CHAPTER 2
REVIEW OF LITERATURE

2.1 Review of Natural and Aramid Fibers

This chapter deals with the various research works done by the researchers in the field of natural and Aramid fibers. The review of these research works includes reports on the following;

- Mechanical characterization of natural fibers
- Mechanical characterization of Aramid fibers
- Mechanical characterization of hybrid composites
- Machining characteristics of hybrid composites
- Applications of hybrid composites

Many researchers are working in the area of composite materials as it is very high in demand of replacing the conventional materials because of its high strength to weight ratio, low cost, availability and stability of the material. Researchers so far worked in composite materials proposed various materials processing methods, fabrication techniques and testing methods and concluded mechanical properties have been improved significantly and high thermal properties due to its ecofriendly, bio degradability and non-corrosive in nature. Also, the researchers investigated the optimization techniques for wear and machining of composites such that it can be easily machined in the application field.

Mittelmanet al (1990) have insisted to do the test on mechanical behavior of unidirectional Kevlar/epoxy composites subjected to tensile
strength and various failure modes have been investigated with minimum deviations occurred are studied.

**Bhattacharyya et al (1998)** have experimentally investigated the drilling characteristics of Kevlar composites by using modified high speed drill bits relatively running at operational speeds. The results concluded that there exist better surface finish, quality of the hole and the life of the tool with the application of liquid nitrogen at the drill site.

**Yue et al (2000)** have experimentally investigated the effect of treatment on Kevlar 29 fiber has been evaluated. The temperature effect on mechanical properties has been investigated. The result shows that the mechanical properties such as tensile strength and tensile strain are decreased with the increase of treatment temperature. It has also been noted that young’s modulus and tensile strength does not affect in vacuum treatment.

**Lin et al (2000)** have investigated the effect of Kevlar fiber as reinforcement with the bismaleimide and the effects of chemical treatments has been studied. In this work, the two categories of bismaleimide have been examined thermally by using differential scanning calorimetry, thermogravimetry and thermo mechanical analysis. The result shows that there is a improvement in interfacial strength by cholosulphuric acid treatment. The fracture surface has been examined by scanning electron microscopy.

**Sarah lee et al (2001)** has examined the filtration characteristics of ground kenaf core. In this work, constant pressure pre coat filtration characteristics were compared to diatomaceous earth. Three challenge solutions were studied in detail. The result found that kenaf and DE both permitted the removal of silica particles from solution without any flux degradation over the course of the filtration. The result found that kenaf and DE have similar filtration characteristics.
Vishal Gupta et al (2001) have been experimentally investigated the kerf characteristics of marble using abrasive water jet machining with the input parameters like transverse speed, water pressure and abrasive flow rate. The process parameters have been analysed using Taguchi method and anova has been done to optimize the significant parameter which affects kerf characteristics. The result shows that the transverse speed has high significant factor affects the kerf taper angle and kerf width.

Nishimura et al (2002) have experimentally studied the differences in lignin content among three varieties of kenaf namely Everglades, Aokawa 3 and Mesta. In this work, the bast, inner bast and core samples were prepared from four different positions. The result concluded that the increase in height of the stem, ligning content deceases. The differences of lignin content between the core and the bast samples were larger in everglades and aokawa 3 than in mesta.

Navin chand et al (2002) have experimentally conducted on woven glass fiber reinforced polyester composites on three different orientations in order to determine the wear and friction coefficient. In this work, various loads and sliding speeds are varied to determine the characteristics. Scanning electron microscope has been done to observe the changes occurred in the composite laminate. The results show significant improvement in friction coefficient as well as wear loss.

Gita Ramasamy et al (2003) have experimentally investigated the kenaf non wovens as substrates for laminated products which can be extensively used in wall coverings, upholstery covers, edge banding materials and other laminates. The purpose of this work to show the feasibility of making non woven kenaf fiber for making laminated products. In this work, kenaf fibers were blended with polypropylene at a ratio of 80:20 and batts were prepared using a modified cotton card in regular widths. The batts are
then either calendered or needle punched and cured in an oven to make the substrate. These substrates were then laminated with various kinds of overlays such as polyester wood grain, phenolic resin and decorative vinyl.

**Yahaya et al (2003)** have studied quasi-static penetration and ballistic properties of non-woven kenaf fibres /Kevlar epoxy hybrid laminates with thicknesses ranging from 3.1 mm to 10.8 mm by hard projectile at normal incidence have been experimentally investigated. Hybrid composites were fabricated by hand lay-up technique in a mould and cured at room temperature for 24 h by static load. Hybrid composites consist of Kevlar layers and non-woven kenaf layers at three different configurations. Kevlar/epoxy and kenaf/epoxy composites were also fabricated for comparison purpose. Quasi-static experiments were conducted using a tensile testing machine at the speed of 1.27 mm/min and 2.54 mm/min. Ballistic tests were conducted using 9 mm full metal jacket bullet using a powder gun at speeds.

**Sarifa Aziz et al (2003)** have experimentally investigated the effect of alkalization and fiber alignment on mechanical and thermal properties of long and random kenaf and hemp fiber. In this work, polyester resin is used as the matrix and the natural fibers are alkalized with 6% NaOH solution. The result shows that the alkalized fibers have significant mechanical properties when it is compared with untreated fibers. Morphological Analysis has been done to observe the internal structure of the composite laminate. The result shows that there is a less fracture observed in hemp polyester composites. Also the treated hemp and kenaf fibers showed the absence of surface impurities which were present on untreated fibers.

**Takashi Nishino et al (2003)** have experimentally investigated the mechanical properties of the kenaf fiber with poly L Lactic acid. Both the anisotropic and quasi isotropic composites could be obtained by laminating
the kenaf sheets with preferential orientation of the fiber. The effects of molecular weight of PLLA, the orientation of the kenaf fiber in the sheet on the mechanical properties of the composite were also investigated. The result shows that the kenaf fiber can be a good reinforcement candidate for high performance bio degradable composites.

**Fahrenthold et al (2003)** have experimentally investigated the effect of aluminium-nextel-kevlar composite which has been prepared as composite shielding materials. Here, the layers are sequenced and the impact simulations has been carried out using numerical models of model projectiles and targets over wide range of velocities. Hence it is concluded that the effective protection of multi layer shielding. It is also found that the hypervelocity impact response of the system has been recorded. He also simulated to model the hyper velocity impact effects in Kevlar fabrics with shear thickening fluid along with aluminium material. The test has been carried out for multi layer structures and the result found that the membrane structures can have a significant effect of hyper velocity impact in multi layered structures.

**Berthelot et al (2004)** have extensively analyzed the damping of unidirectional fiber composites as function of frequency and fiber orientation. In this work, cantilever beam is used to test the specimen and an impulse technique method. The parameters are derived by fitting the experimental fourier responses with analytical motion responses. The experimental results are compared with literature models and the results shows that the in-plane shear damping are associated to the evaluation of the participation of the shear energy to the energy dissipated.

**Mukherjee et al (2006)** have studied the properties of syndiotactic polystyrene composites with surface modified short Kevlar fiber. Matrix used is syndiotic polystyrene and the Reinforcement used as Kevlar fiber. The combination of the matrix and reinforcement increases the crystalline, thermal,
dynamic and mechanical properties. Kevlar fiber enhances the crystallization of the matrix through heterogeneous nucleation. Modified Kevlar fiber reinforcements improve the thermal stability of the composites.

