KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

The Use of Alumina Powder In Adhesive/Flexible Polymer Ceramic Composite

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process). The members of the supervisory committee are as follows:

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ABSTRACT

Traditionally, filler were considered as additives, which, due to their unfavorable geometrical features, surface area or chemical composition, could only moderately increase the modulus of the polymer, while strength (tensile, flexural) remained unchanged or even decreased.

The term reinforcing filler has been coined to describe discontinuous additives, the form, shape, and/or surface chemistry of which have been suitably modified with the objective of improving the mechanical properties of the polymer, particularly strength. Inorganic reinforcing fillers are stiffer than the matrix and deform less, causing an overall reduction in the matrix strain, especially in the vicinity of the particle as a result of the particle/matrix interface.

Reinforcing filler are characterized by relatively high aspect ratio, α, defined as the ratio of length to diameter for a fiber, or the ratio of diameter to thickness for platelets and flakes. For spheres or powder, which has minimal reinforcing capacity, the aspect ratio is unity. A useful parameter for characterizing the effectiveness of a filler is the ratio of its surface area, A, to its volume, V, which needs to be as high as possible for effective reinforcement.

Technologically, the most important composites are those in which the dispersed phase is in the form of a fiber. Design goals of fiber-reinforced composites often include high strength and/or stiffness on a weight basis. These characteristics are expressed in terms of specific strength and specific modulus parameters, which correspond, respectively, to the ratios of tensile strength to specific gravity and modulus of elasticity to specific gravity. Fiber-reinforced composites with exceptionally high specific strengths and moduli have been produced that utilize low-density fiber and matrix materials.

CHAPTER I

INTRODUCTION

1.1 Background and Problem Statement

Humans throughout recorded history have used various types of materials as body armor to protect themselves from injury in combat and other dangerous situations. The first protective clothing and shields were made from animal skins. As civilizations became more advanced, wooden shields and then metal shields came into use. Eventually, metal was also used as body armor, what we now refer to as the suit of armor associated with the knights of the Middle Ages. However, with the invention of firearms around 1500, metal body armor became ineffective. Then only real protection available against firearms were stone walls or natural barriers such as rocks, trees, and ditches.

The next generation of anti-ballistic bullet proof vest was the World War II "flak jacket" made from ballistic nylon. The flak jacket provided protection primarily from ammunitions fragments and was ineffective against most pistol and rifle threats. Flak jackets were also very cumbersome and bulky. When a handgun bullet strikes body armor, it is caught in a "web" of very strong fibers. These fibers absorb and disperse the impact energy that is transmitted to the vest from the bullet, causing the bullet to deform or "mushroom." Additional energy is absorbed by each successive layer of material in the vest, until such time as the bullet has been stopped.

Because the fibers work together both in the individual layer and with other layers of material in the vest, a large area of the garment becomes involved in preventing the bullet from penetrating. This also helps in dissipating the forces which can cause nonpenetrating injuries (what is commonly referred to as "blunt trauma") to internal organs. Unfortunately, at this time no material exists that would allow a vest to be constructed from a single ply of material.

Currently, today's modern generation of concealable body armor can provide protection in a variety of levels designed to defeat most common low- and medium-energy handgun rounds. Body armor designed to defeat rifle fire is of either semirigid or rigid construction, typically incorporating hard materials such as ceramics and metals. Because of its weight and bulkiness, it is impractical for routine use by uniformed patrol officers and is reserved for use in tactical situations where it is worn externally for short periods of time when confronted with higher level threats.

Typically, concealable body armor is constructed of multiple layers of ballistic fabric or other ballistic resistant materials, assembled into the "ballistic panel." The ballistic panel is then inserted into the "carrier," which is constructed of conventional garment fabrics such as nylon or cotton. The ballistic panel may be permanently sewn into the carrier or may be removable. Although the overall finished product looks relatively simple in construction, the ballistic panel is very complex.

Ballistic fabric is available from a number of manufacturers in various styles and compositions, each type having unique ballistic resistant properties. The body armor manufacturer may construct a given model of ballistic panel from a single fabric style or from two or more styles in combination. The location and number of layers of each style within the multiple-layer ballistic panel influence the overall ballistic performance of the panel. In addition, some manufacturers coat the ballistic fabric with various materials. For example, the manufacturer may add a layer of nonballistic material for the sole purpose of increasing blunt trauma protection. Even composites of two or more different ballistic materials are available. As a consequence, it is impossible to compare one product with another based solely on the number of fabric layers in the ballistic panel.

