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APPLICATION OF KENAF FIBER-PP COMPOSITE FOR FABRICATION ON INTERIOR PART OF AUTOMOTIVE COMPONENT

MUHAMAD FITRI BIN SOFIAN

A report submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Structure & Materials)

Faculty of Mechanical Engineering

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2017

DECLARATION

I declare that this project report entitled "Application of Kenaf Fiber-Pp Composite for Fabrication On Interior Part of Automotive Component" is the result of my own except as cited in the references

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Name	: ………………………………
Date	: ………………………………

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Alhamdulillah, thanks to Allah S.W.T for giving me a chance to complete my research for this final year project with the title, "Application of Kenaf Fiber-Pp Composite for Fabrication On Interior Part of Automotive Component".

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ABSTRACT

Nowadays, sustainability of materials and manufacturing, cost and energy consumption, environment and health issue, are the factors that affect the rate of production. Due to that factor, most of the company widely use natural fiber to overcome that difficulty. Furthermore, Kenaf fibre which is one of the natural fibre can be a potential to act as reinforcement with polypropylene (PP) as matrix to create a composite material. In order to make that happen, the mechanical properties and physical properties of this composite material have to be identify. Kenaf fibre and PP are compound together with different fibre composition on each sample. It started with, the natural fibre which is kenaf prepared from raw and then undergoes alkaline treatment. Kenaf is cut into 1 cm and then mixed with PP into the mould and is compressed with hot press and cooling machine in specified parameter of temperature, pressure and time. After the sample is prepared, it will undergo several type test which is tensile test (ASTM D3039), density test (ASTM D792) and hardness test (ASTM D2240). For microstructure analysis, Dino-Lite digital microscope is used to analyse the composition of fibre for each sample. According to the result from tensile test, it shows that maximum load on Kenaf fibre/PP was decreasing linearly with increasing content of fibre. For hardness test, it was found that there is increasing of hardness with the increment of fibre content. However, the trend of density was increasing as the increasing of fibre content in sample.

ABSTRAK

Pada masa kini, kemampanan bahan dan pembuatan, kos dan penggunaan tenaga, persekitaran dan isu kesihatan, adalah faktor yang mempengaruhi kadar pengeluaran. Oleh sebab itu, kebanyakan syarikat menggunakan serat semulajadi untuk mengatasi kesukaran tersebut. Selain itu, serat Kenaf yang merupakan salah satu daripada serat semulajadi boleh menjadi potensi untuk bertindak sebagai tetulang dengan polipropilena (PP) sebagai matriks untuk menghasilkan bahan komposit. Untuk membuatnya berlaku, sifat mekanikal dan sifat fizikal bahan komposit ini perlu dikenalpasti. Serat Kenaf dan PP akan digabungankan bersama dengan komposisi serat yang berbeza pada setiap sampel. Ia bermula dengan, serat semula jadi iaitu kenaf disediakan dari kulit kenaf yang asli dan kemudian menjalani rawatan alkali. Kenaf dipotong menjadi 1 cm dan kemudian dicampurkan dengan PP ke dalam acuan dan dimampatkan dengan mesin akhbar panas dan penyejuk pada parameter suhu, tekanan dan masa yang ditentukan. Selepas sampel disediakan, ia akan menjalani beberapa ujian jenis iaitu ujian tegangan (ASTM D3039), ujian ketumpatan (ASTM D792) dan ujian kekerasan (ASTM D2240). Untuk analisis mikrostruktur, mikroskop digital Dino-Lite digunakan untuk menganalisis komposisi serat untuk setiap sampel. Menurut hasil ujian tegangan, ia menunjukkan bahawa beban maksimum pada serat Kenaf / PP menurun secara linear dengan peningkatan kandungan serat. Untuk ujian kekerasan, didapati terdapat penurunan kekeruhan dalam meningkatkan kadar serat. Walau bagaimanapun, trend ketumpatan semakin meningkat apabila peningkatan kandungan serat dalam sampel.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, sustainability of materials and manufacturing, cost and energy consumption, environment and health issue, are the factors that affect the rate of production. Due to that factor, most of the company widely use natural fiber to overcome that difficulty. Natural fibers have gained interest to automotive industries to increase their production of interior parts. There were three types of natural fiber that can be classified which is animal, plant and mineral fiber. Between these three type of fiber, the natural plan fiber is most potential fiber to be choose because of its advantages. These advantages include low density, high mechanical properties, specific strength, low cost and low in uses on now renewable resources (Fatihou & Zouzou, n.d.). Moreover, it is suitable to be most of interior parts in automotive because it can decrease in weight of vehicles due to its low in weight. Natural plant fiber has been used as interior part of automotive component such as seat backs, door panels, package trays and dashboard (Ishak, Leman, Sapuan, Edeerozey, & Othman, 2010).

