



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**Design, Development and Analysis of Body
Profile for Ballistic Armour Mould using
Reverse Engineering Method**

Thesis submitted in accordance with the partial requirements of the Universiti
Teknikal Malaysia Melaka for the Degree of Bachelor of Manufacturing
Engineering (Design Manufacturing)

By

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DEDICATION

For my mum and dad

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LIST OF ABBREVIATIONS

Al ₂ O ₃	-	Aluminum Oxide
AP	-	Armour Piercing
AUTO	-	Automatic
CAD	-	Computer Added Design
CATIA	-	Integrated System
CNC	-	Computer Numerical Control
CMM	-	Coordinate Measurement Machine
DMFA	-	Design Manufacturing for Assembly
FMJ	-	Full Metal Jacketed
IPK	-	Ibu Pejabat Polis Kontinjen
JHP	-	Jacketed Hollow Point
JSP	-	Jacketed Soft Point
Kg	-	Kilogram
LR	-	Long Rifle
LRN	-	Lead Round Nose
NIJ	-	National Institute of Justice
PC	-	Personal Computer
P/M	-	Powder Metallurgy
POP	-	Plaster of Paris
RN	-	Round Nose
RP	-	Rapid Prototyping
STF	-	Shear Thickness Fluid
UTeM	-	Universiti Teknikal Malaysia Melaka
U.S	-	United States
2D	-	Two Dimension
3D	-	Three Dimension

ABSTRACT

Analysis of the hard body armour profile using reverse engineering method of the existing body armour to design the new ballistic armour mould. In design, the problems are normally not ergonomic and not comfortable armour plate. It normally related to shape, material and weight of hard body armour. The design needs to consider male figure. From that statement, laboratory session is arranged to measure the previous body armour profiles by using 3D Scanner. But, the profile failed to analyse. The manual measurement of the anthropometrics data were collected from IPK Melaka. Then, the profiles are referred to design the new hard body profile. At this point, the new body profile is design and draw in CAD software, Catia. Prototype of armour plate will be produce by rapid prototyping. Finally, the core and cavity mould is design.

ABSTRAK

Penyelidikan profil badan kalis peluru menggunakan kaedah kejuruteraan kebelakang dengan menjadikan profil produk yang terdahulu sebagai rujukan untuk mereka acuan untuk papan kalis peluru yang baru . Dalam rekaan, masalah yang dihadapi adalah papan kalis peluru adalah tidak ergonomik dan tidak selesa. Biasanya ia berhubungkait dengan bentuk, bahan, dan berat papan kalis peluru tersebut. Rekaan perlu mengambil kira bentuk badan lelaki. Dari kenyataan tersebut sesi makmal diatitkan untuk mengukur profil terdahulu dengan menggunakan 3D Scanner tetapi ianya gagal apabila drawing tidak boleh dikaji. Ukuran secara manual juga diambil sebagai data antropometri dari pengumpulan data di IPK Melaka. Kemudian, ia dijadikan sebagai rujukan untuk mereka profil badan yang baru. Pada tahap ini, rekaan akan dilukis didalam perisian CAD, Catia. Prototaip bagi papan kalis peluru akan dihasilkan dengan Mesin Rapid Prototyping. Akhirnya, acuan direka.

CHAPTER 1

INTRODUCTION

1.1 Background

Body armour is nothing new; ancient warriors have worn bronze, copper and iron breast plates as far as recorded history. During World War II flack jackets were introduced and by the Vietnam war nylon filled jackets were issued to troops. Unfortunately, the jackets were very bulky and rather hot [5]. Today, for the army, police officers, security personnel and those that compete in the world of sport, the use of equipment to protect the body is almost common place. From sports shin pads and ballistic vests to thorn-proof gardening gloves, wearers rely on body armour to protect them against severe injury, and at the same time require it to be lightweight and comfortable to wear. The future fighting force will have far superior protective systems that provide enhanced capabilities while imposing less weight on the user. Engineers are looking forward for new materials and composites that offer enhanced protection with less weight. (Hellweg, 2000)

The range of incidents that can cause injury is serious, and while there are various body armours design as solutions of some particular problems, the issues of impact, man-made protection versus natural body protection, and damage to vital organs are often not looked at an integrated manner when designing equipment for body protection. As a part of this design process, the important is to guard against the impact velocity, mass, force, impulse, energy, or momentum [9]. Armour should have ability to stop a bullet or knife blade.

Ian Horsfall from Cranfield University RMCS Shrivenham, UK mention from a technological viewpoint, body armour is now well developed, with a variety of challenging materials systems and manufacturers, all offering good all-round solutions [5]. The current challenge is to engineer a better balance of properties to improve ergonomics and the integration with other equipment and clothing. The military market is relatively mature and its main challenge is to increase the level of protection and coverage while keeping weight low. The police and other civilian markets, such as public transport workers, cab drivers and ambulance paramedic crews, are relatively less mature with significant challenges in providing wearable and often discreet systems for everyday use.

Since the advent of modern, body armour in the 1970s [5], ballistic fibres have become stronger, enabling manufacturers to produce lighter, more flexible body armour. Horsfall also point out, the improvements in fibre technology are providing a steady increase in armour efficiency. It is not unusual for modern systems to incorporate two or three types of fibre in three or more types of crisscross.

The two main fibres used in soft body armour are aramid and polyethylene. It's designed to stop bullets that soften on impact [5], soft body armour offers little protection against bursts of fire from submachine guns. This level of protection is afforded in hard armour bullet-proof vests, which traditionally have rigid ceramic plates in the front and in the back, making them heavy and restricting to movement.

