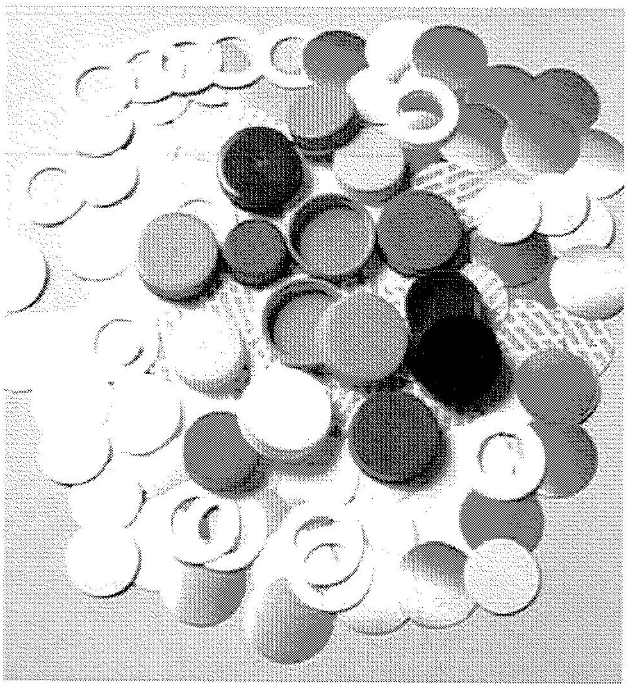
Mould design of a cap of CMOS chip



Written By:

Xiaoping Gong

Submitted to:

Hogeschool van Utrecht

The Netherlands

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Preface

This report is the result of a graduation project performed at Hogeschool Van Utrecht. It could not have been accomplished without many people's help.

First, I like to thank Mr. Anton Honders for his guidance in the design process. I also want to thank Mr. Henny Rademaker for their technica1 support.

Second, I would like to thank all the other people at Hogeschool Van Utrecht, who helped me with this project. Especially, Mr. Robin Goth who helped me a lot with Solidwork.

Finally, I would like to thank my parents, Mr. Gong and Ms. Xu for their support in the whole time.

Summary

Contents

Chapter 1. Introduction

Chapter Ⅰ. Introduction

Ⅰ.1 Introduction of CMOS plate

The CMOS (Complementary Metal Oxide Semiconductor) is an on-board semiconductor chip, which requires very low power generated fromvarious types of CMOS batteries. This chip is used to store important system information and configuration settings while the computer is off and on. CMOS semiconductors use both NMOS(negative polarity) and PMOS (positive polarity) circuits. Since only one of the circuit types is on at any given time, the chips require less power than chips using just one type of transistor. This makes them particularly attractive for use in battery-powered devices, such as portable computers. Personal computers also contain a small amount of battery-powered CMOS memory to hold the date, time, and system setup parameters.

1.2 Problem description

The size of the CMOS chip, used in this project, is about 10mm* 5mm*2mm. The CMOS is a very sensitive and precise electronic device. The complex work environment, such as high temperature, dust and external impact, has a high influence in the performance of the CMOS. A cap, assembled outside the CMOS, is used to prevent the dust, keep cool and buffer the external impact and wear. At the same time, cost should be considered in design process.

1.3 Study goal

The Mould of the CMOS cap is designed to produce an acceptable cap

1.4 Problem approach

There are five main phases made in this project.

The first phase is project analysis. The first thing of the phase is the total design. By this way, all design specification such as including clients, production and markets, are considered. The second thing of this phase is transferring the custorners' requirements to the product design requirements by using the method concerning Quality Function Development. The last thing of this phase is listing the product component-manufacturing process table and the importance table for Function of CMOS cap that will be used in the Chapter 4 (selection of moulding method) and Chapter 5 (concept design).

The second phase is selection of CAD software. The CAD software is introduced firstly. Secondly, the CAD software is selected according to its advantages.

The third phase is selection of moulding method. The moulding method is selected according to the advantages. The moulding tool and the mould process are also selected in this chapter.

The fourth phase is concept design. According to the product design specification, the product design concept is selected, The fifth phase is the detailed design. Material selection of the cap and the structure design are made. In the material selection process, the material of the cap is selected firstly according the advantage/disadvantage of the potential materials of the cap. Then the potential materials of the cap mould can be determined according to the selected cap material and the relative work experience. The final material of the cap mould can be selected based on the criteria (cost, performance and so on) shown in section 1.2. In the structural design process, the performance, shape and production process are considered. The detailed structures, such as size design, are designed according to the relative design document or standard.

The simple mould design process of the CMOS cap, which is made in this project, is shown in Figure 1.1.

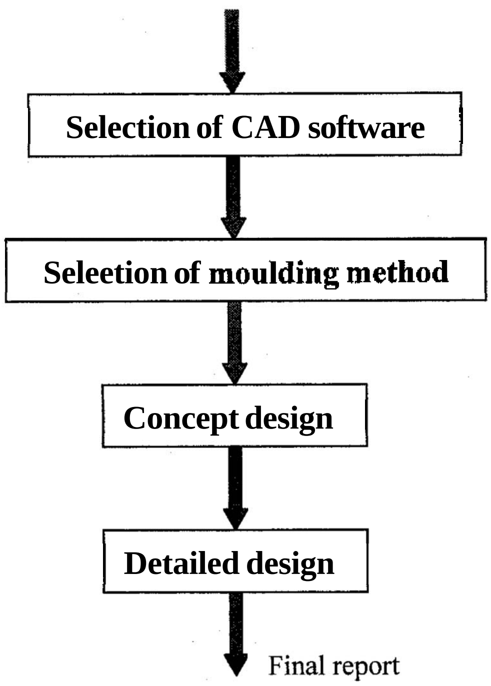

Figure 1.1: Flow chat of mould design of the CMOS cap

Chapter 2. Product analysis

Chapter 2. Product analysis

2.1 Description of total design

"Total Design" is not only an engineer designs something, but also simultaneously considers production, sales, clients, maintenance, recycles and buffer/storage clients (see Figure 2.1). It should be worked out within a group of people, or experts in different areas.

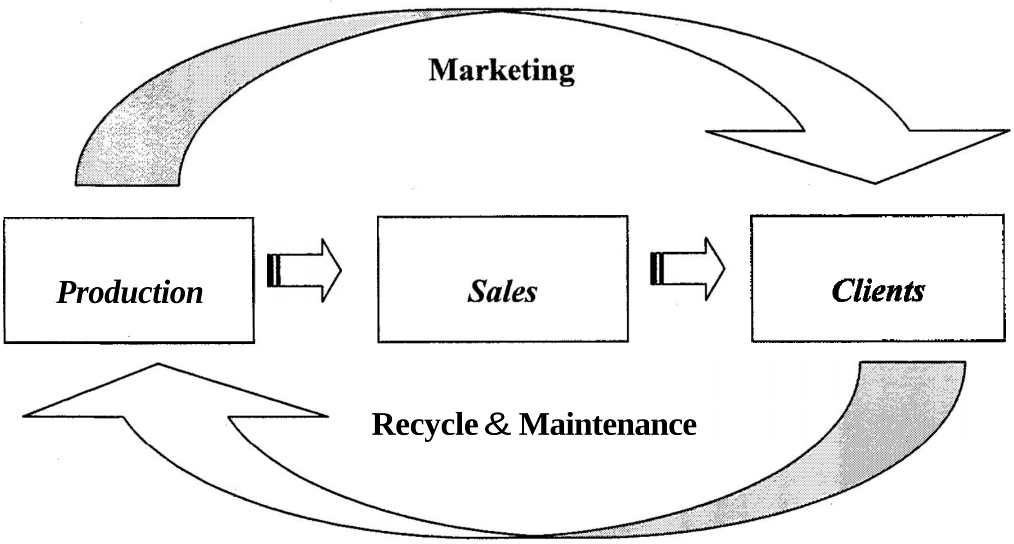

Figure 2.1: *Design full field*

2.2 Quality function deployment

As the most significant of these procedures (see Figure 2.1) is quality functiondeployment, the customer requirements derived frommarket research and competitor analysis are simply stated and involve the expansion of basic wants into secondary and tertiary element.

Then the goal of this next step is to organize these needs into a hierarchical list consists of primary and secondary needs. The list will be typically consists of a set of primary needs, each one will befurthercharacterizedbyasetofsecondaryneeds. Theprimaryneeds, shown in bold letters, are the most general needs; while the secondary ones, which are written below-the primary needs, express needs in more detail.

Product requirements

Customer Requirements	Minimum sound	Exactitude dimension	Height (m)	Depth(m)	Cost (€)	Mass (kg)	Performance	Economy	Durability
High quality product		◆					◆		
Low mechanical noise	◆								
Safety						○			○
Low cost					◆			○	
Operate easily	▽					▽			
Light weight		▽	○	○		◆			
High throughput					○				◆

Good **looking**										

Table 1: Customer Requirements – product requirement matrix:

◆,strong relationship ; ○, medium relationship; V, weak relationdship,

Engineering Characteristics

Customer Requirements	Minimum sound of 10 (db)	Width (m)	Height (m)	Depth(m)	Cost (€)	Mass (kg)	Pressure (N/M2)	Geometric shape of the model
High quality product							◆	
Low mechanical noice	◆							○
Safety						▽	◆	
Low cost					◆			
Operate easily			▽				▽	▽
Light weight		○	○	○		◆		
High throughput					○			
Good looking						▽		▽

Table 2: Customer Requirements – Engineering Characteristics

◆,strong relationship ; ○, medium relationship; V, weak relationdship,

2.3 Product Components, Manufacturing Processes and specifications

- **Product component-Manufacturing Processes table**

This charts indicates the importance of component / assembly in the system.

Components	Injection Molding	Sheet Metal Forming	Sheet Metal Shearing	Buy-Products
Protuberant mould		○		○
Concave mould		○		
Push pole	○		○	
Diaplasis pole	○			
Round chassis 1	○	○		○
Round chassis 2		○		
Fastener				○

Table 3 : Product components – Manufacturing processes

- **Specifications table**

Making of level of importance is set between values of 1, 3, 5, 7 and 9, to realize greater differences between specifications, where 9 is the most important and 1 is least important

No.	Product	Customer Needs	Imp.
1	Cap mould	Exactitude dimension	9
2	Cap mould	Easy to adjust	5
3	Cap mould	Safety	7

Chapter 3. Selection of CAD software

4	Cap mould	Low cost	7
5	Cap mould	High efficiency	9
6	Cap mould	Hand able	3
7	Cap mould	Operate easily	5
8	Cap mould	Light weight	I

Table 4: Level of Importance for Function of CMOS cap

Chapter 3. Selection of CAD software

3.1 Introduction of CAD

CAD (Computer Aided Draughting and Design) is much more than drawing lines by electronic means. There are many reasons for using CAD as follows:

1. The speed is increased by the use of automatic fillets and chamfers;
2. The computer ability to "snap" automatically to particular geometric points and features will spreadthe accurate positioning of linework.
3. Copy, rotate and mirror facilities are also very handy when drawing symmetrical parts.
4. Many hatch patterns are supplied with CAD programs. Filling areas in various colours is a requirement in artwork and presentations.
5. Different style fonts for text are always supplied with any CAD programs.
6. The possibility of importing different graphic file formats and scanning of material (photographs) into a CAD program is also an asset especially as the image can be manipulated, retouched and animated.

Another advantage of a CAD system is its ability to store entities that are frequently used on drawings. Libraries of regularly used parts can be purchased separately or can be created by the draughtsman. For repetitive use on a dsawing, a typical item may be retrieved and positioned in seconds, also oriented at any angle to suit particular circumstances.

Using CAD products, assembly drawings can be constructed by inserting existing component drawings onto the assembly drawing and positioning them as required.

CAD is very suitableforrepetitiveandfastdocumentationwhereaproduct is one in a range of sizes. Assume that you manufacture a range of motor driven pumps operating at different pressures. Many parts will be used in different combinations in the range and the computer database documentation is programmed accordingly.

3.2 Detailed selection of CAD software

There are many software optional for computer aided design nowadays, which one is the best choice? In my opinion, "Inventor 8" is the most suitable software for my project because of the following reasons:

- **Ease of Use**

A simplified user interface, an advanced help and support system, and built-in migration tools for AutoCAD users make Autodesk Inventor the easiest mechanical design software to learn and use.

- **Simplified User Interface**

  Adesign environmentwith fewer, smarter commands r-eflects theway you want to work. Highly visual feedback and gesture-based interactivity respond intelligently to cursor movements to help you work more efficiently.

- **Advanced Help and Support**

  The award-winning Design Support System (DSS) provides browser-based support to bring you up to speed yuickly and gives you an electronic infrastructure for easy learning.

- **Migration Assistance for AutoCAD Users**

  The Design Support System includes a migration tool to help you move easily from AutoCAD® to 3D.

- **Smartest Choice**

Get the best value in 2D and 3D design--and a risk-free migration path to 3D---with the Autodesk Inventor Series.

- **Exceptional Value**

  Only the Autodesk Inventor Series® offers the best of 2D and 3D technologies for virtually the price of Autodesk Inventor. You protect the value of your 2D software investment while you gain the simplest and lowest-cost path to the most current 3D technology.

- **Complete Flexibility**

  Autodesk Tnventor Series eliminates the need to choose between 2D and 3D technology. With the series offering you can do more with your existing design data and protect your investments in AutoCAD®, AutoCAD® Mechanical, and Autodesk® Mechanica1 Desktop® software.

The 3D mould use Inventor

The whole machine is composed by seven parts, they are: one Protuberant mould, one Concave mould ,four Push pole, one Diaplasis pole. one Round chassis 1,one round chassis2, one Fastener [redacted]

The sketch

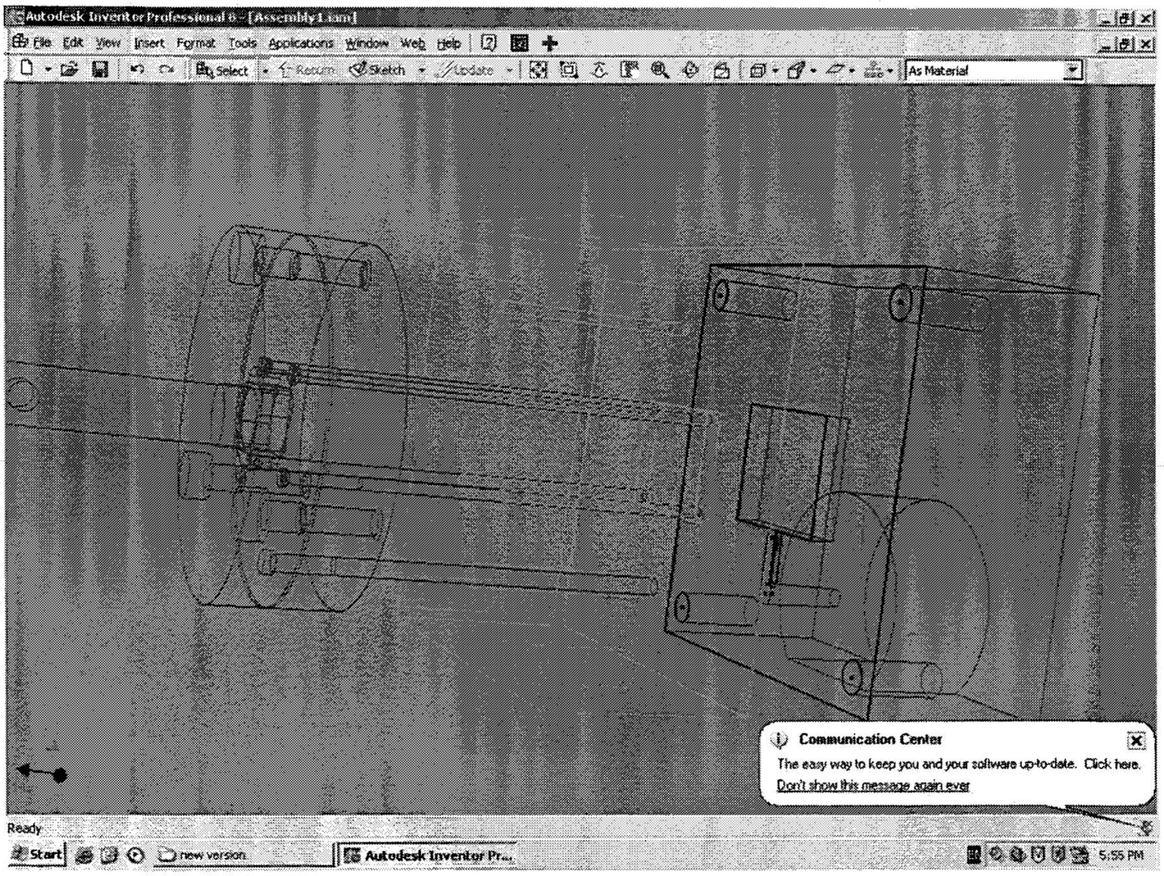

Figure 3.2

Chapter 4. Selection of Moulding method

Chapter 4. Selection of Moulding method

The injection moulding method will be used here.