The manner in which the ballistic panels are assembled into a single unit also differs from one manufacturer to another. In some cases, the multiple layers are bias stitched around the entire edge of the panel; in others, the layers are tack stitched together at several locations. Some manufacturers assemble the fabrics with a number of rows of vertical or horizontal stitching; some may even quilt the entire ballistic panel. No evidence exists that stitching impairs the ballistic resistant properties of a panel. Instead, stitching tends to improve the overall performance, especially in cases of blunt trauma, depending upon the type of fabric used.

Body armor intended for routine use is most often designed to be worn beneath the normal uniform shirt. Again, manufacturers tend to design different methods of attaching armor to the body. Hook-and-pile fasteners are common, as are "D" ring tightening straps. With the exception of metal fasteners of any type (which can deflect a bullet on impact and pose a hazard), the method of attachment is a matter of personal preference.

Figure 1.1 : Example of Bullet Proof Vest

The term PPE (Personal Protective Equipment) refers to clothing and respiratory apparatus designed to shield an individual from chemical, biological, and physical hazards. This chapter includes a description of the types of PPE that address the needs of emergency workers, health care providers, and potential victims of terrorist attacks. It notes the general lack of access of many health care providers and potential victims to any kind of PPE. It also addresses the lack of specific regulatory standards for commercial PPE for use against military agents. Finally, the chapter discusses recently completed, ongoing, and planned research and development programs focused on PPE appropriate for response to terrorist attacks.

The chapter focuses primarily on protection from chemical agents, in part because of the fact that protection from hazardous chemicals will generally provide protection against biological agents as well, and in part because of the committee's belief that, by and large, biological agent incidents are not likely to be evident until well after release of the agent, at which point most agent not already in victims will have dissipated or degraded.

Impact physics and ballistics are areas of expanding engineering and scientific research field. There are many multidisciplinary sciences of interest related with this subject such as:

- Crashworthiness
- Millitary Application
- Impact Fusion
- Aerospace Application
- Meteoroid Hazard and Space Debris Impact

Nowadays, hypervelocity related impact studies has received a great interest in most developed countries due to its important in strategic defense, the search for new propulsions method and materials, and ballistics research (Figure 1.2 and 1.3). The behavior of materials under high pressure, stress and strain plays an important role in penetration mechanics and shock physics which require efficient accelerators and sophisticated data acquisition system to identity key parameters of this field of research. In order to accelerate projectiles in a wide range of impacting velocities, four large group of accelerators are available;

- Explosive propulsions
- Gun accelerators
- Plasma accelerators
- Electrostatic and electromagnetic propulsions.

Figure 1.2: The Bullet to Attack Vest

Figure 1.3: The Marks of Bullet Attack at the Component of Vest.

For the problem in my research, the material selected for this product is alumina plate, e-glass and s-glass. E-glass and s-glass is main types in glass fibers. E-glass is more commonly used glass for continuous fibers. Basically, E-glass is a lime-aluminum-borosilicate glass with zero or low sodium and potassium levels. S-glass has a higher strength to weight ratio and is more expensive than E-glass and is used primarily for military and aerospace applications. However, after combined this product become hard and rigid. This is because of the alumina plate and also some other adhesive. As a result, the user difficult to move and this product is not suitable to use for long times.

1.2 Research Objectives

The objectives of this research are:

1. To find alternative materials that can make the "Bullet Proof Vest" become flexible.

2. To characterize the effects of alumina powder as a filler in adhesive and flexible Polymer Ceramic Composite.

3. To study the influences of the ratio composition of alumina powder and adhesives to mechanical properties and microstructure of the composite.

1.3 Research Methodology

In order to achieve the objectives, the testing steps had been taken:

1. Characterization of alumina powder and silicone rubber.
2. Study the best formulation of alumina powder and adhesive.
3. Fabrication of alumina powder reinforced silicone rubber.
4. Several series of testing were conducted such as Microstructure Test, Tensile Test, Water Absorption Test in order to observe the mechanical properties.