One of the most widely used natural plant fiber is kenaf fiber which is the most potential and suitable to use. Kenaf (ie. hibiscus cannabinus), is in the genus hibiscus and easily found and popular in southern Asia.The fibers in kenaf are found in the bast (bark) and core (wood). Bast fibers have low density and high in mechanical properties, make its suitable to be reinforcements in lightweight impact. Moreover, kenaf fiber is one of the environmentally friendly material, ecofriendly, low in cost and weight that causes it can be in of the automobile part reinforcement in lightweight impact. Not only that, this fiber also has better sound absorption and can act as noise level reduction (Kumaresan, Satish, & Karthi, 2015). Furthermore, its high specific strength and modulus materials, low price, recyclable, renewable, easily to found in certain countries (Hassan, Zulkifli, Ghazali, & Azhari, 2017).

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1.2 Problem statement

Natural fiber such as kenaf fiber is widely used in automotive industries as interior parts in vehicle. This type of fiber is use due to its properties such as cheap, recyclable, renewable, high mechanical properties, specific strength and good sound absorption. Moreover, kenaf fiber are lower in costs that make this fiber a very efficient structural design. However, there is a problem that can consider as major problem which level of durability on impact. On the previous experiment, the result of strength and hardness for kenaf fiber is still low (Kumaresan et al., 2015). This research work was intended to investigate the strength and hardeness of kenaf fiber and level of durability on impact. In this research work, kenaf fiber will mixed with PP polymer and undergo in several tests. Test that include in this research work are tensile test, density test, microstructure test and hardness test.

1.3 Objective

This research is to study the application of kenaf fiber-pp composite for fabrication on interior part of automotive component. Main objective of this research are:

1. To determine the tensile strength and hardness of kenaf fiber-pp composite
2. To study the properties of kenaf fiber-pp composite such as density and microstructure.

1.4 Scope of project

Kenaf manually opened and chopped into small pieces and mixed with PP fiber at 10%, 20%, 30%, and 40% fiber contents. Then the mixture was paced into mold with dimension (140 x 60) mm. Next, the mold is placed between two aluminum plates. This two plates were then pressed between two platens heat compressions machines with gauge length at 2 mm thickness. The temperature, time and pressure of the heat compression were set at 170°C, 5 mins and 2.5 MPa respectively. The 2 mm kenaf fiber-pp sample were then cut into one sample sizes which was (140 x 25 x 2) mm. the sample was prepared in 15 sample with same dimension but different ration of fiber. After that, all the sample is going through 4 type of tests which was density test, microstructure test, tensile test and hardness test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this era, most of automotive industry uses the natural fiber composites as reinforcement in interior part of automotive component. Composite material can be defined as a material that from two or more materials with different physical or chemical properties combined together in order to become stronger and better. The matrix is the key component in the composite material.

There are two categories of material which is matrix and reinforcement. Function of matrix material is to support the reinforcement materials by maintaining the reinforcements in place and transfer stress between the fibres and the reinforcement material impart its physical and mechanical properties to enhance the matrix properties. One of the good example of composite material is sandwich-structured composite. A sandwich-structured composite is a special class of composite material that is fabricated by attaching two thin but stiff skins to a lightweight but thick core. The core material is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density.

Based on studies by (Mahajan, Aher, Student, & Sangamner, 2012) has stated that the term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a “matrix” material that is reinforced with fibres. For instance, the term “FRP" (Fiber Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibres, and this particular composite has the lion's share of today's commercial market.

