# DESIGN AND FABRICATION OF THE BLOW MOLD COMPONENT

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# ABSTRAK

Laporan ini adalah hasil daripada kajian dalam menyiapkan projek tahun akhir, Mereka bentuk dan penghasilan komponen blow mold (Design and fabrication of the blow mold component). Objektif untuk projek ini ialah untuk mereka bentuk dan menjalankan simulasi mengenai acuan untuk botol air 500ml dengan menggunakan perisian Master CAM selain menimba ilmu pengetahuan dalam proses penghasilan acuan untuk botol dengan menggunakan mesin kisar.Bahan mentah yang digunakan dalam penghasilan projek ini ialah aluminium,sebagaimana bahan yang biasa digunakan dalam industri untuk menghasilkan acuan botol. Kaedah yang digunakan dalam menyiapkan projek ini terbahagi kepada tiga bahagian; mereka bentuk acuan botol dengan menggunakan perisian Solid Work,kedua ialah menjalankan simulasi dengan menggunakan perisian Master CAM, ketiga ialah penghasilan produk dengan menggunakan mesin kisar. Proses kajian pula bermula dengan pengenalan mengenai blow mold,termasuklah bahan mold dan rekaan mold disamping ulasan berkenaan perisian Master CAM.Pengenalan lanjut kajian diteruskan dengan pengenalan kepada mesin kisar.Kaedah merekabentuk dan simulasi kemudiannya diterangkan langkah demi langkah diikuti dengan maklumat terperinci mengenai proses penghasilan model menggunakan mesin.Akhir sekali,keputusan simulasi dan model blow mold diterangkan dengan terperinci. Kesimpulan daripada hasil simulasi dan model mold, disamping masalah-masalah yang dihadapi semasa menjalankan projek ini turut dibincangkan.

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| | | |
|---|---|---|
| $^0C$ | - | Celsius |
| $^0F$ | - | Fahrenheit |
| 2D | - | Two Dimensional |
| 3D | - | Three Dimensional |
| No. | - | Number |
| NC | - | Numerical Control |
| MB | - | Mega Bite |
| CAE | - | Computer-Aided Engineering |
| CNC | - | Computer Numerical Control |
| CAM | - | Computer Aided Design |
| MPa | - | Mega Pascal |
| RISC | - | Reduced Instruction Set Computer |
| AISI | - | American Iron and Steel Institute |
| HPCC | - | High Precision Contour Control |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Final year project is one of the subjects for this semester. In this subject, a project needs to do to fulfil the subject requirement .The current project is to design a blow mold for the bottle. Together with the instructor, 1 students are required for accomplishing this project. This student must possess a very high discipline, willing to learn and self – motivated. A know – how to operate the CNC milling machine and its related software is very helpful to the students for implementing this project. In this project the title is Design and Fabrication of the blow mold component by using CNC milling machine. The project involves the designing and fabricating of the bottle blow mold model. Tests are required to be conducted and to verify the design. Overall, this project will involve the development of skills in design, simulation using Master CAM and fabrication. Skill in handling Master CAM program and operating the CNC milling machine is the most important and need to be improve when this project launched.

## 1.2    Problem Statement

In the current competitive world, the life cycles of the products are shorter. The companies who are develop and deliver the product in a short time will win the market. However, there is a dilemma among manufacturers. The dilemma is whether the designed products are able to be fabricated as it is needed be. The application of simulation software such as Master CAM that this can be achieves.

## 1.3    Project Objective

Basically, the specific objectives of this project are:

1. To design a blow mold for water bottle.
2. To run a simulation of blow mold for water bottle.

## 1.4    Project Scope

The scopes of the project are:

1. Design: Design blow mold model using Solid Work.
2. Simulation: Simulate blow mold model using Master CAM.
3. Fabrication: Fabricate the blow mold model using CNC milling machine.

## 1.5 Flow Chart

```
┌─────────────────────────┐
│   Gather information     │
│   (Literature Review)    │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│         Design          │
│  (Design blow mold model │
│     using Solid Work)    │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│       Simulation        │
│ (Simulation blow mold    │
│  model using Master CAM) │
└─────────────────────────┘
             │
             ▼
          ◇ OK ◇
      NO            YES
             │
             ▼
┌─────────────────────────┐
│       Fabrication        │
│ (Fabricate using CNC     │
│    Milling Machine)      │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│      Verification        │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│     Documentation        │
└─────────────────────────┘
```
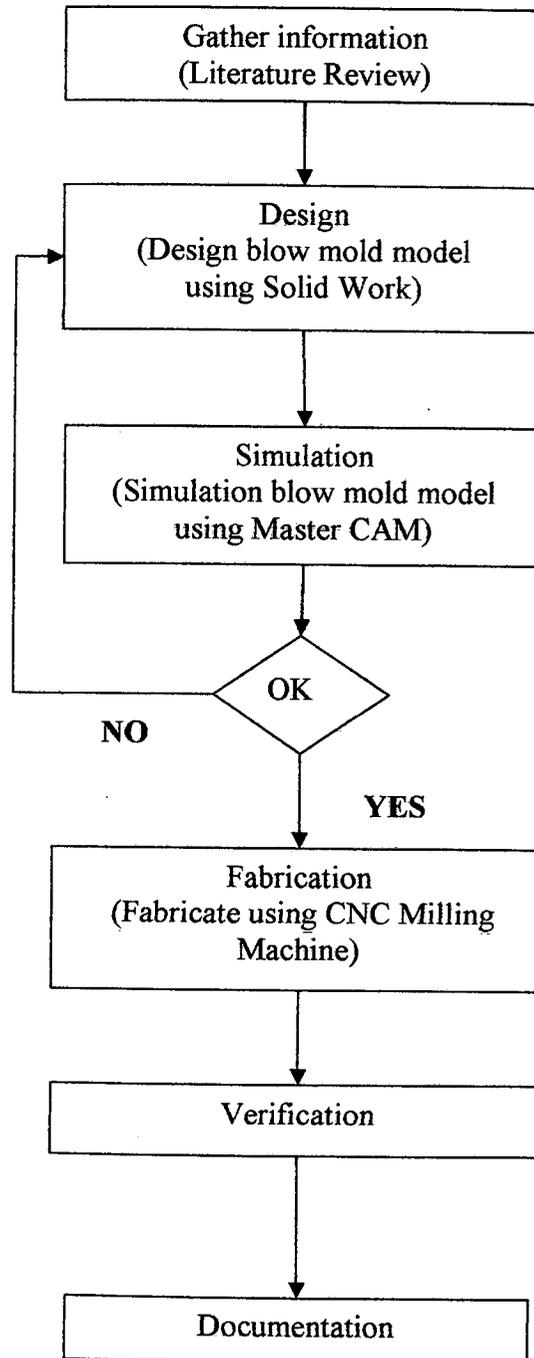
**Figure 1.1**: Project flow chart

