DESIGN AND FABRICATION OF MS88 FIBERGLASS HELMET

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A report submitted in partial fulfilment of the
requirement for the award of the Diploma
of Mechanical Engineering

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NOVEMBER 2007

ABSTRACT

The fabrication of MS88 fibreglass helmet project was focused in design and fabricates the fibreglass helmet. The design of mould based on MS88 design helmet. The mould use polystyrene material coated by aluminium foil. Using the fibreglass as a main material for fabrication, it can reduce the mass of the helmet and increase the conformability to wear. The process to fabricate the fibreglass helmet is called *"lay up"* process where the fibreglass mat is applied on the mould layer by layer with the mixture of 99% of polyester resin and 1% of hardener. However the surface of fibreglass helmet is not smooth enough because of the sphere shape of mold make it hard to apply the fibreglass mat. After the helmet was fabricated, the samples of fibreglass are tested using Compression Testing machine to measure the mechanical properties of fibreglass reinforce plastic(FRP). The overall project can be described as successfully project because the MS88 fibreglass helmet manages to fabricate in the time given.

ABSTRAK

Projek penghasilan helmet MS88 gentian kaca *(fiberglass)* memfokuskan dalam bidang mereka bentuk dan menghasilkan helmet gentian kaca. Reka bentuk helmet yang digunakan adalah berdasarkan reka bentuk helmet MS88. Acuan yang digunakan dalam projek ini merupakan bahan dari polistirina yang dialuti oleh keranjang aluminium. Dengan menggunkan gentian kaca dalam pembuatan helmet ia dapat mengurangkan berat helmet tersebut serta menigkatkan keselesaan penggunaanya. Proses pembuatan helmet gentian kaca dipanggil proses manampal helaian gentian kaca secara berulang kali yang dicampurkan dengan 99% polister resin dan 1% bahan pengeras. Projek tersebut berjaya dilaksanakan dengan sedikit masalah yang berlaku di permukaan helmet tersebut dimana ia tidak selicin yang diharapkan. Selepas berjaya menghasilkan helmet MS88 bergentian kaca, sample yang digunakan dalam pembuatan helmet tersebut di uji mengunakan mesin penguji tekanan untuk mengukur sifat-sifat mekanikal yang ada pada gentian kaca tersebut. Secara kesuluruhannya projek ini boleh dikatakan bejaya kerana helmet MS88 bergentian kaca berjaya disiapkan dalam masa yang ditetapkan.

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CHAPTER 1

INTRODUCTION

1.1 Project Synopsis

The project contains of designing and fabrication of a fibreglass helmet. The material use in this project will reduce the mass of the helmet and also will provide safety to stand high impact. The fabrication required student to familiar the procedure and safety on handling fibreglass and other materials such as resin and other solvent. The project also require student to do research and study on fibreglass material to determine mechanical properties of fibreglass.

1.2 Project Problem Statement

The common helmet in the market is a moulded thermoplastic such as ABS or Polycarbonate. Although these materials are tough enough to absorb the high energy from the crash but it's quite heavy to wear. Using the fibreglass reinforced plastic (FRP), it's not only reduce the mass of helmet but it will also provide versatility and freedom of design, strength & durability.

1.3 Project Objective

The objectives of this project are:

1. Design MS88 fibreglass helmet
2. Fabricate MS88 helmet using polystyrene mold covered with aluminium foil
3. Performed the FRP testing using the Compression Test machine.

1.4 Project Scope

The specific scope of this project is to: -

1. Design and fabricate fibreglass helmet
2. Designed the fibreglass mould according to MS88 helmet
3. Performed fibreglass testing on fibreglass sample

1.5 Project Background

Helmet is essential for motorcycle bikers. It's providing protection against high impact during collision. Helmets nowadays have many varieties to give comforts and good looking. To increase the comfort and safety, Fibreglass helmet is the best choice because the toughness of material, strong, shock absorbent, smooth, responsive, and lighter than ordinary helmet makes it comfort to wear [1]. The properties of the structure of glass in its softened stage are very much like its properties when spun into fibre [2]. The principal of fabricating the MS88 fibreglass is by lay up layer by layer fibreglass mat with the mixture of polyester resin and hardeners on the MS88 helmet mould and wait until it solidify.