**Wu and Cheng (2006)** have experimentally investigated the effect of Kevlar pulp reinforced with epoxy under dry and sliding conditions. The test has been performed against stainless steel on friction and wear tester. The experiments were carried out in ambient temperatures of 10-20°C, 50-60% relative humidity conditions. The relationship between the specific wear rate and the friction coefficient against the Kevlar pulp content has been plotted for both dry and water lubricated conditions. Friction coefficient has been decreased with increase of filler content and obtained optimal solution when Kevlar pulp content as 60%. Also it is noted that, the specific wear rate decreased significantly when Kevlar pulp content has 40% volume of filler content as the optimal solution for the composites.

**Bullent et al (2006)** have experimentally investigated the failure mode and load of fasteners in woven Kevlar epoxy composite plates. In this method, finite elements technique is developed for predicting damage initiation, progression and strength of joints. For failure analysis hashin, Hoffman and maximum stress criteria is used. The experiments were performed to determine the effects of failure and to evaluate the effect of joint on analysis. The results found that the comparison has been made between numerical and experimental methods and obtained better results.

**Haocen et al (2006)** investigated the interfacial micromechanical behavior of fiber matrix by means of the combination of micro bend test and micro raman spectroscopy. The setup is to detect the distribution of micro mechanical properties including fiber axial stress, residual stress, interfacial shear stress and stress transfer along the interfaces between Kevlar fibers and epoxy resin. The result shows that the axial stress transfer will accelerate and
shear stress concentration will be enhanced along with increase in the interfacial edge angle. The geometrical characteristics can effect significantly the stress distributions in the fiber matrix micro droplets.

Wan et al (2006) have experimentally investigated the mechanical properties of 3D braided carbon/Kevlar/epoxy composite and their effects of moisture absorption. The composite is immersed in hanks solution at 37°C for upto 1700hrs. Graphical curves were plotted and the operational parameters were determined. The result shows that Kevlar fibers have both moisture absorption and mechanical degradation enhanced with respect to carbon only. Moreover, the mechanical degradation, the moisture saturated hybrid composites still kept at high flexural strength.

Edeerozey et al (2007) have experimentally investigated the chemical modification of kenaf fiber. In this work, kenaf bast fiber reinforced composites were modified using NaOH solution of different concentrations. Scanning electron microscope has been done to observe the changes in the composite. The result shows that 3% NaOH solution was ineffective to remove the impurities on the fiber surface and 9% NaOH treatment shows the cleanest fiber. It is found that the alkalization treatment has improved mechanical properties of kenaf fiber significantly as compared to untreated kenaf fiber.

Wan et al (2007) have experimentally investigated the short, unidirectional and laminated hybrid composites namely Kevlar and carbon fibers reinforced with bismaleimide resin for better interfacial adhesion. In this work, fibers are hybridized to bismaleimide resin and test has been conducted on 3D braided hybrid composites. In this work, fibers are surface treated and the effect of carbon to Kevlar ratio on mechanical properties has been investigated. It has been concluded that the flexural strength and modulus has been increased with relative ratio of 3:2 and then dropped. And
also, concluded that hybridization with Kevlar fibers improves shear strength, impact energy absorption characteristics and damage tolerance of all grades of carbon composite. Fracture surfaces and micro structures of various 3D braided hybrid composites were also analyzed.

**Shinji ochi et al (2008)** deals with the cultivation of kenaf and application of bio degradable composite materials. Here, the kenaf fiber as reinforcement and an emulsion type PLA resin is used for fabrication purpose. In this work, long kenaf fibers are used for heat molding temperatures at $1600^\circ$C, $1800^\circ$C and $2000^\circ$C for 15, 30 and 60 min respectively for better molding conditions. It has been concluded that the tensile and flexural strength of 223 MPa and 245 MPa respectively was recorded. The bio degradability of the composites also examined and the results shows that weight of the composites decreases to 38% after 4 weeks of composting.

**Gang Li et al (2008)** have experimentally investigated the Kevlar fibers at different concentrations of phosphoric acid. In this work, interfacial shear strength and inter laminar shear strength was examined. The composite mechanical properties are studied with varying combinations of epoxy and hardener. The result shows that the addition of surface oxygen and hydroxyl groups of Kevlar fiber increased significantly and comparison has been done with Kevlar fiber composite exhibits excellent mechanical properties. The micro structural analysis has been done which revealed better interfacial adhesion resulted in high mechanical properties.

**Azmir et al (2008)** experimentally investigated the influence of abrasive water jet machining process parameters of glass fiber reinforced polymer composites. The process parameters such as standoff distance, pressure, transverse speed, abrasive materials have been varied and the corresponding surface roughness has been measured. The result shows that there is insignificant control over cutting speed which affects surface finish.
and also it needs improvement in obtaining optimal solution to satisfy the requirements for machining the glass fiber reinforced polymer composites.

Fang guo et al (2009) have experimentally investigated the performance on tribological behavior of Kevlar fibers subjected to plasma treatment. Friction and wear test has been carried out to determine the performance of the resulting composites. The apparatus used to determine the friction and wear behavior is pin on disk apparatus. The test has been carried out number of times at ambient temperature, a load between 141 N and 251 N at a speed of 0.26 m/s over a period of 2 hours at day conditions. Average value has been taken as 10% of relative errors. The variation of friction coefficient and wear rate plotted against power in such a way that the air plasma bombardment increases up to 70W and then decreases. The Tribological properties of Kevlar have shown the best optimal solution when the power at 50 W for 15 min. Tribological properties initially decreases and then increases with the plasma treatment time.

Siddiqui et al (2009) have done many experiments on abrasive water jet machining (AWJM) in comparing carbon, glass and Aramid fiber reinforced plastics by varying the input parameters such as water jet pressure, abrasive flow rate and quality level for obtaining best output characteristics such as kerf taper angle and surface roughness by using Taguchi techniques and have concluded that the results of the Aramid fiber reinforced composites gives the better results for obtaining minimized surface roughness and kerf taper angle.

Azmir et al (2009) have conducted study on Investigation on glass/epoxy composite surfaces machined by abrasive water jet machining and found that the type of abrasive materials, hydraulic pressure, standoff distance and traverse rate were the significant control factors and the cutting
orientation was the insignificant control factor in controlling the surface roughness.

Chin and Yousif (2009) have attempted to use kenaf fibers as reinforcement and tribological studies has been carried out for bearing applications. In this work, block on disc test has been carried out to determine the sliding wear and frictional behavior of composites under different applications of load ranging from 30 N to 100 N at varying sliding distances ranging from 0 km to 5 km at varying sliding velocities ranging from 1.1 m/s to 3.9 m/s. The effect of fiber orientation, i.e., parallel, anti parallel, and normal with respect to the sliding direction was also considered. Scanning electron microscope has been done to observe the internal structure of the fibers and it exhibits significant improvement which prevents delamination, pull out of fibers and blow holes. It has been concluded that presence of kenaf fibers in normal orientation enhances wear performance by about 85% whereas sliding velocity and applied load shows insignificant effect on specific wear rates. Also, the wear mechanism of the composite was predominated by micro cracks in normal orientation and deboning occurs in fibrous and resinous regions.

