Mathematical Modeling of Plastic Injection Mould

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Abstract

Injection moulding calculation is most important for the mould designing, according to the plastic Injection moulding machine specifications. It is required to determine number of cavities in mould during Injection mould designing. There are basically three methods we are used to determine the number of cavities. These methods are depending upon Shot Capacity, Clamping Force of machine and plasticizing rate of polymer which is used for a product. With the help of these calculations we designed a proper balanced mould and maximum utilize the machine.

Keywords: Shot Capacity, clamping force, plasticising rate

I. INTRODUCTION

Injection moulding machine is use to manufacturing the plastic product such as: Bowl, Plate, Mug, spoon, bottle cap, etc. For manufacturing a product, it is essential to make a mould /Die for that Product. The product and Die is Designed with the help of CAD software (Creo2.0). After analysing the product, the most significant part is mathematical modelling of mould. In mathematical modelling we determine the number of cavities in the mould.

There are three methods we have used:

1) Shot Capacity
2) Plasticizing Capacity
3) Clamping force

According to following calculation we have decided the number of cavities, shape and size of mould.

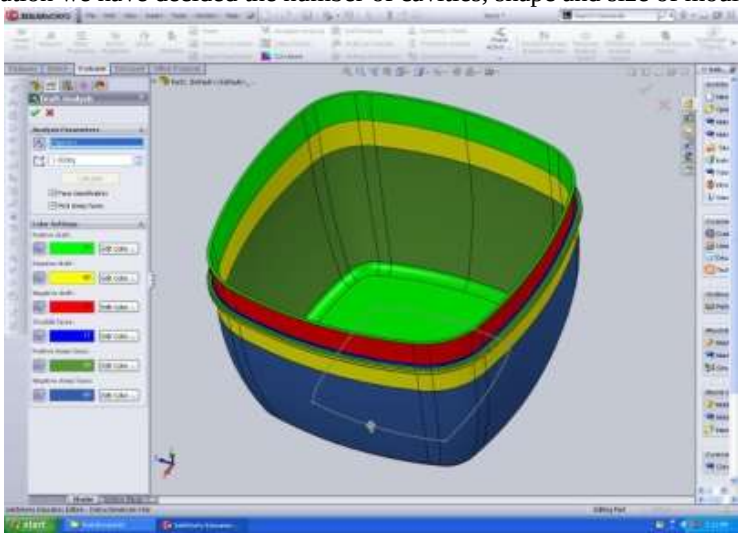

Fig. 1:

II. OBSERVATION

Sr.No	*Properties*	*Values*
1	*Mass of component*	*30gm*
2	*Shot capacity of machine*	*98gm*
3	*Projected area of Component*	*45665mm^2*
4	*Material*	*PVC*
5	*Shrinkage*	*0.4-0.5%*
6	*Density*	*1.45*
7	*Machine*	*Servo 120*
8	*Cycle time*	*17 sec.*
9	*Max. Clamping force*	*800 KN*
10	*Max. Cavity Pressure*	*63 Map*

III. MATHEMATICAL CALCULATION

Following are the method of calculation:

A. Shot Capacity

The maximum weight of molten resin that the injection molding machine can push out with one forward stroke is called shot capacity.
The screw type machine is rated in terms of volume of the injection cylinder (cm^3).
Formula:
1) Shot capacity (w) = swept volume x þ x C
Where,
þ= density of plastic at normal temperature (available from manufactures literature)
C= 0.35 for crystalline plastics
C= 0.95 for amorphous plastics*
Shot Capacity (w) =100 x 1.45 x 0.95

$$w = 137.75 \text{ gm}$$

2) Determination of Number of Cavities
The number of cavities in injection moulds is determined in most cases by the machine performance, but sometimes by the mould shape or the mould locking pressure.
Based on 85% of rated shot capacity

$$Ns = \frac{0.85W}{m}$$

Where, w = Shot capacity
m = Mass of component

$$Ns = \frac{0.85 \times 137.75}{30}$$

$$Ns = 3.9029 \approx 4$$

No. of Cavities (Ns) = 4

Material	*Density (gm/cc)*	*Molding Temp. C^0*	*Specific heat Capacity (J/KgK)*	*Total Heat Content (KJ/Kg)*
Acrylic	*1.18*	*225*	*1470*	*302.4*
Polypropylene	*0.9*	*250*	*1932*	*546*
Polystyrene	*1.05*	*200*	*1344*	*239.4*
PVC	*1.45*	*180*	*1008*	*159.6*

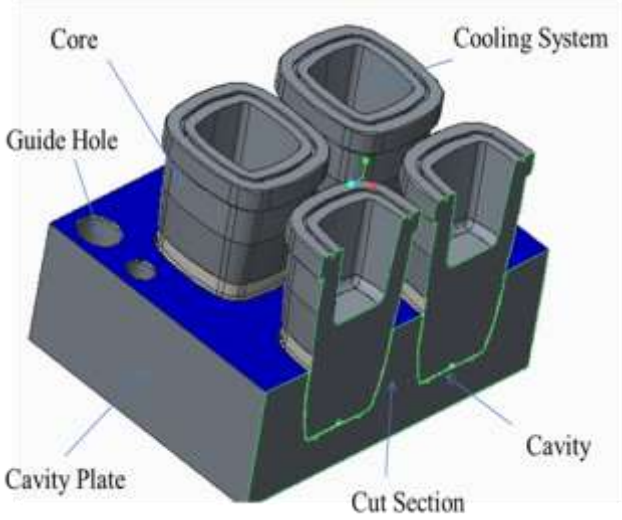

Fig. 2:

