International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 05 - Issue 06 || June 2020 || PP 53-63

Hemp Fibers and Polyethylene: A Review

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Abstract: Beginning from the 3400 B.C to the present date, the composite materials field has observed immense growth and has improved in various research activities. Especially with the use of chemicals to bond the materials, it has led to a huge increase in material properties such as tensile strength, temperature resistance and cost-efficient that includes reduced weight of the materials. One of the new ideasled to the use of Hemp Fibers and Polyethylene Composite Material. It is believed that the Hemp Fibers are one of the best natural fibers on the planet which makes the availability in a large quantity. On the other end, Polyethylene is the most commonly used form of plastic. The availability of these two materials will not be an issue. Although the weight and cost parameters are less, the properties which are observed will restrict the usage to only certain limits where it cannot be used for high tensile and stiffness required applications. This paper gives an overall idea of how the Hemp Fibers and Polyethylene Composite Materials used in the industries and to figure out what methodologies or techniques are used by some of the international published journals on this type of composite material.

Keywords: Composite Materials, Cost-efficient, Environment, Hemp, Natural Fiber, Polyethylene, Strength and Material characteristics.

I. Introduction

Composite Materials

As composite materials can be called a mixture of two or more materials with different physical and chemical properties. When these two or more materials are mixed, they form a substance with various properties that is skilled in performing a particular job, including being stronger, lighter, or electricity resistant. Although different materials of the products are combined to form a single material, the individual components remain the same. The purpose of merging is to enhance the properties of their base materials. [1]

The history of composite materials starts from 3400 B.C to present date, [2]

- 3400 B.C – The first ancient people to use composite materials was the Mesopotamian's who lived in the region of Western Asia, where they used wooden strips by mixing them with glue to create plywood from various angles.
- 2181 to 2055 B.C – The Egyptians used cartonnage to make death masks and immersed in plaster layers of linen or papyrus.
- 1500 B.C – Both the builders from Mesopotamia and Egypt used straw to support mud bricks, pottery and even used to construct boats.
- 25 B.C – Different types of lime and mortars were used. Where some applications included for construction and decorations.
- 1200 A.D – It is noted that the very first hybrid bows made from various materials and pine were used to bond them which were invented by Mongols. Up to the invention of powerful guns in the 14th century, they are used as the tools to defend or kill livestock.
- 1800 A.D – History calls this the chemical revolution in the manufacture of composites. Synthetic resin was converted into a cross-linked molecular structure from a liquid to a solid state using a technique known as polymerization. Celluloid, melamine and bakelite (Polyoxybenzylmethylenglycolanhydride) are also the organic resins.
- 1900 A.D – Plastic production was observed such as plastic, polystyrene, and polyester were produced to provide stability and stiffness. Bakelite was one of the first plastics made with organic materials during the year 1907 A.D. Due to its heat-resistant and non-conductivity qualities, the composite has been commonly used in various applications such as electrical insulations, telephone casings, radio, pipe stems, kitchenware, jewelry, and children's toys.
- 1930 A.D – Thanks to the production of resins used to date, this decade is considered to be among the most important decades in the composite sector. Owens Corning was the first person to develop the first glass fiber around 1935 A.D, and introduced the Fiber Reinforced Polymer (FRP). Despite its drying property, unsaturated polyester resins were patented later.

- 1940 A.D – During World War II, FRP manufacturers discovered that fiberglass composites were invisible to radio frequencies, resulting in the usage of the radar domes. The composites were used in the development of car (automobile) during 1947 A.D, contributing to the production of Chevrolet Corvette (C1) in 1953 A.D.
- 1950 A.D – The manufacturing technologies were developed including vacuum bag molding, pultrusion, and filament winding (which were used in aerospace composite materials).
- 1960 A.D – Carbon fibers were patented that increases the stiffness property and reduced the weight. This was an advantage to use in aerospace and automobile filed. It also observed huge increase in the sports equipment.
- 1970 to 1980 A.D – Composites were used in marine then improvised to custom-molded breakers for applications.
- 1990 to 2000 A.D – Composites were replaced in places were metals were used due to its cost. Most of the current technologies involve composites in one or another way, such as handles and knobs, electrical infrastructures, insulators, weather-resistant stains, etc.