1.6 Project Planning

The Table 1.1 showed the project planning for the fabrication of MS88 fibreglass helmet between weeks 1 until week 15

Table 1.1: Gantt chart

Scope	Week(s)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Review	X	X	X												
Design & Sketching			X	X	X	X									
Acquisition & Material preparation					X	X	X								
Methodology study						X	X	X							
Fabrication								X	X	X	X				
Evaluation & I mprovement									X	X	X	X			
Report writing				X	X	X	X	X	X	X	X	X	X		
Final Report check & submit													X	X	

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In motorcycle traffic accidents, the human head is exposed to loads exceeding several times the loading capacities of its natural protection. Annually, approximately five thousand motorcyclists get killed in Europe as a result of traffic accidents. They account for 9% of all road fatalities. Wearing a helmet reduces the risk of fatality with about 50%. Over the years, helmet standards have evolved to be an effective means to assure helmet quality in terms of minimal performance. In general, helmet testing standards are the result of often rather pragmatic compromises in meetings of technical experts, more than scientific research. As helmet quality improves, the criteria of shock absorption tests are raised and impact severities are increased. [1]

There are unique properties of Fibreglass, which make it suitable and desirable for a wide range of motorcycle helmet applications. These properties offer huge advantages over other types of construction materials. The advantages of Fibreglass are lightweight and durable material. Fibreglass reinforced plastic (FRP) does not rust and is highly resistant to corrosion. In fact, the non-corrosive properties of fibreglass give it a much longer life expectancy than metal, wood, and non-reinforced plastics when used in highly corrosive application environments. [2]

The FRP material is suitable to use in helmet fabrication because it can performed much better in protecting head injury compare to common type of helmet in the market such as thermoplastic or Acrylonitrile Butadiene Styrene (ABS).[2]

2.2 Crash Helmet Design And Test

Humans began protecting their heads using helmets long before injury mechanisms were studied. The way helmets were designed was, and still is, heavily dependent on the application of the helmet. Not until the end of the 19th century, it was discovered that serious head injuries could occur without penetration. It took another 50 years to understand that non-penetrating head injuries are caused by short-duration accelerations acting on the head and its contents. These acceleration injuries are the most common and dangerous form of injuries for motorcyclists and are often caused by blunt impact rather than penetration. [1]

The early motorcycle helmets were designed accordingly: leather covered, shock absorbing liner. In later designs, the leather cover was replaced by a stiffer, plastic outer shell. The function of this shell is not only to prevent penetration, but also to distribute the load over a larger area. Figure 2.1 illustrates the components of a modern full-face motorcycle helmet. The modern motorcycle helmet generally consists of four main parts: the comfort padding liner, the protective padding liner, the outer shell and the retention system. The retention system is used to keep the helmet in position prior to or during an impact. The purpose of the comfort padding liner is to increase the wearing comfort of the helmet and to provide a good fit on the head. It consists of low-density, flexible, open-celled, polyurethane or PVC foams and is often faced with a cloth layer. [1]