B. Plasticizing Capacity

The rate by which polymer get plastic/solid. The plasticizing capacity is expressed in kg/h of plasticized polystyrene.
Formula:

1) Plasticizing Rate of Material B (kg/h) (P)

= plasticizing rate of material A (kg/h) X $\frac{QA}{QB}$

Where,
Q = total heat content of plastic (J/kg)
A = polystyrene
B = material actually to be used (PVC)

$$P = 40 \text{ X } \frac{239.4}{159.6}$$

$$P = 60 \text{ kg/h}$$

2) Determination of Number of Cavities by Plasticizing Capacity:

(Based on 85% of rated plasticizing capacity)

$$Np = \frac{0.85P \text{ X } Tc}{3600m}$$

Where, P = rated plasticizing capacity for particular polymer (kg/h)
m = mass of the moulding per cavity (kg or g)
Tc = overall cycle time
Cycle time is estimated by plasticizing capacity.

$$tc = \frac{m \text{ x } 3600}{P}$$

Where, tc = minimum cycle time
m = mass of shot (kg)
P = plasticizing capacity of the machine with the polymer being moulded. (kg/h)

$$tc = \frac{30 \text{ X } 3600}{60 \text{ X } 1000}$$

tc = 1.85 sec
(Tc > tc) ……. Design safe
But, cycle time, Tc = 17 sec (standard)
No. of cavity, $Np = \frac{0.85P \text{ X } Tc}{3600m}$

$$= \frac{0.85 \text{ X } 60 \text{ X } 17 \text{ X } 1000}{3600 \text{ X } 30}$$

Np = 8 cavities

C. Clamping Force

The clamping force required to keep the mould closed during injection must exceed the force given by the product of injection pressure and projected area of all impressions, runners and gate. Lower clamping values can be used with these machines. Thin sections need high injection pressure to fill and therefore require more clamping force, easy flowing materials like PE, PS fill more readily and hence require a lower clamping force. In case of screw injection machine 33 to 50% of injection pressure need only be considered maximum pressure can be obtained from machine manufactures data sheet.

Determination of number of cavities by clamping force:
Formula:

$$Nc = \frac{C}{Pc \times Am}$$

Where, Nc = number of cavity based in clamping capacity,
C = rated clamping capacity (KN)
Pc = cavity pressure (Map)
Am = projected area of moulding including runner and sprue

$$Nc = \frac{800}{63 \times 1000 \times 45665 \times 10^{-6}}$$
$$= 0.278 \approx 3$$

Nc = 3 cavities

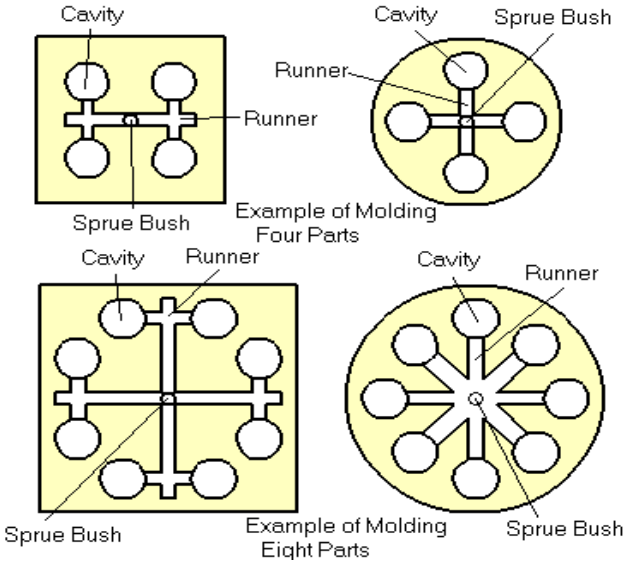

Fig. 3:

IV. CONCLUSION

From the above calculations we got three different values of cavities.
No. of cavity by Shot capacity = 4
No. of cavity by Plasticizing capacity = 8
No. of cavity by Clamping Force = 3
So for balancing and size of machine we consider No. of cavities = 4

ACKNOWLEDGEMENT

First of all, we thank the almighty for providing us with the strength and courage to do the research study.

we avail this opportunity to express our sincere gratitude towards PROF. BHUSHAN MAHAJAN head of mechanical engineering department, for permitting us to do the project work. We also at the outset thank and express our profound gratitude to our guide Prof. Aswad Sagdeo for his inspiring assistance, encouragement and useful guidance.

We are also indebted to all the teaching of the department of mechanical engineering for their cooperation and suggestions, which is the spirit behind this research work.

Thanks to all our seniors who gave us the information and basic important knowledge about the topic.

Our best regards go to all our colleagues for their pleasant cooperation last but not the least, we wish to express our sincere thanks to all our friends for their goodwill and constructive ideas..

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