# Gating System Design Optimization for Injection Moulding

[1]Dr. M P Singh, [2]Akhilesh Jaguri

[1]Department of Mechanical Engineering, Jagannath University, Jaipur, India
[2]Department of Mechanical Engineering, Jagannath University, Jaipur, India

***Abstract*: Injection moulding process is a vast and advantageous process in the field of science and technology. Injection moulding process gives birth to vast application which replaces not only industrial products and parts but also capture home appliances and the products of our day to day life. But from the technology point of view we are still using hit and trial methods. In industries, workmen and craftsmen who are engaged in these operations are only expertise but to a certain extent they are also dependent on hit and trial methods which sometimes increases the manufacturing cost of the product. There is a need to develop a technology which guides the designer that what methods he has to follow to design a particular product. There are basically three step in the injection moulding cycle. Firstly, design of sprue which are tapered to increase the rate of flow. Secondly, design of runner whose efficiency is pre determined and fixed. Efficiency here refer to smoothness or least obstruction provided to the flow material. Thirdly, selection of the gate which pour the flow material finally into the cavity. Selection of gate is quite a difficult task for the designer; only skilled crafts-men can handle easily. Now again the problem arrives to assemble these the three steps according to the type of cavity. In this paper i tried to develop a system with the help of CAD/CAM which facilitates the user to work on injection moulding operations starting from the cavity to the selection of gates and then to the efficiency of runner and finally to sprue. This results time reduction in designing process and to a certain extent reduces manufacturing cost also.**

***Keywords:*** **Moulding, Sprue, Lead time.**

## 1. INTRODUCTION

It is a manufacturing process for producing parts in which thermoplastic and thermosetting plastic materials are used. Raw material is feed into a heated barrel, where it cools and hardens to get desired configuration and shape of the cavity. Mold maker (or toolmaker) is used to make molds from metal (usually either steel or aluminum) and precision-machined to form the desired part. For manufacturing a variety of parts injection molding is used.

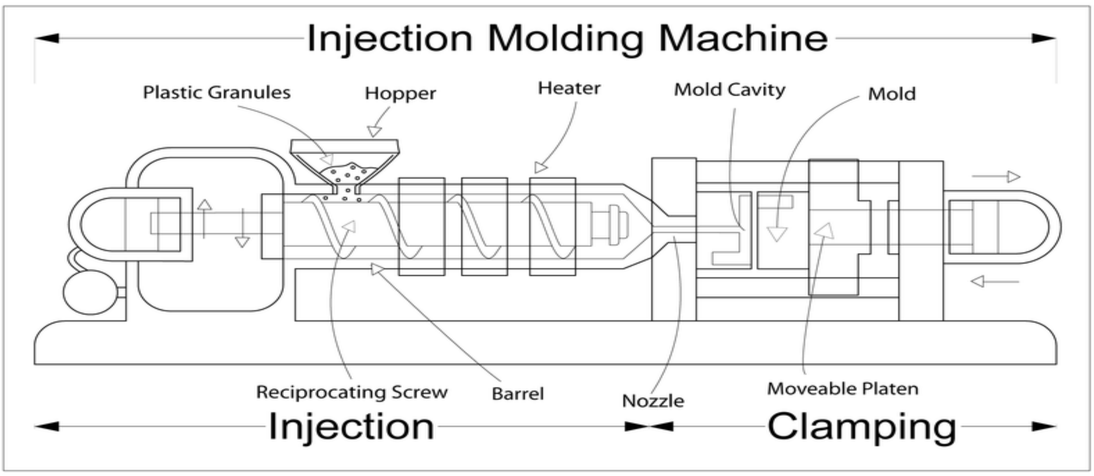



**Fig:-1 Injection moulding machine**

**Process characteristics:**

- A ram or screw-type plunger to force molten plastic material into a mould cavity.
- Uses thermoplastic or thermo set materials.
- Produces a parting line, spruce, and gate marks.
- Ejector pin marks are usually present.
- Produces a solid or open-ended shape.