Recent studies by (Lopresto et al, 2016) has mentioned that composite materials are made of two or more different materials to create properties that cannot be obtained from any one material component alone. In the composite, one of the materials is performed as matrix while the other one is performed as reinforcement. The properties of composite material are depends on the nature reinforcement and matrix. However, the composite is the combination between two materials but they do not dissolve or blend into each other easily, the materials need to undergoes several process before it become a new composite material.

Refer to the (US Department of Energy, 2015), a composite can be defined as a combination of two or more materials that retain their macro-structure 50 resulting in a material that can be designed to have improved properties than the constituents alone.2 51 Fiber-reinforced polymer (FRP) composites are made by combining a polymer resin with strong, 52 reinforcing fibers. These lightweight composites enable many applications where the potential energy 53 savings and carbon emissions reduction occurs in the use phase.

2.2 Natural Fibre

The definition of fibre is a form a class of hair-like materials that occur as continuous filaments or in discrete elongated pieces alike to pieces of thread. They are of two types which is natural fibers and synthetic fibers. Fibers are of great importance in the biology of both plants and animals, for holding tissues together. Humans use natural and synthetic fibers for diverse purposes. For instance, some fibers are spun into filaments, thread, string or rope.

Some are components of composite materials. In this research, natural fibres work as reinforcements, providing the required strength and stiffness to the final composite part.

Natural fibre can be defined as substances that hairlike raw material directly obtainable from an animal, plant, vegetable, or mineral source that can be spun into filament, thread or rope. The most viable structural fibres typically derive from specifically grown textile plants and fruit trees. Nowadays, natural fibres are more up-to-date than they have ever been, as they show outstanding mechanical properties and are 100% sustainable. Natural fibre composites with significant reduction in weight became a serious alternative to conventional composite materials like glass and carbon fibres. In recent years, natural fibers are being increasingly used in the textile, building, plastics, and automotive industries. Those from plant sources include cotton, flax, hemp, sisal, jute, kenaf, and coconut.

(Bongarde & Shinde, 2014) has stated that natural fiber composites include coir, jute, baggase, cotton, bamboo, hemp. Natural fibers come from plants. These fibers contain lingo cellulose in nature. Natural fibers are eco-friendly; lightweight, strong, renewable, cheap and biodegradable. The natural fibers can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins such as epoxy, polyester, polyurethane, phenolic are commonly used composites requiring higher performance applications. They provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels.

Natural fibres can be classified according to their origin and grouped into leaf: abaca, cantala, curaua, date palm, henequen, pineapple, sisal, banana; seed: cotton; bast: flax, hemp, jute, ramie; fruit: coir, kapok, oil palm. Among them flax, bamboo, sisal, hemp, ramie, jute, and wood fibres are of particular interest(Cristaldi, Latteri, & Cicala, 2010) The most important physical and mechanical properties are summarized in Table 2.1.

Plant fibre	Tensile strength (MPa)	Young's modulus (GPa)	Specific modulus (GPa)	Failure strain (%)	Length of ultimates, l (mm)	Diameter of ultimates, d (μm)	Aspect ratio, l/d	Microfib angle, θ (º)	Density ($kg.m^{-3}$)	Moisture content (eq.) (%)
Cotton[s]	300-700	6-10	4-6.5	6-8	20-64	11.5-17	2752	20-30	1550	8.5
Kapok[s]	93.3	4	12.9	1.2	8-32	15-35	724	-	311-384	10.9
Bamboo[b]	575	27	18	-	2.7	10-40	9259	-	1500	-
Flax[b]	500-900	50-70	34-48	1.3-3.3	27-36	17.8-21.6	1258	5	1400-1500	12
Hemp[b]	310-750	30-60	20-41	2-4	8.3-14	17-23	549	6.2	1400-1500	12
Jute[b]	200-450	20-55	14-39	2-3	1.9-3.2	15.9-20.7	157	8.1	1300-1500	12
Kenaf[b]	295-1191	22-60	-	-	2-61	17.7-21.9	119	-	1220-1400	17
Ramie[b]	915	23	15	3.7	60-250	28.1-35	4639	-	1550	8.5
Abaca[l]	12	41	-	3.4	4.6-5.2	17-21.4	257	-	1500	14
Banana[l]	529-914	27-32	20-24	1-3	2-3.8	-	-	11-12	1300-1350	-
Pineapple[l]	413-1627	60-82	42-57	0-1.6	-	20-80	-	6-14	1440-1560	-
Sisal[l]	80-840	9-22	6-15	2-14	1.8-3.1	18.3-23.7	115	10-22	1300-1500	11
Coir[f]	106-175	6	5.2	15-40	0.9-1.2	16.2-19.5	64	39-49	1150-1250	13

