermocouple, given the force on the lever, the connecting mechanism will transform the force into the injector. Melting thermoplastics will flow through the mold cavity, the thermoplastic will experience a significant drop in temperature, then undergo a change of shape to solid. When the thermoplastic material becomes solid, the mold can be opened and the thermoplastic material will form a gap according to the desired mold. Block diagram are shown in figure 1.

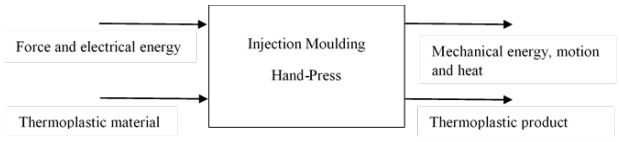


Fig. 1. Block Diagram

C. *Mold Planning*

Mold planning in this stage aims to find out the capacity of thermoplastic materials needed for ASTM D 3039 tensile test, ASTM D 6110 impact test and ASTM D 695 bending test. Drag testing standards, impact testing, and bending testing should be followed in planning. Standardization can also be interpreted as a rule used in a process that will be used as a reference.

D. *PPHI Flow Analysis*

Once the test dimensions are known, 2 kind designs based on PPHI inflow melt with material specifications found in Solid works are seen in the following table.

TABLE 2 PPHI SPECIFICATION

Melt temperature	230 °C
Maximum Melt Temperature	280 °C
Minimum Melt Temperature	200 °C
Mold Temperature	50 °C
Maximum Mold Temperature	80 °C
Minimum Mold Temperature	20 °C
Specific Heat	3100 J/Kg.K
Thermal Conductivity	0.15 W/m.K
Elastic Modulus	1350 MPa
Thermal Expansion	9.05e-005 1/°C

PPHI melting materials and prints using Al 7075 T6 material, the first and second designs seen in figure 2, the first design shows that the inflow of material is located on one side of the specimen with a vent on one side, the design of both material inflows located at the center of the specimen with vents on either side.

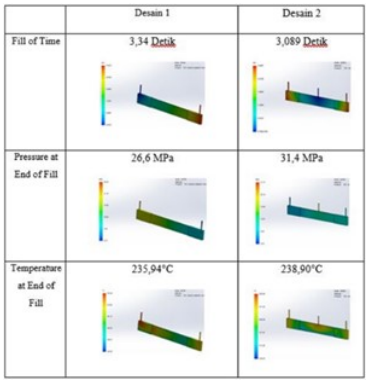


Fig. 2. Molding design selection

The result of software analysis, the first design is selected for the mold making process, the first design excels in filling time, pressure at end of fill and temperature at end of fill compared to the second design, the design of both materials flows in two directions so that turbulence can occur and is not constant.

E. *Flow Analysis on Cylinder Tubes*

Analysis of the flow on the cylinder tube is obtained the time of emphasis, pressure on the inlet and the outlet for the tube. An emphasis time of 9.3484 seconds is performed so that the melted PPHI material can exit the heating tube, show in figure 3.

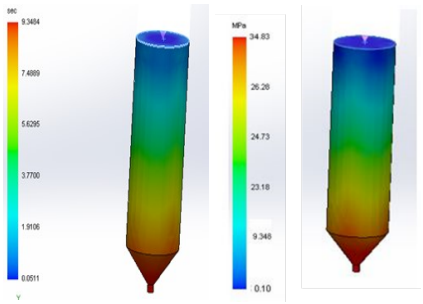
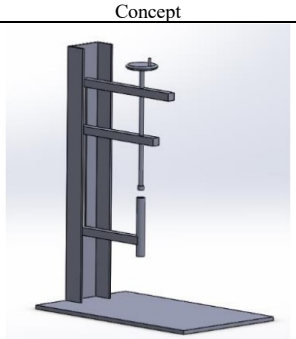
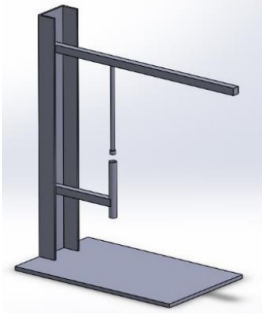
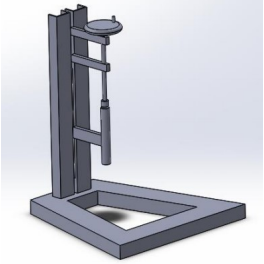
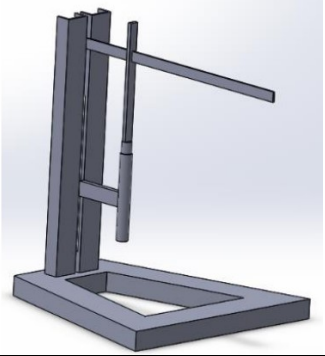


Fig. 3. Heating Cylinder Flow Simulation

F. *Alternative Concept Planning and Concept Selection*

At this stage there will be several alternative concepts of construction and mechanism of hand-press injection molding machine. In this concept the material used UNP ST 60 iron because the iron is very easy to obtain in the market at a low price. As well as using mechanisms that can provide good efficiency.

TABLE 3 CONCEPT SELECTION

Concept	Feasibility Judgement
	The frame uses little material and is simple, using a thread mechanism to transform the force into an injector. Production time is about 3 weeks with a fairly high level of production difficulty.
	The frame uses little material and is simple, using a rod mechanism to transform the force into an injector. Production time is about 2 weeks with sufficient production difficulty.
	Sturdy, simple, and efficient frame. There is a mold mount and thread mechanism to transform the force into the injector. Production time is 4 weeks, with a high degree of difficulty.
	Sturdy, simple, and efficient frame. There is a mold mount and a connecting rod mechanism to transform the force into the injector. Production time is 3 weeks, with moderate difficulty.

In realizing the concept, mechanical calculations of construction components and mechanisms will be carried out. The analysis stages for selected concepts can be done by calculating using analytics methods and stress analysis using Solid works.

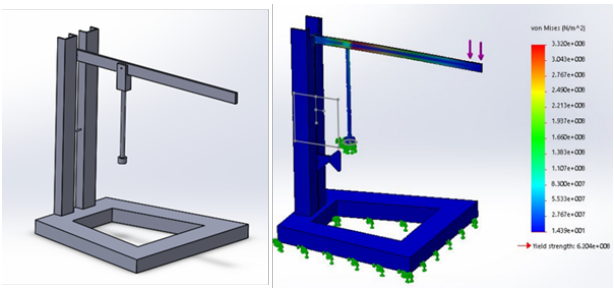


Fig . 4. Selected Concepts And Stress Analysis

V. RESULT AND DISCUSSION

It is necessary to prepare in advance before the production of materials to be used (both construction, mold, and specimen material used) according to the specified dimensions, the maximum temperature imposed on the heating cylinder is 280°C. This is so as not to burn on composites, when injection, mold needs to be heated first with a temperature of 50°C, so that the composite melting material does not experience rapid cooling, injection molding machine operation hand-press, emphasis on the lever should be constant. Construction components of hand-press injection molding machine using ST 60 material, mold for tensile testing specimens, bending testing and impact testing using Al 7075 material, heating cylinder tube using Al 7075 material, the force given to the 200kg suppressor lever transmitted on the suppressor shaft obtained 0.29MPa. The maximum voltage at construction is 332 N/mm2 with a safety factor of 2.12 and a deflection of 13.09 mm.

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