**Applications:**

Injection moulding is the most common method and best method of part manufacturing. It is ideal for producing large volumes of the same object. Injection moulding is used to make many

things such as pocket combs, wire spools, bottle caps, packaging, automotive dashboards, mechanical parts, and most other plastic products available in a variety of forms. Some advantages of injection moulding are high production rates, repeatable high tolerances, and the ability to use a wide range of materials, low labour cost, and minimal scrap losses.

**Injection Process:**

**Fig:-2 Hopper, nozzle and die area shown in Small injection molder**

In process of injection molding, from a hopper granular plastic is fed by gravity into a heated barrel. By a screw plunger the granules are moved forward, the plastic is forced into a heated chamber, where it melts completely. When the plunger moves forward, through a nozzle the melted plastic is forced in, letting it to enter the cavity through a gate and runner system. As the plastic solidifies the mold remains cold almost as it is completely filled.

**Cycle of Injection Molding:**

The injection molding cycle is the sequence of events that occur during the injection mould of a plastic part. With the mould closing the cycle begins, followed by injecting the polymer into the cavity. A holding pressure is maintained when the cavity is filled, to compensate for material shrinkage operation. The screw turns, feeding the next shot to the front screw- in the next step of the cycle. The mould open and the part are ejected, once the part is cooled.

## II. RESEARCH METHODOLOGY

Methods of gating system design are categorized under followings steps which are numerated as follows:

**STEP -1**

**Firstly**-Surface Area, Volume and Type of material is calculated. This data is provided by the customer to the designer that what are the geometric properties of the product.

**Secondly**- velocity of flow is decided by the designer which is fixed for every material.

For Example Gate velocity = 5m/s to 30m/s

(Minimum for house hold product and max for ABS material)

**Thirdly**-No. of cavities are selected either it must be single cavity or multi cavity according to the demand of customer.

**Fourthly**, de-gating of gates are selected by the designer.

**Material constant (n):**

**Table .1 Material types**

| | | |
|---|---|---|
| Group1 | Polythene, polystyrene: DENSITY = 1.05 gm/cm$^3$ | n=0.6 |
| Group2 | Polyacetal, polycarbonate: DENSITY = 1.21 gm/cm$^3$ | n=0.7 |
| Group3 | Cellulose acetate, polymethyl methaacrylate, nylon DENSITY = 0.941 gm/cm$^3$ | n=0.8 |
| Group4 | PVC: DENSITY = 1.38 gm/cm$^3$ | n=0.9 |

**STEP-2**

Firstly gate area is calculated by:

Gate area: $\frac{\text{Total volume of cavity}}{\text{Gate velocity}}$

Width of gate: $\frac{n*A}{30}^{\frac{1}{2}}$

Secondly, gate thickness is calculated by the relation

Gate thickness: $\frac{\text{Gate area}}{\text{Gate width}}$

Now gate thickness determines the type of gate should be used for a particular type of cavity.

