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CHOOSING A PLASTIC INJECTION MACHINE IN DESIGNING MEDICINE BLISTER MOLD

Nguyen Thi Le Hang and Nguyen Duc Chinh

College of Economics and Techniques
Group 8, Thinh Dan ward, Thai Nguyen city, Viet Nam

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ABSTRACT

To make plastic products to serve human life, manufacturing or other fields, a combination of many factors is needed: plastic injection molds, production facilities, types of plastic materials and plastic injection machines, The machine actually installs a mold so that the mold and machine directly create a plastic injection molding process. Therefore, engineers need to clearly understand the technical parameters of injection molding machines as well as injection molds to design and choose a plastic injection machine suitable for the product to be pressed.

The technical parameters of the press such as mold clamping force, injection flow, plasticization ability, injection force, injection pressure all have a theoretical basis for calculation so that the designer can calculate specific values and Calculation results are important data to choose the optimal injection molding machine. The content of the article is to help engineers easily calculate and quickly select an injection molding machine to help in the process of designing plastic injection molds.

Keywords: Plastic injection molding machine, mold clamping force, injection flow, plasticization ability.

1. INTRODUCTION

Plastic injection molding machines, also known as plastic molding machines or glue molding machines, are equipment commonly used in the production of plastic products. The plastic injection molding process involves pushing molten plastic into a mold under high pressure, then cooling it to create a product of the desired shape.

Main structure of plastic injection molding machine: Mold clamp part to hold and fix the mold during the injection process. The plastic injection part converts the plastic from solid to liquid and pushes it into the mold. The system cools the plastic after it has been pushed into the mold to shape the product.

Operating principle: Plastic (powder or granules) is put into the hopper. The plastic is melted by heating rods. Liquid plastic is pushed into the mold through a pressure system. The plastic in the mold is cooled and solidified into the product.

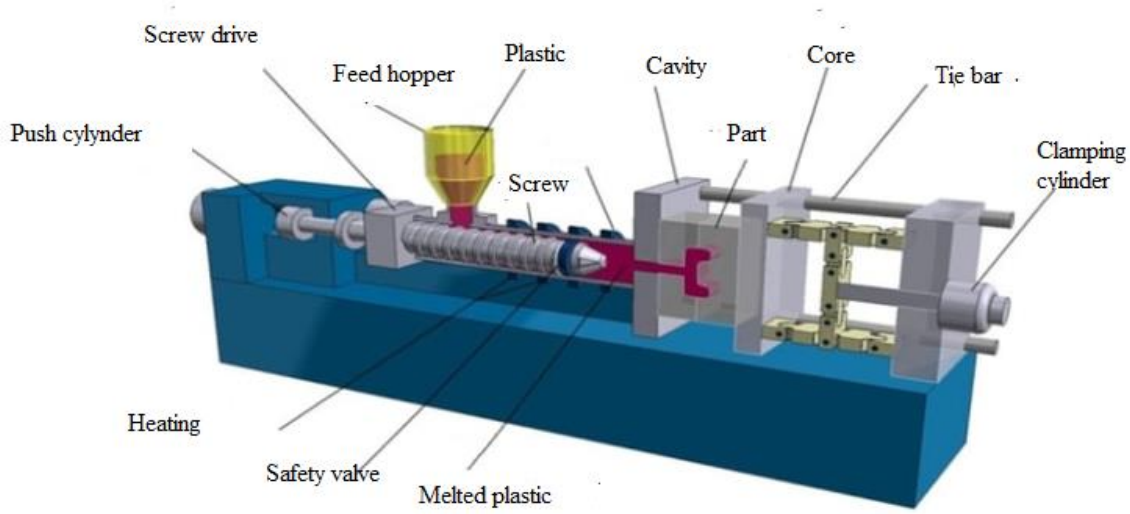

Figure 1. Main structure of plastic injection molding machine.

Formulas for calculating technical parameters of plastic injection molding machines.