Summerscales et al (2010) have reviewed the bast fibers those are obtained from outer cell layers of stems of various plants. The fibers are composed primarily of cellulose which potentially has a high value of young’s modulus, when compared to manmade synthetic fibers. This paper deals with growth, harvesting and fiber separation techniques which is more suitable to yield fiber of appropriate quality. Various natural fibers like flax, hemp, nettle, jute and kenaf are discussed in detail. The result concluded that the bast fibers have weight specific properties which may be superior to the corresponding properties of glass fiber reinforcement which may be very much suitable for various environmental conditions. It has also been addressed the characterization of bast fibers which makes the fiber as, unlike
manmade fibers, being the cross section neither circular nor uniform along the length.

Fang Guo et al (2010) have investigated the Tribological behavior of spun Kevlar fabric filled with PolyfluoWax (PFW) and Lanthanum Fluoride (LaF$_3$). The experiments were carried out in pin on disk test and wear test under variable load and rotating speed. The result shows that there is a decrease in friction coefficient with increasing the content of PFW and hence it was found that the wear rate was best when the PFW content has got 15 weight % as the optimal solution for the composite.

Jeebory et al (2010) have experimentally investigated the mechanical properties of araldite matrix composites reinforced hybrid carbon Kevlar fibers. In this work, various mechanical tests like tensile strength, impact strength, flexural strength and hardness were carried out. The effects on the mechanical properties were studied and the result shows that the mechanical properties will increase with increasing percentage of reinforcement.

Lei zhenkin et al (2010) have experimentally investigated the influence of a polymer coating on a Kevlar 29 fiber with the effect of stress. In this work, symmetrical fiber is imposed with and without polyvinyl chloride. Raman spectra on the embedded fiber are recorded under different strain levels. The result shows that the fiber axial stress increases with the applied loads, and the anti symmetric interfacial shear stresses load to the appearances of shear stress concentration. Scanning electron microscope is done and observed that the existence of a flexible polymer coating on the fiber surface reduces the stress transfer efficiency.

Rongxian Ou et al (2010) have experimentally investigated the effects of Kevlar used as reinforcement for the wood-flour/HDPE composites to improve tensile, flexural and impact properties. Surface grafting of KF with a
The mixture of allyl chloride and 3chloropropyltrimethoxysilane resulted in significant mechanical properties which are interfacial adhered. The purpose of grafting is to increase the strength and toughness properties.

**Jiangbo et al (2011)** have experimentally investigated the tear resistance of Kevlar fiber. In this work, the parameters like notch sensitivity and fracture behavior of Kevlar fibers was investigated. The Kevlar fibers are reinforced with thermoplastic polyurethane film and the result shows that the notch sensitivity increases with the increase in size of the hole and also it decreases only a less percentage when compared to unnotched specimens. Four types of specimen are implemented to measure notched strength and fracture toughness and their results are compared with each other. Static tension and tear test has been carried out using MTS system. Notched sensitivity increases with the increase in size of the hole. Tear resistance exist at significant notch sensitivity. It provides an insight into notch sensitivity and fracture behavior of Kevlar PWF reinforced TPU film.

**Yan Wang et al (2011)** have experimentally investigated the effect of Kevlar oligomer functionalized grapheme (FGS) for polymer composites. The reinforcement given above is synthesized for the polymer and their properties are studied. Tensile modulus and strength of the polymer composites increase by the reinforcement synthesized. FGS was prepared by simple grafting of amino terminated Kevlar oligomer on graphene oxide followed by reduction with hydrazine hydrate. FGS is present in PMMA and PI less than 0.2% of weight. Upto 0.2% of FGS addition to the polymer increases the properties above that the property does not change.

**Anuar and zuraida (2011)** have experimentally developed the thermo plastic elastomer composite reinforced with 20% kenaf fiber. In this work, two types of impact modifiers were blended with thermo plastic natural rubber and polypropylene / ethylene propylene diene monomer. Both the
Composites were produced using internal mixer through double melt bending method. Both the polymer blends the ratio of thermoplastic to elastomer is 70:30. For better adhesion of matrix and reinforcement, maleic anhydride polypropylene has been added. For thermoplastic natural rubber is about 12% higher than PP/EPDM matrix. Also, flexural properties and impact strength has been greatly improved for treated kenaf composite. Scanning electron microscope has been done to observe the internal structure of the fiber thereby there is a significant improvement in mechanical properties due to the interaction between the matrix and the reinforcement. Also in addition of MAPP increased about 81% of tensile strength of PP/EPDM when compared to untreated thermo plastic natural rubber.

**Ku et al (2011)** have reviewed on the tensile properties of natural fiber reinforced polymer composites. In this review, mechanical properties, eco friendly environmental conditions, bio degradability characteristics have been studied in detail. Several chemical properties are employed to improve interfacial matrix fiber bonding. The tensile properties of natural fiber composites are mainly influenced by the interfacial adhesion between the matrix and the fibers. In general, tensile strength of natural fiber reinforced polymer composites increase with fiber content to maximum value and then it will drop, Whereas, young’s modulus of natural fiber increases with increase of fiber loading. Mathematical modeling has been done to predict the experimental results using Halpin-Tsai equation which is most effective method to predict the young’s modulus of composites containing different types of natural fibers.

**Min su et al (2011)** have experimentally investigated the effect of oxygen plasma treatment for Kevlar fibers with bismaleimide as the matrix for better interfacial adhesion. In this work, Kevlar fibers were immersed in acetone for 24 hours and it is washed with distilled water to remove foreign contaminations. Fibers were dried at oven for 3 hours at 120°C and then
bombarded with oxygen plasma. Finally the treated Kevlar fibers are investigated with power and time dependent variables. It is found that oxygen plasma treated Kevlar fibers significantly affects the interfacial adhesion. Thereby, changing the parameters of the chemical structure and morphology of the surface, inter laminar shear strength, water resistance and dielectric properties of the composite has been improved. It has been concluded that, after oxygen plasma treatment, Kevlar fibers has the best condition of 70 W for 5 min as optimal solution for overcoming poor interfacial adhesion. And also concluded that it has high potential in fabrication of high performance copper clad laminates

Akhil et al (2011) have reviewed the developments made in the area of kenaf fiber, in terms of market availability, manufacturing methods, mechanical and thermal properties. In this review, several critical issues and suggestions for future scopes are discussed. It has been concluded that kenaf fiber can be replaced with conventional materials or synthetic fibers as reinforcement in composites. Kenaf fiber can be very useful in application of various fields in both rural and urban areas. In addition to that, it helps to reduce the waste which contributes healthier environment. Finally, kenaf fibers in future scope requires more attention towards commercialization and manufacturing processes for large scale end products.

Ananth ram et al (2011) have investigated and examined the fracture behavior of a single edge v nothched aluminium plate repaired with Kevlar 49/epoxy or E glass/ epoxy prepreg patches on both sides. In this work, contour integral method is used to estimate the effectiveness of the composite patch repair. The influence of the patch material, crack length and the adhesive thickness has been investigated. The result shows that the crack induced damage increased non linearly with a larger crack size. Also, thinner adhesive layer results in higher percentage of load shared by the composite patch.
Muthukrishnan et al (2011) have investigated study on Optimization of machining parameters of Al/SiC MMC with ANOVA and ANN analysis, has predicted the output parameters and the behavior of the system within the operating range using ANOVA. Hence the required process parameters are selected as abrasive flow rate, cutting feed rate and standoff distance, which are varied during the machining and the output parameters such as MRR and surface roughness is checked and verified in the fabricated hybrid composite by ANOVA and Taguchi’s method.