## 1.5    Flow Chart
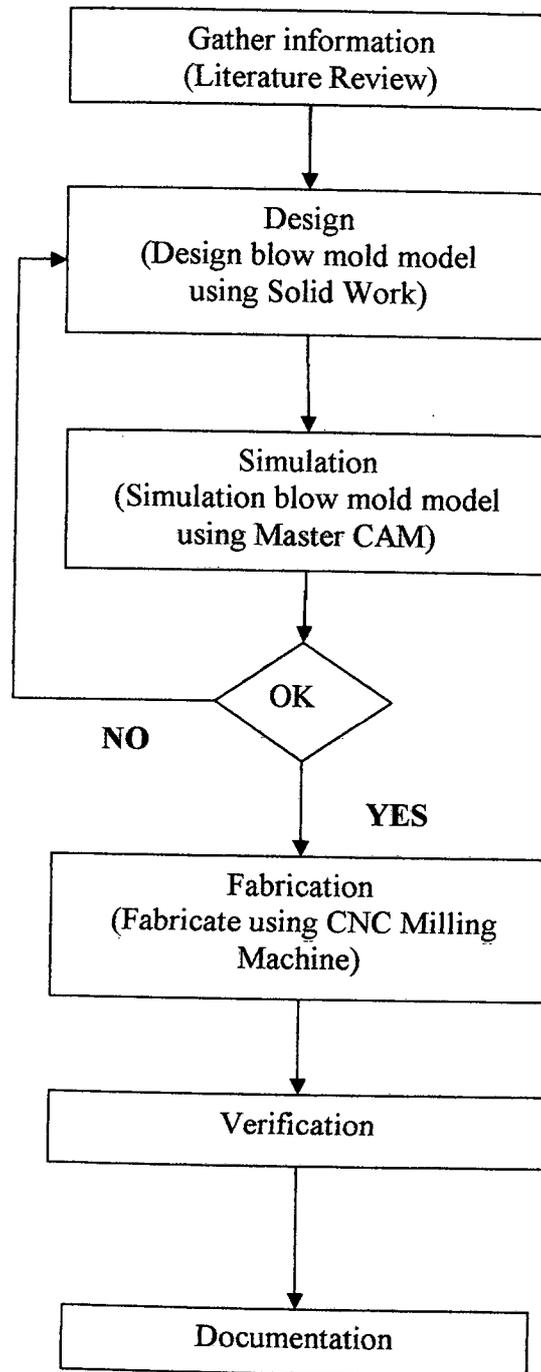


**Figure 1.1**: Project flow chart

## 1.6    Project Planning (Gantt chart)
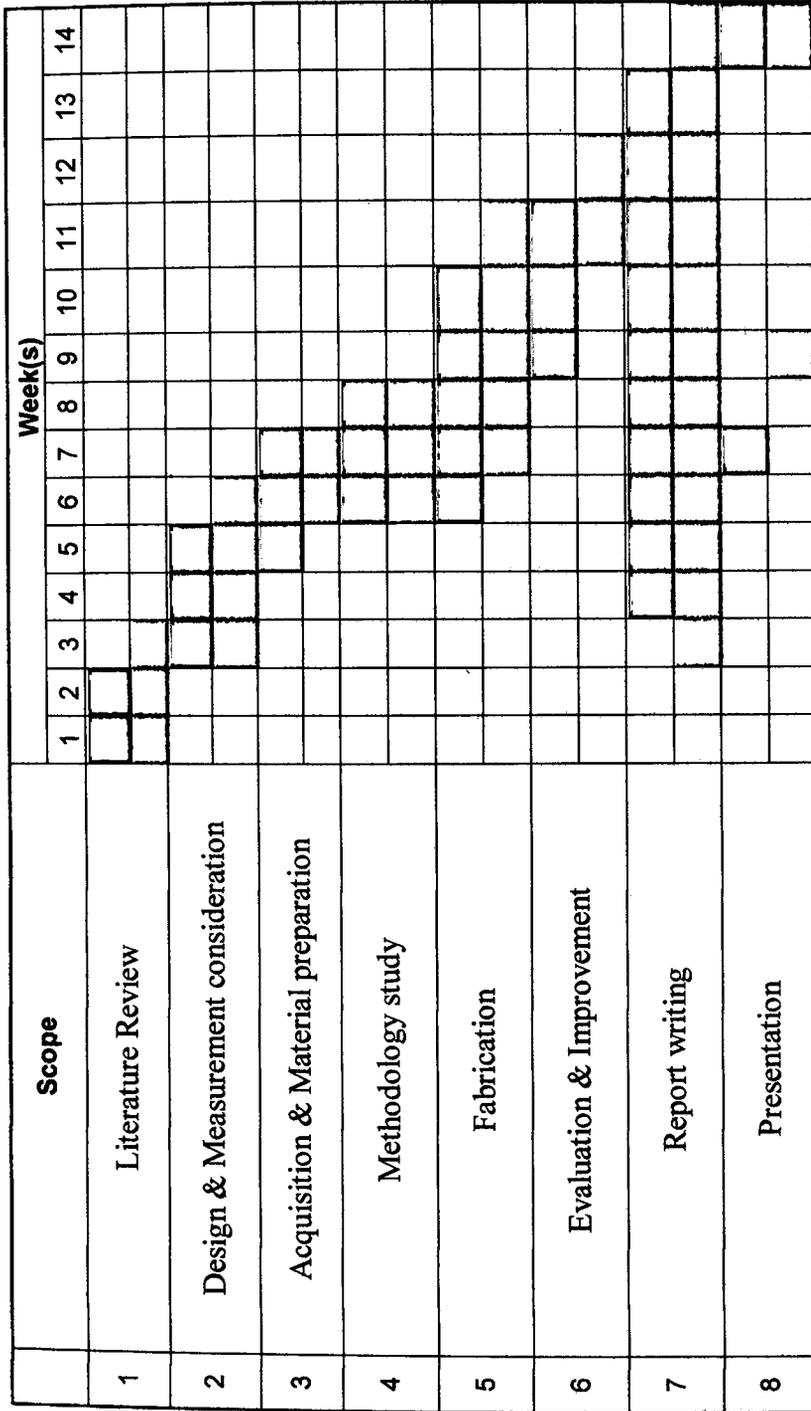
| Scope | | Week(s) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | Literature Review | ■ | ■ | | | | | | | | | | | | |
| 2 | Design & Measurement consideration | | | ■ | ■ | ■ | | | | | | | | | |
| 3 | Acquisition & Material preparation | | | | | | | ■ | | | | | | | |
| 4 | Methodology study | | | | | | ■ | | ■ | | | | | | |
| 5 | Fabrication | | | | | | ■ | ■ | | ■ | ■ | | | | |
| 6 | Evaluation & Improvement | | | | | | | | | ■ | | ■ | | | |
| 7 | Report writing | | | | ■ | ■ | ■ | ■ | | ■ | ■ | | | ■ | |
| 8 | Presentation | | | | | | | | | | | | | | ■ |