Shot capacity, cm, g(oz): This is the value that represents the press's ability to operate like the mold clamping force, this value is based on the value representing the maximum value of a spray times. This is calculated using the 2 methods below.

a. Spray volume (Shot capacity, Shot volume) (cm^3).

$$V = \frac{\pi . D^2 . S}{4} \ cm^3 \quad (1)$$

V: Spray volume (cm^3)

D: diameter of screw (cm)

S: stroke (cm)

b. Spray amount (Shot capacity, Shot volume), g(oz).

$$W = V.\ p.\eta = \frac{\pi.D^2.S.\rho.\eta}{4} \quad (2)$$

p: Density of molten plastic(g/cm^3)

η: Spray performance (85~95%)

V: Spray volume (cm^3)

W: Spray amount (g), 1oz= 28.4 g

Plasticizing capacity (kgf/h): Expresses the performance of the press in kgf/h based on the ability of the cylinder to plasticize the shaping material per hour.

c. Plasticizing capacity.

$$Q_m = \frac{\delta.N.p.60}{1000}\ (kg/h) \quad (3)$$

Q_m: Theoretical plasticization ability (kg/h)

p: Pitch of screw (cm)

d: Screw diameter(cm)

h: Screw head groove depth(cm)

e: Thread table width (screw plate) (cm)

α : Flank (equal a half of the screw thread angle)

N: Screw rotation speed(rpm)

p: Specific gravity of molten plastic (g/cm^3)

$$\delta = \frac{\pi.p.h(t-e)\ .cos^2}{2} \quad (4)$$

$t = \frac{d}{p}$

Injection pressure, (kg/$\boldsymbol{cm^2}$): This is the maximum value of the total pressure or pressure per unit area used for the plastic at the head of the screw or plunger.

d. Injection force: Maximum value of boost pressure at the firing cylinder.

$$F = \frac{\pi.D_0^2.Px}{4} \quad (5)$$

F: Spray force (ton)

D_0: Diameter of cylinder (cm)

P: oil pressure [kg/cm^2]

e. Injection pressure: pressure per unit area applied to the plastic on the final side.

- Injection screw

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$$P = \frac{10^3.Fx}{\pi.\frac{D^2}{4}} = \frac{Q^2.D^2}{D_0^2} \qquad (6)$$

P: injection pressure (kg/cm^2)

D: Diameter of screw or piston(cm)

f. Spray flow (Injection rate), ($\boldsymbol{cm^3}$/s).

- Represents the rate at which plastic is injected in the nozzle, representing the maximum volume per unit of time

Spray rate.

$$Q = \frac{\pi.D^2.v}{4} \text{ or } Q= \frac{V}{t}\,[cm^3/s] \qquad (7)$$

Q: Spray flow(cm^3/sec)

D: Diameter of screw or piston (cm),

v: Spray speed (cm/s)

t: Spray time (s)

V: Spray volume (cm^3)

$$Q = \frac{D_0{}^2.P_0}{D^2} \qquad (8)$$

Q_0 : Oil flow rate (cm^3/s)

D_0 : Diameter of hydraulic cylinder (cm)

In the case of thick and deep pressed products or easily solidified plastics such as nylon or polystyrene, a high injection flow rate will be better. However, for plastics with poor thermal stability such as hard PVC, a low injection flow rate will be better.

2. METHOD

a) Clamp the mold using a hydraulic mechanism (Hydraulic).

This is a direct moving method, moving to the ram position of the hydraulic cylinder, directly connected to the mold plate.

- Usually, mechanisms such as booster ram (Booster Ram). Support cylinders, booster cylinders... are used.

The initial pressure of the clamping device is low but the clamping speed is fast. Just before the end of mold closing, the mold closing speed slows down and the mold closing pressure increases. Clamping force is evenly distributed throughout the mold. The mold is protected due to pressure control. Compared to the crankshaft type (Toggle type), the cost is often more expensive. Easily control mold opening and closing speed.

- Mold clamping force formula: F = $\frac{\pi.D^2.P.10^{-3}}{4}$

F: Clamping force (Ton)

D: Main Ram outer diameter (cm)

P: Oil pressure (kg/cm^2)