Flow chart for single cavity

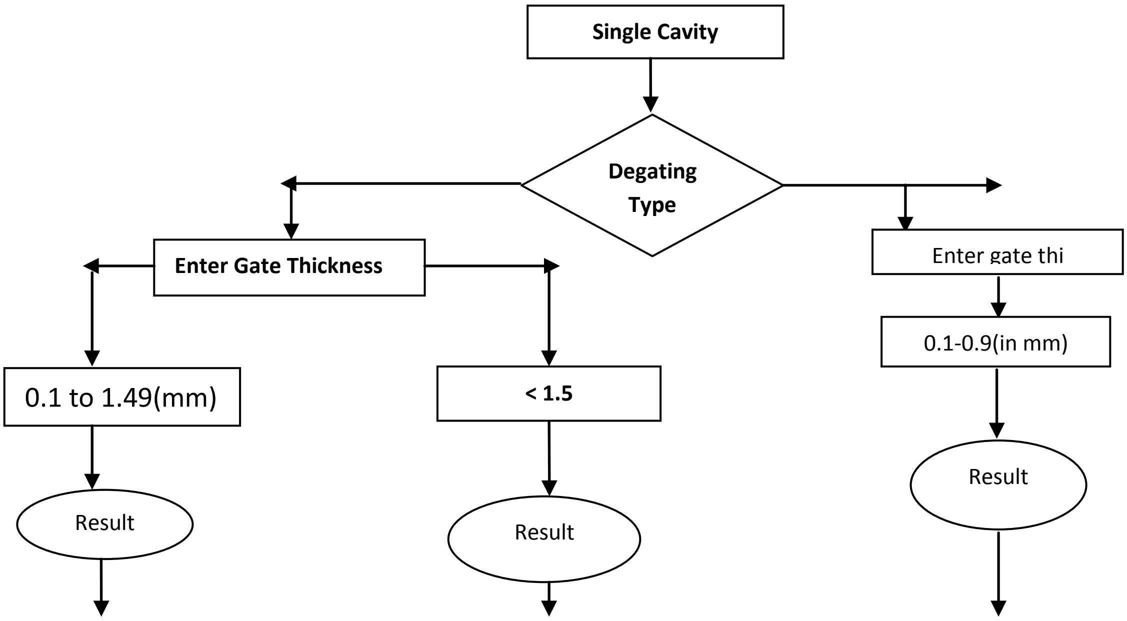
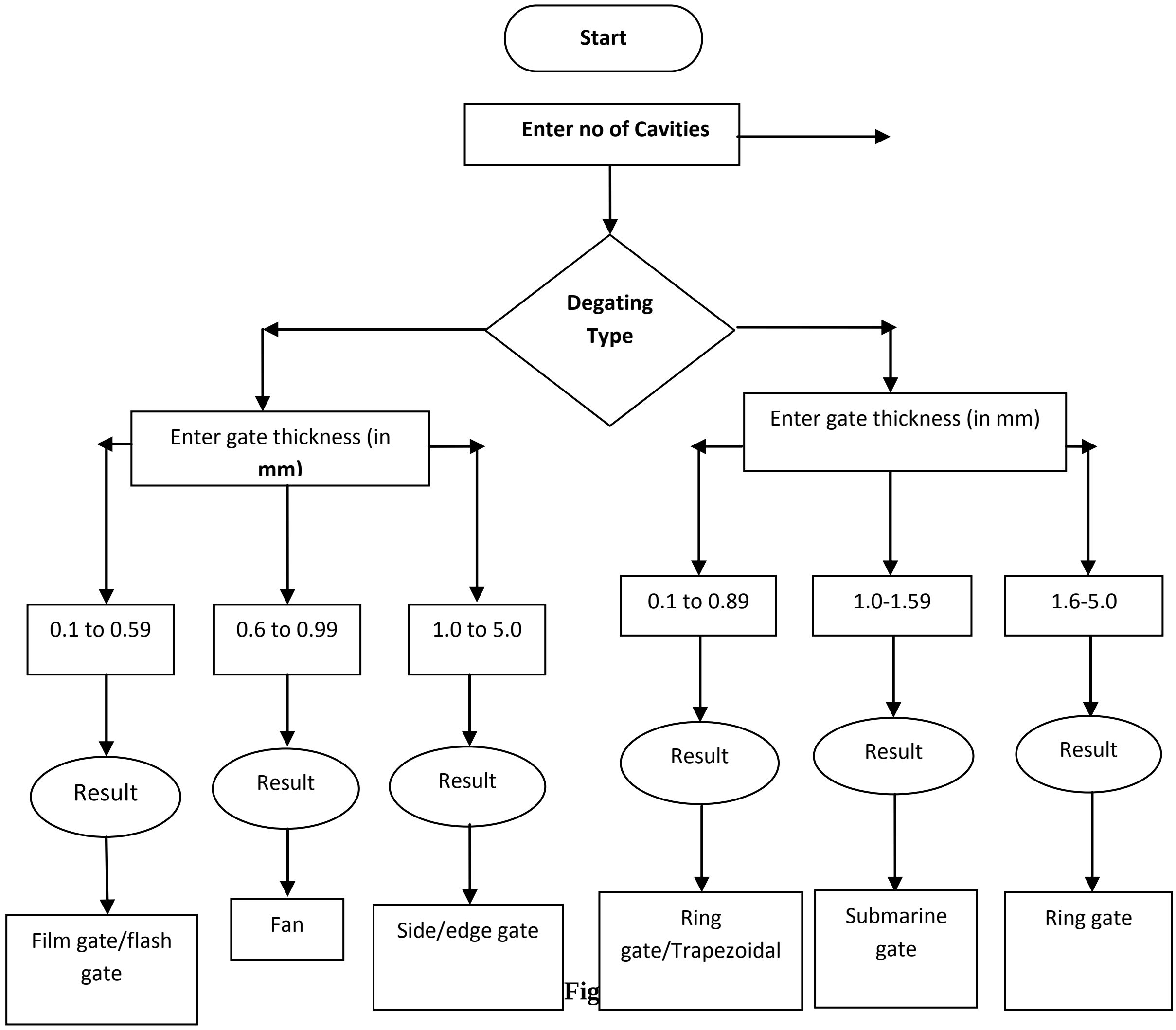