Table 2.1: Natural fibre properties Source: Natural fibre'09 Proceedings (Cristaldi et al., 2010)

Based on research by (Rask, 2012), natural fibres can be derived into several different plant species as shown in Figure 2.1. Bast fibres are found in the stems of the corresponding plants. In the plant, the fibres serve the purpose of keeping the plant stem erect, so the top of the plant is high above the ground. Therefor the fibres are stiff and elongated. The fibres in a stem are arranged in 30-40 bundles each containing 10-40 elementary fibres, with pectin cementing the elementary fibres together, to form the bundles.

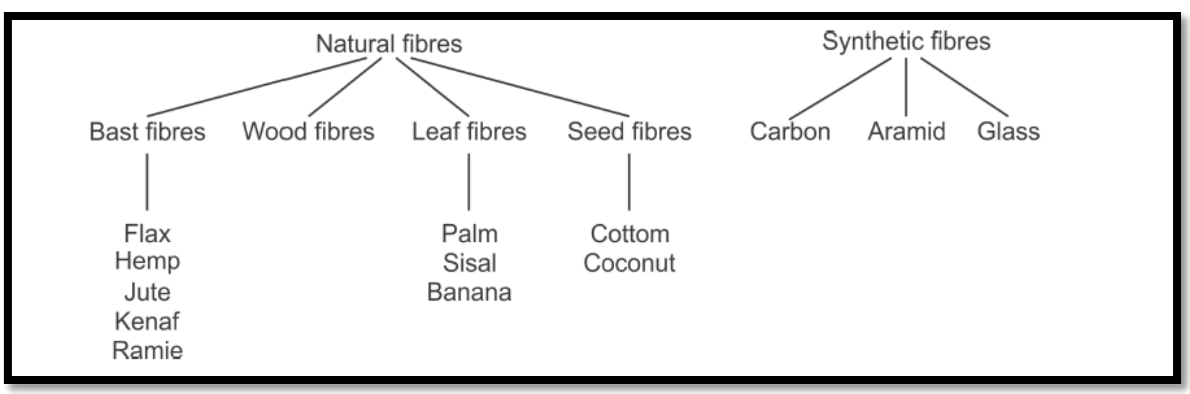

Figure 2.1: Overview of variety of fibres (Rask, 2012)

Refer to previous research by (Jeyanthi & Janci Rani, 2012), the natural fiber-reinforced composite has growing rapidly due to their mechanical properties, low cost, processing advantages and low density. The availability of natural fibers such as kenaf in Asia is more and also has some advantages over traditional reinforcement materials in terms of cost, density, renewability, recyclability, abrasiveness and biodegradability. The performance of the fiber reinforced composites mainly depends on the fiber matrix and the ability to transfer the load from the matrix to the fiber.

2.3 Kenaf

Kenaf as known as (Hibiscus cannabinus L.) is a fiber plant that are native from east-central Africa where it has been grown for several thousand years for food and fiber. It is a common wild plant of tropical and subtropical Africa and Asia. It can grow to 1.5-3.5 m tall with a woody base and the stems are 1–2 cm diameter. The leaves are 10–15 cm long, variable in shape, with leaves near the base of the stems being deeply lobed with 3-7 lobes.