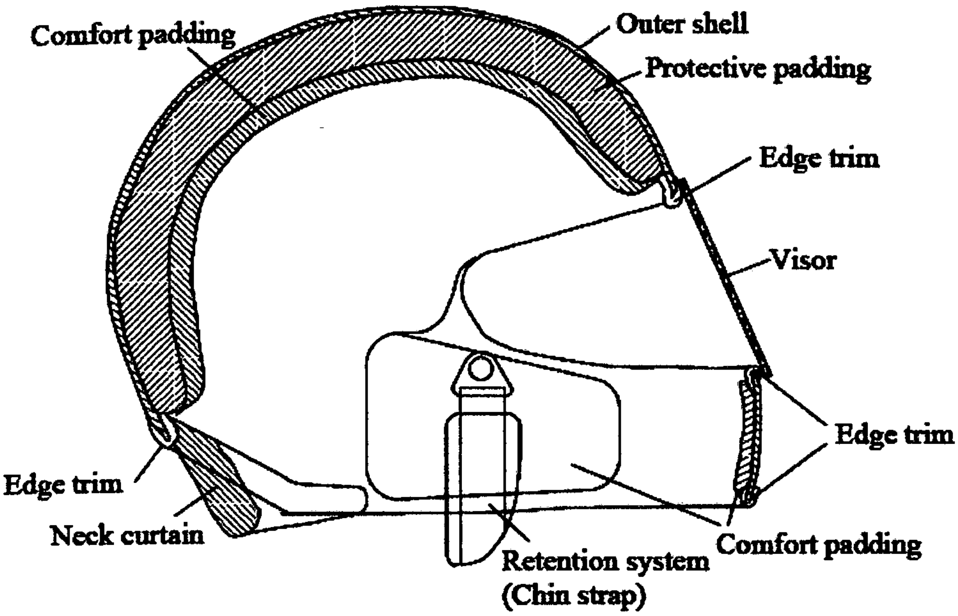

Figure 2.1: Cross Section of a Full-Face Motorcycle Helmet [5]

Surface helmet impact test results could be ranked by order of best performance: DOT (U.S Department of Transporting), ECE (European Community Standard), BSI (British Standard Institution), and Snell. Energy-absorbing liners on modern helmets are generally more complex and perform better than helmets made 15 years ago. The overall best performing model was qualified only to the DOT standard. Helmets qualified to the high-energy Snell standards generally had the highest peak accelerations in these tests. [3]

The experiments were carried out on a drop test setup which meets the requirements of the European standard for energy absorption testing of helmets, ECE Regulation. The test setup is depicted in Figure 1.2 the helmeted head is dropped onto an anvil using a guided free fall (monorail test). The anvil is mounted on a rigid, vibration-free floor to prevent external vibrations from influencing the measurements. [1]