**Fig:-3**

**Flow chart of multiple cavities:**




Fig

**STEP-3**

In this step Runner is selected according to the performance efficiency.

It is being observed by designer that

**Table .2.Material types**

| Type | Priority ( Acc. To efficiency) |
|---|---|
| Trapezoidal (D=W) | 2nd |
| Round (D) | 3rd |
| Modified Trapezoidal (R=D/2) | 1st |
| Hexagonal | 4th |

Diameter of runner: = $\frac{\sqrt[2]{\text{weight of moulding}}}{3.7} * \sqrt[4]{\text{length of runner}}$

**Graph b/w diameter of runner and length of runner.**

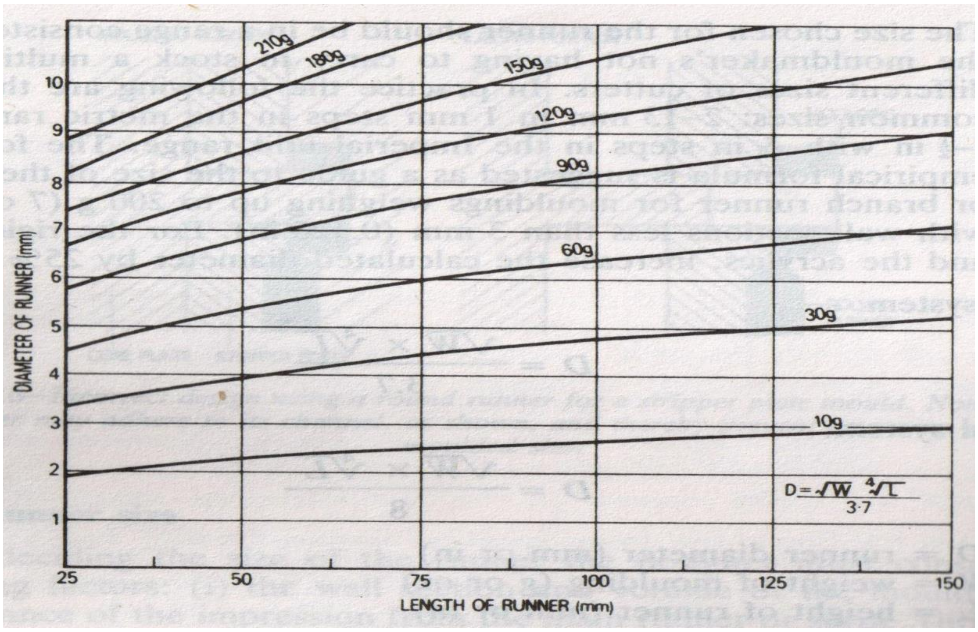



**Fig:-5**

Hence length, height and diameter of the runner are determined by the designer according to the type of gate selected

**STEP-4**

In this step standard sprue is selected by the designer and its diameter is adjusted according to the diameter of runner at one end and other diameter is derived from the relation,

**$D_2 = D_1 + 2L \tan A$**

Where, $D_1$=diameter of runner/diameter of one end of sprue.