The fibres in kenaf are found in two type which is bast (bark) and core (wood) as shown in Figure 2.2. The bast constitutes 40% of the plant. "Crude fibre" separated from the bast is multi-cellular, consisting of several individual cells stuck together. The individual fibre cells are about 2–6 mm long and slender. The cell wall is thick (6.3 µm). The core is about 60% of the plant and has thick (≈38 µm) but short (0.5 mm) and thin-walled (3 µm) fibre cells. Paper pulp is produced from the whole stem, and therefore contains two types of fibres, from the bast and from the core. The pulp quality is similar to hardwood. The kenaf plant characteristic are shown in figure 2.2.

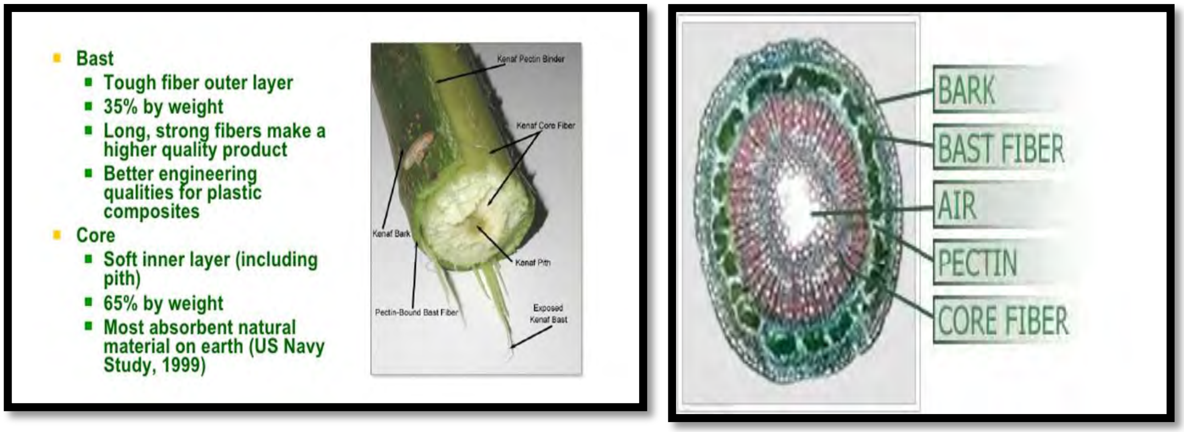

Figure 2.2: Characteristic of kenaf plant

There are many uses of kenaf fibre such as engineered wood, soil-less potting mixes, insulation, clothing-grade cloth, packing material, and material that absorbs oil and liquids. Additionally, as part of its overall effort to make vehicles more sustainable, Ford and BMW are making the material for the interior parts for automobile from kenaf. The first implementation of kenaf within a Ford vehicle was in the 2013 Ford Escape. The BMW i3 uses kenaf in the black surrounds.

According to previous research from (Kumaresan et al., 2015), automotive manufacturing has use kenaf fiber because it can provide lower density and has resulted in lightweight and eco-friendly automotive interiors. Moreover, it has been shown that this fibre has better sound absorption and noise level reduction. Not only that, the sandwich layer of this fibre is a very efficient structural design with the benefit of being lower in cost. Another example for automotive industry, as (Mcrandal & Mcnulty, 2015) start that the 1996 Ford Mondeo which sold abroad features interior automobile panels made of kenaf fibre. Kenaf international supplies the fibre, which is processed by the supplier to Ford. The company expects that sales to European automobile manufacturers will steadily increase as the industry becomes comfortable with the product and the kenaf products from automotive group are capable of meeting required demand.

Several research has been run from time to time. The mechanical properties of kenaf have been researched and vary from study to study. This is most likely due to the nonuniformity of kenaf. Kenaf is not processed like carbon and glass fibers and therefore each individual fiber is very different from the other. The density of kenaf was researched and a range of 1130 kg/m^3 to 1500 kg/m^3 was found.

By referring the research from (Loveless, 2015), its stated that University of palermo has tested to get kenaf fiber's mechanical properties. The tests were performed with a tensile tester and were statistically analyzed due to the high scatter of data. The tensile modulus was found to be around 40 GPa and the ultimate stress was found to be between 350 MPa – 600 MPa. They also tested unidirectional and mat kenaf composites with epoxy resin. The flexural tests reported a flexural modulus of 3.75 MPa for untreated kenaf and 4.2 MPa for treated 5 kenaf mat composites.