4.1 Why use injection moulding?

With our modern injection moulding machines, we process a wide variety of different thermoplastic materials into high-quality moulds for the automotive supply industry, commercial vehicle industry, aeronautical engineering and electrical engineering.

Housings and moulded parts with complex geometry and in practically any size can be produced in a single step. Using our own 3D CAD system, and in close collaboration with our tool shop, we are able to meet the demands of our customers in the shortest possible time.

4.2 Introduction to injection moulding

Injection moulding is the most widely used plastics processing method. The process consists of clamping two moulds together into which a molten polymer is injected. High pressure is used in order to obtain fast filling speeds and in order to stop the mould being over filled. The mould is held at a temperature below the melt temperature. This is commonly achieved by circulating water at a specified temperature through the cooling channels in the mould. Once the polymer melt has been set to the shape of the cavity, the mould is opened, the moulded part is ejected, and the process recommences. Injection moulding is the process of choice for producing precision parts in medium to high volume. The major advantages of the process include its versatility in moulding a wide range of products, the ease with which automation can be introduced, the possibility of high production rates and the manufacture of articles with close tolerances.

Injection molding is the most commonly used process for molding plastics because it gives a good surface finish and can be used for very complex moldings. Although requiring a substantial capital investment, injection molding becomes very economically viable in mass production and gives a very low unit production cost. Injection molded plastics are invariably thermoplastics because thermosetting plastics assume their final shape through heat and so cannot be molded with this process.

Familiar products manufactured by injection moulding include: computer enclosures, milk crates, CD cases and mobile phones.

The plastics that are used in injection moulding include: polythene, low-density polyethylene (LDPE), high-density polyethylene (HDPE), polystyrene (PS), polypropylene (PP) and acrylonitrilebutadienestyrene (ABS).

Advantages of the Injection Molding Process:

- High productivity
- Interchangeability
- No waste in the form of scrap
- Cost reduction
- Main power reduction
- Skill reduction

4.3 Moulding Tool − Babyplast

A rnoulding machine, Babyplast (see Figure 4.1), is used to perform this project successfully. Babyplast is a patented model which has been designed and according to the EN201, EN60204-1-1992, EN 292-1, EN292-2 standard.

Figure 4.3: *Mouding machine--- Babyplast*

4.3.1 Introduction to Babyplst

4.3.1.1 General condition

The detailed type of the machine, used here, is babyplast 6/6. It' s needed to emphasize that this injection machine can only be used according to the instructions set out in this manual. If instructions are applied incorrectly, injuries or material damage may be caused.

4.3.1.2 What does Babyplast do?

The **BABYPLAST** 6/6 injection machine is the result of thirty years experience working in the specific fields of plastic injection moulding and mould design and construction.

The machine' s research and development began more than eight years ago, in response to an important area of demand:

---- Small serried production
---- Prototype development
---- Low cost of moulds
----Technical training

Babyplast 6/6 offers adefine solutionto producing smallplasticmoulded parts, without using multiple cavity moulds. This is particularly useful when developing phototypes or producing small series. Owing to the low cost of the moulds used in our machines, in-depth experiments can be carried out before the final mould for large series production is built.

As a result, both small and medium series can be produced easily, and completely independently.

4.3.2 Advantage of using Babyplast

There are many advantages for those that produce small size parts (max 15 grams) in thermoplastic materials:

- ***Lowerproduction cost, even for smallproduction batches.***

Themachine, withonly 3 KW of power consumptionandalowpurchasing cost, allows the production of parts using molds with a low number of cavities (minimum investment in tooling and more precision in the molded part) and minimum production costs. Using conventional machines, it is possible to obtainproductioncosts of parts similartothose obtained with Babyplast, but only with molds having many cavities, and thus a high investment in tooling.

- ***Reduced tooling costs.***

Babyplast, thanks to the particular concept of its platens, allows a reduction in mold costs from 20 to 40% for the same number of cavities. In fact only the cavities have to be made, because the machine platens acts as the mold bolster. In the two drawings that follow, one can see the difference between a four cavity Babyplast mold (75 x 75 mm), and a conventional (176 x 176 mm) 4 cavity mold, for the production of the same part.

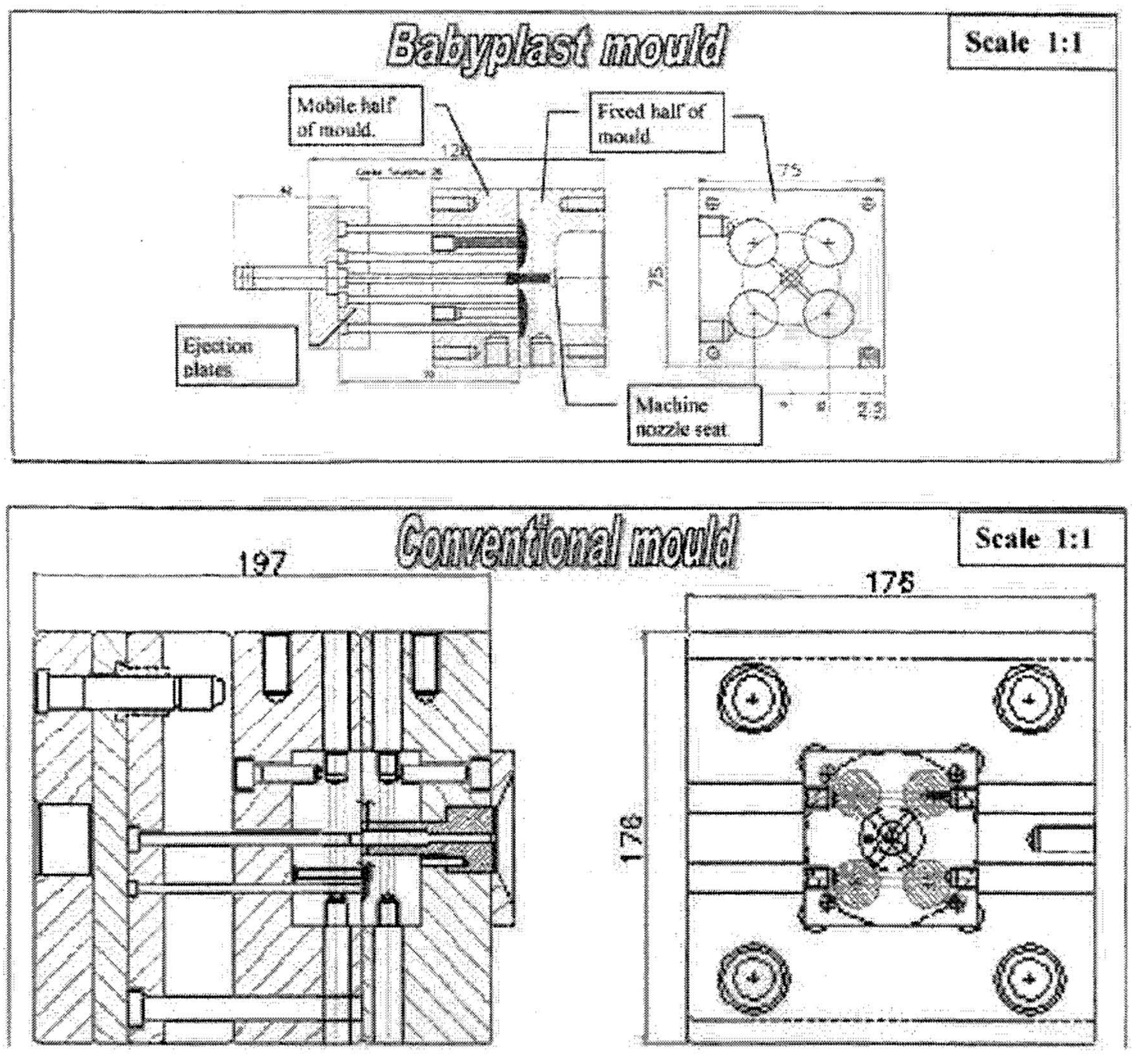

Figure 4.32(1)

- ***Precision of parts produced.***

Technica1 fields require a high standard of precision in the dimensions of parts, this can only be obtained using molds with only a few cavities, and above all thermoplastics materials that are easily degradable. Under such circumstances Babyplast allows the possibility to have precision molds with a few cavities, with low tooling and production costs. Only a small volume of material is held in the cylinder, thus reducing to a minimumthetimethat the plastic material remains at themelttemperature, and hence reduces the risk of degradation.

- ***Low cost samples and preliminary production.***

To ensure a new product enters the market at a competitive cost, a Baby mold can be constructed with a minima1 investment. If the demand becomes greater than the production capacity of the mold, one can evaluate the possibility of constructing a conventional mold with more cavities, or divide the production between a number of Baby molds.

- ***Flexibility.***

By dividing the production between a number of Baby molds, it is possible to save time andreduce the risk of stopping production, ratherthanusing traditional multi-cavity molds.

It is also possible to produce different colored parts from each mold, avoiding waste in material and time. The ratio piece/sprue is greatly improved compared to conventional machines.

- ***Special applications at a reduced risk.***

Without additional costs, the injection unit can be easily moved off center. It is possible to inject directly into the part from the machine nozzle or by means of runner multi tip.

- ***A higher quality product.***

Aonecavitymoldensurestheproductionofuniformandperfectlybalanced parts.

- ***Significantly lower tooling investment.***

By purchasing Babyplast, a mini-robot complete with accessories for loading inserts, and a single cavity baby mold, the customer spent 20% less than the cost of a conventional mold, with 4 cavities, and modifications to the robot for the inserts (the customer already had the robot). If the customer needed to purchase the machine and robot as well, the conventional solution would have cost 4 times that of the Babyplast. Reduction in time. The moldchangeover and start up times associatedwith the conventional solution, where the production demand is insufficient to saturate the production capacity of a 60-ton press, are inexistent. The Babyplast machine has been purchased exclusively for this product. Babyplast 6/10, thanks to its particular characteristics, plays a key part in many cases, for solving various problems simply and economically. For example, a customer had to produce 2,500,000pieces a month of a small part of PA 66 + 30% GF that weighed 0.1 gram.

To obtain an acceptable cost of the part, they had to construct a mold with 250 cavities, preferably with a hot runner system, to reduce the size of the sprue, and purchase a conventional machine with a low tonnage.

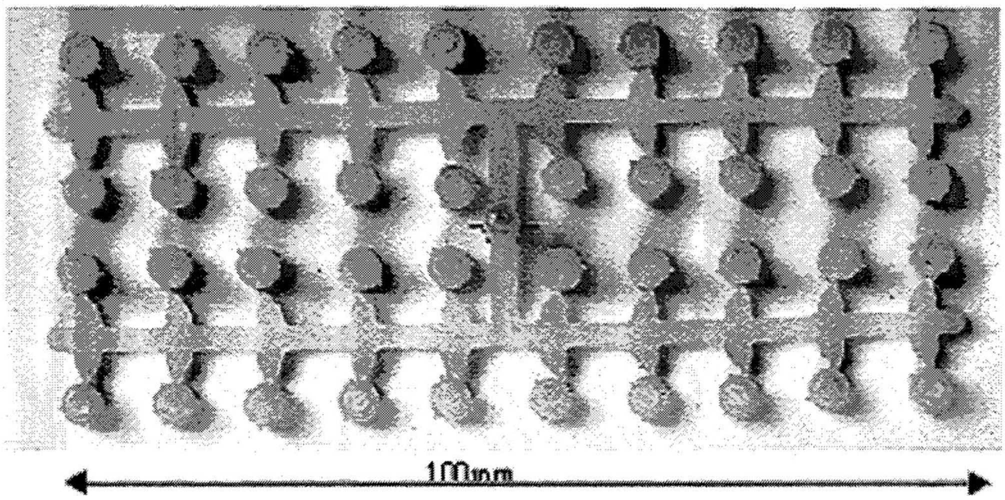

Figure 4.32(2)

Instead with Babyplast 6/10, they were able to construct a mold with 40 cavities and the sprue only weighed 2 grams (L 100 mm - H 30 mm). The machine is used exclusively for the production of this part. There are no mold or material changes. The investment in the Baby mold and Babyplast machine is 20% less than the cost of just the mold for a conventional system.

The customer has also achieved the following advantages: it was not necessary to purchase a new machine, the space occupied was reduced (Babyplast occupies less than 1 m^2), the size of the sprue has been reduced making it easier to recycle, reduced costs for production changes, simplified mold construction, and improved the dimensional uniformity of the part.

4.4 Injection Molding Design Guidelines

Much has been written regarding design guidelines for injection molding. Yet, the design guidelines can be summed up in just a few design rules.

Use uniform wall thicknesses throughout the part. This will minimize sinking, warping, residual stresses, and improve mold fill and cycle times.

Use generous radius at all corners. The inside corner radius should be a minimum of one material thickness.

Use the least thickness compliant with the process, material, or product design requirements. Using the least wall thickness for the process ensures rapid cooling, short cycle times, and minimum shot weight. All these result in the least possible part cost.

Design parts to facilitate easy withdrawal from the mold by providing draft (taper) in the direction of mold opening or closing.

Use ribs or gussets to improve part stiffness in bending. This avoids the use of thick section to achieve the same, thereby saving on part weight, material costs, and cycle time costs.

4.4 Injection Moulding

- Basic process – Heat a thermoplastic material until it melts. Force it into a hollow (cooled) cavity under pressure to fill the mold. When cool remove the finished part.

- Typical materials are,
  -Nylon
  -Styrene
  -Ethylene

• A typical injection moulding machine is seen below with the covers removed. Plastic pellets are poured in the hopper, and finished parts emerge from the dies.

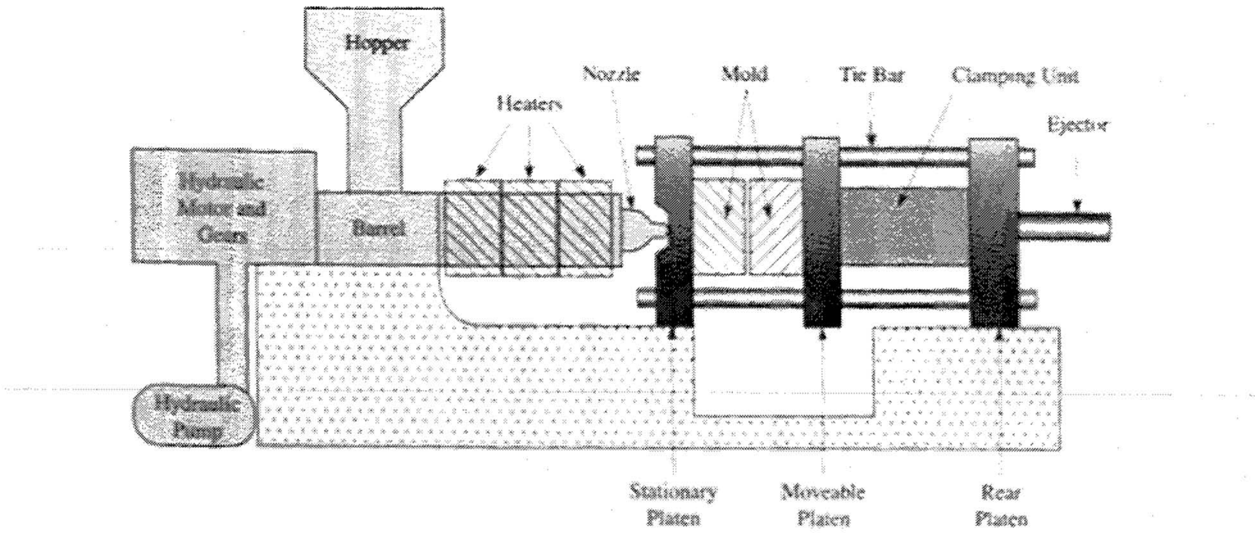

Figure J.4

Injection system,

1. – a material hopper acts as an input buffer
2. – a heated chamber melts the material
3. – an injector forces the now viscous fluid into the mold

• [redacted]

（什么？图呢，有用吗，没有用 de 话，删）

• Current mechanisms use a reciprocating screw,

1. – basically the screw extends from the hopper to the injection chamber.
2. – along the length of the screw chamber, heater bands are used to melt the plastic.
3. – as the screw turns, it moves raw solid plastic from the hopper, to the injection chamber. The buildup of pressure in the injection chamber forces the screw back until enough for a shot has accumulated.

4. – the screw is forced forward to inject the plastic into the mold.

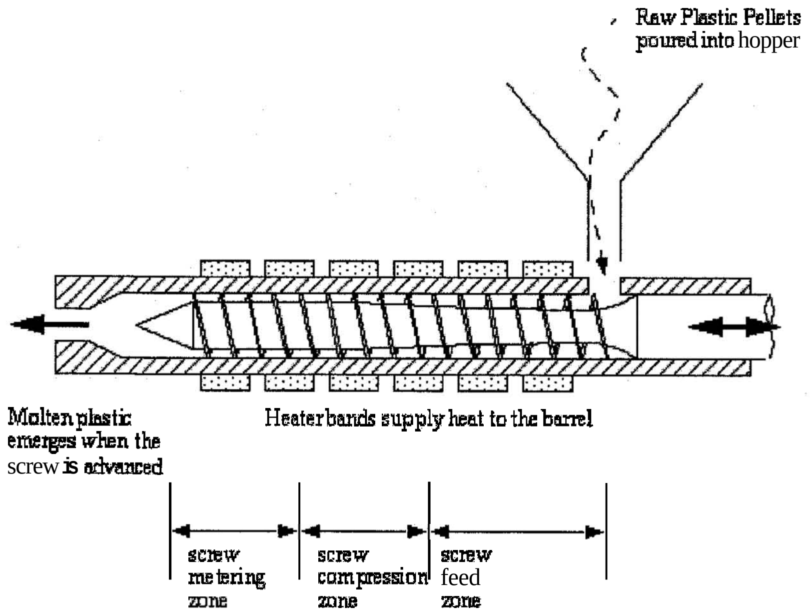

Figure 232

1. – there is a contribution to melting by pressure that allows the temperature of the heating bands to be lower.
2. – the purpose of the screw is to generate a homogenous melt with little orientation in flow direction.

- Typical zones can be identified on the screw,

1. – feed – a screw with large cavities to carry more material.
2. – compression – the depths of the screw thread reduce, leading to elevated pressures, and pressure induced melting.
3. – metering – small and uniform threads to provide controlled quantities. This also serves as a final mixing stage.

- Screws are often low/medium/high compression ratio as a result of the change of screw volume from the feed to the metering stages – screw selection will vary between materials, but a low compression ration screw will ensure good melting in most cases.

- Screws are nitride treated to improve tool life. Screws might also be made slightly smaller to compensate for thermal expansion when heated.

- Screws are often driven by electric or hydraulic motors.

- The heat capacity and melting point temperatures of various materials determine the energy required to melt the plastic and the energy to be removed for solidification (and for ejection).

- The volume of the injection chamber determines the maximummold cavity size. The volume provided is often for polystyrene. When using other materials the volume can be corrected using the following formula. For example a 10 oz. shot,

$$\left(\frac{SG_{material}}{SG_{polystyrene}}\right)(oz_{shot}) = \left(\frac{SG_{material}}{1.05}\right)(oz_{shot})$$

The mold is held closed with a certain clamp tonnage.

- As cycle times decrease, the plastic melt becomes less consistent.

- Each heating zone uses electrical heating bands with thermocouples, or pyrometers to control the temperature.

- When injecting, the mold is moved then clamped shut. The mold halves are mounted/clamped/screwed on two platens, one fixed, one moving. The stationary platen has a locating ring to allow positioning on the mold half over the injection nozzle. The moving half has ejector pins to knock out the finished part. Larger plates are found on larger injection molding machines.

- Injectionmoldingmachines pressure is calculatedasinjectionpressure over an area in the mold. Consider the case where a mold with a 10 square inch mold is being filled in a 200-ton machine.

$$P = \frac{F}{A} = \frac{200}{10} = 20\frac{tons}{inch^2} = 40ksi$$

4.4 Moulds

- Injection molds are mainly made of steels and alloys steels. A simple mold is shown below.

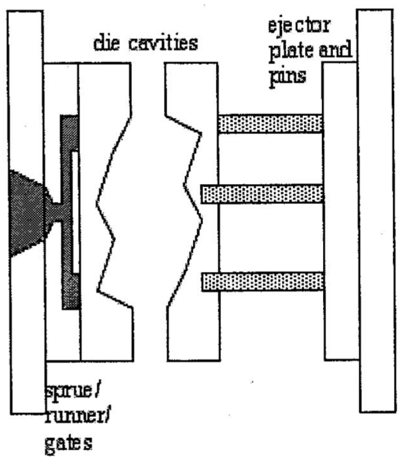

Figure 4.4(1)

1. Locating ring - guides the injection nozzle into the mold.
2. Sprue Bushing - where the injected material enters the mold cavities.
3. Clamp front plate - Secures the front cavity, locating ring, and other components to the stationary platen.
4. Front cavity - holds half of the negative of the shape to be motded. Guide pin holes are put in this plate.
5. Rear cavity - the mating half for the front cavity that completes

the negative of the final part. Guide pins are mounted on this to ensure correctly aligned cavities.

6. Spacer Blocks/Rails – used to separate the rear cavity from the rear clamp plate.
7. Ejector housing – contains the ejector pins to knock the parts out of the mold and forces the cavity back when the mold is closed.
8. Rear Clamp Plate – Supports the rear half of the mold on the moving platen, and provides rigidity under molding pressures.

Components to consider in mold design,

1. – part design
2. – material
3. – machine used

- Factors that are often altered in the design are,
  1. gating
  2. runners
  3. rnold cooling
  4. ejection

- Gating can be done a number of ways

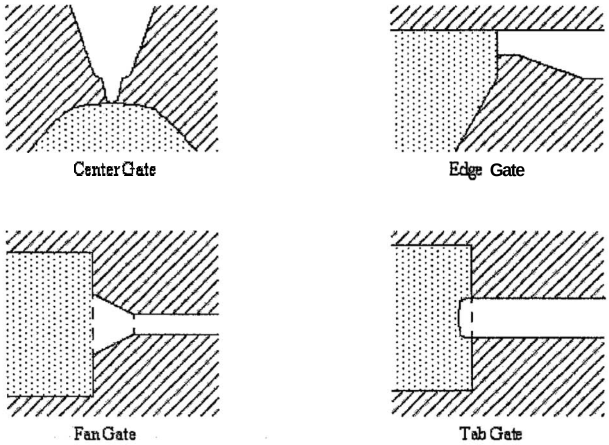

Figure 4.4 (2)

Runners carry the plastic to the injection gates and are often considered disposable or reusable. Typical runner systems are,

1. cold runner
2. hot runner
3. insulated runner

- **Cooling systems allow rapid uniform cooling to increase cycle times, and reduce scrap. Typical** techniques **are,**

1. – water lines
2. – baffles
3. – fountains
4. – thermal pins

- **Ejection systems will push the part out of the mold when it is** opened.

1. knockout pins
2. blades
3. stripper rings
4. air
5. hard stripping

Chapter 5. Concept design

Chapter 5. Concept design

5.1 The Product Design Specification (PDS)

5.11 what is PDS?

The starting point for any design activity is thus market research, competition analysis, literature searching, patent extracting, etc., from which a comprehensive PDS must Be prepared. The end of the design activity, the design of the product must be in 'balance' with the PDS.

When beginning a design work, to know what the customers need is really important. This is the first and basic stage to help you to make idea. Many products fail on the market because the rnanufacturers don' t pay enough attention to the customers' words. This results they miss some important points and their product is not so perfect.

In order to improve this aspect, we can collect the information in many ways: through questionnaire, interview, advertisements, and posts. The customers are forefront users. Normally they can give us suggestions from their experience. And these first-hand statistics are very precious to the designer. We can learn from the customer needs that what they want, what they expect to the product, or do they have special requirements from the product. They can be collected first, then, of course, many of them have to be screened according to our design ability, material cost and producing technology etc.

For the product Yogurt Holder, some customer needs and market demands were collected. After screening, the points below were listed due to its importance.

5. 12 Elements of the product design specifications

Here is the photo of the element, there are total 32 elements which surrounding the design core:

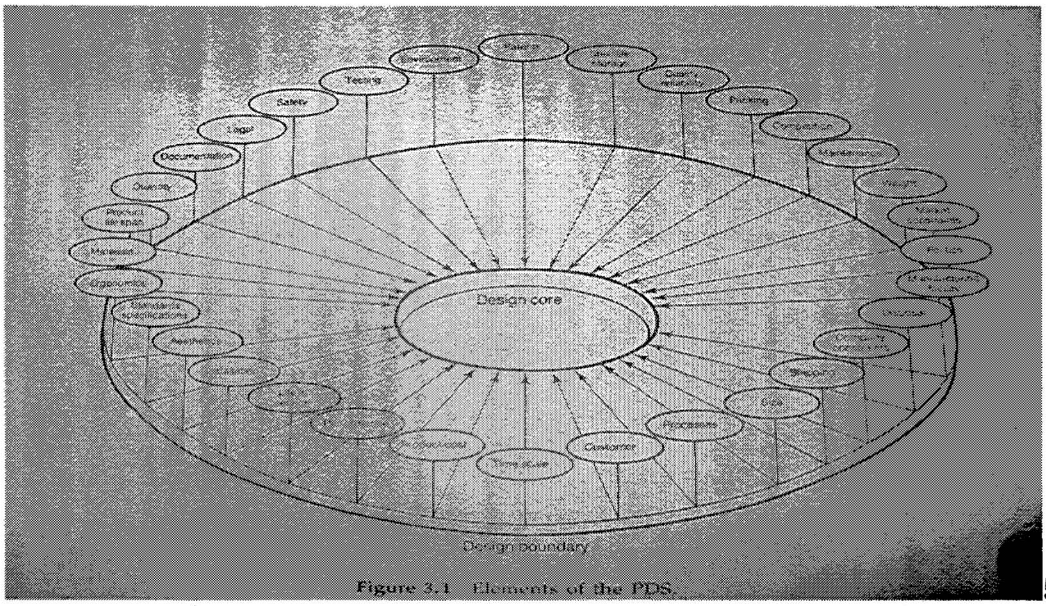

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Figure 5.12

They are:

(1) Performance

(2) Environment

(3) Life in service

(4) Maintenance

(5) Target product cost

(6) Competition

(7) Shipping

(8) Packing

(9) Quality

(10) Manufacturing facility

(11) Size

(12) Weight

(13) Aesthetics, appearance and finish

(14) Materials

(15) Product life span

(16) Standards and specification

(17) Ergonomics

(18) Customer

(19) Quality and reliability

(20) Shelf life (storage)

(21) Processes

(22) Time-scales

(23) Testing

(24) Safety

(25) Cornpany constraints

(26) Market constraints

(27) Patents, literature and product data

(28) Political and social implications

(29) Legal

(30) Installation

(31) Documentation

(32) Disposal

We choose ten of the 32 as the prior considered elements, in according to which one do the most important effect.

1 performance

2 product cost

3 materials

4 time scale

5 weight

6 manufacturing facility

7 environment

8 safety

5.2 The requirement of the product

Serviceability and Functionality

- Easy to use
- Light
- Portable

Produce-ability

- Quantity: 100,000 per year
- Easy to manufacture
- Common material
- Easy to assemble
- Attractive shape

Maintainability

- Easy to clean
- Detergent are acceptable to be used
- Life more than 10 years

Safety

- **Using non-toxic** material
- **Round edge**

Reliability

- Using **non-toxic material**
- **Round** edge
- **Durability**

Marketing

- Production: 100,000 per year
- Price of product: 2 Euro
- Impressive, colorful surface
- Time from production to marketing: one month
- Collect customers needs on time

5.3 Design preparation

The design of plastic is very complicated since its various variety, its outstanding capability and its broad purpose. Design preparation of plastic product will be made in two fields described below.

1. Main design ideas

Like any other industry product, the plastic product design should meet the performance requirements. Creativity is also considered in the product design to reduce cost and improve the competition. With the development of the industrial technology and the improvement of people' s living level, the nice and delicate plastic product is more popular.

2. Information collection and idea selection

The purpose of the information collectlon is to understand the market situation and the production technology. Market is not only the product distribution but also the product development. Production technology includes detailed information on technology such as the material types and cost, production equipment.

Chapter 6. Detailed design

Chapter 6. Detailed design

6.1 General description

This chapter describes the detail design base on the result of selected and principle design in chapter 3 and chapter 4.

6.2 Detailed design of CMOS cap

6.2.1 Material selection of CMOS cap

- **Possible materials**

There are some possible typical materials shown in Table5

MATERIAL	IDENTIFICATION	PROPERTIES	APPLICATION
A.B.S.	Soluble in toluene and ethylene dichloride, burns with a yellow flame continue to burn after the removal flame with black smoke	Tough, hard heat resistance. Dimensional stability. Chemical resistance Easy Processing & Manufacturing	Protecting and decorative housing for telephones, radio, machines, automotive instruments.
NYLON	Burns with blue flame & odor of burned hair or burned wool.	Tough, relatively hard low coefficient of	Gear, bearings, bushes, bulb. Making ropes,

	Soluble in Phenol formic acid type solvents	friction excellent wear resistance. It absorbs water and alcohol but doesn't cause any permanent changes. Good thermal resistance.	sport's equipments, load bearing supports.
POLYCARBONATE	Burns with yellow or orange flames, and gives odor like phenol. Soluble in methylene dichloride, sometimes in ethylene dichloride.	Good impact strength, good creep resistance, good dimensional stability. Low water absorption, 88% transparency.	
POLYPROPYLENE	Floats on water, burns with blue flame with yellow tip and gives acidic odor similar to diesel fumes, it is soluble in hot toluene.	Outstanding electrical insulating material, unaffected by moisture. Excellent surface appearance rigid and resistant to staining. Unaffected by attack of bacteria or fungi. Mould shrinkage is less.	Automotive Parts, Doors frames kick panel, hospital sterilized equipments, luggage, washing machine parts, combs, furniture, wire coating, caps.

POLYSTYRENE	Burns with yellow flame and gives odor of illuminating gas create dense black smoke soluble in acetone, benzene, toluene and ether.	P.S. is modified with rubber to improve its impact strength, excellent mold ability, excellent dimensional stability, negligible absorption of water, excellent resistance to chemical corrosion.	House wear like jugs, plate's combs, tooth brush handle toys, decorative articles, and jewelry boxes refrigerator components.

Table 5: Types of **plastic** materials

- **Result of material selection of CMOS cap**

As said in section 1.2, the material of CMOS cap should have high strength and have a resistance in wear. I choose POLYPROPYLENE as the final selection according to the properties of possible materials and application shown in Table 10.

6.2.2 size design of CMOS cap

The dimension of the cap:

27×22×4 outside

24×19×2.5 inside

There is the picture of the cap:

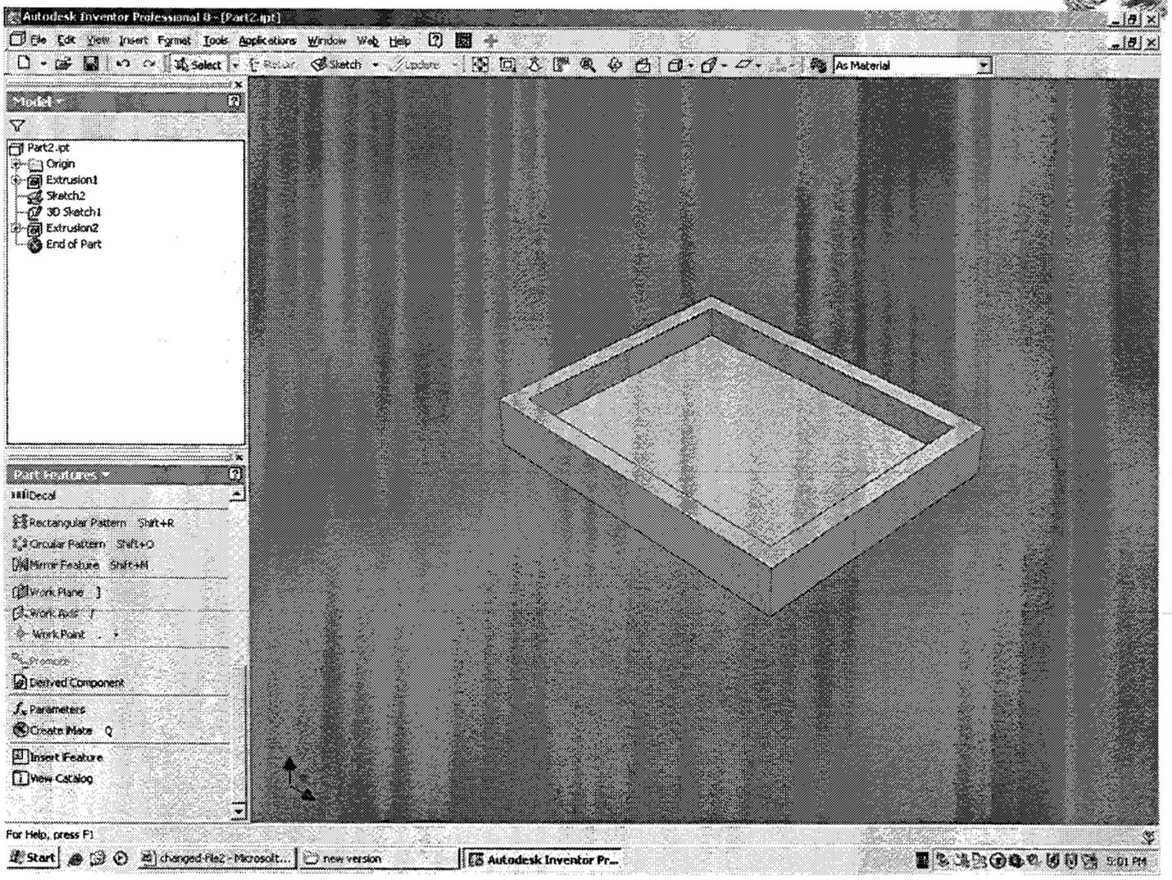


Figure 6.22

6.3. Detailed design of cap mould

6.3.1 Material selection of cap mould

➢ **Possible materials of cap mould**

The material of CMOS cap is selected as POLYPROPYLENE. The concerned materials of mould will be AISI1045, 40cr and so on (see P. 171 of *Ref. 9*).

➢ **Result of material selection of Cap mlould**

Since that the total cost of mould should be as cheap as possible when the other performances are satisfied, AISI 1045 is used as the material of cap mould here. The other materials, such as 40cr, will not be used in this case due to their higher cost.

6.3.2 Thickness design of the cast

Each plastic piece including configuration piece and ply, according to

the requirements of using, should have a certain thickness for keeping mechanism strength. In general, the thickness should be as thin as possiblewhen the requirements ofthe mechanicalperformancesare met. By this way, the cost of producing can be reduced and the solidification time of plastic piece can be shortened. And the quality problems arising due to the large thickness can be avoided efficiently.
However, the floating resistance of molten plastic inside the mould cavity increases when the thickness of the plastic piece is too thin. It will be very difficult to make a mould. In addition, the big disparity between thickness and superficial extent will warp plastic pieces and as well reduces their quality.

It should be stated that the difference of the thickness of the stepped plastic piece walls should be small. Otherwise, the plastic piece will be broken. At the same time, the circular arc transition should be used if possible.

The thickness of the plastic pieces with small sizes can be selected from lmm to 2.5 mm. Furthermore, the good fluid capability of materials such as polyethylene, polypropylene and polyester, can make the plastic pieces thinner. Considering that the CMOS cap is a plastic piece with small size (see section 6.2.1) and the polypropylene is selected as the material of the CMOS cap in this case, I selected 1mm as the thickness of the CMOS cap here.

6.3.3 Pitch design of mould off

Because of the shrinkage of the plastic piece during the molding cooling process, theplasticpieceis hoopedonthebulgeofmouldor coretightly. Both the internal and external surface of plastic piece paralleling the direction of mould off should have a certain pitch in order to take off mould and avoid draw plastic piece broken or surface damaged (see

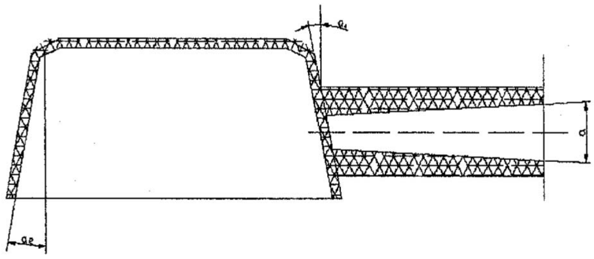


Figure 3. 3).

Ficture 3-3

Figure 6.33

The pitch of mould off (脱模斜度)from 30' to 1°30' can be selected for the plastic pieces under the appropriate condition. A smaller value will be selected for the pitch of mould off when the molding Core is longer or the cavity is deeper. Contrarily, the larger pitch will be selected. Furthermore, the pitch of the external surface is designed smaller than that of the internal. The pitch of the mould off also have to be considered when there is some flower pattern or sign designed on the plastic piece. 1° is added in the pitch of mould off when 0.02 mm is added in the deepness. In addition, the pitch of mould off also relates with the thickness of the wall and the rate of the material shrinkage.

6.34 Round angle

currently, plastic piece dopt round-angle to connect on the each well joints, only especial requirement use sharp-angled. However, when it bears force or strikes that sharp-angled engender stress-convergence, to break easily. Therefore, round-angle is not only advantaged for molding but also advantaged for floating of molten plastic on the mould cavity and mould off of plastic piece. Figure 3-4 given the extension to choose value of round-angle. Figure 3-5 show relation between the ratio is the radius of well thickness of plastic on joints compare with around well thickness R/t, and stress-convergence coefficient. The curve run to smooth after R/t =0.6.

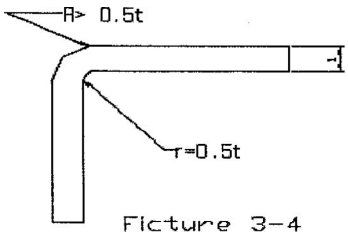


Figure 6.34

6.35FLOW PROPERTIES OF THE MOLTEN PLASTICS

6.36SHRINKAGE

For a sure quantity plastic, the bulk ofmelting always biggerthan solid, so the dimension of cast must smaller than mould, which should be considered and plus some spacing there when we design the cast. The shrinking measure can be figure out:

$$Q=(a-b)/a \times 100\%$$

a—the dimension of cast in molding temperature.

b —The dimension of cast in normal temperature

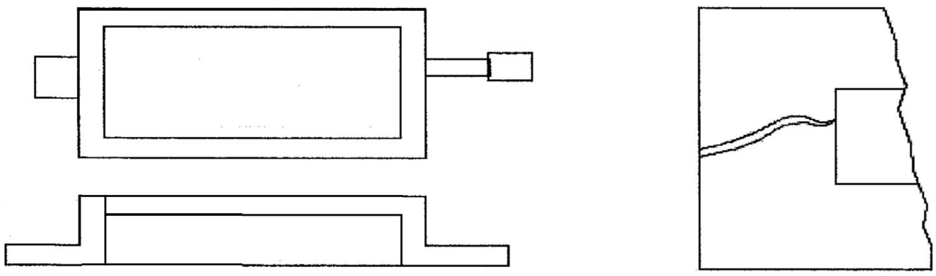
The shrinking measure of POLYPROPYLENE is 1.0-2.5 (%)

Definition: – The individual plastic molecule expands more and takes up more space as the temperature rises.

6.37 VENTING

VENTING: is the channel designed for evacuating the air from the cavity at the time of moulding.

Venting **POSITION**: The vent should be set at the end of the approach of melting material (a). As figure (b) the venting channel should be made to curving, and the section is form narrow to broad, in order to decrease the kinetic energy of melting material.



(a) (b)

Ficture *5-25*

Figure 6.37

VENTING SIZE: - The breadth of vent can be designed to 1.5–5mm, a shallow slot with depth is 0.02 mm to 0.03mm thickness. In case of very viscous material it is up to 0.05mm. The deep of vent of PP is 0.02.

In case of necessity to provide the vent through the mould plate, then it can be achieved by incorporating ejector pins in the required positions.

6.38 Thermoregulation

Thermoregulation: Increase or reduce the temperature of injection molding by water or oil in order to control the effect of temperature to flowing, solidify and productivity

The simplest and cheapest one id water, most cooling is used water, The quantity of heat used water can be numerate as:

$$Q_W = Q - (Q_n + Q_k + Q_l)$$

Q_W--- diffused quantity of heat of mould

Q --- the quantity of heat from plastic to mould

Qc--- the quantity of heat of convection

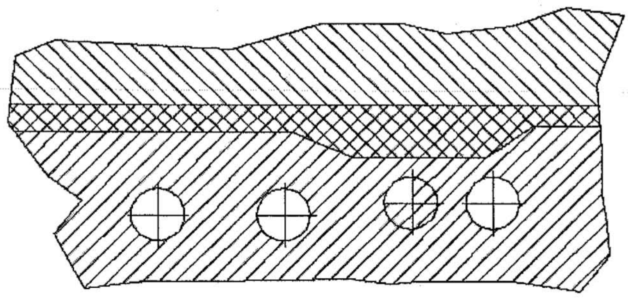
Qr--- the quantity of heat of radiation

&I--- the quantity of heat of refluence

The principle of design of thermoregulation:

- More amount, more proportion if possible.
- The position should as close the surface of mould as possible .

The thick part should be intensifying cool, as follow:



Ficture 5-33

Figure6.38

- The entrance of cooling channel should as close as the orifice, in order to intensify cooling.

6. 4The design of the jig

The jig of the cap includes seven parts. They are protuberant mould, convexity mould, push pole, diaplasis pole, round chassis 1, round chassis 2, fastener.

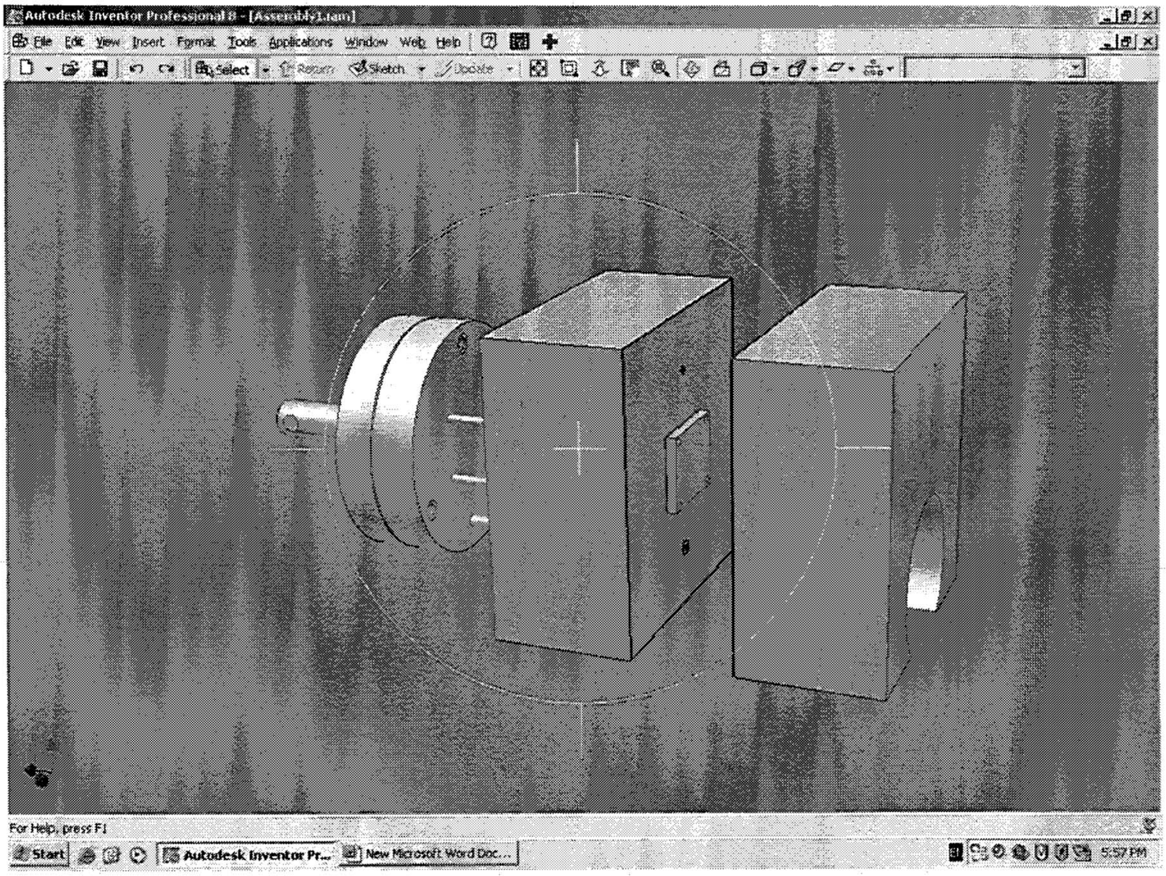


Figure 6.4 (Ij

- The design of the protuberant mould

This part is one of the most important parts of the jig .When I start to design it, there are two feasibilities can be chose. One is like this ( ) The other one is

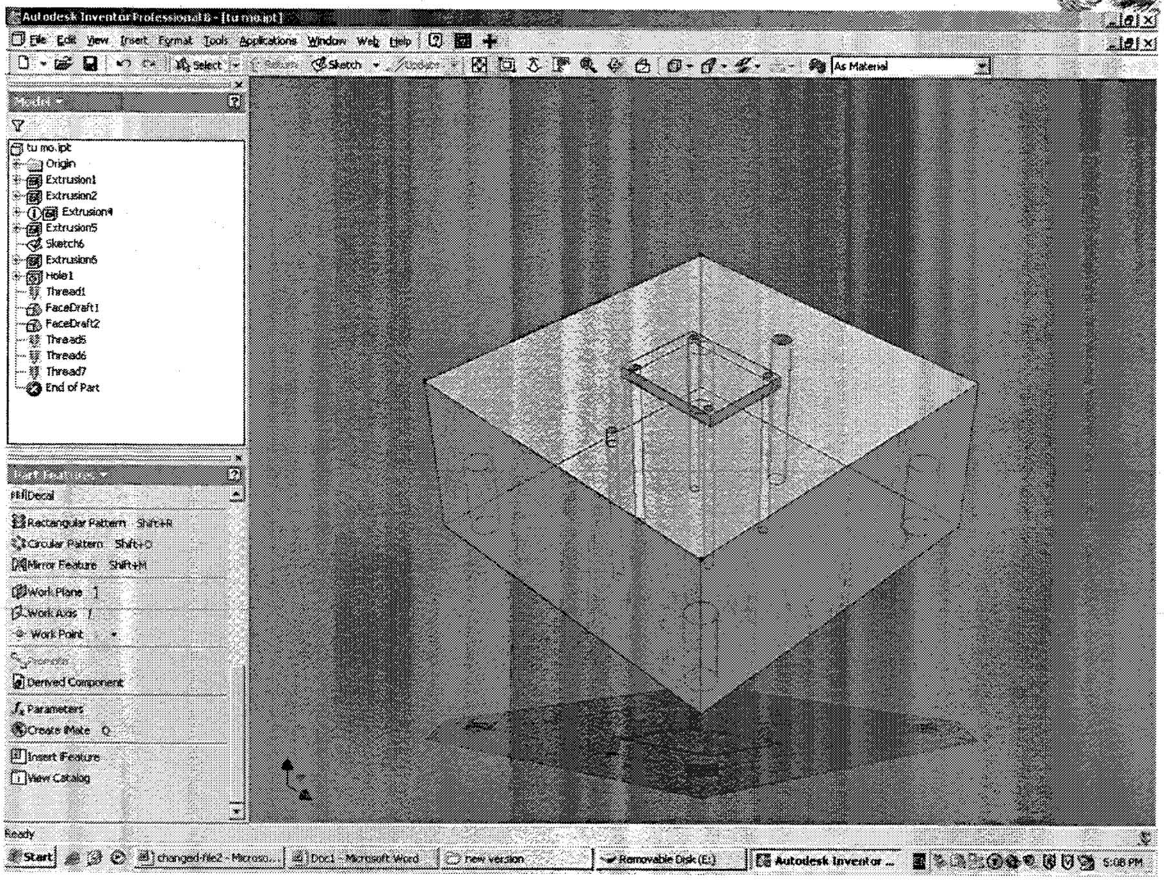


***Figure** 6. 4(2)*

At least, by the comparing of the two projects available, I prefer the last one. It is the best way that the rectangular cap be extruded the thrust act on the four angles. Obviously, thrust is the equal that way, then the hardest situation the four angles will be extrude easily for the concentrated power on them.