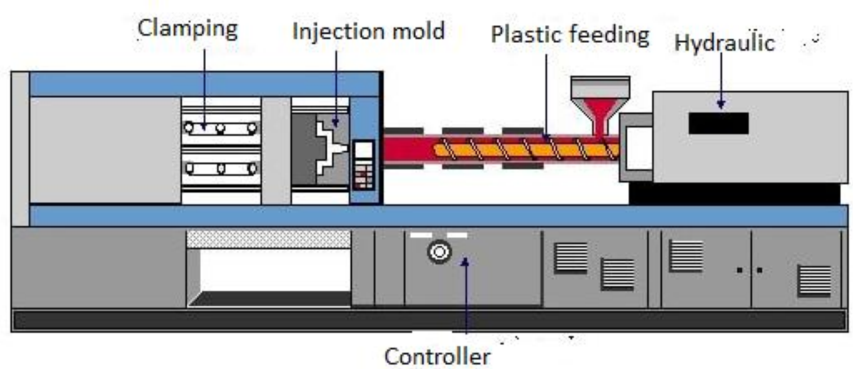

Figure 2. Structure of a plastic injection molding machine using a hydraulic mechanism

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b) Type of crankshaft mechanism (Toggle type).

- This is a form of enhancing the force created by the power source of the hydraulic cylinder by the crankshaft mechanism, then a larger clamping force will be received.

- During the initial stages of mold closing, the movable shaft moves rapidly, however proportionally

The increase in force is small, when the mold starts to close, the speed of the movable shaft suddenly decreases but the force ratio increases, then a larger mold clamping force can be obtained.

- Fast mold opening and closing speed.

- Small energy consumption (small hydraulic cylinder).

- Clamping stroke is fixed.

- Force is not evenly distributed.

F = $\frac{E.A.\Delta L.10^{-5}}{L}$

F: (Ton)

A: (Tie Bar) = $\frac{n.\pi.d^2}{4}$

$E = 2{,}1.10^6$ (kg/cm^2)

d: Guide bar diameter (Tie Bar) (mm)

n: Number of guide bars (Tie Bar)

L: Guide bar length (Tie Bar) (mm)

ΔL: The amount of extension of the guide bar (Tie Bar) (mm)

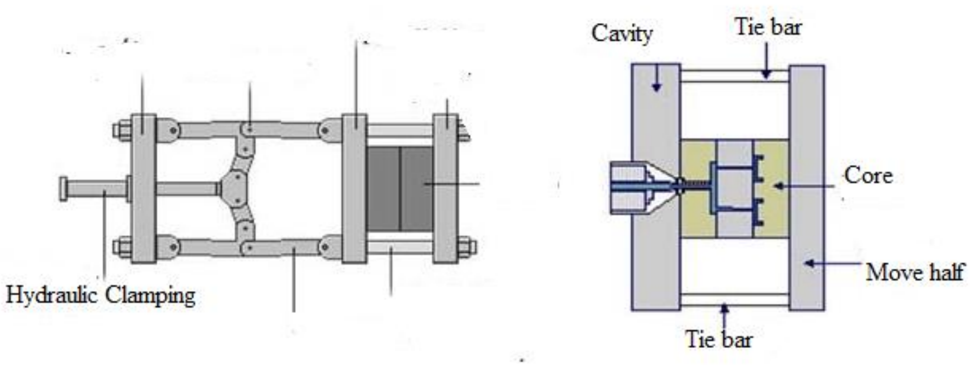

Figure 3. Operation diagram of crankshaft plastic injection molding machine.

3. RESULTS

Calculating and choosing a plastic injection molding machine to install a mold set for PVC medicine blister products for the design stage is necessary to complete the design of the plastic injection mold set.

Mold clamping force, ton.

- The maximum value of the clamping force used to clamp the mold is called the mold clamping force. The mold clamping force required when filling the forming material is:

$F \geq P.A.10^{-3}$

F: Mold clamping force (ton)

P: Average plastic pressure in the mold cavity (cavity) (kg/cm^2)

A: Projected area of the mold cavity(cm^3)

Plastic type	Average pressure (kgf/cm^2)

PS, AS, SAN, ABS, PP, PE	200-300
PMMA, PVC, PA, POM, PBT, m-PPE	300-400
PC, *PPS*, PSF	400-500

Table 1: Average pressure of plastic types.