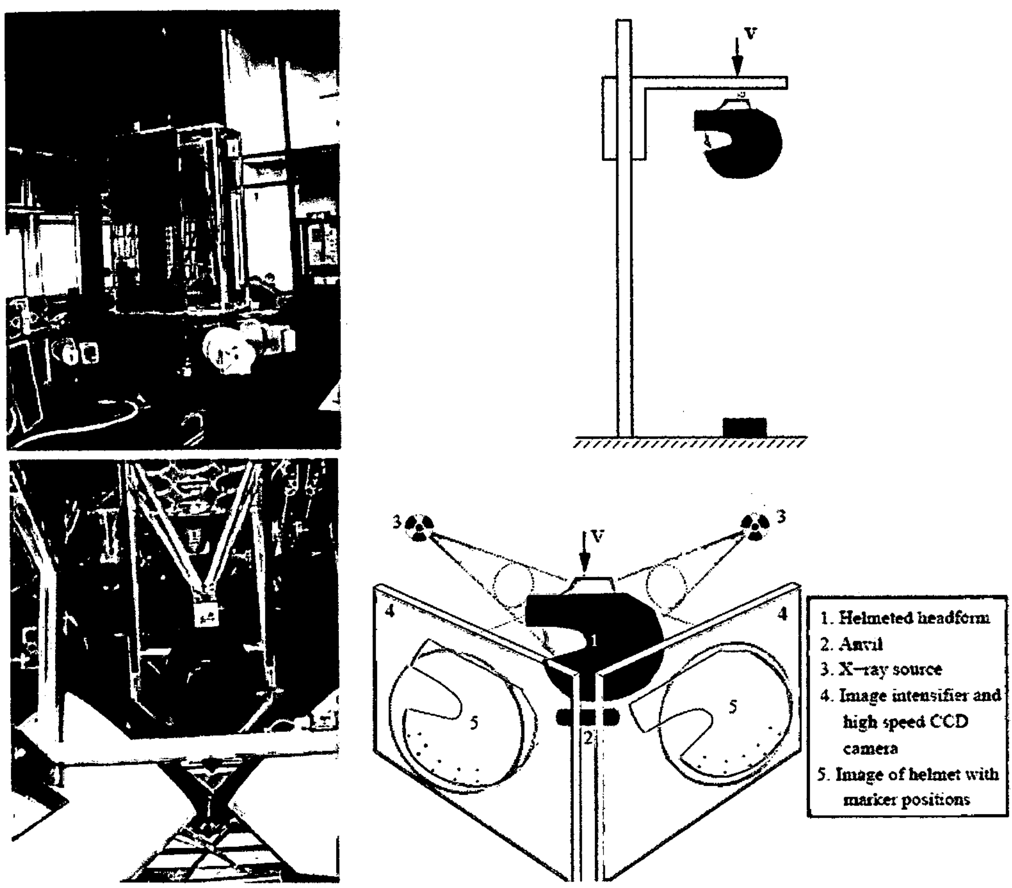

Figure 2.2: Drop test setup. Upper left: Photograph of overview. Upper right: Schematic of drop tower. [1]

Table 2.1: Summary of Result [3]

ID 1	ID 2	Standard(s) Met	Weight, grams	Shell Material	Shell Thickness, mm	Liner Thickness, mm	No. EPS liner parts in crown	Overall liner density, kg/cu.m (lb/cu.ft.)	Peak g Front Left, 2m Asphalt	Peak g Front right, 3m Asphalt	Peak g Rear Left, 2m Asphalt	Peak g Rear Right, 2m Edge
M	27	DOT	1583	Thermoplastic[5]	4.0	39	1	53 (3.3)	152	173	175	130
M	29	DOT	1552	Thermoplastic	4.0	39	1	53 (3.3)	154	173	175	129
R	36	DOT	1662	ABS[6]	4.6	39	1	55 (3.4)	163	199	185	152
R	37	DOT	1672	ABS	4.6	39	1	55 (3.4)	163	196	185	154
F	13	DOT	1514	ABS/PC[7]	4.7	31	1	39 (3.4)	149	176	154	130
F	14	DOT	1538	ABS/PC	4.7	31	1	39 (3.4)	157	177	164	138
		Average DOT	**1587**		**4.7**	**36**		**49 (3.1)**	**157**	**177**	**164**	**138**
C	7	DOT+ECE	1711	FRP[8]	3.2	34	5	47 (2.9)	151	180	176	137
C	8	DOT+ECE	1750	FRP	3.2	34	5	47 (2.9)	161	194	178	138
Q	34	DOT+ECE	1416	FRP & Kevlar & CF[9]	2.9	38	1[10]	47 (2.9)	166	187	201	141
Q	35	DOT+ECE	1407	FRP & Kevlar & CF	2.9	38	1	47 (2.9)	166	187	194	136
P	32	DOT+ECE	1422	FRP	2.7	30	1	55 (3.4)	156	200	190	140
P	33	DOT+ECE	1472	FRP	2.7	30	1	55 (3.4)	155	196	190	138
G	15	DOT+ECE	1489	FRP	2.2	33	1[9]	61 (3.8)	171	198	166	162
G	16	DOT+ECE	1469	FRP	2.2	33	1	61 (3.8)	172	197	166	158
		Average ECE	**1517**		**2.8**	**34**		**53 (3.3)**	**162**	**192**	**183**	**144**

[5] Thermoplastic, actual material not specified
[6] Acrylonitrile Butadiene Styrene
[7] Acrylonitrile Butadiene Styrene & Polycarbonate alloy
[8] Fiber reinforced plastic, a.k.a. Fiberglass
[9] Carbon Fiber
[10] Deeply grooved "crumple zone" design

The Table 2.1 showed the result of comparison tests of motorcycle fiberglass helmets qualified to international standards. From the table 2, we can conclude that Fiberglass material is definitely much better than Thermoplastic and Acrylonitrile Butadiene Styrene (ABS). Even though the shell thickness of fiberglass is much thinner than thermoplastic and ABS, yet it still qualify to get the DOT and ECE standard.

To create an affordable fiberglass helmet, it must be simple design to cut the material cost and manufacturing cost. By using the MS88 helmet design as a mold, it's very suitable for design selection because the simple shape of MS88 fiberglass helmet can make it easily to produce and make the MS88 fiberglass helmet less expensive.