Jai Aultrin and Dev Anand (2011) have investigated the prediction of Material Removal Rate (MRR) and surface roughness on lead tin alloy and some non ferrous alloys in AWJM and have said that machining parameters play the lead role in determining the machine economics and quality of machining.

Azmir et al (2011) have been studied the machining characteristics of glass epoxy reinforced composites. Parameters such as surface roughness and kerf taper ratio have been determined using Taguchi method and ANOVA has been carried out to find the optimal condition. It is found that increasing the abrasive flow rate and pressure results in better machining performance.

Song fang Zhao et al (2012) have studied the properties and crystallization behavior of PA6 and Kevlar fiber reinforced isotactic polypropylene. Kevlar fibre was modified with caprolactum using toluene diisocyanate. Thermal and mechanical properties were improved with the modified KF. Interfacial interaction of isotactic PP/KF/PA6 composite is increased. The compatibiliser content plays a major role in the enhancement of thermal and mechanical properties. The modification of Kevlar fiber has improved the mechanical and thermal properties of the composites.
Kabir et al (2012) have reviewed the super toughest fiber the Kevlar structure, objectives, various grades of Kevlar, properties, uses and its applications. The applications of Kevlar in various fields like military body armor jackets, protection vest, military helmets, and energy transmission applications were discussed in detail. Kevlar fiber also can act as a composite material which possesses high end applications in all transportation vehicles and finally concluded that light weight composite will be implemented in commercial purposes in future.

Abu Talib et al (2012) have studied the impact performance of a hybrid composite made of woven fiber Kevlar-29 and Al$_2$O$_3$ powder/epoxy subjected to high velocity. The energy absorbed due to the impact of small rigid projectiles on composite material targets was studied both theoretically and experimentally. A cylindrical projectile is used in this investigation. A relation between the ballistic limit velocity and the thickness of composite material was established. It has been concluded that Kevlar and Al$_2$O$_3$ with Epoxy shows better ballistic limit velocity.

Yilbas et al (2012) have experimentally investigated the effects of laser cutting on Kevlar laminates. In this work, laser cutting is carried out with the help of high pressure nitrogen gas as an assisting gas. Here, the thermal stress field is predicted in the machining zone using finite element program. The result shows that the temperature predictions are normal with thermocouple data, high von misses stresses are observed in the cutting zone. The morphological analysis has been analyzed using optical and scanning electron microscopy and the result shows that the laser cut edges are free from whiskers and also striation formation is formed at the top edge and small burning is observed at the kerf edges.

Zheng et al (2012) have investigated the machining parameters of ceramics/Kevlar fiber reinforced polymer with double plate composite armor
by using diamond core drill. The parameters such as machining mode, drilling sequence and machining efficiency have been discussed on drilling experiments. The results discussed and concluded that machining using manual feed with drilling the Kevlar plate backboard firstly and selecting the reasonable parameters results in higher production. The machining efficiency tends to increase with a increase of spindle speed upto 2600 r/min and decreases from 2600 r/min and also with the increase of wall thickness of the drill.

Yousif et al (2012) have experimentally investigated the flexural properties of unidirectional long kenaf fiber reinforced epoxy composites. In this work, kenaf fibers were prepared into two types as untreated and treated with 6% sodium hydroxide solution. The results revealed that after treatment, the kenaf fibers increased the flexural strength of composite about 36% while an untreated fiber exhibits 20% improvement. Scanning electron microscopy has been done to observe the failure mechanism and damage features of the composite material by observing the internal structure, there is a significant improvement on the interfacial adhesion of the fibers and the porosity of the composites which highly prevented deboning, detachments or pull out of fibers. The treated fibers exhibit superior properties when compared with natural or synthetic fibers.

Asumani et al (2012) have experimentally investigated the effects of alkali silane treatment of kenaf fiber reinforced polymer composites were manufactured by compression molding. The effects of chemical treatment on tensile and flexural properties of the composite were investigated. The result shows that the alkali silane treatment which significantly improves the tensile and flexural properties of short fiber non woven kenaf polypropylene composites. Fiber treated with sodium hydroxide solution of 6% is the optimum for alkali stage of the combined alkali silane treatment. The result shows that the specific tensile and flexural strengths of treated with 30% fiber
mass fraction are respectively, only 4% and 11% lower than glass fibers. Scanning electron microscope has been done to observe and the result shows that significant mechanical properties as alkali silane treatment can be attributed for better adhesion of fiber and the matrix.

Ghani et al (2012) have experimentally investigated the mechanical property of kenaf/ fiber glass polyester hybrid composite. In this work, water absorption test has been carried out in different environmental conditions which include standard, sea water, distilled water, and rain water at room temperature from first day until 4th week. The effect of mechanical strength of the hybrid composite has been investigated. Here, the tensile strength of hybrid composite has been tabulated at different environmental conditions. It has been concluded that there is a decrease in tensile modulus due to longer immersion time because of formation of hydrogen bonding between the water molecules and cellulose fibers. Scanning electron microscope has been done to observe the internal structure of the fiber. Here, the fracture surface, effect of humidity aging is observed which contributes the reduction of tensile modulus. Also, the strain to failure mechanism rate improved by inclusion of kenaf fiber reinforced in glass hybrid composite until 3rd week of immersion in water absorption. Due to this, water molecules filled into cavities and cracks thereby the composite is more flexible.

Jeyanthi et al (2012) have conducted study in Improving Mechanical Properties by Kenaf Natural Long Fiber Reinforced Composite for Automotive Structures and has told that a twisted kenaf hybrid material, present a good mechanical properties than an untwisted one. Thus, these studies have explicitly shown that the strength of a hybrid composite can be increased by using twisted kenaf fiber hybridization with natural fibers.

Yuqin et al (2012) experimentally investigated the tribological properties of fiber reinforced polyamide 6 composites. In this work, block on
ring wear test is used to determine the wear behavior of composites. The worn surface was investigated using scanning electron microscope. The result shows that the wear resistance has been improved with monomer casting polyamide 6 composite with optimal content of Kevlar being approximately 5 volume %. Also, the friction coefficient of the composite was larger than that of monomer casting polyamide 6. The morphological result shows that there is a significant wear due to the large friction force; the worn surface showed micro cracking which was perpendicular to the sliding direction.

**Masowi et al (2012)** have experimentally investigated the mechanical properties of araldite matrix composites reinforced hybrid palms-Kevlar fibers. In this work, various mechanical tests like tensile strength, impact strength, flexural strength and hardness were carried out. The effects on the mechanical properties were studied and the result shows that the mechanical properties will increase with increasing percentage of reinforcement.

**Reis et al (2012)** have experimentally investigated the impact behavior and damage tolerances due to impact on the Kevlar filled epoxy matrix. In this research work, nanoclays cloisite 30 B and cork powders are used as fillers to improve the impact resistance. Silane treatment has been done prior to improve dispersion and better adhesion between the fiber and the matrix. The result shows that better impact properties and it has recorded maximum residual strength with minimum displacement.

**Sarawut Rindusit et al (2012)** has been experimentally investigated the Kevlar fiber reinforced with polycarbonate and acrylonitrile butadiene styrene was prepared. Mechanical tests such as tensile and flexural test have been done and the result shows that there is a significant flexural property in all regions of polycarbonate contents where as the tensile strength was found in some areas of polycarbonate contents and it is increased with the increase of matrix contents. And also the various tests such as peel test, water contact
measurement and SEM has been conducted and the result shows that interfacial adhesion between the Kevlar fiber and the matrix has been improved by adding polycarbonate content in the matrix.

Nordin et al (2013) have experimentally investigated the specific wear rate for kenaf polyester composite which then compared with kenaf epoxy composite. Here, long kenaf fiber is used for investigation of composites. The epoxy resin and polyester resin is mixed with hardener in the ratio of 3:1 and 10:1 respectively. The wear test is carried out in abrasion resistance tester in dry sliding conditions at a constant velocity of 1.4 m/s. the test has been carried out in room temperature with different application of loads ranging from 5 N and 30 N. The mechanical properties such as density, tensile strength and young’s modulus have been compared for both the composites. Kenaf polyester composite has been grouped under thermo plastics whereas kenaf epoxy composite has been grouped under thermosetting plastics. It has been concluded that for both the composites exhibit same amount of specific wear rate at a certain distance and beyond 6 km sliding distance, both the composites converged to similar values.

Guru raja et al (2013) have experimentally investigated the effect of fiber orientation on Kevlar /glass hybrid composites. The process has been done by vacuum bagging technique with three different angle orientation combinations thereby results in improvement of mechanical properties. In this study, Kevlar is used as the reinforcement and epoxy resin as the matrix. The result shows that the angle with horizontal/vertical orientation got the significant result of peak stress, tensile strength and tensile modulus. Finally the failure analysis of the hybrid composites was also discussed in detail.

Channabasavaraju et al (2013) have presented and compared the mechanical properties of glass, graphite and Kevlar fiber reinforced polymer matrix composites individually irrespective of the thickness of the laminate.
The process involved the hand layup method by vacuum bag molding technique so as to enhance the better adhesion between the fiber and the matrix. The tested samples are studied and the result shows that the increase in thickness of the specimen increases tensile and flexural properties of Kevlar fiber when compared to glass and graphite samples.

**Abu talib et al (2013)** have experimentally investigated the effects of with and without cut holes on Kevlar 29 fiber with various fiber orientation angles. The results of quasi static compression and tensile properties have been experimentally studied. The result shows that the ultimate load of failure is low at $45^0$ when compared to $90^0$ orientation angles. And also comparison has been done with theoretical and practical applications using the simulation software AutoDyn under Ansys software and the result of maximum difference found to be 5.8%.

**Deju zhu et al (2013)** have investigated the stress strain response in warp and fill direction, Poisson’s ratio and in plane shear response of Kevlar 49 fiber. The experimental result shows that the fabric exhibits non linear and orthogonal behavior in tension and it can deform up to 20% before complete failure. The apparent Poisson’s ratio is a non linear function of strain and dependent up to the levels of pre loading. These results can be implemented in the area of ballistic applications.

**Reis et al (2013)** have experimentally investigated the impact response on the Kevlar/epoxy laminate with the various percentages of carbon nanotubes. In this work, the nanoclays cloisite 30B are dispersed in the epoxy system with 1.5%, 3% and 6% in weight. The performances of the nanoclays are obtained in terms of elastic recuperation and penetration threshold. The result shows that the 6% nanoclays dispersed in the system have the best optimal solution when compared to 1.5% and 3% in weight. Also tensile residual strength has been done to confirm the best impact resistance with
increase in filler content and the differences shown as the result of impact energy.

Nilakantan et al (2013) have experimentally investigated the yarn pull out behavior of woven Kevlar subjected to various combinations of yarn pull out speed and fabric pre tension. The result shows that the pull out forces increased with increasing pre tension levels and decreased with increasing pull out speeds. Also the inter yarn direction characteristics of woven Kevlar fabrics are sensitive to yarn sizing, pull out rates, fabric pre tension which have implications on ballistic impact response of Kevlar fibers.

Ramadhan et al (2013) have experimentally investigated the sandwich structure based on Kevlar 29 fiber with epoxy resin as medium with the combination of different stacking sequence of 6061 aluminium plates placed in composite laminate. High velocity impact test has been carried out using a nitrogen gas with cylindrical shape of 7.62 mm diameter steel projectile at varying velocities. The parameters like ballistic limit velocity, energy absorbed by the target and comparing the results with the simulation software Ansys autodyne. The result shows that the aluminium stacking sequence at the back side gives the optimum structure to resist the impact loading. The maximum error of 3.64% has been recorded while comparing theoretical and experimental results. It is also noted that sandwich structures exhibits high energy absorbing power under high impact loading conditions which is suitable for armor applications.

Salleh et al (2013) have experimentally investigated and developed a long kenaf composite and long kenaf woven glass reinforced polymer resin composite. In this work, both the composites have been tested for tensile properties with drilled holes. The values have been recorded from the residual tensile strength impacted specimens and the open hole specimen thereby the damage area of the composite could be easily predicted. The result shows that
the long kenaf composite was more notch sensitive than long kenaf woven glass hybrid composite. Also, the hybrid composite was stronger than long kenaf composite. The polymer matrix failed initially around the hole with crack followed by matrix deboning.

Nabihah sallih et al (2014) have experimentally investigated the kenaf /polypropylene composite sheets were manufactured by extrusion method. The various shear properties like inplane, outplane, tensile and flexural properties were analyzed by conducting experiments through design of experiments technique. It is concluded that there is a significant improvement in mechanical properties in various modes of testing with higher content of kenaf and lower die barrel temperature. And also, it concluded that the properties of very short fiber composites produced are comparable to those reinforced with longer discontinuous and long fiber mats.

Mahjoub et al (2014) have experimentally investigated the properties of kenaf fiber were determined. The effects of initial water treatment and various alkaline treatments of kenaf fiber were investigated. In this study, 360 fiber specimens were tested for 24 various conditions of initial treatment and alkaline surface modifications. The results were analyzed using three methods namely regression method, averaging the data and system compliance method. Scanning electron microscopy is employed to observe the specimen’s appearance, fracture area and fibers diameter. The results showed that untreated kenaf fiber was 67.6 micro meter, density of 1.2 g/cm$^3$ and tensile strength of 780 MPa. Also, 5% alkali solution was the best for kenaf fiber treatment, when compared to 10% and 15% alkali solution.

Shekeil et al (2014) have experimentally investigated the kenaf bast fiber reinforced poly vinyl chloride/ thermo plastic polyurethane poly blend was prepared by melt mixing method. The fibers were prepared with different contents of 20%, 30% and 40% by weight and mixed under compression
molding machine. Scanning electron microscopy has been done to observe the internal structure of fibers. The result shows that there is a poor fiber and matrix adhesion. Thermal properties have been studied using thermo gravimetric analysis. The result shows that lower tensile strength, strain and impact strength found to decrease with increase of fiber content.

Bella et al (2014) have experimentally investigated the effects of natural fibers reinforcements in various lime plasters which were prepared and analyzed to evaluate their performance. Each lime plasters was realized by adding to the mortar the same amount of 0.2% w of polypropylene. The fiber such as sisal and kenaf is used as reinforcement. Compression and bending strength, resistance to freeze/thaw conditions and to marine environment of lime plasters were investigated. The result shows that the natural fibers can be considered as valid alternative to polypropylene as reinforcement of lime plasters. The result concluded that the decrease of mechanical properties due to freeze/thaw cycles is comparable under flexural load condition.

Subramani et al (2014) experimentally investigated the single fiber and tow transverse compression response of Kevlar KM2 fiber and are analyzed using plane strain finite element models. The result shows that the comparison between numerical and experimental values plays a dominant role of geometric stiffening at finite strains due to growth in contact width. For homogenized approaches, the value has been accurately predicted the transverse compression response of the fiber.

Shan shan shin et al (2014) has carried out the sandwich composites of carbon fiber and aluminium honey comb are fabricated. Here, Kevlar fiber is used as an interfacial bond between the sandwich composites. The property of bending , uniaxial compression, feasibility and the effectiveness of short Kevlar fibers has been examined. The result shows that there is an increase in
adhesion bond between the sandwich composites which forms the strong bridge between them. And also comparison has been done for peak load and energy absorption with and without Kevlar fiber interfacial toughening and the internal structure has been discussed in detail using fractography observations.

Sanborn et al (2014) have experimentally investigated the tensile stress strain response of Kevlar KM2 fibers at multiple gauge lengths and different loading rates to study the effect of weaving and surface finish of the fibers. Here the result shows that there is an effect on both fatigue strength and stiffness of the fiber. And also comparison has been made between the wrap and weft direction of fiber which influences the fiber orientation results in lower failure stresses and the modulus of rigidity. The hydophobically treated fibers influences high mechanical properties.

Ting Ting Li et al (2014) have experimentally investigated the compound fabric was prepared using glass fabrics and Kevlar fabrics as well as recycled polyester non woven via needle punching and thermal bonding processes. The result shows that the fibers have improved effect on static and dynamic puncture resistance.

Majumdar et al (2014) have experimentally investigated the low velocity impact response on a Kevlar with nano silica based shear thickening fluid. In this work, the effect of various parameters like padding pressure and the Nano silica concentration the fluid were studied. The process improved the impact resistance because of the viscosity of the fluid increases drastically during impact, the parameters are determined by using the dynamic impact tester and the velocity with which it imparts can be investigated using the low speed bullet impact test with 0.3 mm caliber revolver. The impact energy increases with the increase of padding pressure and the concentration of the shear thickening fluid reduces add-on percentage of the soft composite. The
result shows that the significant improvement on the impact energy based on the type of the Kevlar fabric conditions.

Taragi et al (2014) have investigated the low velocity impact response on a Kevlar/epoxy laminate with enhanced different weight percentages of multi walled carbon nanotubes under ambient and low temperature conditions. For better performance of the impact energy and the penetration threshold, energy profile diagrams has been incorporated to determine the best optimal solution and also to impart all specimens in the same energy level of 45 J. The graphs has been plotted for stiffness bending, maximum deflection and penetration limit with respect to time history of absorbed energy, deflection and velocity are reported. The results concluded that the increase on multi walled CNTs increases the impact response and restricted the damage size of the Kevlar fiber composites. It also noted that the addition of MWCNTS increases the capability of energy absorption under ambient and low temperature conditions.

Hulin li et al (2014) have studied the influence of Nano Si$_3$N$_4$and submicron size WS$_2$fillers with Kevlar composites. The addition of both the fillers influence the reduction of wear rate but it does not reduce the friction coefficient. Hybrid composite fillers can significantly reduce both the wear rate and friction coefficient of composites. The graphs has been plotted for various compositions of Si$_3$N$_4$ and WS$_2$ fillers with Kevlar fiber composite and the result shows that the wear rate and friction coefficient of hybrid composite is less than mono composite with unfilled fillers. Hence, both the fillers have to investigate the effect of combination of two types of fillers to improve tribological properties. The wear rate has slightly decreased with the increase of content of Si$_3$N$_4$ nano particles.

Sudhir Sastry et al (2014) have studied on the impact performance of ballistic applications with the help of numerical models. The models have
been experimentally conducted on various composite samples. The fabrication model consists of 8 layers with different orientation. A Steel projectile is prepared for conducting the test with high velocity. The composite plate is placed and the projectile is imparted with a velocity of 100 m/s. the results shows that there is a significant stress and displacement of the composite panel.

Salleh et al (2014) have experimentally investigated the effect of extrusion processing temperature on rheological, dynamic and tensile properties of kenaf fiber with high density polyethylene composites were investigated for low and high processing temperatures. The result shows that there is a significant improvement in tensile modulus of composites but displayed diminished properties. When processed, at low processing temperature especially at high fiber content. Also, concluded that both low and high processing temperature, the tensile strength and strain of the composite decreases with increasing content of the fiber.

Thakur et al (2014) have reviewed the recent trends in natural cellulose fibers from bio renewable resources. The intrinsic properties such as bio degradability, easy availability, environmental friendliness, flexibility and mechanical properties have been studied in detail. Also the processing of bio renewable natural cellulose fibers, chemical function of cellulose fibers, synthesis of polymer resins, different strategies to prepare cellulose based green polymer composites and applications are discussed in detail. This review paper concluded to demonstrate the recent development and emerging applications of natural cellulose fibers and their polymer materials.

Ying ying et al (2014) has experimentally investigated the effect of pre treatment methods on oil palm empty fruit bunch and kenaf core for sugar production. In this work, oil palm empty fruit bunch and kenaf core fibers were converted into sugar for bio ethanol production. Here, for pre treatment
process, empty fruit bunch and kenaf core fibers were carried out in different conditions. The yield were washed, dried and stored in a fridge for further use. In this work, enzymatic hydrolysis and chemical composition analysis has been carried out. The result shows that by adopting simple aqueous pre treatments with water, acid and alkaline mediums and the hydrolysibility of the fiber was enhanced substantially. Among two fibers, pre treated empty fruit bunch fiber exhibited the highest total glucose yield in all the pre treatments.

**Sumi and Unnikrishnan (2014)** have reviewed the paper based on various types of surface treatments for natural fibers and their properties. The various types of properties such as cell dimensions, structure, angle and defects are discussed in detail. Various treatments such as enzyme treatment, alkali treatment, transesterification using vegetable oils, alkalization treatment are elaborated in detail. Various compositions of fibers have been compared. The reviewed results show that the developments and applications of natural fibers play a vital role. The modifications and techniques are suitable in design based for optimum results.

**Arsath Rahuman et al (2014)** have experimentally investigated the wear characteristics of glass and jute fiber reinforced epoxy composites. In this work, two specimens are prepared namely glass and jute with epoxy matrix using hand layup method. The friction coefficient and wear characteristics have been investigated in various dry sliding conditions. From the experimental values, it is concluded that the jute fiber reinforced composite shows better results than glass fiber reinforced epoxy composites.

**Temesgen Berhanu Yallew et al (2014)** have experimentally investigated the effect of wear characteristics of jute fiber reinforced polypropylene composites. In this work, compression molding process is used for the preparation of the specimen. The effect of the reinforcement under
friction was investigated. The apparatus used here is pin on disk test to determine the wear and friction coefficient. The input parameters such as load, sliding distance and speed are varied and the output responses are recorded. Scanning electron microscope has been done to observe the internal structure of the composite laminate. The result shows that the percentage reduction is observed in both the friction coefficient and the specific wear rate.

**Vijayakumar et al (2014)** has experimentally investigated the wear behavior of jute reinforced polypropylene composites. In this research work, pin on disk test apparatus is used to determine the wear behavior of the composite. Here the wear characteristics has been observed and studied at different loading conditions and sliding velocities by varying fiber weight percentage. The result shows that the coefficient of friction and wear loss decreases with increase in normal loads.