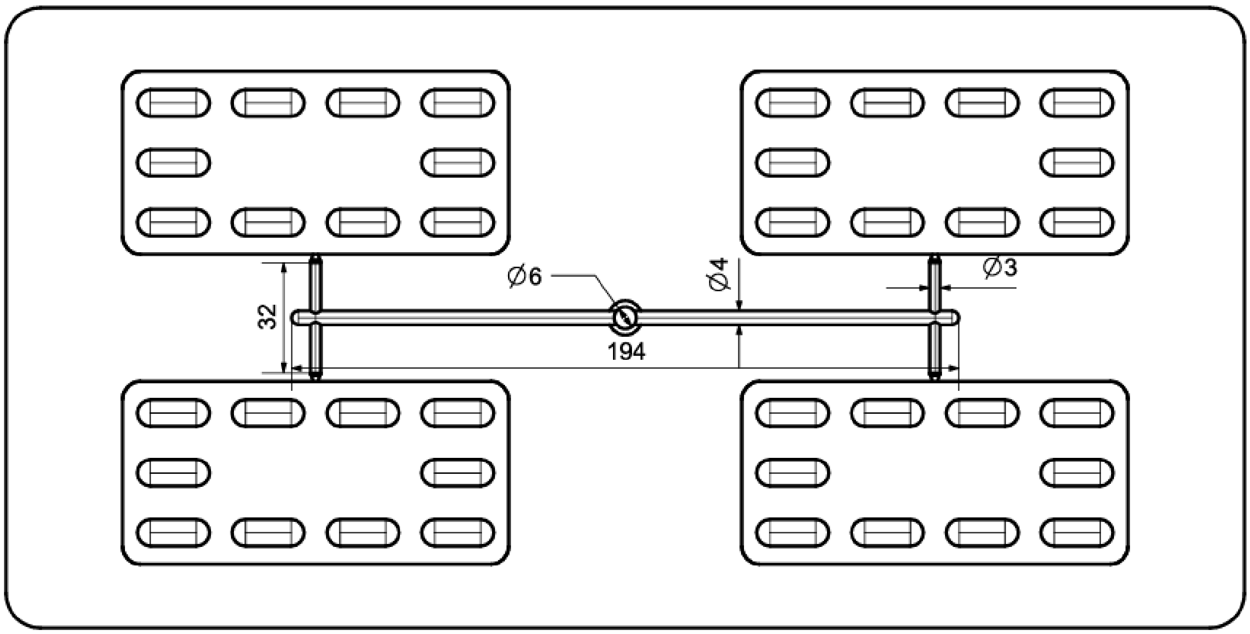

Figure 4. Preliminary shape of the plastic channel.

Apply calculations and product blister packs. - Calculate the projected area (Ar) of the plastic path.

Ar = d.L = 0,4.19,4 + 0,3.3,2 + 0,3.3,2 + $\frac{\pi.6^2}{4}$ = 38 (cm^2).

Calculate the product projection area.

Ap = a.b = 5,2. 11 = 57,2 (cm^2)

Calculate the entire projected area (Aa).

Aa = Ap. (number of parts) + Ar = 57,2. 4 + 38 = 266,8 (cm^2)

Calculate mold clamping force (Fo) (theoretical).

Maximum value of PP according to the table = 300 [kgf/cm^2]

Fo = P.Aa. 10^{-3} = 300. 266,8. 10^{-3} = 80.04 (ton)

- Calculating the mold clamping force requires considering the safety ratio.

$$Fc = \frac{Fo}{80\%}$$

$$Fc = \frac{Fo}{80\%} = \frac{80.04}{80\%} = 100.05 \text{ (ton)}$$

Based on the parameters we calculated above, we chose the J220ADS plastic injection machine from JSW Japan.