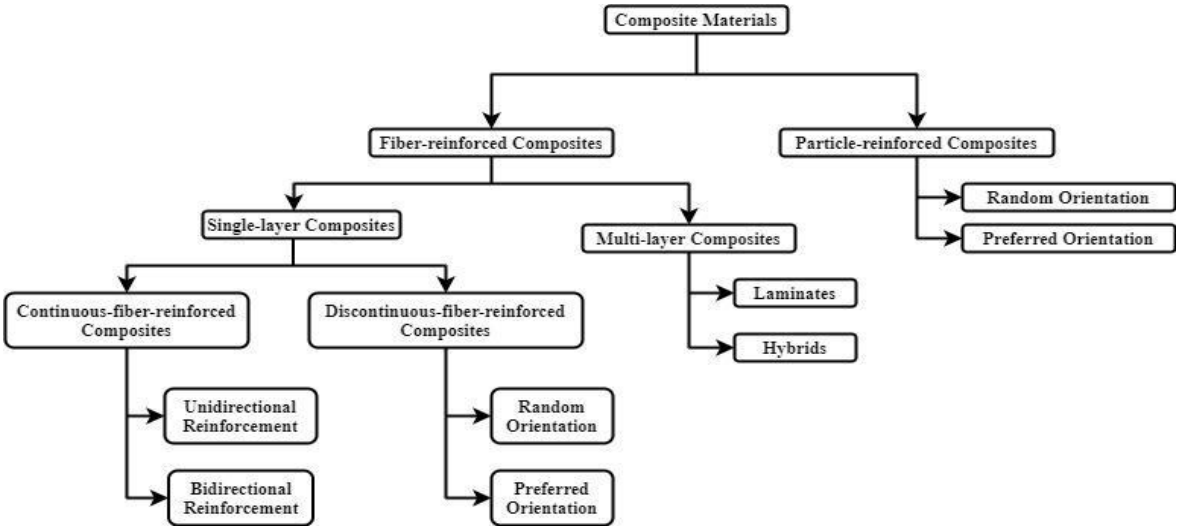

Figure 1 – Classification of Composite Materials

In general, the classification of composite materials is represented in Figure 1 where the composite materials are developed to improve mechanical properties such asstiffness, toughness, and high temperature. Also, the author [3] denotes that the characteristic of a particle isnon-fibrous in nature. The shapes can be in any forms such as circle, spherical, tetragonal, regular or irregular shapes. The fiber is differentiated by the greater length over the cross-sectional length.

Hemp

Hemp is also called as industrial hemp. It is a component of the plant species of cannabis sativa and is primarily cultivated for industrial purposes. It is top listed among the fastest-growing plants on the planet and the oldest. Drugs like marijuana do come from the same plant species as cannabis sativa but it is high in Tetra Hydro Cannabinol (THC) and synthetic hemp is non-intoxicating and has less (0.3%) THC. There is a wide range of usage of hemp such as clothing, food, nutrition, fiber, fuel, plastic, paper, milk, clean soil, pet food, and bedding, hemp-based cannabidiol (CBD) oil, etc. [4]

Hemp	**Marijuana**
Plants don't produce flowers.	Plants yield building flowers
THC < 0.3%	THC > 1-20%
No psychoactive effect	Affects mind and body
Industrial – Fiber, etc.,	Medical and recreational
Legal to grow	Illegal to grow

Table 1 – Comparison of Hemp vs Marijuana

Figure 2 represents the general classification of cannabis sativa. The differences between them is as mentioned in Table 1, where it is observed that Hemp is one of the best natural fibers known on the planet and has more than 50,000 uses that includes to make a variety of products, such as rope, textile, shoes, food, paper, bioplastics, and biofuel. [5]