L= length of sprue selected by the designer

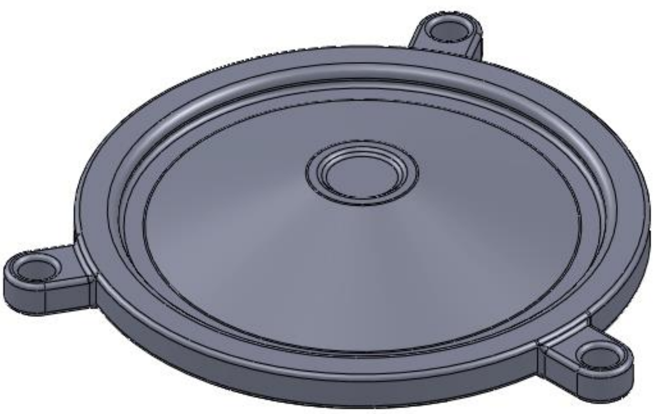
A= tapered angle ($2^0$ to $5^0$)

Hence sprue is selected with desired diameter, length and tapered angle.

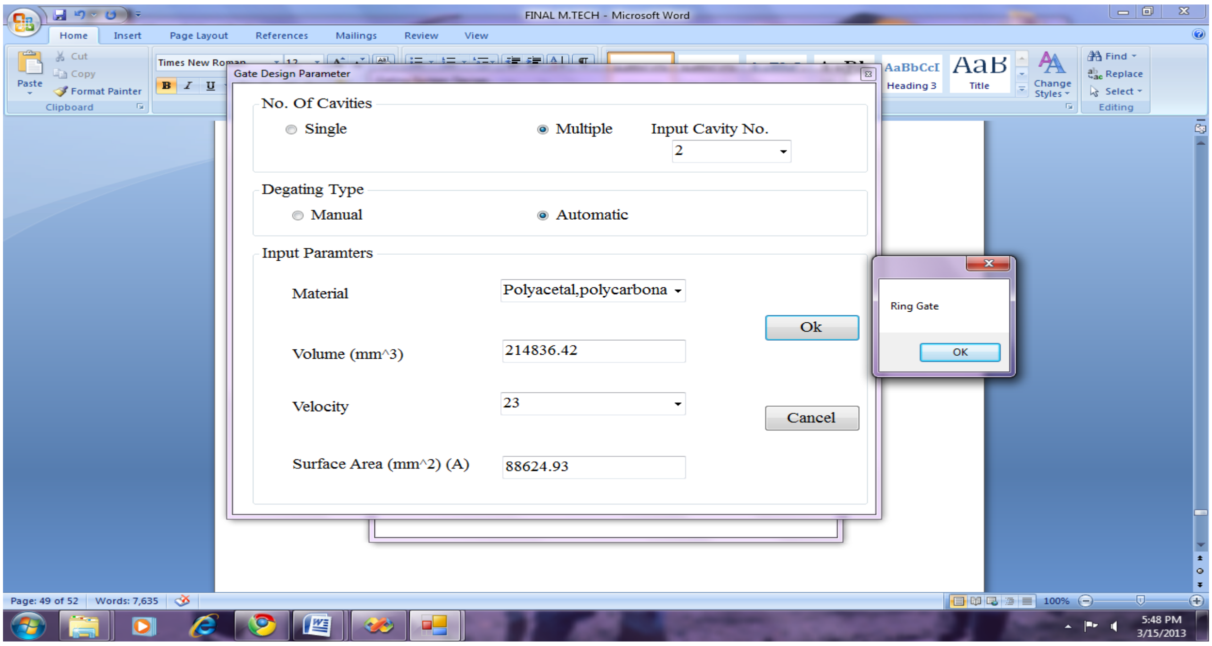
**Example**

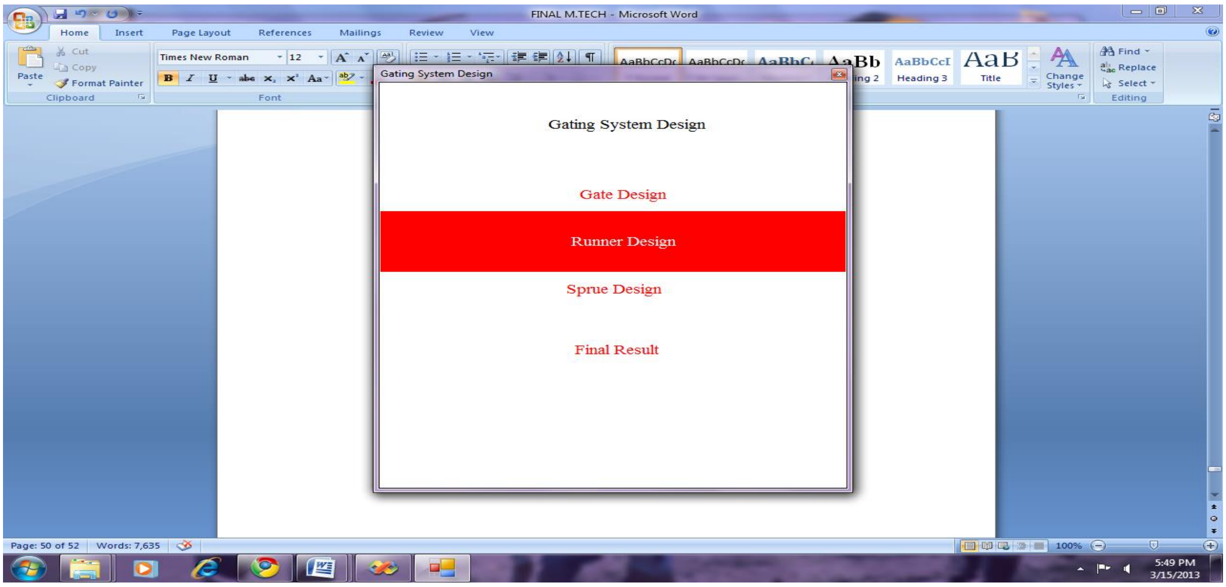
**Volume = 214836.42 cubic millimeters**

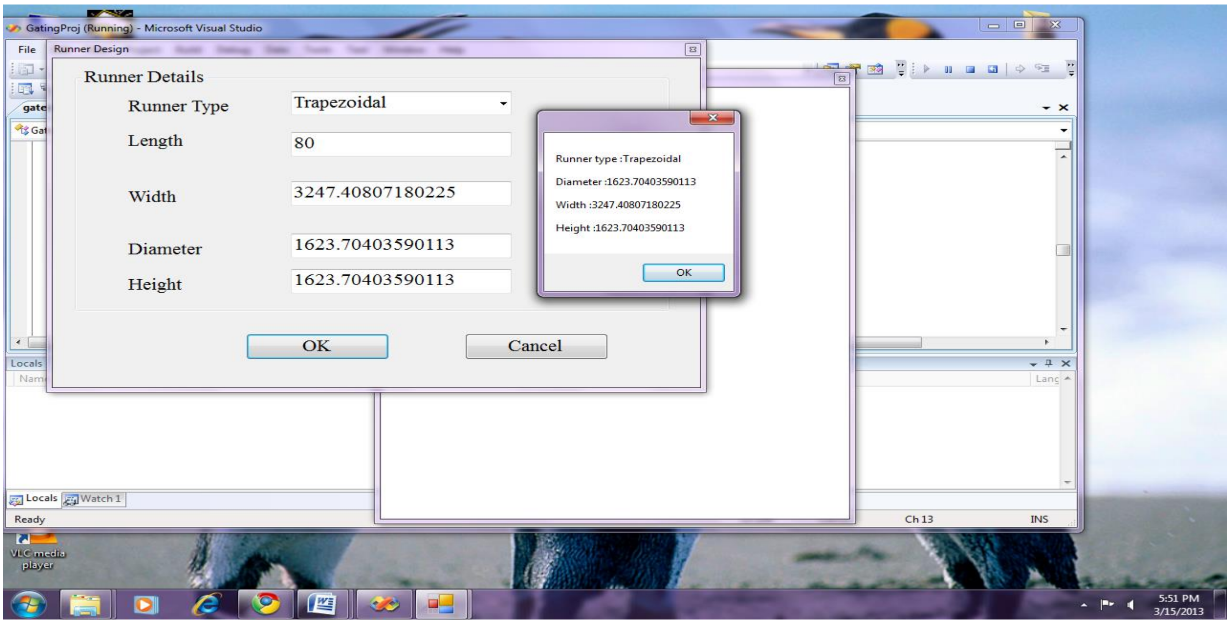
**Surface area = 88624.93 millimeters^2**