Unit		Item \ Model	J220ADS								
			300H			460H			890H		
Injection Unit		Screw Diameter in (mm)	1.57 (40)	1.81 (46)	2.01 (51)	1.81 (46)	2.09 (53)	2.28 (58)	2.28 (58)	2.60 (66)	2.83 (72)
		Screw Stroke in (mm)	7.087 (180)			8.268 (210)			10.236 (260)		
		Theoretical Injection Capacity in³ (cm³)	13.79 (226)	18.25 (299)	22.46 (368)	21.30 (349)	28.26 (463)	33.87 (555)	41.93 (687)	54.31 (890)	64.63 (1059)
		Injection Capacity (GP—PS) oz (g)	7.3 (206)	9.6 (273)	11.8 (335)	11.2 (318)	14.9 (421)	17.8 (505)	22.0 (625)	28.6 (810)	34.0 (965)
	Standard	Injection Pressure (Max.) psi (Mpa)	36,260 (250)	27,410 (189)	22,340 (154)	33,940 (234)	25,670 (177)	21,320 (147)	33,210 (229)	25,670 (177)	21,610 (149)
		Holding Pressure (Max.) psi (Mpa)	32,920 (227)	24,950 (172)	20,310 (140)	30,890 (213)	23,350 (161)	19,430 (134)	30,170 (208)	23,350 (161)	19,580 (135)
		Injection Speed in/s (mm/s)	9.45 (240)			6.30 (160)			6.30 (160)		
		Injection Rate in³/s (cm³/s)	18.4 (302)	24.3 (399)	29.9 (490)	16.2 (266)	21.5 (353)	25.8 (423)	25.8 (423)	33.4 (547)	39.7 (651)
		Plasticizing Rate (GP–PS) oz/s (kg/h)	1.27 (130)	1.80 (184)	2.27 (232)	1.13 (115)	1.60 (163)	1.93 (197)	1.93 (197)	2.76 (282)	3.29 (336)
		Screw Speed rpm (min⁻¹)	400			250			250		
	High Speed (Option)	Injection Pressure (Max.) psi (Mpa)	36,260 (250)	27,410 (189)	22,340 (154)	33,940 (234)	25,670 (177)	21,320 (147)	33,210 (229)	25,670 (177)	21,610 (149)
		Holding Pressure (Max.) psi (Mpa)	32,920 (227)	24,950 (172)	20,310 (140)	30,890 (213)	23,350 (161)	19,430 (134)	30,170 (208)	23,350 (161)	19,580 (135)
		Injection Speed in/s (mm/s)	12.99 (330)			11.81 (300)			10.63 (270)		
		Injection Rate in³/s (cm³/s)	25.3 (415)	33.4 (548)	41.1 (674)	30.5 (499)	40.4 (662)	48.4 (793)	43.5 (713)	56.4 (924)	67.1 (1099)
		Plasticizing Rate (GP–PS) oz/s (kg/h)	1.27 (130)	1.80 (184)	2.27 (232)	1.58 (161)	2.23 (228)	2.69 (275)	1.93 (197)	2.76 (282)	3.29 (336)
		Screw Speed rpm (min⁻¹) m	400			350			250		
		Nozzle Touch Force U.S.ton (kN)	4.4 (39.3) Center Nozzle Touch								
		Nozzle Stroke from Platen in (mm)	1.97 (50)								
		Type of Nozzle	Open Nozzle (Tip Type)								
		Barrel Temperature Control	Barrel4, Nozzle1			Barrel5, Nozzle1					
		Heater Wattage kW	12.0			12.4			18.7		
Clamping Unit		Mechanism	Double Toggle								
		Clamping Force U.S.ton (kN)	242.8 (2160)								
		Daylight Opening (Max.) in (mm)	48.43 (1230)								
		Opening Stroke (Max.) in (mm)	21.65 (550)								
		Mold Height in (mm)	9.055~26.772 (230~680)								
		Distance Between Tie-bars (H×V) in (mm)	25.59×23.23 (650×590)								
		Platen Size (H×V) in (mm)	36.61×34.25 (930×870)								
		Locating Ring Diameter in (mm)	4.0 (101.6)								
		Ejector Point	13 Points								
		Ejector Force U.S.ton (kN)	4.97 (44.2)								
		Ejector Stroke in (mm)	5.906 (150)								
General		Machine Weight U.S.ton (t)	11.57 (10.5)			12.24 (11.1)			12.79 (11.6)		
		Machine Dimensions (L×W×H) ft (m)	21.42×5.64×6.56 (6.53×1.72×2.00)			21.42×5.64×6.66 (6.53×1.72×2.03)			23.04×5.63×6.77 (7.02×1.72×2.06)		

Table 2. J220ADS machine parameter table.