| planning |
|---|
| actual |

**Figure 1.2:** Project gantt chart

# CHAPTER 2

# LITERATURE REVIEW

## 2.1    Introduction

Blow molding is a manufacturing process by which hollow plastic parts are formed. In general, there are three main types of blow molding; Extrusion Blow Molding, Injection Blow molding, and Stretch Blow Molding. Molding is the process of manufacturing by shaping pliable raw material using a rigid frame or model called a mold [7].

## 2.2    Injection blow molding

Injection blow molding is a two stage processes since the parison is produced in a separate operation. In the first process molten plastic is injected into a heated preform mold around a hollow mandrel blow tube or core rod. This is similar to insert injection molding. The workpiece for the second, blow molding, process is the preform-mandrel assembly. The preformed parison is placed in a larger mold cavity for blow molding. Between the preform production and blow blow molding processes a heated preform

may be held in a temperature conditioning stage or a cooled preform re-heated. After blow molding the part is stripped from the core rod at an ejection station [7].

## 2.3 Process Steps

### Step 1: Injection

The injection blow molding machine is based on an extruder barrel and screw assembly which melts the polymer. The molten polymer is fed into a manifold where it is injected through nozzles into a hollow, heated preform mould. The preform mould forms the external shape and is clamped around a mandrel (the core rod) which forms the internal shape of the preform. The preform consists of a fully formed bottle/jar neck with a thick tube of polymer attached, which will form the body [Oxford Engineered Materials Corporation].

### Step 2: Blowing

The preform mould opens and the core rod is rotated and clamped into the hollow, chilled blow mould. The core rod opens and allows compressed air into the preform, which inflates it to the finished article shape [Oxford Engineered Materials Corporation].

## Step 3: Ejection

After a cooling period the blow mould opens and the core rod is rotated to the ejection position. The finished article is stripped off the core rod and leak-tested prior to packing. The preform and blow mould can have many cavities, typically three to sixteen depending on the article size and the required output. There are three sets of core rods, which allow concurrent preform injection, blow molding and ejection [Oxford Engineered Materials Corporation].

## 2.4 Mold Design

A mold is a controllable, complex mechanical device that must also be an efficient heat exchanger. Hot melt, under pressure, moves rapidly through the mold. Air is released from the mold cavity to prevent the melt from burning, to prevent voids in the product, and/or to prevent others defects. To solidify the hot melt, water or some other medium circulates in the mold to remove heat from thermoplastic; with thermoset plastics, heat is used to solidify the final product. There are various techniques to operate the mold such as sliders and unscrewing mechanism. Computer-aided Design (CAD) and computer-aided engineering (CAE) programs are available that can assist in mold design and in setting up the complete fabricating process [8].