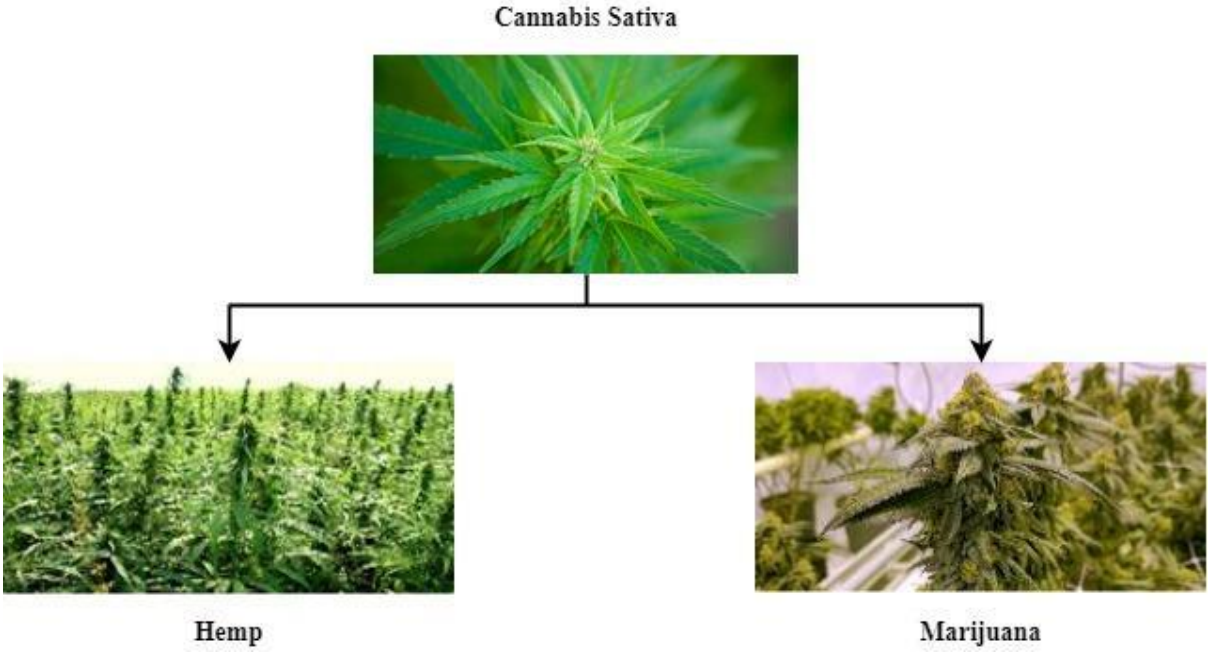

Figure 2 – Classification of Cannabis Sativa

The cannabis sativa plant is illegal to grow in most of the places, due to the usage of marijuana drug which causes side effects to human health that leads to death when consumed in high quantity. The government has banned to grow the cannabis sativa plant even though the THC content is less. But in few places in the United States, such as California, Washington, Oregon, Maine, Florida, Kentucky and Tennessee [6] also its widely grown in the Canada compared to all other countries such as China, India, Russia, etc., it is legally grown and distributed to make use of the cannabis sativa plant of wide applications (main intension it to not grow with high THC which leads to marijuana).

Polyethylene

It is known to the world that the most popular plastic produced is Polyethylene. Due to the simple process of extraction and demand for various applications in daily day life, it is produced in a large quantity as it is made from the polymerization of ethylene (ethene) monomer. Its chemical formula is $(C_2H_4)_n$.

Polyethylene	Properties
Low-Density Polyethylene (LDPE)	● LDPE is a flexible material which is commonly used in shopping bags, wash bottles, trash bags, laminations, tubing and laboratory equipment. ● The advantages would be low cost, excellent electrical insulating properties and good resistance to alcohols, dilute alkalis and acids. ● The disadvantages would be less strength, less stiffness, poor UV resistance, highly flammable and limits usage at high temperatures.
Linear Low-Density Polyethylene (LLDPE)	● LLDPE is similar to LDPE but has high impact strength. It is used in film applications, garment packaging, toys and covering of cables. ● The advantages would be excellent for buffers, good chemical resistance, good stress crack and impact resistance. ● The disadvantages compared to LDPE would be lower gloss, processing is difficulty and less temperature resistance.
High-Density Polyethylene (HDPE)	● HDPE is a robust, moderately stiff plastic with a highly crystalline structure. It is used to make garbage bins, chairs, cutting boards, ice-cube trays, bottle crates, milk jugs, jerry cans and house wrap. ● The advantages would be high tensile strength compared to other type of polyethylene, high quality electrical insulating properties, very low water