By using kenaf fibres as a material, there are many advantages such as low density, low production cost, minimal wear to machinery, good damage resistance and high specific strength compare to any other natural fibres (Fernando, 2009). Figure 2.3 shows the experimental result of tensile strength that run by (Ishak, Leman, Sapuan, Edeerozey, & Othman, 2010). on this research, the study was to compare the mechanical properties of kenaf bast and core fibre reinforced unsaturated polyester composites with variable of fibre weight fraction by 0%, 5%, 10%, 20%, 30% and 40%. It shows that kenaf fibre has proven that the composite of 20% fibre content showed the highest tensile strength for kenaf bast and core fibre.

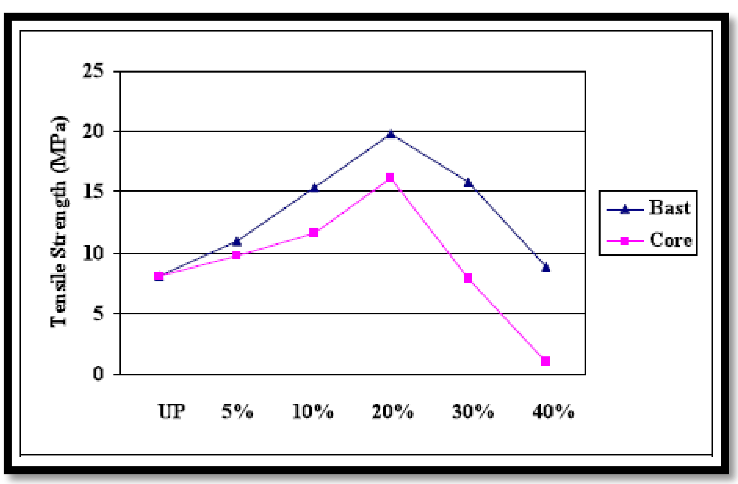

Figure 2.3: Tensile strength of kenaf and core fibre reinforced unsaturated polyester composite (Ishak et al., 2010)

2.4 Polypropylene (PP)

Polypropylene (PP) is a thermoplastic material and made from the combination of propylene monomer. PP has remarkable properties such as low density (weight saving), high stiffness, it has a lower impact strength, but superior working temperature and tensile strength and recyclability that makes it wide range of application in industry. There are variety of applications from this thermoplastic polymer including packaging and labeling, textiles, plastic parts and reusable containers of various types, laboratory equipment, automotive components, and medical devices. PP have the density which is between 0.895 and 0.92 g/cm^3. Therefore, PP is the plastic product with the lowest density. Because of its lower density, moldings parts with lower weight and more parts of a certain mass of plastic can be produced. The Young's modulus of PP is between 1300 and 1800 N/mm^2.

PP is an economical material that have good mechanical, chemical, thermal and electrical properties compare to other thermoplastic. PP also light in weight, good stain resistance and low moisture absorption rate. Other advantages are excellent dielectric properties, resists stress cracking, easily fabricated, resists most alkalis and acids, non-toxic and high heat resistance. This thermoplastic material can be fabricated through several techniques such as hot gas welding, machining with wood or metal working tools, vacuum forming, and ultra-sonic sealing. Table 2.2 shows all the properties according to its standards.