In terms of both performance and cost, it is necessary for the mold cavity to be at required initial temperature to blow mold the desirable product (Table 2.1) [8].

Table 2.1 Temperatures for mold cavities in blow molds [8].

| Plastic | Recommended Temperature | |
|---|---|---|
| | ($^0$C) | ($^0$F) |
| Polyacetates | 80-100 | 176-212 |
| Polyamides | 20-40 | 68-104 |
| Polyethylenes and PVCs | 15-30 | 59-86 |
| Polycarbonates | 50-70 | 122-158 |
| Polymethyl methacrylates | 40-60 | 104-140 |
| Polypropylenes | 30-60 | 86-140 |
| Polystyrenes | 40-65 | 104-149 |

## 2.5 Material

Mold material can be classified according to the size and the numbers of articles required, such as:

(1) Blow molds for continuous production and large batches and

(2) Blow mold for small batches and prototype production.

Only metal molds can be considered for continuous production and long runs, where as for small batches and prototypes, casting resins in water-permeable backed shell construction are also suitable [8].

It is necessary to further subdivide metals into tool steels, aluminium, and alloys. Table 2.2 shows the material normally used for blow molds along with their hardness, tensile strength, and thermal conductivity. Fastenings and guide components and edge inserts should be hardened [8].

The advantages pf blow molds produced in aluminium, beryllium, and zinc alloys include excellent thermal conductivity, low weight, and economical manufacture by precision casting [8].

The most widely used steels have been given identifying numbers by the American Iron and Steel Institute (AISI). The properties of the tool material usually are as follows:

i.    Wear resistance to provide a long life

ii.   Toughness to withstand processing and particularly factory handling

iii.  High modulus of elasticity so that the die channels do not deform under melt operating pressure and the die's weight

iv.   High uniform thermal conductivity

v.    Machinability so that good surface finish can be applied particularly near the die exit.

**Table 2.2:** Blow mold tool material [8].

| MATERIAL | TYPE | HARDNESS (HRC) | TENSILE STRENGTH (MPA) |
|---|---|---|---|
| Aluminium | No A356<br>No 6061<br>No 7075 | BHN-80<br>BHN-95<br>BHN-150 | 225<br>275<br>460 |
| Beryllium-Cooper | No 25<br>No 165<br>No 0-1<br>No A-2<br>No P-20 | BHN-285<br>HRC-30<br>HRC-32<br>HRC-52-60<br>BHN-530-650<br>BHN-298 | 930<br><br>2000<br><br>1000 |

Table 2.3 Properties of blow mold materials [8].

| Material | Thermal conductivity | Wear Resistance | Ability to be cast | Ability to be repaired | Density lb/in3 | Ability to be machined and polished |
|---|---|---|---|---|---|---|
| Aluminium | 0.53 | Poor | Fair | Good | 0.097 | Excellent |
| Beryllium-copper | 0.15-0.51 | Excellent | Good | Good | 0.129-0.316 | Fair |
| Cast iron | 0.08 | Good | Good | Good | 0.24 | Good |

## 2.6 Master CAM

### 2.6.1 Introduction

CAD/CAM is an acronym for Computer Aided Design / Computer Aided Manufacturing. In essence CAD is simply a drafting board in a computer and facilitates engineering and design with a monitor and a keyboard instead of a paper and pencil. The drawing is saved in an electronic data file for editing [4].

CAM is what can be done with the electronic data to help manufacture the engineered part represented in the electronic file. Although there can be hundreds of different manufacturing processes (stamping, forging, molding, etc) "CAM" when teamed with "CAD" as in "CAD/CAM" has come to refer almost exclusively as the process of machining the CAD geometry on CNC machinery. Of course the computer file alone cannot machine a part nor can the computer. But with a CAD/CAM system the electronic CAD file can be used to create another file of tool paths that can be fed into the controls of the CNC machinery [4].

A direct link between product design and manufacturing can be established using CAD/CAM software. Product engineers use a CAD system to establish the part geometry, dimensions, and tolerances. This design data can be transferred to the CAM system where the part programmers develop the CNC program to machine the part [4].