	absorption and wide ranges of daily day applications. ● The disadvantages would be less stiffness, high mold shrinkage, susceptible to stress cracking and poor weathering.
Ultrahigh Molecular Weight Polyethylene (UHMWPE)	● UHMWPE has molecular weight of 10 times more than HDPE. It is used in vehicle armor, fishing line, bow strings, climbing equipment, cut-resistant gloves, parachutes, rigging in yachting and kites. ● The advantages would be high abrasion resistance, high impact strength, low coefficient of friction, aggressive to environments, UV stable, transparent to radar. ● The disadvantages would be subject to creep under tensile load, since its slippery it is difficult to tie knots or cut smoothly.
Cross-Linked Polyethylene (PEX, XPE or XLPE)	● PEX is produced under high pressure with organic peroxides. It is used in building services, pipework systems, heating and cooling systems, insulation for high tension electrical cables and oil applications. ● The advantages would be high abrasion resistance, potable water, approved, high extrusion speed on standard lines and tougher. ● The disadvantages would be restricted usage at outdoors, cannot be recycled due to its shorter lifespan and sensitive to UV light.

Table 2 – Comparison between different types of Polyethylene

There are different types of polyethylene which is categorized based and their applications, advantages and disadvantages as mentioned in Table 2. The mentioned other notable types of polyethylene also come under Table 2 but it is not considered in majority side there is slight difference in the properties such as density, tensile strength, temperature resistance and other chemical compositions. Of course, the process of making these types will vary including the applications where each of them is used for specific purposes. [7][8][9][20][21][22]

Few other notable types of polyethylene are,

- Ultralow Molecular Density Polyethylene (ULMDPE)
- Very Low-Density Polyethylene (VLDPE)
- Medium-Density Polyethylene (MDPE)
- High Molecular Weight Polyethylene (HMWPE)
- Chlorinated Polyethylene (CPE)

II. Objective

The objective of this literature survey is to understand the usage of hemp fiber and polyethylene composite materials in the composite sector, the base material properties to combine and also reviewing the other research papers published in international journal sites. The relevant research papers are gathered and required information is filtered or extracted to observe what are the changes and methodologies used in them. As this is a literature survey paper, the approach would be majorly focused on the journal papers and articles or blogs relevant to hemp fibers and polyethylene composite materials, and summarizing what the content is about whether the research is focused on the effects, or the strength (tensile), chemical properties or the applications, etc. and also giving out few points as own research within the existing literature. The major challenge would be in understanding the methodologies used in the relevant papers where each has their own way of producing the results or concluding their objectives and also sorting out what content goes to this paper from the referred papers. The expected results would be a good literature paper of hemp fiber and polyethylene where the intension is to convey the information of what are hemp fibers and polyethylene materials, what are their types and properties, how are used they in general, what are the merits, demerits and limitations, the existing process of how the composite materials are made and used in the specific type of purposes (applications). The trend in literature survey will also give an over idea of what the journals speak about in general which will be discussed along with other information.

III. Literature Survey

One of the importance of using composites is to reduce the cost and weight, improving the tensile strength and properties of the material to improvise the overall efficiency. In recent times, there is a significant increase in the use of bio-inspired composite materials such as hemp fibers and polyethylene. The motivation is from nature

where it starts from plants, bone, wood, that have complex hierarchical structures. To replicate these structures by man-made processes requires high research skills and technology. Instead, using them as one of the materials is always a better and convenient resource.The bio-inspired term also relates to the natural materials which are not been helped by external parameters in the process of its structure. Almost all living creatures are bio-inspired due to its distinct features. Plants are used in many ways since the beginning of human life. Humans consume some types of plants or vegetables as food every day. Various parts of plants are used in different requirements for example wood is used to make furniture, as fuel, etc., leaves are used in some medical applications, seeds are used to make oil which is later used for various purposes, fibers are extracted and used to make ropes, some plants give fruits, etc., Here we are majorly focused on the fibers of the plant. We are extracting the fiber from the hemp plant as one of the materials for the composite structure. Even cotton can be used as fibers which is almost similar to hemp fiber but the properties of hemp fibers are more useful for the composite materials world to make high load-bearing applications. Cotton is mainly used in textile industries to make clothes which is considered as soft material, even though hemp fibers are used in textile industries but it is not as soft as cotton.