In a move to overcome the problems of wearing hard armour vests, a new type of material has been designed that not only protects the body from soft bullets but is also designed to withstand a burst of fire from an automatic firearm. The Lorica Armour Vest, recently demonstrated on the BBC's Tomorrow's World programme, is the brainchild of Digby Dyke from Lorica Research. The vest uses the new material, which is made from three types of synthetic polymer fibre that have very high impact and penetration resistance. These fibres are already used in the manufacture of body armour, but the key to the new fabric's strength lies in deeply impregnating the fibre textile with an ethylene-based thermoplastic resin to form a strong net. In the finished vest, twenty two layers of the fabric work independently to absorb and dissipate the energy from the bullet. [5]

In order to make sure body armour is safe to use, there are two current methods for testing the body armour based on the use of a ballistic or drop-weight driven missile with a knife blade as the source of the stab. Professor Thomas Gray from the Department of Mechanical Engineering at the University of Strathclyde (UK) said that the specimen is mounted against a support medium, which mimics the compliance of a human torso [5]. Other speaker lined up for the seminar said there are two parts to the testing system, the delivery part (the attacker) and the target, which can vary substantially depending on the part of the body that is struck and what kind of armour there is. Ideally, different kinds of armour are needed for different places.

The University of Strathclyde was commissioned by Strathclyde Police [5] to set up a facility to test body armour according to the then-current standards. Concerned that the test machine was doing something different from real attacks, which could have meant the whole thrust of materials development was aimed in the wrong direction, the Bioengineering Department set up a project, funded mainly by the Scottish Office and Police Union contributions, to measure what actually happens when a range of volunteers were invited to stab a dummy target. Gray said that this showed that fears had not been unfounded and, in conjunction with findings elsewhere, this led to the development of a new standard, using a different form of test system.

Body armour is a highly competitive field with a large number of manufacturers selling armour. However, one market and challenge that remains is the provision of the same levels of comfort for female wearers as is already afforded to most male wearers. Horsfall [5] bring up there are both technological, medical and ergonomic problems still to be solved in order to provide comfortable and effective protection to female users.

Whether the body protection is for male or female wearers, it needs to be practical to wear, light, flexible and must cover the vulnerable areas for its particular application. Gray said although manufacturers have made great strides, there is still plenty of opportunity for improvement. The next few years, Horsfall [5] from Cranfield University believes it should be possible to apply powerful modelling capabilities to body armour to allow much better optimisation of current systems. Improvement in fibres and other technologies are likely to provide further incremental gains but there may be other technologies that can be applied, such as reactive and active systems. With such optimism, many could soon be wearing body armour with enhanced features such as active cooling.

1.2 Problem Statements

This research paper would analyse the hard body armour profile using reverse engineering method and design the hard armour profile. The existing body armours that used by police department in IPK Melaka are benchmarked. Some survey is conduct to collecting data based on customer needs. The data are collected by cooperation with policemen in crime department in IPK Melaka.

In designing, the problems are normally not ergonomic and uncomfortable body armour plate. It normally related to shape, material and weight of hard body armour. The design also needs to consider the body figure.

From the above statements, one laboratory session could be arrange to analyse re-document the body armour profile by 3D Scanner; in applying reverse engineering method as an intention to design and develop the new armour profile easily and reducing time. Then, the profiles are refer to design the new hard body profile and transfer to CAD drawing, Catia. Finally, the core and cavity mould is designed.

1.3 Objectives of the Project

The main objective of this project is to create the mould for hard body armour profile:

- i. Hard body armour profile measurement:
Scan the profile for existing hard body armour using 3D scanner
- ii. Design new body profile of hard armour plates and the moulds:
Draw the new hard body armour plate in Catia software and transfer drawing to rapid prototyping (RP).
- iii. Prototype of hard body armour plate:
Making hard body armour plate prototype for front and back by using rapid prototyping (RP) machine.

1.4 Scope of the Project

The focus of the project is on development of body armour profile in the current market while implements the reverse engineering method, which is concentrates on developing new hard body profile and produce the prototype. This project involves design and development on body armour plate based on customer needs. The armour plate is design for men in medium size.

1.5 Hypothesis

After completing this research, the assumption should produce a prototype of armour plate for new body armour design and the mould. This is simply a practice of using the Catia software and other engineering knowledge that had been studied before.

1.6 Rational of Research

There are some rationality will be considered in this project as following statements:

- i. Practicing a reverse engineering method.
- ii. Applying the Catia software in making ergonomic armour plate.
- iii. Design stage of designing the new hard armour mould.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter two consists of investigation about the profiles of hard body armour and designs the mould and die complete with prototype from POP. There are certain aspects that needed to be considered in order to achieve the objectives of this investigation process, such that:

- i. Design new profile of hard armor based on analysis the existing profile
- ii. Design consideration of making a mould; size and type of material
- iii. Process involve in producing the ceramic hard armor
- iv. Process of making a mould prototype model

The new profile is design by done the reverse engineering method using CMM. Then, analysis is continued in order to making a mould. Type of material and size are consideration of process of manufacturing an armour plate. Mainly, this project is focused on ceramic armour plate. Last but not least, this project assumed to produce a prototype model for mould by rapid prototyping. The design which is drawn in Catia software is converted to STL or STEP file and transferred the 3D design of mould to rapid machining program. Some literatures are referred as per following topics: