UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF COMBAT ARMOR FROM RAMIE-ARAMID-POLYESTER COMPOSITE

ZAINAB SHAKEH RADIF

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DEVELOPMENT OF COMBAT ARMOR
FROM RAMIE-ARAMID-POLYESTER COMPOSITE

By

ZAINAB SHAKER RADIF

Thesis submitted to The School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for The Degree of Master of Science

JUNE 2009
DEDICATION

I would like to present my scientific effort in this research for my lonely love IRAQ

my Continuous sacrifice will be until the last driblet from my blood for his dignity and development. Deeply thanks for whom truly are behind my success love and support, my beloved mother, lovely father, my faithful husband, also deeply thanks for my small partners and lovely friends for their patience at the troubles in this complicated journey

Sarah, Mohamed and Yeser.
Abstract of Thesis Presented to The Senate of University Putra Malaysia in Fulfillment of The requirement for the Degree of Master of Science

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Chairman : Dr. Aidy Ali
Faculty : Engineering

In this study the laminates composite material is developed from ramie-aramid-polyester resin. The aim of this study is to developed solid body armor by using ramie-aramid reinforced polyester composite structure design. The design of body armor meet the specific requirements of ballistic resistance. The matrix of the developed composite is unsaturated Polyester resin reinforced with aramid-natural ramie fiber. This ramie-aramid composite is subjected to high impact loading. The target is shot by using gas gun machine supported by camera hardware to capture the projectile speed. To achieve the goal of the research, experiments were conducted with a focus on estimation the ballistic limit, maximum energy absorption, composite failure mode, life time rupture, target geometry and environmental effect. The results of these experiments indicated that the maximum ballistic limit validated at impact speed is in the range of 250 m/s to 656.8 m/s for the second protection level. The targets are improved in the area of impact respond with increase in the relative humidity in the range of 50% ± 20%.
Whereby, reduction of resistance results in the increase of temperature. The range of temperatures was between 20 °C to 70 °C. A limited delamination was generated under multiple shots. Targets geometry plays a main role in increasing impact response. Hence, the results were presented high resistant impact for pairs from panels with total thickness of 15 mm ± 3mm. This body armor is one of most economical armor products in that; common materials were used in its production especially to the reduction of the using Kevlar amount that led to decrease in its cost. On the other hand this armor met the ballistic threats under 623 m/s of 15 mm ± 3 mm target thickness and 837.5 m/s of 25 mm ± 2 mm. Thus, the armor is equivalent to third level of protective ballistic limits in National Institute of Justice (NIJ) standards.
Keputusan eksperimen ini menunjukkan had maksimum kalis peluru adalah pada kelajuan impak diantara 250 m/s hingga 656.8 m/s bagi tahap perlindungan ke dua. Sasaran diperbaiki dalam lingkungan maklumbalas impak dengan peningkatan kelembapan relatif di antara 50% ± 20% ; di mana pengurangan ketahanan menyebabkan peningkatan suhu di antara 20 °C hingga 70 °C. Pelekangan yang terhad diperolehi dari pelbagai tembakan. Geometri sasaran memainkan peranan penting dalam meningkatkan maklumbalas impak. Oleh itu keputusan menunjukkan impak ketahanan tinggi bagi pasangan lapisan yang mana jumlah ketebalannya adalah di antara 15 mm ± 3 mm. Perisai ini merupakan produk perisai yang paling ekonomi kerana bahan-bahan biasa yang digunakan untuk menghasilkannya terutama bagi pengurangan penggunaan amaun Kevlar yang menyebabkan kos berkurangan. Selain itu, kalis peluru ini memenuhi hentaman balistik di bawah 623 m/s dari 15 mm ± 3 mm ketebalan sasaran dan 837.5 m/s dari 25mm ± 2mm. Oleh itu, perisai tersebut adalah sama dengan tahap ketiga had perlindungan balistik mengikut piawaian Institut Kehakiman Kebangsaan (NIJ).
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APPROVAL

I certify that an Examination Committee has met on 29th September 2009 to conduct the final examination of Zainab Shaker Radif on her Master of Science thesis “The Development of Combat Armor from Ramie-Aramid-Polyester Composite” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree.

Members of the Examination Committee are as follows:

Ir. Nor Mariah Adam, PhD  
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

Ir. Barkawi Sahari, PhD  
Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

Khairol Anuar Mohd Ariffin, PhD  
Senior Lecturer  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

Mariatti Jaafar @ Mustapha, PhD  
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(External Examiner)

__________________________________________________________________________________

BUJANG KIM HUAT, PhD  
Professor and Deputy Dean  
School Of Graduate Studies  
University Putra Malaysia

Date:
This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

**Aidy Bin Ali, PhD**  
Senior Lecturer  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Khalina Abdan, PhD**  
Senior Lecturer  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**Ir. Mohd Sapuan Salit, PhD**  
Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

---

**HASANAH MOHD GHAZALI, PhD**  
Professor and Dean  
School Of Graduate Studies  
University Putra Malaysia

Date:
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

ZAINAB SHAKER RADIF

Date:
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LIST OF ABBREVIATIONS / GLOSSARY OF TERMS

KRP  Kevlar29 –Ramie Fiber Reinforced Polyester
UP   Unsaturated Polyester
FEA  Finite Element Based Analyses
MMC  Metal Matrix Composite
CMC  Ceramic Matrix Composite
PMC  Polymer Matrix Composite
$V_f$ Fiber Volume Friction
$V_m$ Matrix Volume Friction
$V_l$ Composite Volume Friction
$G_{ij}$ Composite Shear Modulus
$v_{ii}$ Composite Poisson Coefficient
$v_f$ Fiber Poisson Ratio
$v_m$ Matrix Poisson Ratio
$e_{warp}$ Elastic Modulus of Warp Direction
$e$ Total Layer Thickness
$n_1$ Number of Warp Yarns Per Meter
$n_2$ Number of Fill Yarns Per Meter
$e_{fill}$ Elastic Modulus of Fill Direction
$E_x$ Elastic Modulus of x Direction
$E_t$ Elastic Modulus of Transverse Direction
$E_l$ Elastic Modulus along The Direction of Fiber
\( G_{xy} \)  \( G_{yz} \)  Shear Modulus in Two Directions
\( V_{xy} \)  Volume Friction in Two Direction
\( C \)  Velocity of Longitudinal Strain Wave
\( E \)  Dynamic Modulus of Elasticity
\( \rho \)  Yarn Density
\( V_b \)  Ballistic Limit Velocity
\( N_{PLY1} \)  Number of Nylon Plies
\( N_{PLY2} \)  Number of Humpt Plies
\( MEKP \)  Mety1 Ethy1 Ketone Peroide
\( NIJ \)  National Institute of Justice
\( OSP \)  One Separated Panel
\( TSP \)  Two Separated Panels
\( FTP \)  Flexible –Tough Panels
\( P_a \)  Cylinder Gas Pressure
\( D \)  Diameter of The Projectile
\( E_{abs} \)  Energy Absorption
\( m \)  Mass of The Projectile
\( V_{imp} \)  Strike Velocity
\( b \)  Target Thickness
\( FMJ \)  Full Metal Jacket
\( ACP \)  Automatic Colt Pistol
\( AP \)  Armor Piercing
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Sarah, Mohamed and Yeser.
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