The three general most required factors for the mechanical performance of Natural Composite Fiber (NFC) are: [10]

a. Fiber Selection – (Hemp Fiber)
b. Matrix Selection – (Polyethylene)
c. Fiber Matrix composite orientation and manufacturing

Fiber and Matrix Selection

There are plenty of natural or bio fibers available in nature. One among them is Hemp Fiber. The fiber selection process includes the harvesting of hemp fiber, extraction process, properties of the fiber and availability.

In general, the hemp fiber extraction process includes the following procedures, [11][12]

- Harvesting – Hemp is grown in most of the temperature range and climatic conditions of the world, excluding extreme weather conditions. It does not require advanced methods or special equipment to grow. Once the hemp is grown in normal harvesting conditions, there is a specific duration in which the hemp is fully grown and ready to be harvested. It is usually between 70 – 90 days from the initial seeding process.
- Retting – Once the hemp is harvested then the chemical bonds which makes the structure of hemp hold together must be separated individually. To do this process, retting method is used which involves the usage of moisture and microorganisms. Retting method has many ways but most commonly used are,
  1) Water Retting – The harvested hemps are kept in large waters tanks where the stems are immersed into the water for at least 10 – 14 days. The water used in the water tanks must be hot enough and also loaded with bacteria or microorganisms in the process of separation.
  2) Dew Retting – If there is scarcity of water to use in certain regions, the dew retting method is used which does not requires water. The harvested hemps are laid over the open field over the night, due to the climatic changes over the night until the sunrise and when it's hot during the morning, the stems of the hemp start to lose its bonding properties. Dew retting can also be called as field retting which takes at least 28 – 42 days that is 2.5 times the water retting.
- Decoration – Now when the retting methods are carried out and the stems are dried. Further it is processed into the rolling machinery in a sequence. Doing this separate the woody core from the rest of the bonded substances.
- Softening – This process is similar to decoration but the machinery used here will make the hemp roll over again and again until its soft enough. This process also removes the hard particles from the hemp if they are not removed from decoration method.
- Combing – Now the fibers from the hemp are in a stage of separated from other bonded substances. The length of the fibers will be approximately 3m. This is shortened around 650 mm or depending on the application specific lengths using various cutting tools. The short fibers are combed so that if there are any small woody particles in it will be further removed.
- Spinning – The short fibers when combed will go onto the final process of spinning which is carried over the slivers. The sipping method is used to make yarns so that it is easy for using into any applications. The quality and specific quantity of yarn requirements will be sometimes provided by the industries for a specific application usage, otherwise the yarn is made referring to general standards.

Figure 3 shows the final finished hemp fiver yarn which is ready to be used for various applications. The yarns can be also added natural or artificially colored using additives to get few attractive variations. [13] Figure 4 shows the overview of the hemp process from the harvested hemp to the hemp fiber yarn. [14]

Figure 3 – Hemp Fiber Yarn

Figure 4 – Hemp Fiber process overview

Just to compare the Hemp Fiber with the Cotton Fiber, the process of harvesting is similar in both the cases but wet climatic condition is not suitable for cotton. The process of extraction is also similar to Hemp Fiber but only difference is that the cotton is already in its fibrous form, separating the cotton from rest of its plant or substances does not require complex machinery or equipment. The dry retting, decoration, softening, combing and spinning is carried out to make the cotton yarns. It is widely used in textile industries and medical applications from the ancient period from around 6000 B.C. It is legal to grow cotton in almost all countries since there is no illegal activities noted using cotton. [15]

Properties/Fiber	**Hemp**	**Cotton**
Density (g/cm^3)	1.5	1.5 – 1.6
Length (mm)	15 – 25	20 – 30
Diameter (µm)	22 – 25	15 – 19
Failure Strain (%)	1.6	3 – 10
Tensile Strength (MPa)	550 – 1110	287 – 800
Stiffness (GPa)	58 – 70	5.5 – 13
Cost ($/lb)	0.6 – 0.65	0.6 – 1.5
Weight (gm/cm^3)	1.47	1.52
Production (10^3 tons)	215	18,500

Table 4 – Properties of Hemp vs Cotton

Chemical Composition /Fiber	**Hemp**	**Cotton**
Cellulose (%)	70	95
Hemicellulose (%)	17.9 – 22.4	5.7
Moisture (%)	20	8
Ash (%)	2	1.2
Wax (%)	1 – 2	0.6
Sugar (%)	0.3	0.3
Pectin (%)	0.9	0 – 1