I used to design this part like:

Besides, a reverse angle is put on the end of cast meatus specially. The function of the reverse angle is important is can part the cast after cooling. The pitch of the reverse angle can not very big, neither very small, the good way is more than 1° at least.

- **The design of the convexity mould**

Considering the cast is subminiature, the design of the cast [redacted] has three mould principles, there are

- Avoiding melt breach and disfigure in process
- be propitious to improving the capability of products
- Be propitious to flow & exhaust

So, I design the cast meatus under the cast, it like below:

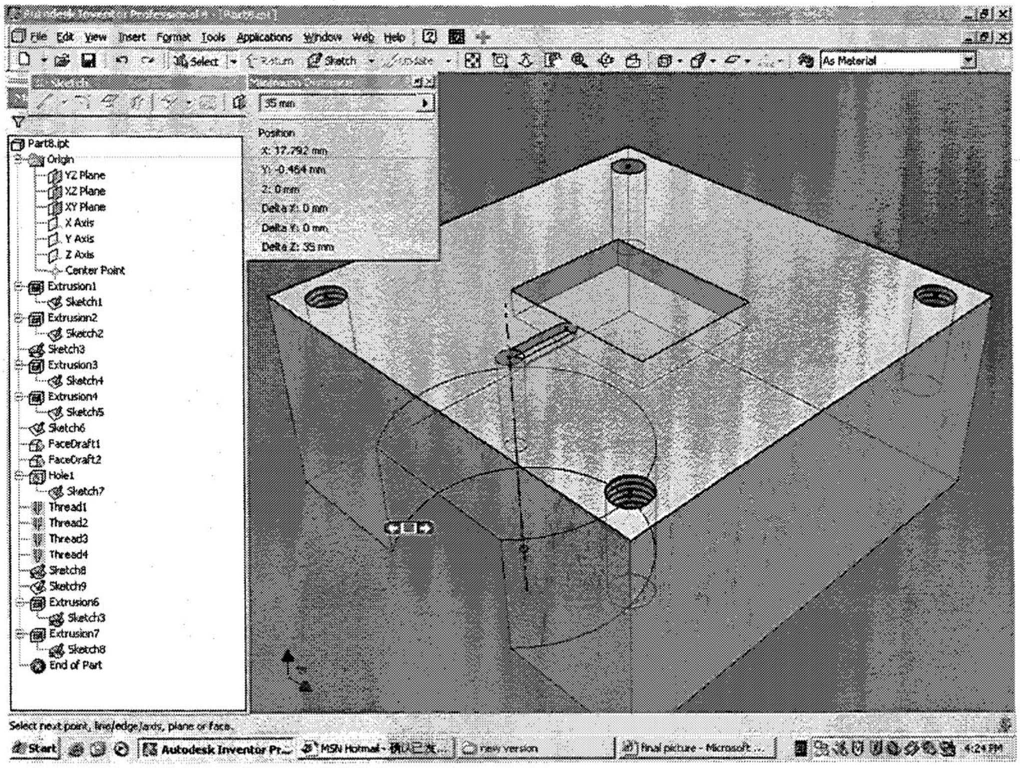


Figure 6.4(3)

The space back of concave mould is for the nozzle of the machine.

- The design of the other parts of jig

- The screen-print of push pole:

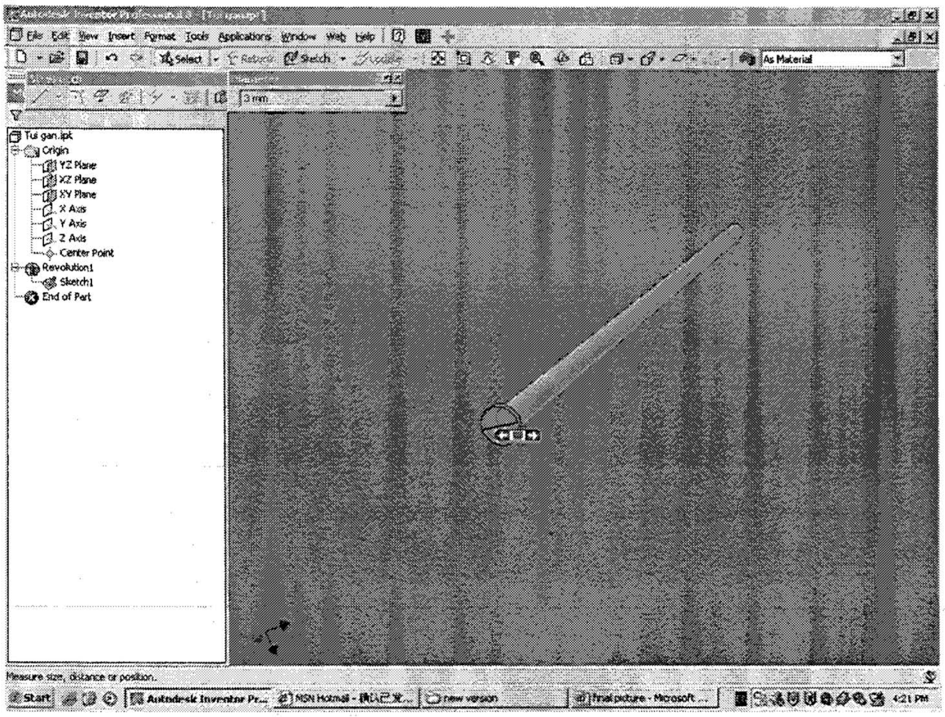


Figure **5.4** *(4)*

✓ The design of the diaplasis pole,

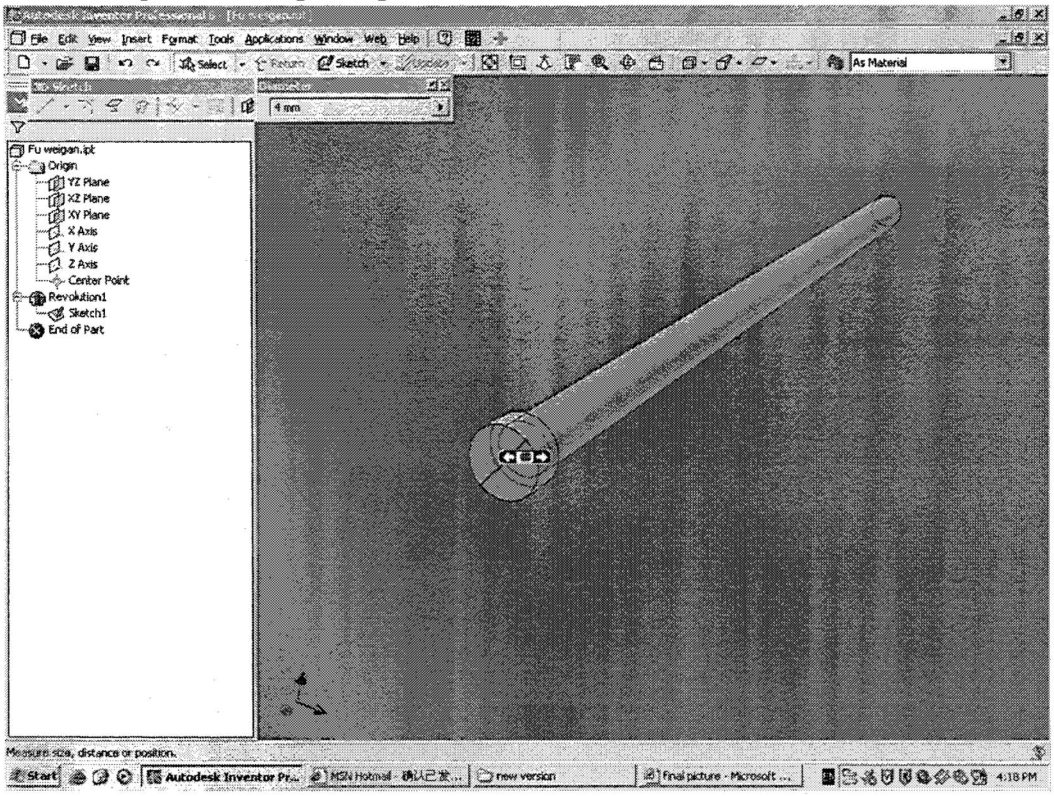


Figure6.4 (5)

J The design of the round chassis

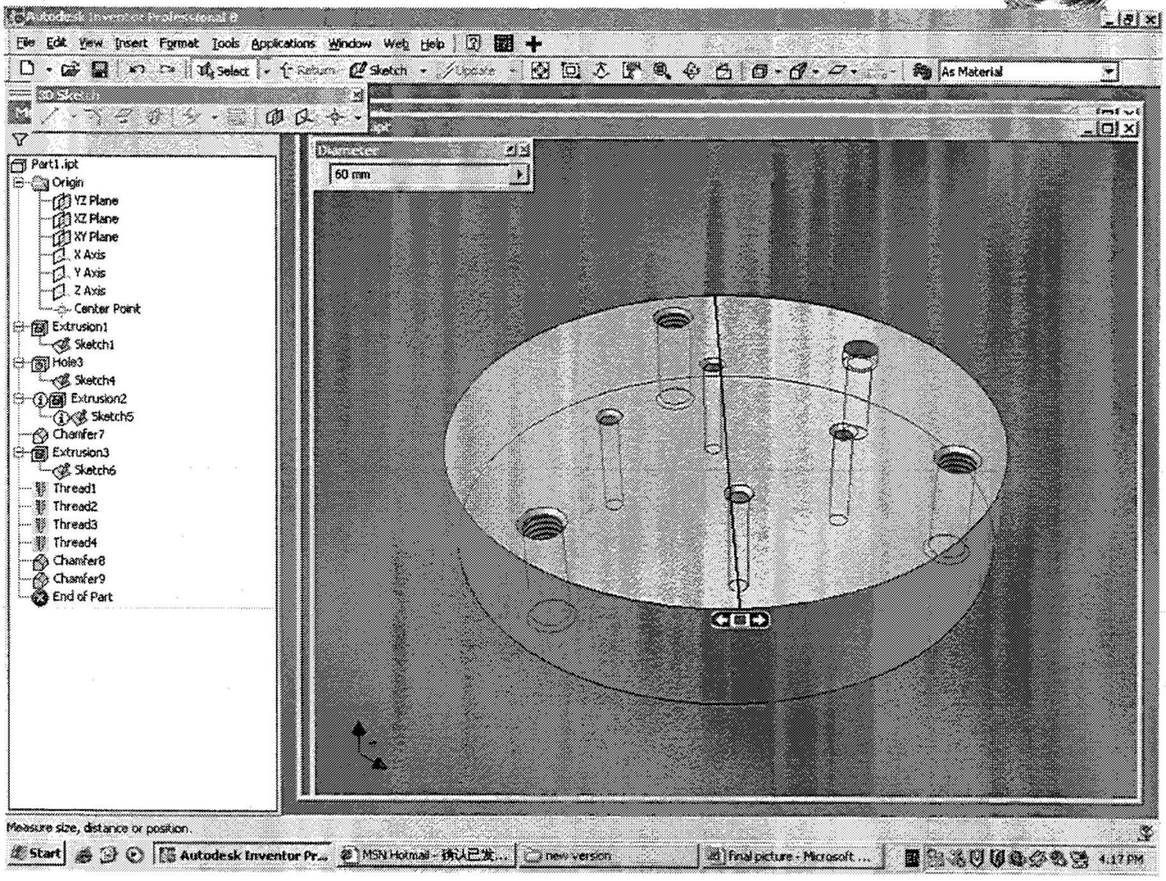


Figure **6.4** （6）

✓ The design **of** the round chassis 2

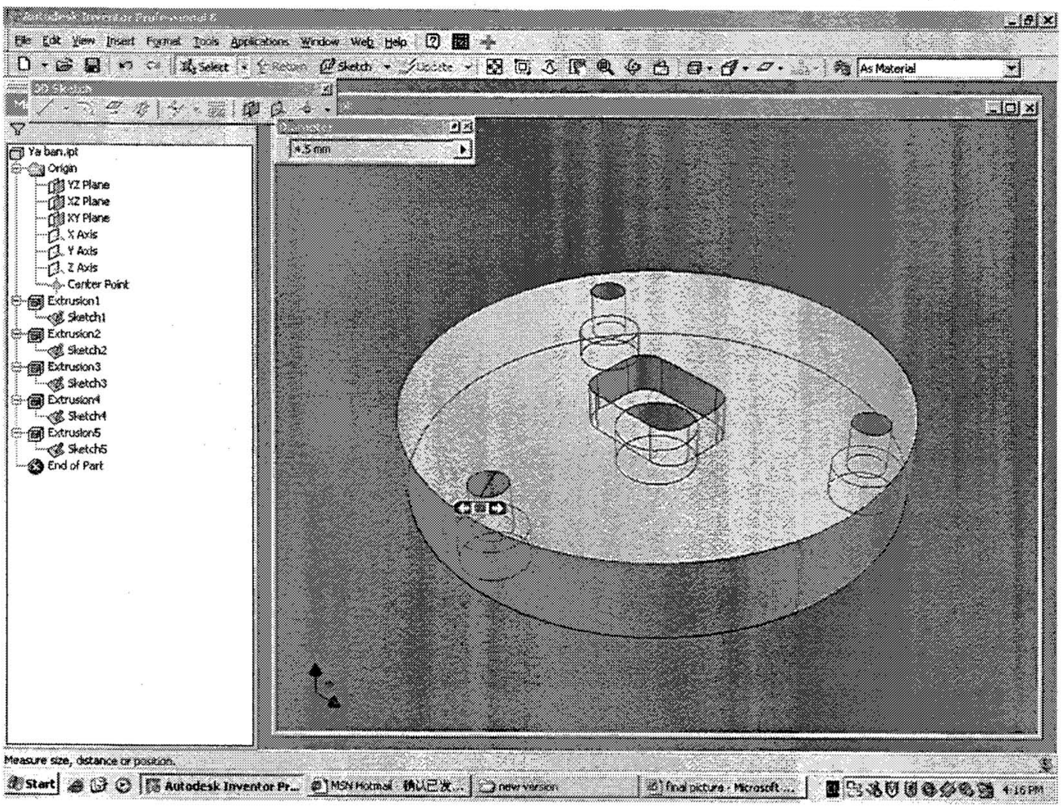


Figure 6.4 （7）

✓ The design of the fastener

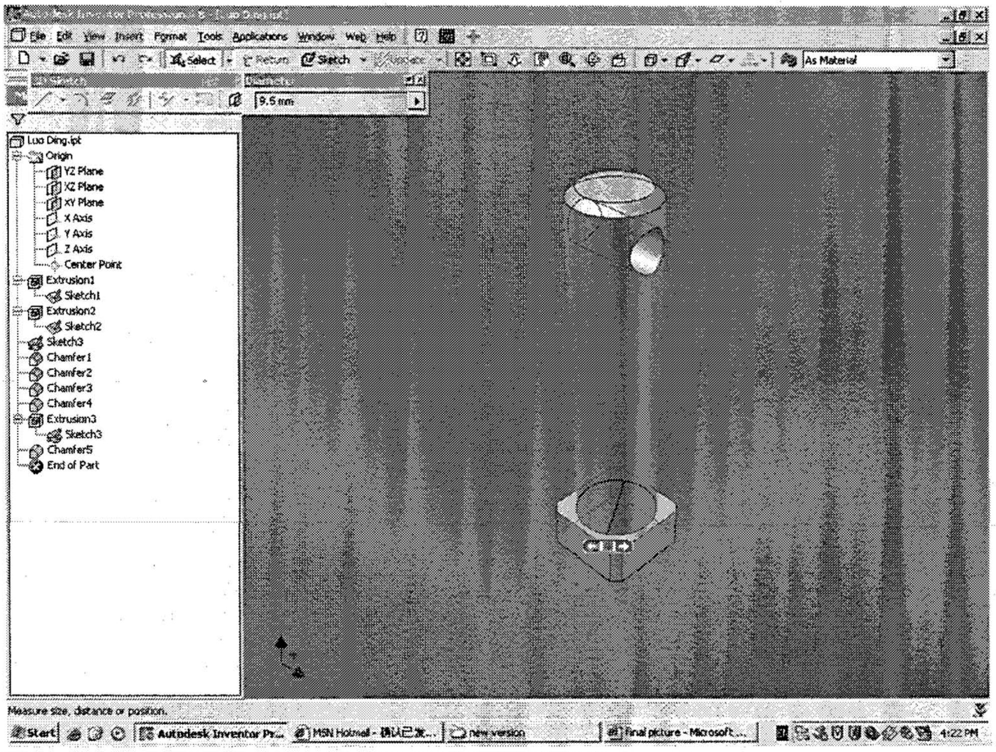


Figure 6.4 (8)