ASTM or UL test	Property	Homopolymer	Co-Polymer	Flame Retardant
	PHYSICAL			
D792	Density (lb/in³) (g/cm³)	0.033 0.905	0.033 0.897	0.035 0.988
D570	Water Absorption, 24 hrs (%)	<0.01	0.01	0.02
	MECHANICAL			
D638	Tensile Strength (psi)	4,800	4,800	4,300
D638	Tensile Modulus (psi)	195,000	-	-
D638	Tensile Elongation at Yield (%)	12	23	28
D790	Flexural Strength (psi)	7,000	5,400	-
D790	Flexural Modulus (psi)	180,000	160,000	145,000
D695	Compressive Strength (psi)	7,000	6,000	-
D695	Compressive Modulus (psi)	-	-	-
D785	Hardness, Rockwell R	92	80	-
D256	IZOD Notched Impact (ft-lb/in)	1.9	7.5	0.65
	THERMAL			
D696	Coefficient of Linear Thermal Expansion ($x\ 10^{-5}$ in./in./ºF)	6.2	6.6	-
D648	Heat Deflection Temp (ºF / ºC) at 66 psi at 264 psi	210 / 99 125 / 52	173 / 78 110 / 43	106 / 41 57 / 14
D3418	Melting Temperature (ºF / ºC)	327 / 164	327 / 164	327 / 164
-	Max Operating Temp (ºF / ºC)	180 / 82	170 / 77	180 / 82
C177	Thermal Conductivity (BTU-in/ft²-hr-ºF) ($x\ 10^{-4}$ cal/cm-sec-ºC)	0.76-0.81 2.6-2.8	- -	- -
UL94	Flammability Rating	HB	n.r.	V-O
	ELECTRICAL			
D149	Dielectric Strength (V/mil) short time, 1/8" thick	500-660	475	500-650
D150	Dielectric Constant at 1 kHz	2.25	2.2-2.36	2.3
D150	Dissipation Factor at 1 kHz	0.0005-0.0018	0.0017	-
D257	Volume Resistivity (ohm-cm) at 50% RH	8.5×10^{14}	2×10^{16}	10^{15}
D495	Arc Resistance (sec)	160	100	-

Table 2.2: Properties of polypropylene according to standards.

According to research by (Technologies & Republic, 2010), the automotive industry nowdays, polymer composite and plastic is one of the big role this industry. The average vehicle uses about 150 kg of plastics and plastic composites versus 1163 kg of iron and steel. Automotive engineers are keep designing to optimize other systems such as injection and blow molded parts offering a better product without expensive assembly work. Tank fuel system is one of the most complicated design problem and it has been solved because of this material. There are four parts that requires priority research and development using plastic materials which are interior, body and exterior, powertrain and chassis, and lightweighting. Focusing on interior, improving safety in passenger compartment was taking priority. Moreover, designing for increased vehicle compatibility, more efficient manufacturing capabilities, accommodating an aging driver population, including more safety features in reduced package space, and enhancing safety belt designs.

(Dibaei, Abdouss, Torabi, & Haji, 2013) has stated that polypropylene (PP) is a crucial thermoplastic material because it has high strength, chemical resistance, and low cost.

Because of that properties, this material has been a choice as a material for interior auto parts and other component applications. However, higher of stiffness and strength of polypropylene, but low in scratch resistance. A wide range of inorganic materials, such as glass fibers, calcium carbonate and clay minerals have been used as a reinforcement to improve the stiffness and strength of polypropylene.

Refer to (Technologies & Republic, 2010), stated that polypropylene is highly chemically resistant and almost completely resistant to water. Black has the best UV resistance and is increasingly used in the construction industry. It also has widely application such as automotive bumpers, chemical tanks, cable insulation, battery boxes, bottles, petrol cans, indoor and outdoor carpets, carpet fibers. Table 2.3 shows several components that use polymers plastic as it materials. From that table it shows up to 13 different polymers may be used in a single car model but there are three types of plastics majority uses which is 66 % of the total plastics used in a car: polypropylene (32 %), polyurethane (17 %) and PVC (16 %).

Component	**Main types of plastics**	**Weight in av. car (kg)**
Bumpers	PS, ABS, PC/PBT	10,0
Seating	PUR, PP, PVC, ABS, PA	13,0
Dashboard	PP, ABS, SMA, PPE, PC	7,0
Fuel systems	HDPE, POM, PA, PP, PBT	6,0
Body (incl. panels)	PP, PPE, UP	6,0
Under-bonnet components	PA, PP, PBT	9,0
Interior trim	PP, ABS, PET, POM, PVC	20,0
Electrical components	PP, PE, PBT, PA, PVC	7,0
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4,0
Lighting	PC, PBT, ABS, PMMA, UP	5,0
Upholstery	PVC, PUR, PP, PE	8,0
Liquid reservoirs	PP, PE, PA	1,0
Total		**105,0**

Table 2.3: Types of plastic use in a typical car (Technologies & Republic, 2010)