2.3 Fiberglass

Fiberglass is material made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP), is called "fiberglass" in popular usage. [2]

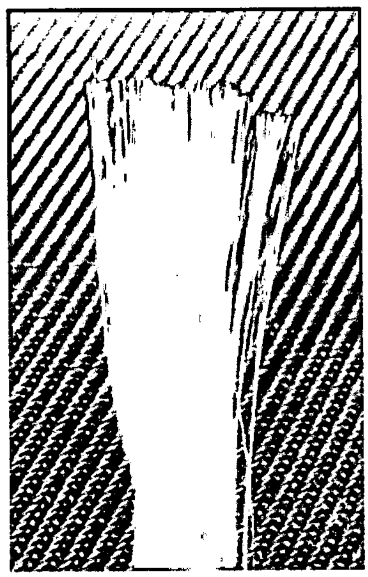

Figure 2.3: Fibreglass Strands **[2]**

Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing as shown in Figure 2.3. Glass is unlike other polymers in that, even as a fiber, it has little crystalline structure (see amorphous solid). The properties of the structure of glass in its softened stage are very much like its properties when spun into fiber. [2]

Glass strengths are usually tested and reported for "virgin" fibers which have just been manufactured. The freshest, thinnest fibers are the strongest and this is thought to be due to the fact that it is easier for thinner fibers to bend. The more the surface is scratched, the less the resulting tenacity is. Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity. [2]

There are six type of fiberglass:-

- **E-glass** - Still makes up most of the fiberglass production in the world. Its particular components may differ slightly in percentage, but must fall within a specific range. The letter E is used because it was originally for electrical applications. [2]
- **S-glass** - High strength formulation for use when tensile strength is the most important property. [2]
- **C-glass** – It was developed to resist attack from chemicals, mostly acids which destroy E-glass [2]
- **T-glass** – It is a North American variant of C-glass [2]
- **A-glass** – Is an industry term for cullet glass, often bottles, made into fiber. [2]
- **AR-glass** – Function as an alkali resistant glass [2]

2.4 Fiberglass Properties

Fibreglass is *chemically inert*. This means that it will not react chemically with other substances with which it may come into contact. This can prevent potentially hazardous and explosive situations that arise with other metallic or petroleum based materials. [2]

Fibreglass also has superior and more desirable acoustic qualities than plastic or metal. Under similar conditions Fibreglass and composites tend to vibrate less and remain quieter than sheet metals. This can reduce the overall operating volume of your machinery and even help you achieve acceptable or required sound levels for your equipment. For even more sound deadening capability, fibreglass and composites can layered with matte material in order to achieve the desired level of acoustic deadening. [2]

Fiberglas is structurally stable. Fiberglas and composites exhibit the least amount of expansion and contraction with heat and stress compared to plastic, metal, or wood. This means that your products will hold their shape better under severe mechanical and environmental stresses. [2]

The Table 2.2 showed the difference between fiberglass with Kevlar and carbon fiber. The fiberglass showed the potential to be use in the wide range production because it less expensive and high strength of compression ratio compare to Kevlar and carbon fiber. [3]

Table 2.2: Characteristic of Fibre Materials [6]

Density	E	P	E
Tensile Strength	G	F	E
Compressive Strength	P	G	E
Stiffness	G	F	E
Fatigue Resistance	E	G-E	G
Abrasion Resistance	E	F	F
Sanding /Machine	P	E	E
Conductivity	P	P	E
Heat Resistance	F	E	E
Moisture Resistance	F	G	G
Resin Capability	F	E	E
Cost	F	E	P

P= Poor

F= Fair

G= Good

E= Excellent

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discussed about methods taken order to fabricate helmet using fibreglass material.

Before start on fabrication process, design and sketching has to be done to decide which design would be the most suitable for fabrication. The design must be carefully analyze before the fabrication process can begun because it is important for the helmet to function and easy to fabricate. The aspect that should be considered for design the helmet is:-

a) **Shape of helmet**: The helmet design must not consist sharp corner to prevent material weakness at the corner end.
b) **Cost**: The cost must not exceed beyond the budget limit.
c) **Helmet** availability: The design based on the existing helmet. The existing helmet will be the mould of the helmet.
d) **Material**: The material of helmet must be strong enough to stand high energy from impact.