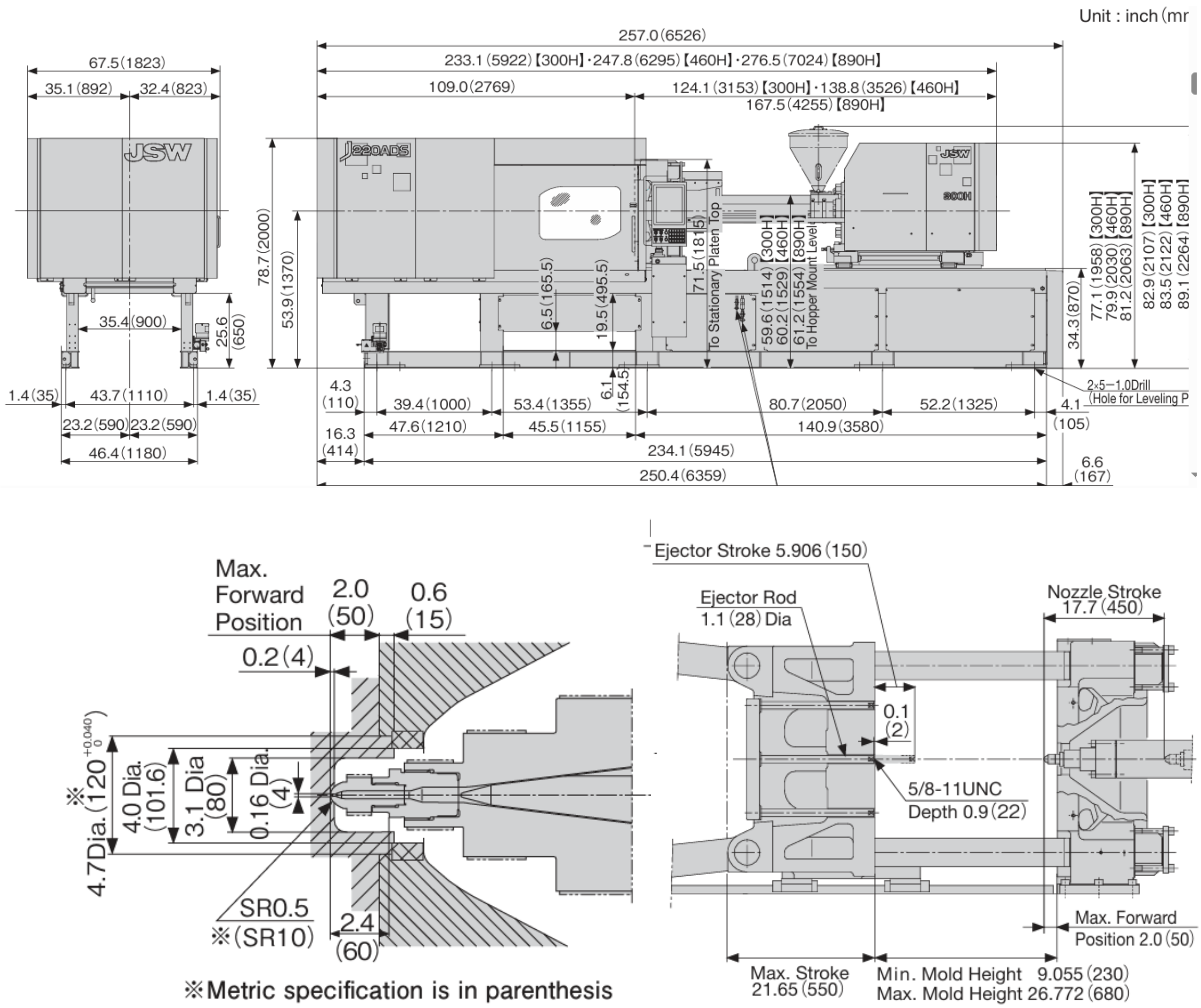

Figure 5. J220ADS plastic injection molding machine.

4. DISCUSSION

Figuring out your plastic injection product is the first tip. Product model, shape, weight, size, material are the basic information you must provide. Having a clear idea of your plastic injection product can simplify the process of choosing the right large injection molding machine. If you want to develop a new product, it is best to discuss your ideas with injection molding machine manufacturers.

Molds are an important part when designing large plastic injection molding machines. It is important to consider not only the size but also the design, construction, thickness and cavity as they can all affect the performance of the machine. The size and thickness of the mold will determine the size of the machine needed. Furthermore, the length, width and height of the mold need to match the platen size to ensure proper force during molding.

ACKNOWLEDGMENTS

Customizing your plastic injection molding machine can help improve your manufacturing process and increase your competitiveness in the market. Features such as shortening cycle times, increasing injection speeds, saving energy or facilitating mold changes can be customized to fit your needs. It is essential to list the features you desire and discuss them with your plastic injection molding machine manufacturer.

In our case, customers with specific requests always receive positive responses from us. Additionally, by listing your customization needs at the outset of the discussion, cost considerations can be more comprehensive, making your investment more valuable.

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