Table 5 – Chemical composition of Hemp vs Cotton

Polyethylene /Properties	**Density (g/cm^2)**	**Cost ($/lb)**	**Temperature Resistance (ºC)**	**Tensile Strength (MPa)**	
				Yield	**Break**
LDPE	0.91 – 0.925	0.52	80	10 – 15	10 – 20
LLDPE	0.91 – 0.94	0.44 – 0.48	60	10 – 30	25 – 45
HDPE	0.941 – 0.965	0.38 – 0.46	120	25 – 30	30 – 40
UHMWPE	0.97	0.43	136	21.4 – 27.6	38.6 – 48.3
PEX, XPE or XLPE	0.95	0.48 – 0.54	94	20 – 23	42 – 44

Table 6 – Properties of different type of Polyethylene

Table 4 gives general information about the properties and Table 5 chemical composition of hemp compared to cotton fibers. It can be observed from Table 4 that the tensile strength property of hemp is much larger compared to cotton fibers, from Table 5 the Hemicellulose of hemp is higher than cotton. Table 6 gives information about the properties and of polyethylene comparing different types.

[7][8][9][10][16][17][18][20][21][22][31][32][38]

The Fiber selection is Hemp Fiber and Matrix Selection is High Density Polyethylene (HDPE) or sometimes called as recycled High-Density Polyethylene (rHDPE). rHDPE is considered as one of the best recycled polyethylene among the other categories since the recycling process is easy. It is accepted in almost all recycling plants.

Fiber Matrix composite orientation and manufacturing

The volume fraction plays a major role in the composite materials. Since both the base materials are important contribution to the final product but each had its own properties. The Hemp Fiber is approximately selected between 20 – 40% and the rest 80 – 60% would be the rHDPE. Various research and publications sources have information about the experimented test results over Fiber Matrix composite material to find out the tensile strength of the composite material with different volume fractions of base materials.

Lu et al. [23][24][25] has a patent on production of Hemp Fiber and polyethylene composite materials which gives the information about the production process and experimental test results. The Hemp Fiber volume fraction is selected with 20 – 40% where the test results suggests that if the Hemp Fiber is treated with Sodium Hydroxide (NaOH) before the production of composites, then the maximum tensile strengths are achieved. The manufacturing process includes pultrusion, vacuum infusion and compression techniques to produce the composite material. The Hemp Fibers are inserted or layered around 20% cross directional orientation. From the results it is observed for 40% Hemp Fiber and 60% rHDPE, the maximum tensile strength of 60.2 (MPa) is achieved which is the highest compared to other volume fractions that were tested.

Naik et al. [26] research was carried out to observe the swelling properties of natural fibers/high density polyethylene composites. The natural fibers include banana, hemp and sisal fibers with HDPE in a volume fraction of 40:60% and 45:55% were considered to carry the research. The experimental specification is mentioned in the journal [26] where they compare the results of water absorption content with and without treatment of Maleic Anhydride (MA) which is a coupling agent. The results conclude that when the hemp fibers are used, the lesser the fiber implies the lesser in absorption of water (40:60% volume fraction is efficient).

Singh et al. [27] research focuses on the tensile behavior of hemp fiber reinforced with rHDPE. The manufacturing process of the composite is done using injection moulding technique with the volume fraction from 10 – 30% of Hemp Fiber and 90 – 70% of rHDPE. The surface of the fiber when treated with NaOH shows rough surface compared to untreated fiber surface which is a positive indication of less water absorption. The test results show that the 10:90% and 30:70% volume fraction has decreased in tensile strength but the 20:80% volume fraction has slightly increased in tensile strength property. Among the 3 variations of volume fractions, the 20:80% has the maximum tensile strength of about 16.67 MPa.

Singh et al. [28] research is similar to Singh et al. [27], but here the research is focused by comparing the mixture of both sisal and hemp fibers which has different volume fractions that is treated with NaOH and MA. The HDPE was composed of 50% fresh and 50% recycled materials. The tests were conducted and the results show that for the 30:70% volume fraction (15+15% = Sisal+Hemp fiber) has the maximum tensile strength of 18.748 MPa.