6. 5 Relationship between injection moulding and injection machine

- **The proof of quantity**

N — amount of moulding room

ms -- the volume of cast

mj --- the volume of else parts

mi--- the gross of melting material

The concerning expression is:

$$mi = N*ms + mj$$

mi should be less than the maximum injection volume of injection machine (m_I). According to the concerning experience, the relationship between them can be described as:

$$mi = (0.1-0.8)mI$$

So,

$$N \le ((0.1-0.8)mI - mj/ms$$

- **The proof of injection press**

Considering that the press relates with the liquidity ratio, the different injection pressure is selected for the various materials with different liquidity ratio. The liquidity ratio can be calculated by:

$$V = \sum Li/ti$$

Where V--- the liquidity ratio

Li--- the length of channels

ti -- the height of channels

- **The proof of force**

FI---The rating force

FL--- The composition of forces

$$FL \leqq (0.8-0.9)FI$$

- **The proof of thickness moulding**

The minimum thickness --- Hmin

The maximum thickness --- Hmax

The actual thickness --- Hm

Expressions:

$$Hmin \leqq Hm \leqq Hmax$$

- **the proof of the extent**

Hl--- the cast needing distance for separate

H2--- the height of cast

(5～10)mm--- clearance

Smax---the maximum extent

Expressions: $S_{max} \geqq H1+H2+(5-10)$ mm

6.6 Agglutinating

TENAX-7R: This space age plastic WELDER is super fast drying that is excellent for models and plastic sheets. Remember you will be welding, not gluing. This means that in order for your TENAX-7R to work the parts must be in place and touching. Then you simply touch the seam with your TOUCH-N-FLOW applicator(76075 or 76076) The TENAX-7R will fuse the seam by capillary action. This will actually weld the parts. Now hold the parts for approximately 10 seconds or until you have a firm bond. The complete weld will take about five minutes to cure but you are able to continue before a full cure is complete.

Figure **6.6**

Weight: 0.10 **lbs** $2.75

Chapter 7. Conclusion

Chapter 7. Conclusion

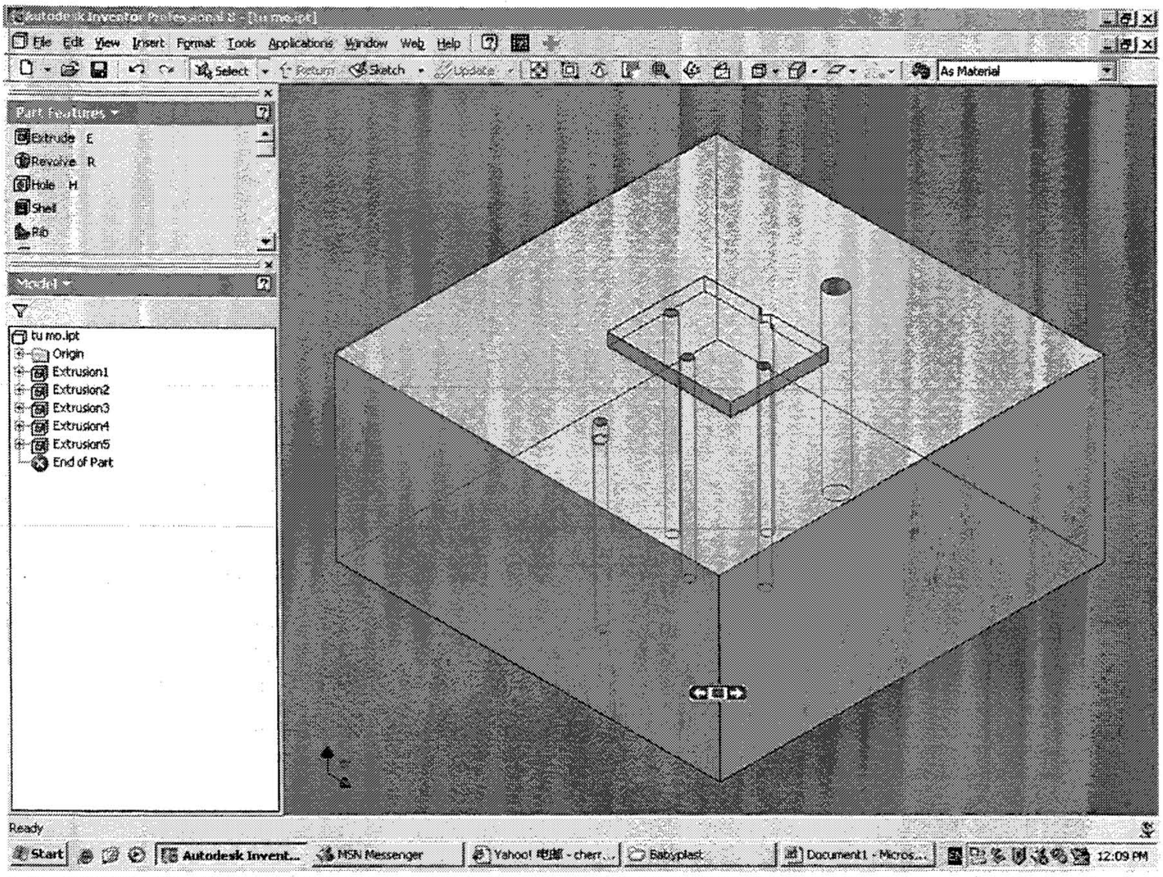
The super small-scale mould technology is growing and growing nowadays, and plastic has been used wildly in many areas. The gole of this implementing knowledge rules and control the geometric shape of the product was represents and achieved a useful tool especially for the fact that itassures afiltering ofthe informationinsertedinthe application, but also for the fact that a template for a certain product can be created, and modified easy by the customer needs and specification.

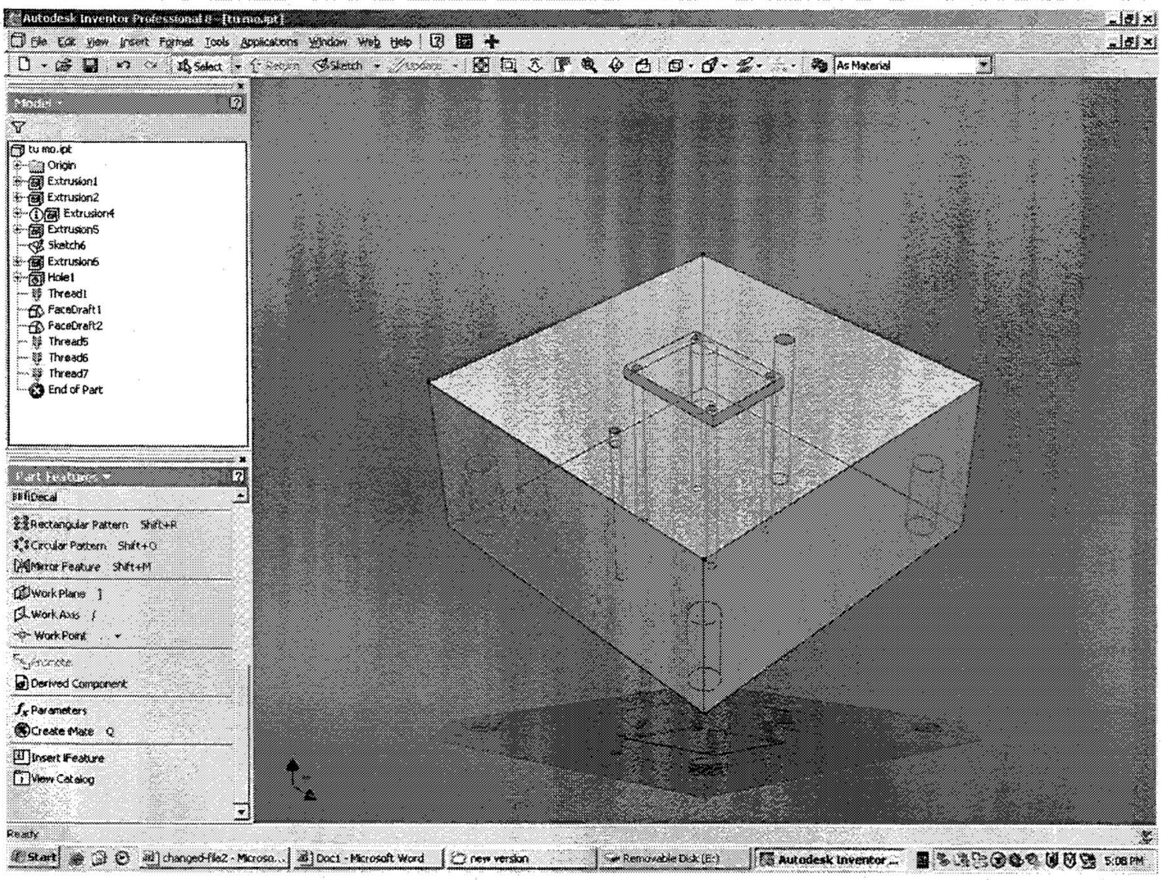
By the way to design the mould I learn much thing about found and plastic extrusion. While plastic in exact injection moulding, the material, machine, and moulding project has already sure , the quality and efficiency are decide to the kind of the configuration and the characteristic. The cost of exact injectionmoulding almost as expensive as a set of exact injection machine.Beside, the requirement of moulding, not only consider the precision of the cast, but also consider from the side of user, namely be required convenient, efficient, automatic.

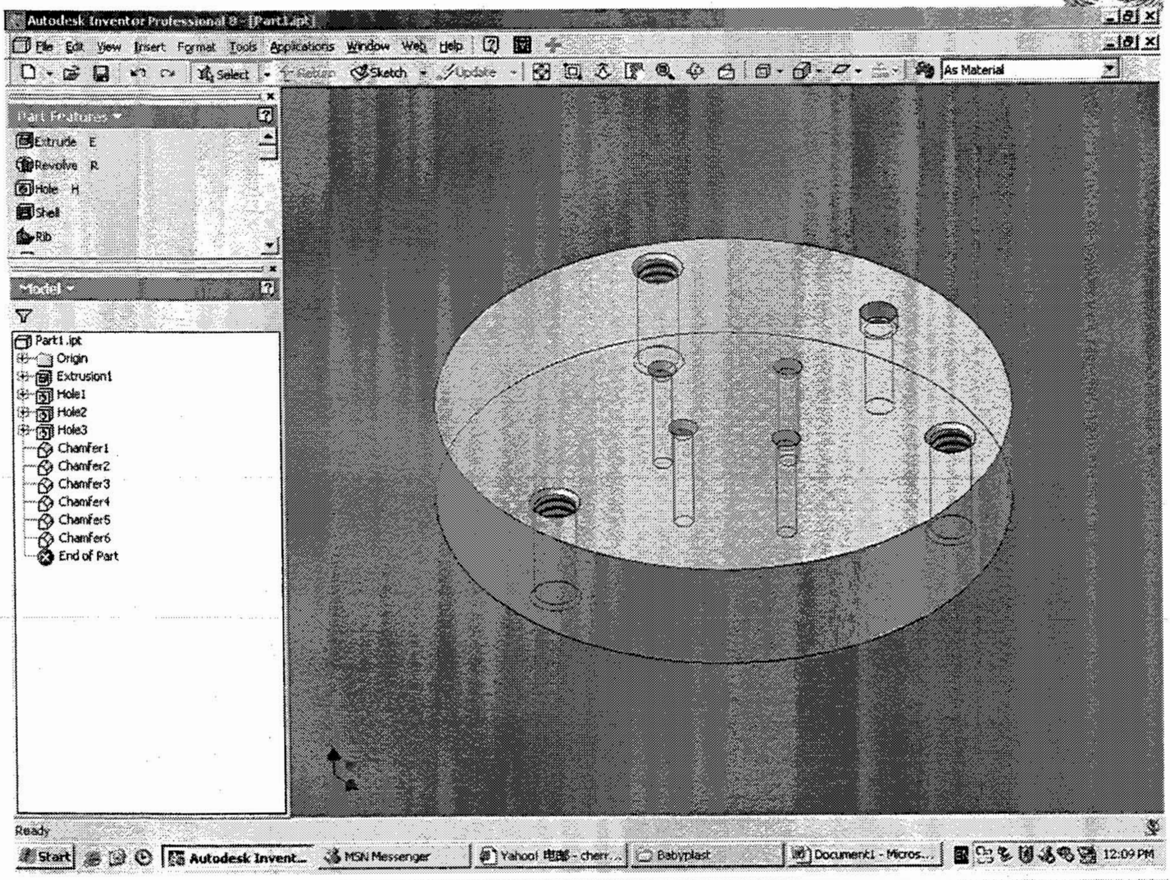
Chapter 8. Recommendation

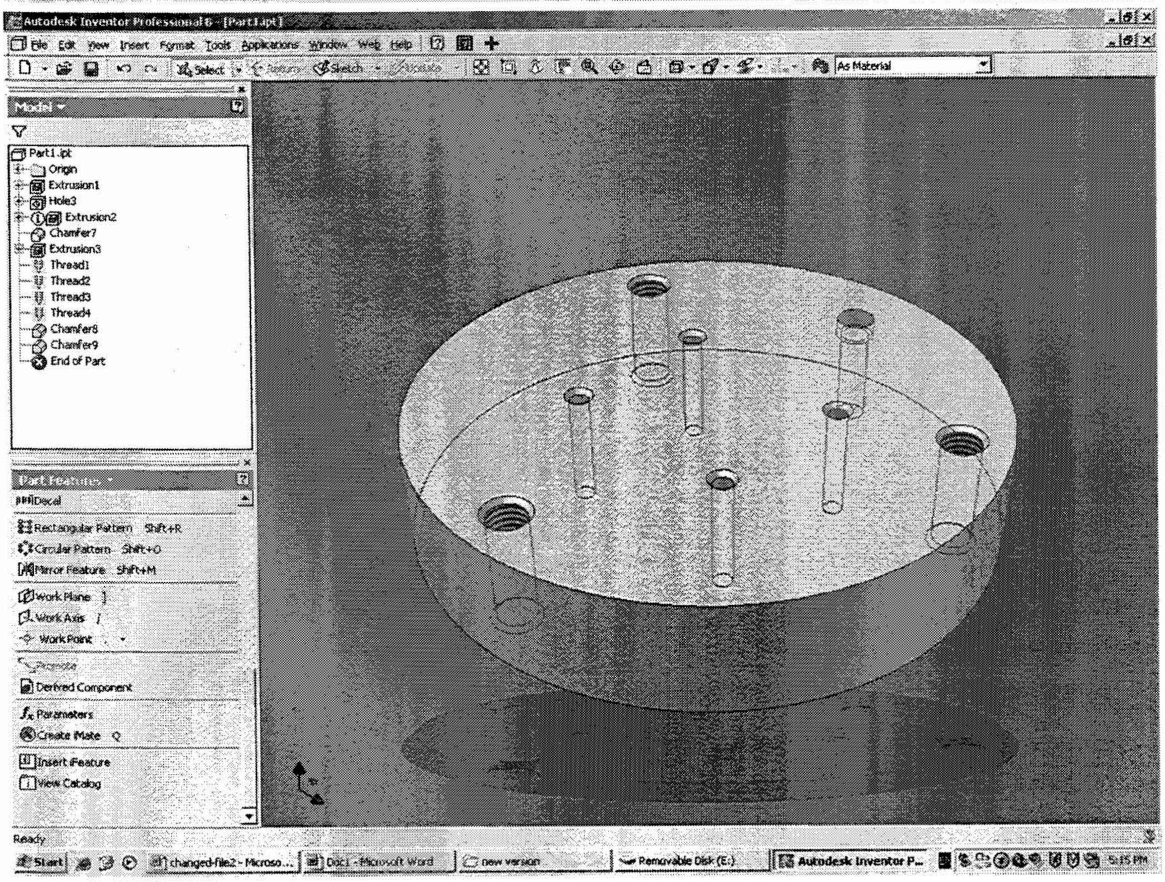
The tolerance and the roughness of the cap mould are not designed in this project due to the limited time. They have to be designed in the further study since the quality of the mould and the manufacturing cost are strongly affected by them. Furthermore, samples of the cap should be tested in performance, which is described in section 1.2, to control the quality of the cap mould.

Appendix A: Original assignments









Appendix B: Introduction to plastic extrusion

An extruder is somewhat like a long, hot, motor-driven meat grinder... The Extrusion Process is: The process for making extruded products, such as medica1 tubing, profiles, tape, filament, hose, pipe, wire jacketing, stainless steel braided catheters, multi-lumens, etc., starts with an extruder. Solid plastic pellets are poured into the extruder hopper. The extruder melts the plastic (resin or polymer) and pumps the melt (molten plastic) through a die orifice that yields the desired shape. The die orifice is generally a percentage larger than the actual size of the finished product. This percentage is based on a number of factors: size, shape, and material. The melt enters a vacuum sizer or a water-cooling tank where the correct size and shape are developed and cooled. The shape might be helped along by use of profile shaping tools or plates that are water or air-cooled. Next, the newly formed product enters a puller, which is often a pair of motor-driven, urethane-covered rolls or belts. It is the puller (take-off, haul-off, pinch rollers, cat) which pulls the molten resign from the end of the die through the vacuum sizer, water tank, etc. At the end of the line a cutting machine, coiler, traveling saw, punch press, etc., does the final processing of the product.

Appendix C: Design of a feasible practice

7.1 Needed resources

hot glue; hot glue gun; pliers; scalpel; balance; scissors; staples; red tape.

; silicon hardener; bucket; electrical drill.

7.2 General technica1 information of cast machine:

Pistondiameter(mm):	10	12	14	16	18
Volume(cm ^ 3):	3	4.5	6	8	10

Injection pressure(Kg/c m^2):	2.650	1.830	1.340	1.030	0.815
Closing force:	6.250Kg. 62.5 KN				
Opening force:	400Kg. 4KN				
Opening stroke:	30-110mm.				
Ejection force:	500Kg. 5KN				
Ejection stroke:	40mm.				
Hydraulic pressure:	130Kg./c m^2				
Oil tank capacity:	121. (approximately)				
Idling cycle:	2.4s.				
Rated power	2.5Kw				
Weight:	～120Kg				
Noise level:	< 70db				
Voltage	2～220V. 50/60 Hz.+ grounding connection + frequency converted 3 ～220V. 50/60 Hz + grounding connection 3 ～ 380V. 50/60Hz. + Neutro + grounding connection				

Appendix D:

Typical Values of shrinkage for molding of selected plastics

Plastic	Shrinkage, in./in. (mm/mm)

Thermoplastic	
ABS	0.006
Nylon6.6	0.020
Polycarbonate	0.007
Polyethylene	0.025
Polystyrene	0.004
Polyvinyl chloride	0.005
Thermosetting	
Phenolics	0.010

Appendix E: Viscosity factor for thermoplastics

Thermoplastics	Viscosity factor
GPPS (PS)	1
PP	1 - 1.2
PE	1 - 1.3
Nylons (PA6 or PA66), POM	1.2 - 1.4
Cellulosics	1.3 - 1.5
ABS, ASA, SAN	1.3 - 1.5
PMMA	1.5 - 1.7
PC, PES, PSU	1.7 - 2.0
PVC	2

Appendix F: Defects of molding

Defects of Molding	CAUSES	REMEDIES
Burn Mark	• Not Proper Venting • Trapping of air • Oxidation of material	• Should have proper vents.

Cracking	• High injection pressure • If the plastic is too hot • Presence of residual stress in molding • Thick section bosses & ribs.	• Redesign and increase the injection pressure • Should have proper injection pressure • Increase feed
Sink Mark De-lamination	• Injection speed too slow • Due to stress in molding surface layer • Unbalance gate • Extensive use of mould releasing material • Variation in mould opening time	• Proper design up mould • Balance the gate • Less use of mould release agent • Raise the mould and cylinder temperature
Splash Mark	• Vaporization if volatile material. • Incorrect component design • Absorption of water by the plastic prior molding • Any thing that prevents injection • Differential thermal shrinkage	• Alter the gate position • Material should be eliminated from all the volatile matter. • Avoid the orientation • Use of equal wall thickness
Warpage Distortion	• Mould has not been allowed to cool sufficiently before removal from the mould. • Due to excessive or too long flow-up pressure.	• Use uniform temp. all over mould surface. • Applying the proper cooling time. • Watch cylinder design.
Flow Mark	• Improper venting • Improper location of the gate its type and position • Incorrect gate position • Low mould temperature	• Should have proper mould temp. • Should have proper location of gates, its type and position. • Proper venting
Weld line	• Low injection pressure • Plastic material too hot	• Proper injection pressure • Reduce the material temp. • Proper gate location • Increase the cycle time
Flash	• Plastic too hot • Excessive feed and high pressure. • Mould parting line • Mixture of coarse and fine granules • Insufficient plasticizing capacity • Excess feeding to plastic • Intermittent flow in cavity	• Reduce cylinder temp. • Decrease the mould temp • Use uniform granulation • Lower the injection pressure • Pre-heat the material • Reface the parting line. • Reduce injection pressure
Silver Streaking	• Mould temp. too low • Cold material • Moisture in granules • Cold mould	• Balance the gates or relocates the gates • Increase the plastic temp. • Increase the mould temp
Poor Surface Finish / **Short Filling**	• Cold material • Slow injection • Cold mould • Poor flow within mould cavity • Insufficient pressure • Poor mould cavity finish. • Poor venting	• Increase plastic temp. • Increase injection pressure • Increase mould temp • Redesign parts • Polish the mould cavity • Increase the injection pressure • Surface to correct finish.
	• Improper balance of plastic flow.	• Increase no. of vents.

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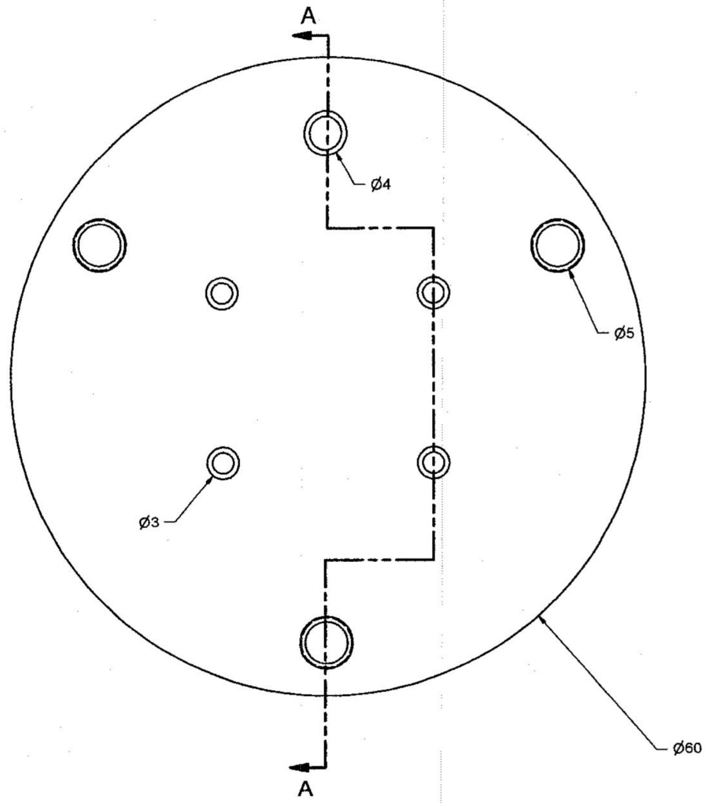
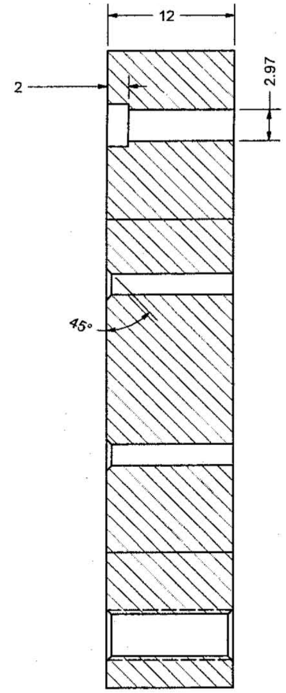
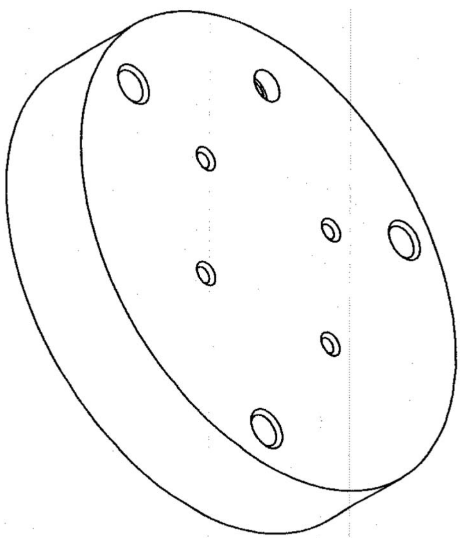
9. 模具设计





SECTION A-A
SCALE 3 : 1



DRAWN default user	6/3/2005	AISI1045		
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MFG				
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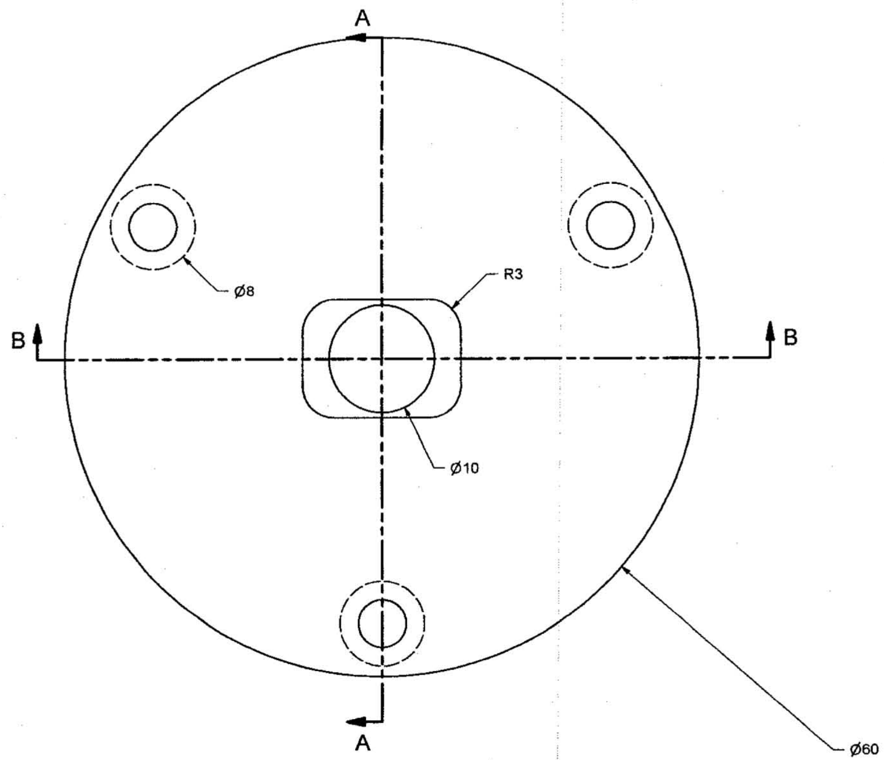
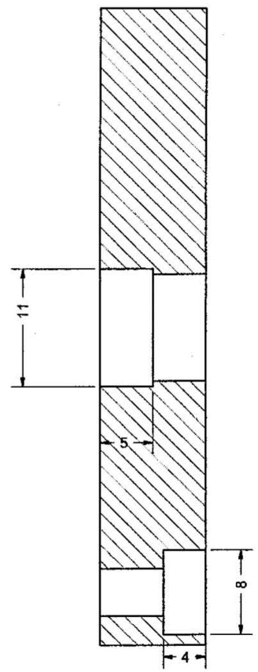
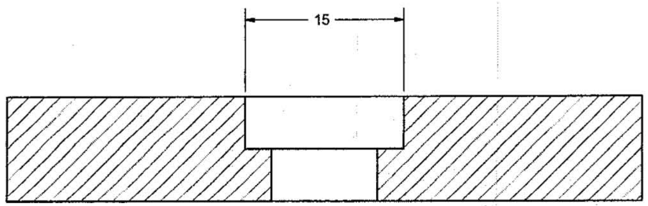


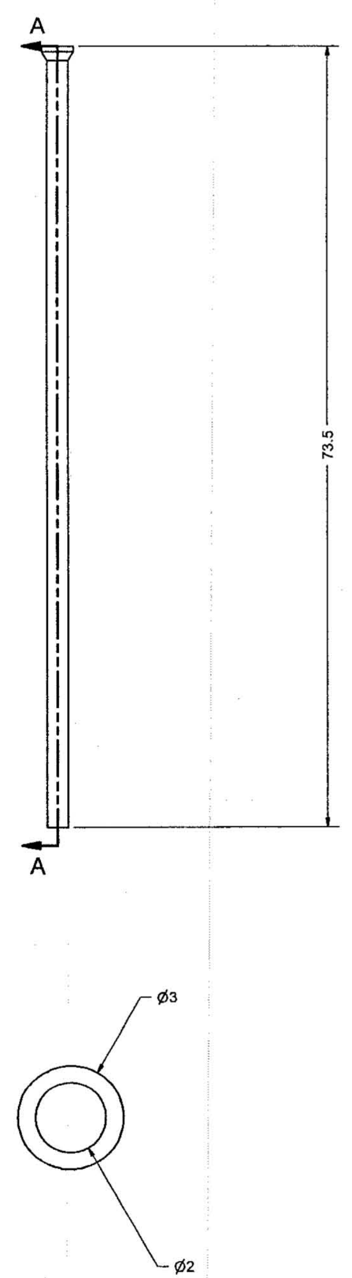


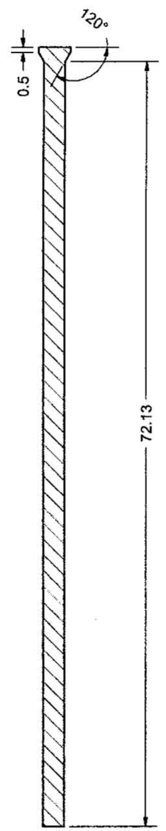
SECTION A-A
SCALE 3 : 1



SECTION B-B
SCALE 3 : 1

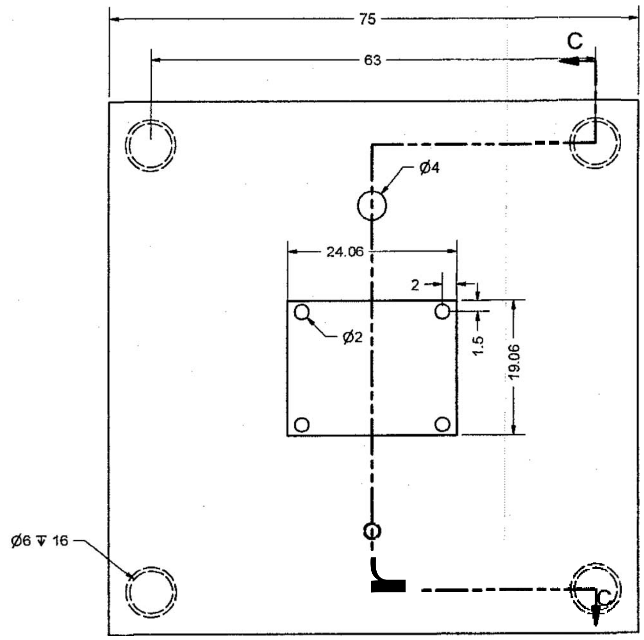
DRAWN default user	5/30/2005	AISI1045		
CHECKED		TITLE Round chassis 1		
QA				
MFG				
APPROVED		SIZE C	DWG NO Ya ban-1	REV
		SCALE		SHEET 1 OF 1

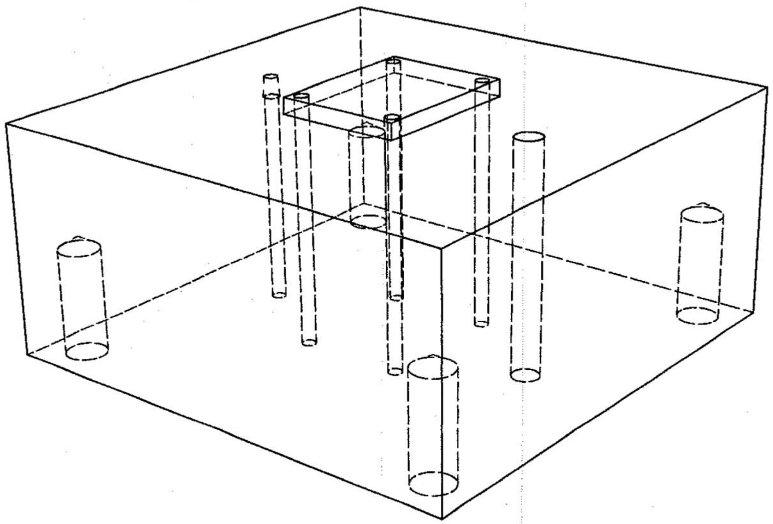


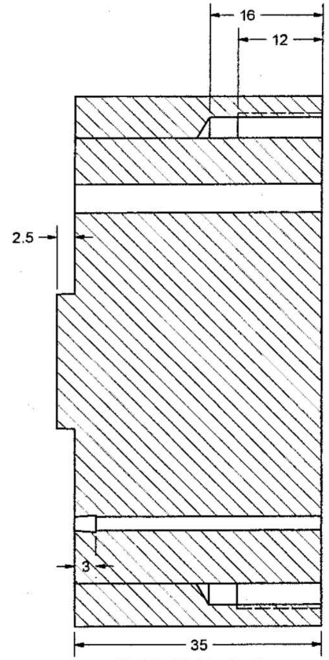


SECTION A-A
SCALE 3 : 1

DRAWN Default User	7/8/2005	AISI1045			
CHECKED		TITLE Push pole			
QA					
MFG					
APPROVED					
		SIZE C		DWG NO Tui gan	REV
		SCALE		SHEET 1 OF 1	

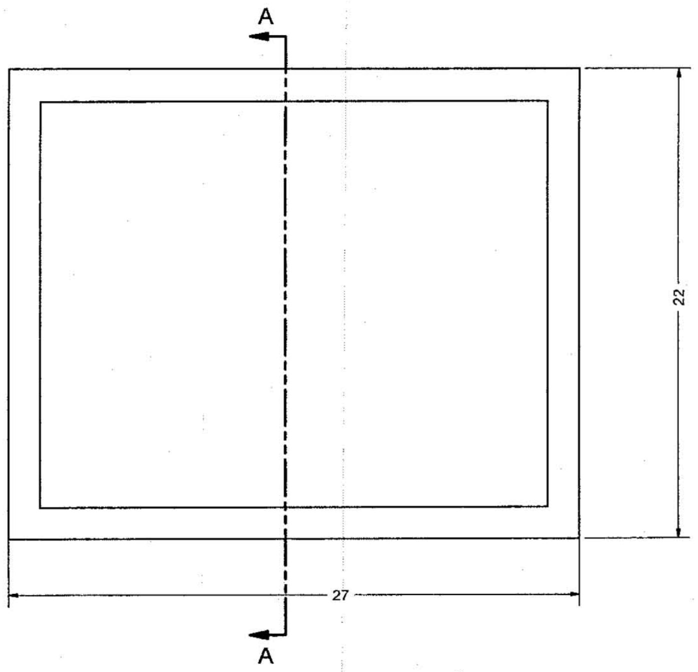


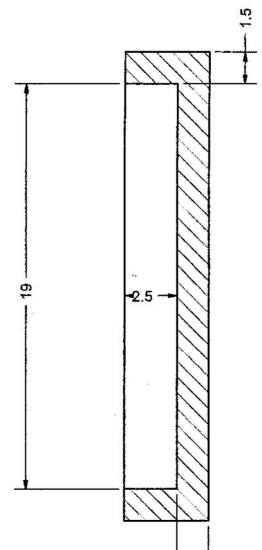




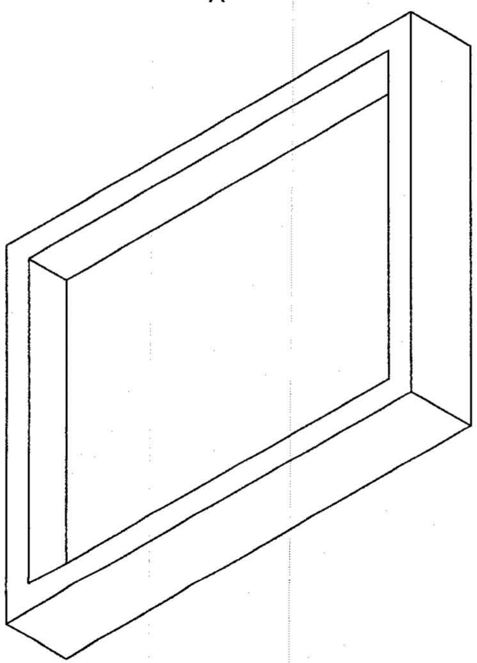
SECTION C-C
SCALE 2 : 1

DRAWN default user	5/30/2005	AISI1045			
CHECKED		TITLE Protuberant mould			
QA					
MFG					
APPROVED		SIZE C	DWG NO tu mo		REV
		SCALE		SHEET 1 OF 1	

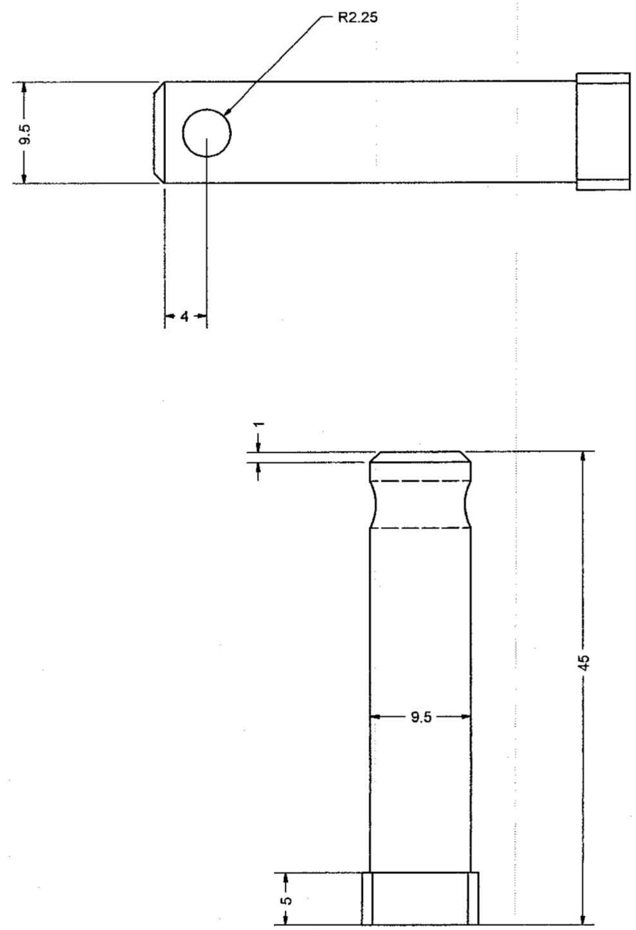


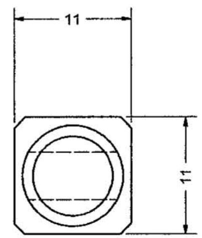


SECTION A-A
SCALE 6 : 1

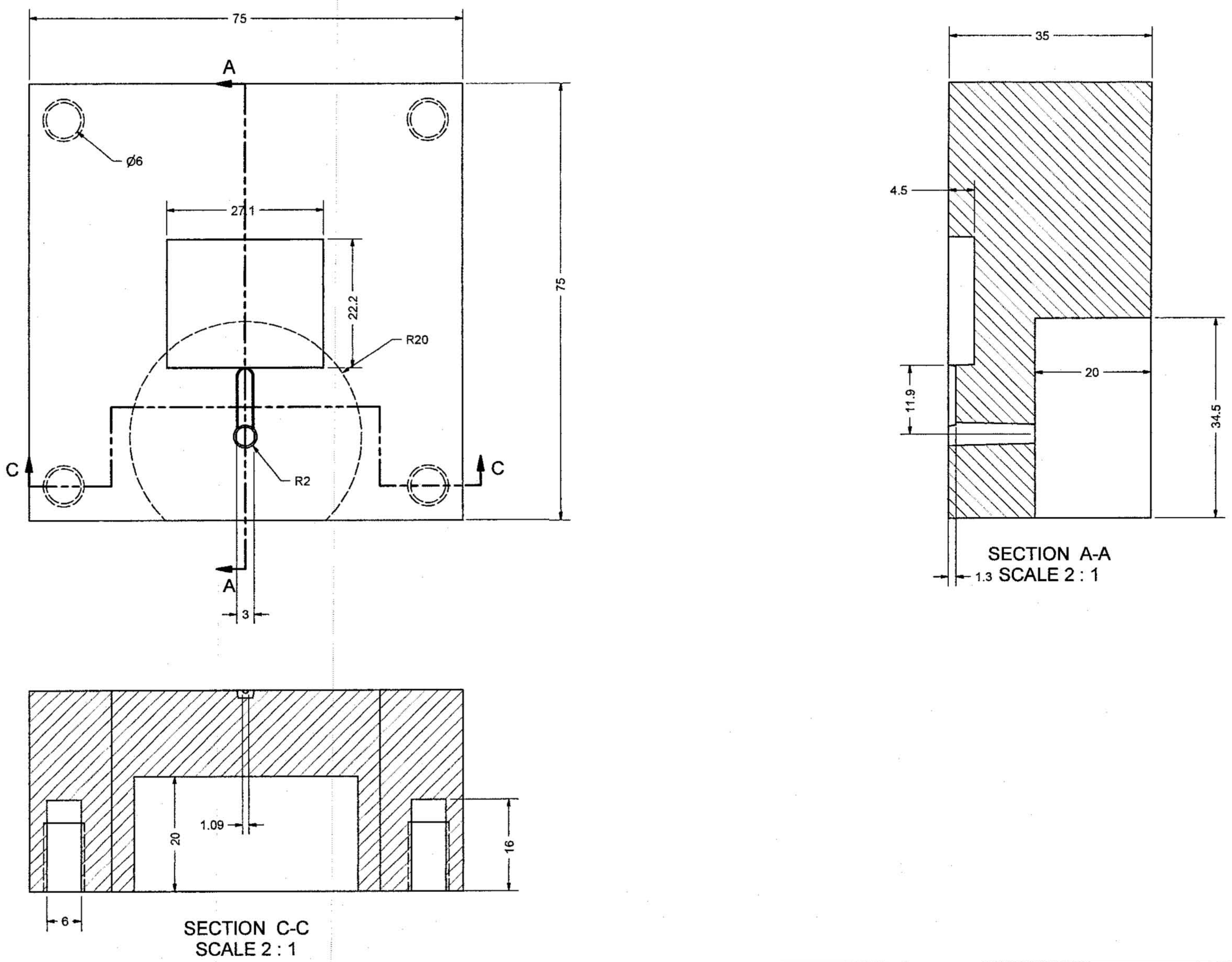


DRAWN default user	06/13/2005	POLYPROPYLENE		
CHECKED		TITLE The cap		
QA				
MFG				
APPROVED		SIZE C	DWG NO Part2	REV
		SCALE		SHEET 1 OF 1

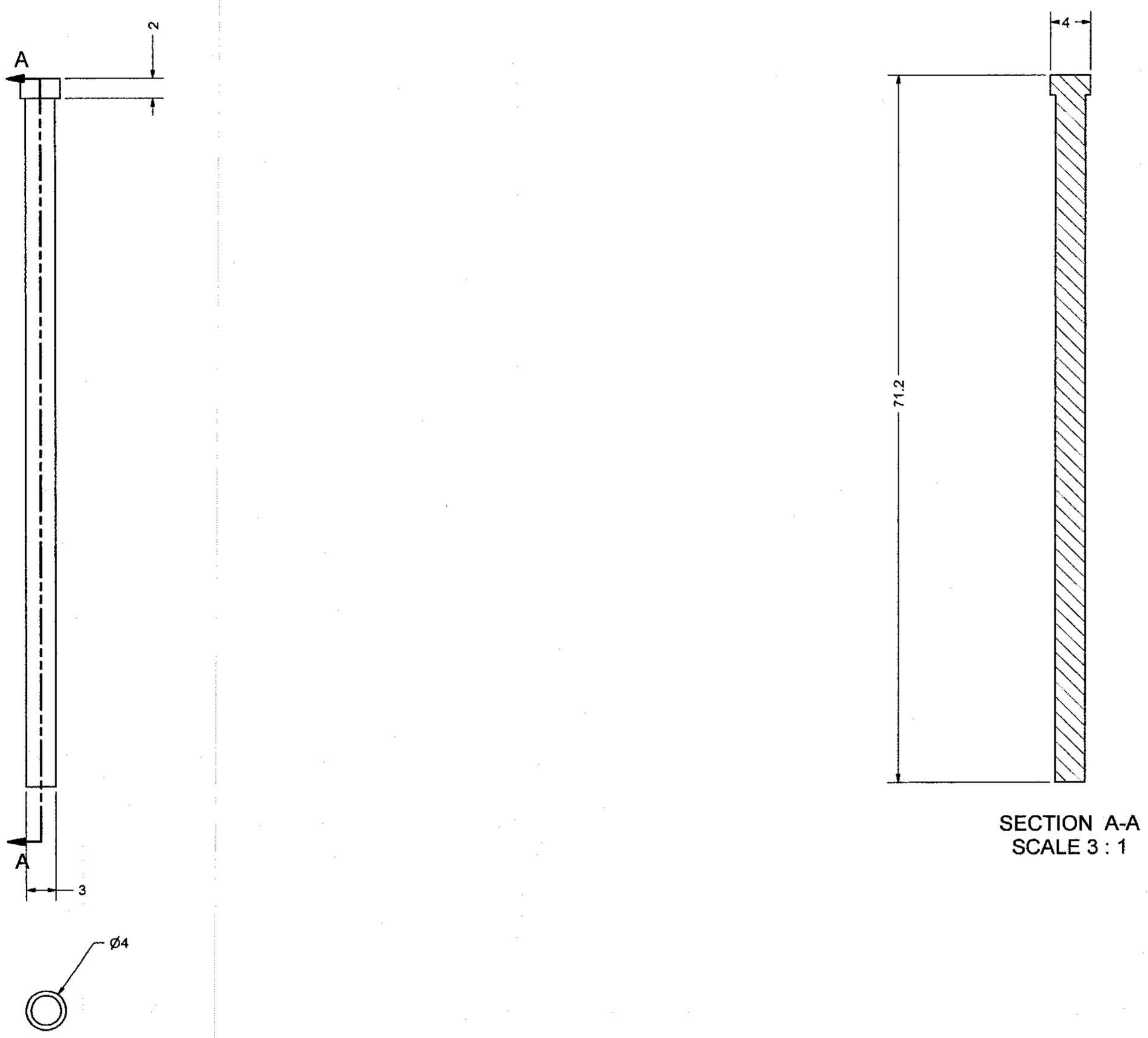




DRAWN default user	6/3/2005	AISI1045		
CHECKED		TITLE Fastener		
QA				
MFG				
APPROVED		SIZE C	DWG NO Luo Ding	REV
		SCALE		SHEET 1 OF 1



DRAWN default user	6/3/2005	AISI1045		
CHECKED		TITLE convexity mould		
QA				
MFG				
APPROVED		SIZE C	DWG NO Part8	REV
		SCALE		SHEET 1 OF 1



SECTION A-A
SCALE 3 : 1

DRAWN Default User	7/8/2005	AISI1045			
CHECKED		TITLE Diaplasis pole			
QA					
MFG					
APPROVED					
		SIZE C		DWG NO Fu weigan-1	REV
		SCALE		SHEET 1 OF 1	