A CAD/CAM system can consist of separate or integrated CAD and CAM software. For a system using separate CAD and CAM packages, transfer of drawing geometry using either direct or indirect translation is required. In this case, part geometry is first created on the CAD system and then transferred to the corresponding CAM system. After the geometry has been recreated in the CAM system, the programmer specifies the tools that will be used. Detail information for each tool, such as material, diameter, number of flutes, and length, will be specified (above right)). Next the order of the machining process will be established (right). And finally a tool path with proper feed rate information is provided (below right) [4].

An integrated CAD/CAM system is a dedicated system that will allow the user to create product geometry and generate CNC programs all in one package. Data transfer from CAD to CAM is not required, and there is no data compatibility problem. This feature is important since it ensures the accuracy and reliability of the data [4].

## 2.7    G-code

G-code is a common name for the programming language that controls Numerical Control (NC) and CNC machine tools. Developed by the Electronic Industries Alliance in the early 1960s, a final revision was approved in February 1980 as RS274D [3].

Due to the lack of further development, the immense variety of machine tool configurations, and little demand for interoperability, few machine tool controllers (CNCs) adhere to this standard. Extensions and variations have been added independently by manufacturers, and operators of a specific controller must be aware of differences of each manufacturer's product. When initially introduced, CAM systems were limited in the configurations of tools supported [3].

Manufacturers attempted to overcome compatibility difficulties by standardizing on a machine tool controller built by Fanuc. Unfortunately, Fanuc does not remain consistent with RS-274 or its own previous standard, and has been slow at adding new features and exploiting the increase in computing power. For example, they changed G70/G71 to G20/G21; they used parentheses for comments which caused difficulty when they introduced mathematical calculations so the use square parentheses for macro calculations; they now have nano technology recently in 32bit mode but in the Fanuc 15MB control they introduced HPCC (high precision contour control) which uses a 64-bit RISC (reduced instruction set computer) processor and this now has a 500 block buffer for look ahead for correct shape contouring and surfacing of small block programs and 5 axis continuous machining [3].

This is also used for NURBS to be able to work closely with industrial designers and the systems that are used to design flowing surfaces. The NURB has it's origins from the ship building industry and is described by using a knot and a weight as for bending steamed wooden planks and beams [3].

## 2.7.1 The Master Software supports these standard G-Codes and M-codes:

**These codes in G-Codes represent:** [Mill Workbook]

G00 = Position (Fast speed)

G01 = Linear interpolation (Feed speed)

G02 = Circular interpolation (CW)

G03 = Circular interpolation (CCW)

G17 = Cancels G60 Command

G27 = Reference point return check

G28 = Return to reference point

G29 = Return from reference point

G60 = Switch data from Y to W * radius factor

G70 = Input in inches

G71 = Input in millimeters

G80 = Cancel Peck Drilling Cycle

G83 = Peck Drilling Cycle

G90 = Absolute move (Modal)

G91 = Relative move (Modal)

G98 = Return to initial point in canned cycle

G99 = Return to R point in canned cycle

**While for M-codes, the codes represent:** [Mill Workbook]

M00 =Program Stop

M01 =Optional Program Stop (Setting 17)

M02= Program End

M03 =Spindle On, Clockwise (S)

M04 =Spindle On, Counterclockwise (S)

M05 =Spindle Stop

M06 =Tool Change (T) (Setting 42, 87)

M08 =Coolant On (Setting 32)

M09 =Coolant Off

M10** =4th Axis Brake On

M11= 4th Axis Brake Release

M12** =5th Axis Brake On

M13 =5th Axis Brake Release

M19 =Orient Spindle (P, R)

M21-M28= Optional User M Code Interface with M-Fin Signals

M30 =Program End and Reset (Setting 2, 39, 56, 83)

M31 =Chip Conveyor Forward (Setting 114,115)

M32 =Chip Conveyor Reverse (Setting 114, 115)

M33 =Chip Conveyor Stop

M34 =Coolant Spigot Position Down, Increment

M35 =Coolant Spigot Position Up, Decrement