CHAPTER II

LITERATURE REVIEW

2.1 Personal Protective Equipment

2.1.1 Introduction of PPE

The term PPE (Personal Protective Equipment) refers to the clothing and respiratory apparatus designed to shield an individual from chemical, biological, and physical hazards. This chapter includes a description of the types of PPE that address the needs of emergency workers, health care providers, and potential victims of terrorist attacks. It notes the general lack of access of many health care providers and potential victims to any kind of PPE. It also addresses the lack of specific regulatory standards for commercial PPE for use against military agents. Finally, the chapter discusses the recently completed, ongoing, and planned research and development programs focused on PPE appropriate for response to terrorist attacks.

2.1.2 Definition of PPE

PPE is an acronym for Personal Protective Equipment, and refers to whatever protective equipment may be used to insulate an individual from the chemical, thermal, explosive or other hazards presented by the environment in which he or she is working. In most instances, the PPE will comprise such items as safety glasses, laboratory coat, protective shoes and chemical-resistant gloves.(http://ptcl.chem.ox.ac.uk/MSDS/glossary/ppe.html [2005, September 08])

2.1.3 Purposes of PPE

This Directive applies to personal protective equipment, hereinafter referred to as 'PPE'. It lays down the conditions governing its placing on the market and free movement within the Community and the basic safety requirements which PPE must satisfy in order to ensure the health protection and safety of users. For the purposes of this Directive, PPE shall mean any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards.

PPE shall also cover:

(a) A unit constituted by several devices or appliances which have been integrally combined by the manufacturer for the protection of an individual against one or more potentially simultaneous risks.

(b) A protective device or appliance combined, separably or inseparably, with personal non-protective equipment worn or held by an individual for the execution of a specific activity.

(c) Interchangeable PPE components which are essential to its satisfactory functioning and used exclusively for such equipment.

Any system placed on the market in conjunction with PPE for its connection to another external, additional device shall be regarded as an integral part of that equipment even if the system is not intended to be worn or held permanently by the user for the entire period of risk exposure.

This Directive does not apply to:

1. PPE covered by another directive designed to achieve the same objectives as this Directive with regard to placing on the market, free movement of goods and safety.
2. The PPE classes specified in the list of excluded products in Annex I, independently of the reason for exclusion mentioned in the first indent.

2.1.4 Levels of PPE

Military personal protective equipment also has been graded into levels, which are known as mission-oriented protective postures (MOPP). Seven levels of MOPP have been defined, ranging from MOPP ready (prepared to use MOPP gear within 2 hours) to MOPP 4 (maximum protection in protective respiratory mask and battledress over garments). The higher the level of MOPP, the greater is the level of protection (and greater is the negative impact on individual performance).

Level D PPE is the minimum basic level of personal protection equipment used in the tank farms or areas or operations where no air contaminants are present that would require respiratory protection. While en route from one work location to another, modesty clothing is acceptable as the minimum dress. Workers exiting a radiological surface contamination area may remove protective clothing at the step-off pad and proceed to the change trailer in modesty clothes. No work may be performed in modesty clothing. Specific PPE requirements will be determined by hazards associated with the work activity and may include the following:

- Coveralls and/or street clothes - covering the legs and shoulders
- Anti-contamination clothing
- Safety glasses or goggles

- Substantial footwear or protective footwear
- Hard hat
- Hearing protection
- Gloves.

Level C PPE is required where airborne contaminant levels are known or characterized, and a potentially hazardous atmosphere exists. Use of Level C PPE is not permitted in oxygen-deficient atmospheres (less than 19.5 percent oxygen), for contaminants with poor warning properties (odor detection level is greater than the threshold limit value), or when contaminant concentrations exceed the respirator limits. Personnel working inside the tank farms and wearing Level C PPE shall wear the following, as a minimum:

- Full-face air-purifying respirator (with appropriate filters and/or canisters and appropriate prescription eye wear without temple bars)
- Disposable chemical-resistant coveralls
- Anti-contamination clothing (as required by Health Physics if radiological hazards exist)
- Substantial footwear or protective footwear
- Chemical-resistant shoe covers
- Hard hat
- Inner chemical-resistant gloves (impervious to chemical agent of interest)
- Outer chemical-resistant gloves (impervious to chemical agent of interest)
- Hearing protection.

Level B PPE is required where airborne contaminant levels are unknown, and a potentially hazardous atmosphere exists. Level B PPE may be used only when it is unlikely that workers will be exposed to high concentrations of contaminants or chemical splashes that will affect the skin or be absorbed by it. Level B is generally the