3.2 Project Flow Diagram

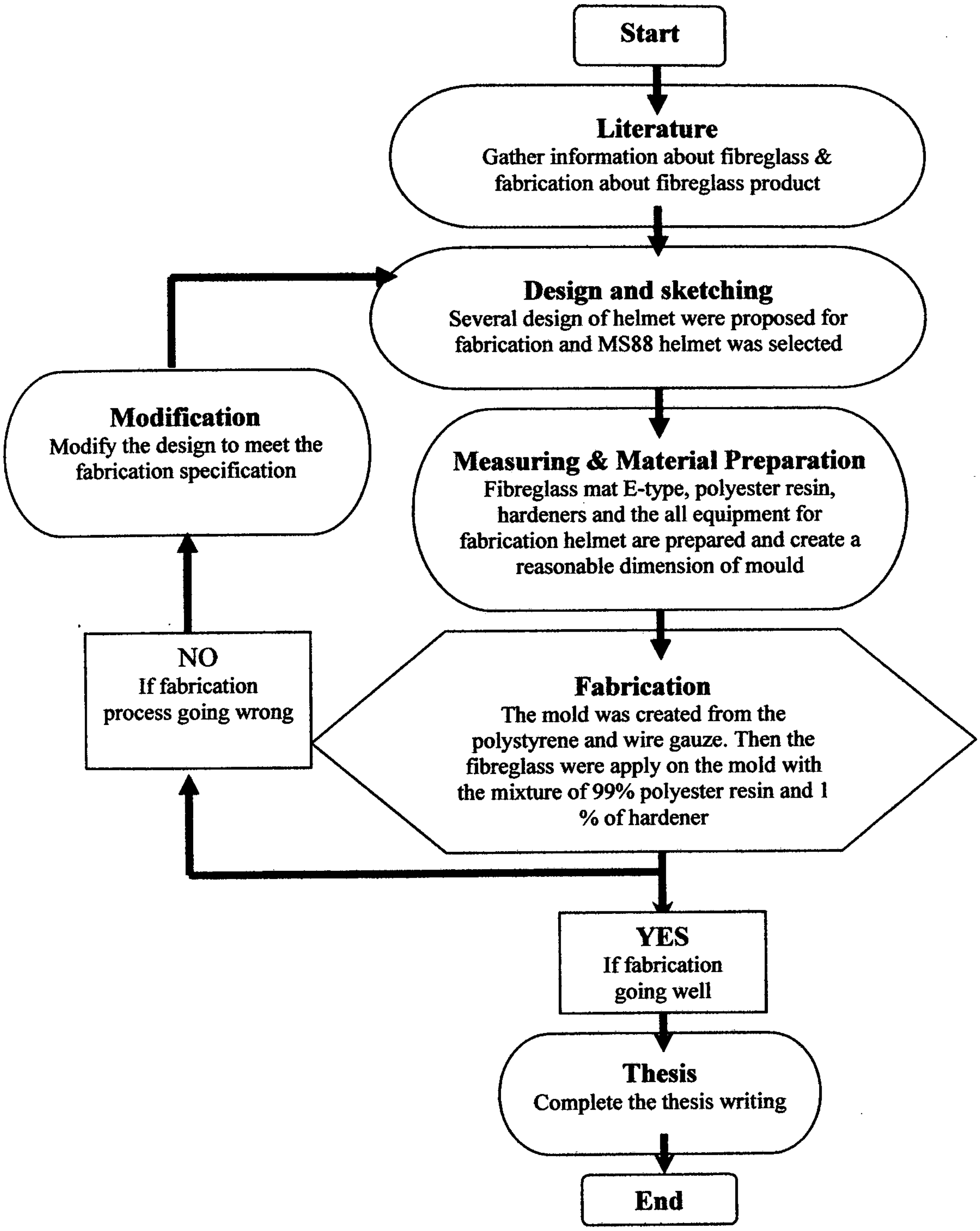

Figure 3.1: Flow Chart