**Meenu Gupta et al (2015)** have experimentally investigated the machinability of unidirectional glass fiber reinforced polymer composites in turning process. Various parameters like cutting speed, tool rake angle, depth of cut, tool nose radius, and feed rate are varied in each operation to determine the effect on output characteristics such as material removal rate and surface roughness. The result shows that feed rate increases, surface finish also increases. And also concluded that feed rate has high significant factor than depth of cut and cutting speed.

**Park et al (2015)** have experimentally investigated the effect of rice washed water treatment of kenaf fiber and comparison has been done with untreated fiber. Mechanical and interfacial properties have been investigated in order to evaluate the treatment effects. Differences in surface morphology of treated and untreated fiber was observed by FE-SEM photography. Thermo gravimetric analysis was performed and the result shows that treated kenaf fiber improved the fibers thermal stability. This relatively simple and
environmentally friendly rice washed water treatment of kenaf fibers resulted in improve mechanical and interfacial properties.

Valenca et al (2015) have experimentally investigated the mechanical behavior of epoxy reinforced composite with Kevlar plain fabric and glass Kevlar hybrid fabric. Kevlar plain fiber and hybrid fiber were manufactured by hand layup method and the results shows that the significant improvement on the mechanical properties such as strength, bending and impact energy. The minimum curing time of the epoxy resin has been ensured by Fourier Transform Infra Red spectrometer for performing mechanical tests. Finally, Scanning electron Microscope has been done to observe the interfacial adhesion between the matrix and the reinforcement. Tensile, bending, impact tests were carried out in parallel direction or fill direction of the wrap and in 90\(^\circ\) direction. The fracture has been identified with SEM. The composite with Kevlar/glass hybrid structure the reinforcing fabric shown the better result with respect to specific mechanical strength as well as bending and impact strength.

Jackson singh et al (2015) have reviewed the characterization of Kevlar fiber and its composites. In this study, various mechanical properties such as tensile strength, modulus, strength to weight ratio has been discussed. Kevlar fibers are used as reinforcement in various applications was discussed in detail.

Sirui Fu et al (2015) have studied the combined effect of interfacial strength and fiber orientation on mechanical performance of short Kevlar fiber reinforced olefin block copolymer. Olefin block copolymer (OBC) is poor strain mechanical strength and stiffness to bear the load. So their defects are rectified with Kevlar reinforcements in the form of newly formed microfibers in the OBC matrix. Prestine Kevlar fibre has no significant tensile strength so that the Kevlar fibre is added as microfiber. It clearly indicates the
key role of interfacial interaction between Kevlar fiber and OBC matrix in improving mechanical properties of the composites.

**Aswani kumar et al (2015)** have studied the ballistic impact response of Kevlar reinforced thermoplastic composite armors. In this study, the composite (armor) is made of Kevlar (fibre) + Polypropylene (matrix) and additive of maleic anhydride grafted PP. The matrix is composed of 10 % Mg polypropylene + MI 3530 Polypropylene. The composite is manufactured by the vacuum assisted compression molding technique. In this study three different woven’s are taken 2D (Plain woven), 3D (orthogonal), 3D (angle interlock). The ballistic impact result showed that 2D armor is 2.4 – 7 % more susceptible to damage than 3D armor. The ballistic limit ranges in the order 2D plain < 3D orthogonal< 3D angle interlock. The result shows that 3D angle interlock woven show superior mechanical properties and ballistic velocity limit.

**Sapaun et al (2015)** have experimentally investigated the effect of layering sequence and chemical treatment of woven kenaf with Kevlar composites. In this work, kenaf mat was treated with 6% sodium hydroxide and compared mechanical properties with untreated kenaf hybrid composite. The result shows that the tensile properties of hybrid composites improved in 3 layers when compared to 4 layer composites. Also, tensile and flexural properties of hybrid composites are better than non treated hybrid composites. Scanning electron microscopy is done to observe the fractured surface of hybrid composites. Hybrid composites with Kevlar as outer layer display better mechanical properties as compared to other hybrid composites.

**Saba et al (2015)** have reviewed the kenaf fiber and their mechanical properties reinforced with polymer composites. Mechanical properties of kenaf fibers are comparable to existing materials and it is used in varied ranges of structural and non structural industrial products reinforced with
polymer matrix. In this review work, highlights the previous works involving mechanical properties of kenaf fiber and it can be explore to be used as a construction and building materials. Various topics such as kenaf based thermoset, thermoplastics and bio degradable polymer composites have been discussed in various types of polymer composites. The result concluded that 40% fiber loading consider as optimum condition in polymer composites which give better mechanical properties. Kenaf fiber has great probability of substituting the synthetic fiber for building and construction materials and also it can be molded into lightweight panels in several applications. Finally it can be concluded that the future work would be production of green composite materials and Nano composite from kenaf fiber with bio degradable resin polymeric matrix with improved properties.

Hazarika et al (2015) have experimentally investigated the addition of zinc oxide nano rods on woven Kevlar fibers and performance has been studied. In this work, seeding treatment has been done to grow zno rods on a surface functionalized woven Kevlar with polyester resin by vacuum assisted resin transfer molding. Various operational tests such as thermal stability, impact test, energy profile diagram, energy time response, velocity time response has been recorded. The result shows that by adding zno nano rods results in better surface finish and also better interfacial reinforcement of Aramid composites. The addition of ZNO nano rods has increased impact energy and tensile strength and the overall improvement in mechanical and thermal properties of the composite.

Xia et al (2015) have experimentally investigated the process of applying vacuum assisted resin infusion using calcium carbonate nano particle impregnation to improve the mechanical properties and water resistance of kenaf fiber reinforced polymer composite. In this work, various mechanical tests have been carried out such as tensile strength, flexural strength and modulus has been determined. Scanning electron microscope has
been done and the result shows that there is a significant improvement in interfacial compatibility between the fibers and the matrix when compared to untreated fibers. Also the comparison of mechanical properties, density and water resistance has been impregnated which indicates a high possibility of kenaf fiber reinforced composites in the automotive field.

**Suharty et al (2016)** have investigated two categories of composites which prepared and reactively synthesized in xylene solution. The first category involves recycled polypropylene, divinyl benzene, coupling agent, halloysite and kenaf fiber and the other category without the presence of kenaf fiber. The mechanical properties such as tensile, flexural and impact has been determined. The results shows that improved mechanical properties of the category which involves kenaf fiber. SEM analysis has been carried out and the result shows that there is a strong interaction between the fiber and the reinforcement.

**Shamsuddin et al (2016)** have investigated and aims to find out the changes occurring in kenaf core fiber when it is reacted with phosphoric acid. The surface area coated was determined by physical adsorption of nitrogen gas. In this work, Fourier transform infrared spectroscope analysis has been performed to observe the presence of carbonyls, alkenes and hydroxyls. Field emission scanning electron microscope has been done to show the image of formation of pores due to elimination of volatiles and contaminants. Power x ray diffraction analysis indicates the appearance of broad diffraction revealed amorphous structure. The result shows that high percentage of carbon and low percentage of ash which is an indication of good material for production of porous carbon.