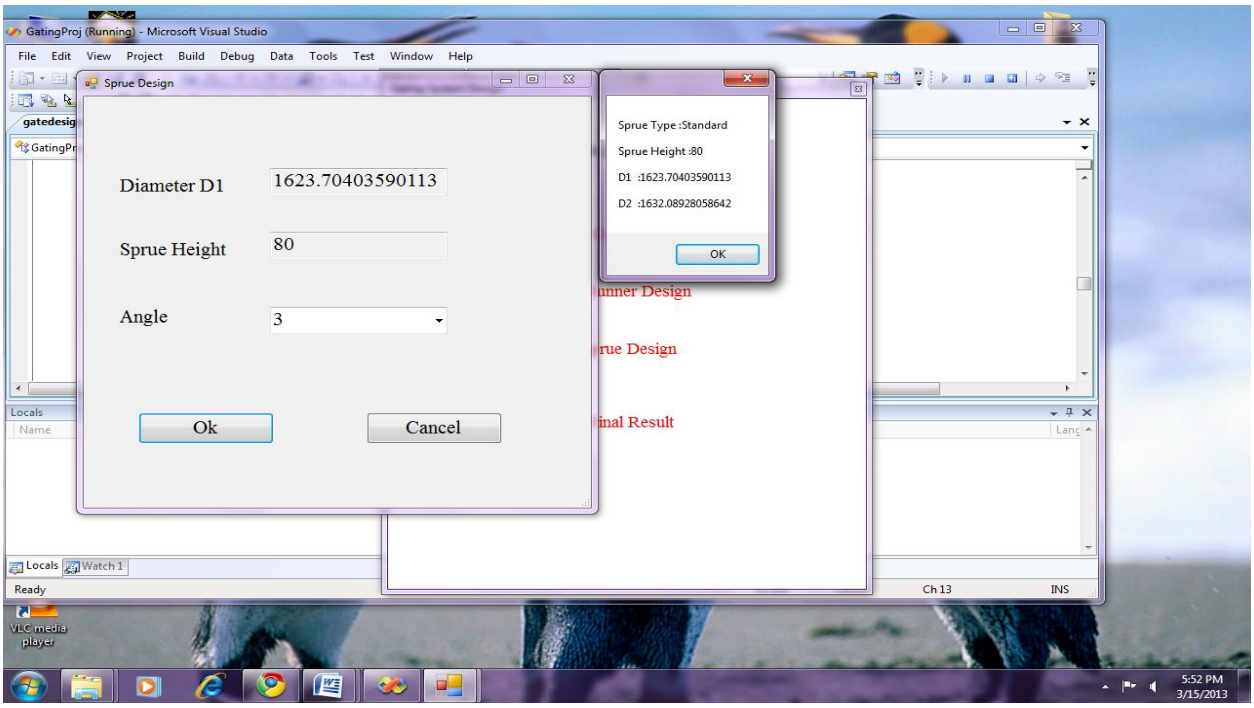


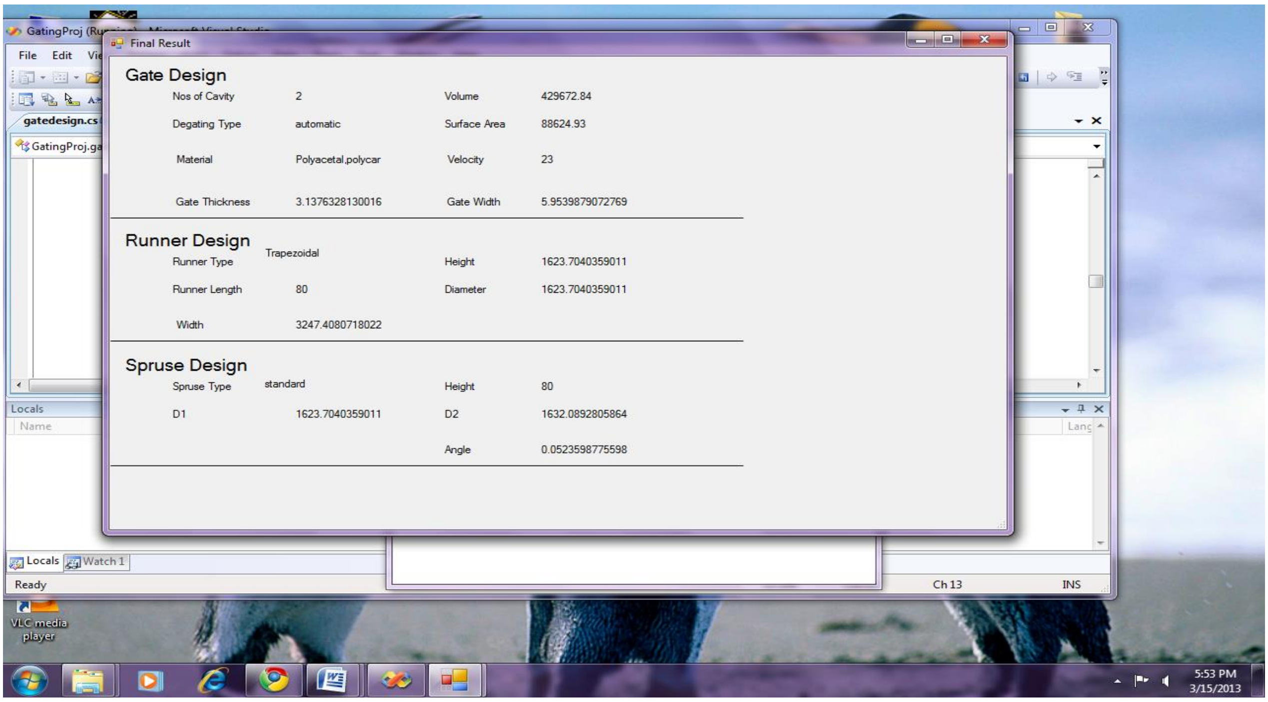
**Example Part Model**


FINAL M.TECH - Microsoft Word
Gate Design Parameter
No. Of Cavities
Single
Multiple
Input Cavity No.
2
Degating Type
Manual
Automatic
Input Paramters
Material
Polyacetal,polycarbona
Volume (mm^3)
214836.42
Velocity
23
Surface Area (mm^2) (A)
88624.93
Ok
Cancel
Ring Gate
OK


FINAL M.TECH - Microsoft Word
Gating System Design
Gating System Design
Gate Design
Runner Design
Sprue Design
Final Result


GatingProj (Running) - Microsoft Visual Studio
Runner Design
Runner Details
Runner Type
Trapezoidal
Length
80
Width
3247.40807180225
Diameter
1623.70403590113
Height
1623.70403590113
OK
Cancel
Runner type :Trapezoidal
Diameter :1623.70403590113
Width :3247.40807180225
Height :1623.70403590113
OK




## III. CONCLUSION

When designing a gating system, it is very important to fill the molten metal to fill the cavity properly. Therefore, the design of gating system is very difficult. A proper runner and gating system is very important to secure good quality die castings through providing a homogenous mould filling pattern. For mouldings with multiple cavities, adjusting injection parameters of each cavity to the same level is particularly difficult. The resultant rate of failed product is untenable. The aim is to gain high levels of productivity and to reach a level of accuracy that meets the required conditions.

To achieve a good gating system design, the following aspect should be taken into consideration:

Firstly, total volume of the cavity, to be injected. In regular practice, a single cavity is chosen frequently. But by using a multi-cavity die will save labour cost and improve the production efficiency. The designer should consider the economic and technical issues in order to select an acceptable cavity number that meets the overall requirements.

Secondly, degating type selection which means to separate mouldings from the runner or the feeding system.

Thirdly, by increasing the gate thickness or area will result characteristics curve with reduced slope, so that the filling time and gate velocity vary accordingly. A larger gate area will decrease both the filling time and gate velocity. A low gate velocity will lead to high air entrapment and porosity. On the other hand low flow rate will result in poor casting surface; a short filling time gives good surface finish.

Modern injection moulding–especially in the 3C industry–needs less time to fabricate accurate products such as the cell phone with digital camera, the camera lens and the cell phone shell. To achieve the above mentioned goals in the current product development, the CAD/CAM is preferred method to provide essential part of solution. It provides the technology for the representation of design intent, design schemes and solution. CAD/CAM technology greatly enhances product design quality and shortens design and manufacturing lead time.

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