**Bajuri et al (2016)** have experimentally investigated the effects of flexural and compressive properties of kenaf combined with silica Nano particles in epoxy composites. The filler material used in this work was silica
Nano particles to improve the quality of kenaf reinforced composite. The composites were prepared by using vacuum infusion process in which kenaf mat are laid in. the silica Nano particles are dispersed into epoxy resin using a homogenizer at 3000 rpm for 10 minutes before being infused into fibers. The result shows that there is a significant mechanical property with the inclusion of silica Nano particles.

Shuhimi et al (2016) have experimentally investigated the tribological characteristics of oil palm and kenaf fiber with epoxy resin as medium and it has been compared. Pin on disk test is carried out to determine the wear behavior. A pin with sample of diameter 10 mm has been done with suitable machining process. A dry sliding test is performed using pin on disc tribometer. Test parameters such as weight percentage of fiber, load, sliding speed and temperature ranges are taken as operational parameters. The result shows that the increase in temperature resulted in decreased coefficient of friction and increased wear rate for both the composites. Scanning electron microscope has been done and the result shows that the composites having blow holes, micro cracks, fiber pullout and some regions deboning has been observed.

Zamri et al (2016) have experimentally investigated the effect of kenaf with different yarn sizes and their mechanical properties. The kenaf fiber is fabricated via pultrusion process. The mechanical tests such as tensile, compression and flexural has been carried out and compared with different kenaf yarn tex. Pultruded composites shows better mechanical properties made with smaller tex number when compared to larger tex number, because of it helps to produce better wetting of fiber during production of composites, consequently helps to increase its properties. Scanning electron microscope has been done and the result shows that there are poor wetting of kenaf fiber recorded lower properties of kenaf yarn larger tex number than the smaller tex number.
Yahaya et al (2016) have experimentally investigated the ballistic performance of woven kenaf Aramid hybrid composite. In this work, the percentage of kenaf content can be varied in terms of volume fraction with two different categories. Failure analysis has been done for the damaged samples. The result shows that the ballistic performance has been improved with inputs of areal density and thickness.

Yahaya et al (2016) have experimentally determined the performance of kenaf and Kevlar with fiber orientation for military applications. In this work, mechanical properties such as impact resistance and tensile strength have been done with unidirectional and mat samples and comparison has been done. The result shows that the kenaf in the form of woven structure shows significant results when compared to other samples.

Yahaya et al (2016) have experimentally investigated the hybrid composites consist of kenaf and Kevlar for ballistic applications. In this research work, fragment simulating projectiles has been investigated with various parameters like fiber interface and failure mechanisms like delamination, fiber shear, fracture and impact resistance has also been investigated. The results show that there is a significant improvement in performance and there is an increase in energy absorption.

Yang et al (2017) have investigated the fracture and impact properties of novel auxetic Kevlar fiber filled with epoxy composites. In this research work, comparison has been done with and without polyurethane treatment. The process is done by vacuum infusion method in which the compaction has been achieved optimized for fabricating the composites. The result shows that there is a significant improvement in fracture toughness and also an enormous reduction in damage area which influence the impact energy absorption.
Chouchan et al (2017) have studied the effect of specimen thickness of high strain rate of Kevlar filled with polypropylene composites. In this investigation, split Hopkinson pressure bar test is used for varying aspect ratios of the composite specimen. In this method, compression molded and laser machining is done to obtain round specimens of desired aspect ratios. The result shows that there is an increase in 90% strain rates with least thickness composite.

Srivathsan et al (2017) have investigated the mechanical behavior of woven glass fiber along with Kevlar composites to obtain the fiber in plane orientation and stacking sequence. In this research work, hand layup process is done to fabricate the composite laminate and it is then cured by using hydraulic compression Maudling. The result shows that there is a significant improvement in the stacking sequence and fiber orientation. Also SEM has been done to interpret the internal structure of the composite laminate.

2.2 Conclusions based on Literature Review

Among all, the literature reviews stated so far, the following conclusions can be drawn.

i. Composite materials have been tremendously increasing and highly demandable one which grows steadily and it reaches the customers easily.

ii. Natural fibers can be used as the composite materials such as kenaf, sisal, flax, cotton hemp, jute, bamboo, abaca, acacia etc among the fibers are frequently known to be used as reinforcement to make the composite.

iii. For fabricating the composites, polymeric resins have been used to make the composite bio degradable and eco friendly environment.
iv. Thermo plastics and thermo setting plastics can be used as the matrix medium such as polyester resin, vinyl ester resin, and epoxy resin can be used for better stability of the composite.

v. Composite materials can be used due to its less cost, density, high characteristic properties as the fabrication and the molding processes can be done easily.

vi. Hybrid composites possess good interfacial adhesion between the reinforcement and the matrix which can be improved.

vii. Glass fibers can be used on either ends of the composite for exhibiting good mechanical properties.

viii. Fiber parameters such as fiber length, density, volume fraction, fiber orientation influences high mechanical properties.

ix. Kevlar fibers can be used as the reinforcing material with the combination of natural fibers for better mechanical properties.

x. For fabrication of composites, various methods and processes can be adopted. Hand layup method is the simplest method to fabricate.

xi. Hybrid composites can possesses better mechanical properties than the individual fiber.

xii. For long durability of the composites, wear and friction tests have been adopted.

xiii. For better machining characteristics of the composite, various machining experiments were carried out in hybrid composites.

xiv. For optimization of the machining parameters, various optimization tools have been used by various researchers.
xv. The conventional method of machining natural-Aramid fiber is done by abrasive water jet machining, in which the parameters can be optimized and it can be implemented in the industrial applications.

2.3 Knowledge Gap in the Investigations

The following knowledge gap has been found in the research so far is given below.

i. Though the reinforcements can be used as natural fibers in the composites, a very few works has been reported in the neem fiber in spite of its several advantages over other.

ii. Though the natural fibers can withstand the mechanical properties, a very few work has been done on kenaf fiber which has got good tensile strength ad high absorption capacity which is not adequately addressed so far.

iii. Though the composites as high mechanical properties, a very few works has been attempted to combine with synthetic fibers.

iv. Though the combination of natural- Aramid fiber, no work has been carried out with twisting of fibers to make the composite laminate.

v. Though the Tribological analysis has been done on various fibers, a few works has been done to determine the wear characteristics of the hybrid composites.

vi. In many research works, various fiber orientations have been implemented and their mechanical investigations have been done. But, so far a few works has been done on arranging the
fibers in alternative manner which has parallel, inclined and orthogonal orientations by hand layup method.

vii. The various numbers of literatures has been done to optimize the machining parameters in case of natural and Aramid fibers individually. But in case of twisted hybrid composites, few works has been carried out in optimizing the parameters.

viii. Though the parameters with few inputs to optimize, many other vital parameters play a major role can also be done for better optimization of machining parameters.

ix. Abrasive water het machining is the best way among other machining methods as it is very high cost and demand.

x. Optimization tools such as ANOVA and Taguchi techniques can be implemented in natural fibers whereas only few works are available in case of Aramid natural twisting hybrid composite.

2.4 Motivation for the Research

Based on the survey on literature works, it can be seen that the works related to the combination of Aramid – Natural fibers are a few. A majority of work has been carried out with only natural fibers and its combinations for enhancing mechanical properties. Hence, the resources are not adequate for fabrication of twisted hybrid composites with different layers and fiber orientations. Hence, this research work focuses on fabricating, testing and machining of twisted hybrid composites and determining the characteristics and the optimal solution.