Lu et al. [29] research is conducted to investigate the effects of NaOH and Silane of hemp fibers and how it affects the thermal stability and thermo-mechanical properties of HDPE composites. The tests were conducted for volume fractions of 20:80, 30:70, 40:60 and 50:50% for untreated, NaOH and Silane treated hemps. The conclusion was made based on the tests which says that the Silane treated hemp fibers have good thermal stability property compared to NaOH treated and untreated hemp fibers. Coming to the thermo-mechanical property, the stiffness is increased for untreated and NaOH and Silane treated hemp fibers up to 40:60% volume fraction, as in case of 50:50% volume fraction of the composites, the stiffness decreased for untreated, NaOH and Silane treated hemp fibers. In overall the Silane shows much impression in increment of thermal stability and thermo-mechanical properties of the composites.

Sepe et al. [30] research gives information about the various chemical treatments over the hemp and the outcome of mechanical properties. The vacuum infusion technique was implemented in order to produce the composite material. The hemp fiber was treated with 1% and 5% NaOH, 1%, 5% and 20% Silane and compared with untreated hemp fiber for their tensile strength property. The comparison results show that the maximum tensile strength of 80.74 MPa is observed for untreated hemp fiber, while the tensile modulus is observed maximum for 1% Silane treated hemp fiber.

Roumeli et al. [32] research was carried on the effects of coupling agent MA up on the hemp fiber HDPE composite, to also study the mechanical and thermal properties. The volume fraction was varied between 10:90, 20:80, 35:65 and 50:50% of hemp and HDPE and also different compositions of MA (1%, 2%, 3.5% and 50%). The test results show that the for the Hemp of 20% and 2% MA has achieved highest tensile strength of about 35.3 MPa. The second highest would be for 35% Hemp and 3.5% MA which has the tensile strength of 31.4 MPa.

Dauvegis et al. [39] conducted and experiment to determine the tensile and flexural propertiesof the hemp and HDPE composite material. The coupling agent here used was the Malleated Polyethylene (MAPE). The

composite material was made using extrusion and compression moulding technique. The volume fraction of hemp was between 0% – 30%. The composite materials were made in laminated structure like a sandwich for example 1st material had 3 layers of 10-20-30% of hemp in each layer. Likewise other materials were layered up at different % of hemp fibers. The test results show higher values of flexural modulus when the hemp is treated with MAPE where it is observed for 30-0-30, 30-10-30 and 30-20-30% hemp fiber volume fraction has got around 1150 MPa flexural modulus but the values for 10-0-10, 20-0-20 and 30-0-30% hemp fiber volume fraction were in the increasing order. Coming onto the tensile strength, there were no much variations observed for various% of hemp fiber volume fraction although the 30-30-30% has achieved the maximum tensile strength of about 17.9 MPa.

To summarize the literature survey conducted over several journals, the tensile properties vary with individual volume fraction, with the treatment of coupling agents such as NaOH, Saline, MA or MAPE. The common trend which can be observed here is that the hemp fiber is ranged within 20% – 40% and rest 80% – 60% would be HDPE that shows good agreement in producing high tensile strength provided with the treatments of coupling agents. When the coupling agent is treated over the hemp fibers, it gives the roughness to the surface which is an important factor in water absorption. Various manufacturing techniques are used in the production of composite materials, but the most common techniques are vacuum infusion and compression moulding techniques.

IV. Applications

The Hemp Fiber and Polyethylene composite materials are used in various applications. The main motivation to implement this is due to its bio-degradable property. Recycled polyethylene (rHDPE) is reinforced with natural fiber (Hemp Fiber) where both the base materials are recyclable if not when the product is left out to degrade under the soil then the degradable factor is very less compared to other plastic materials. The temperature of the hemp fiber and polyethylene material can range approximately between -5° to 85ºC. It is also considered as good thermal conductivity material. Due to its less tensile strength compared to other composite materials, it cannot be used on high tensile strength such as aerospace sector, etc., but it is not limited to, since the utilization of this composite materials has given out some good products. Some of the applications or product made from the hemp fiber and polyethylene composite materials are as mentioned below,

Figure 5 – Sun Glasses

Figure 6 – Cell Phone Back Case

Figure 7 – Cigarette Rolling Machine

Figure 8 – Guitar Body

Figure 9 – Pen Case

Figure 10 – Car Door and Bumper

Figure 5 shows the product sun glasses where the frame is made of composite material. These type of sun glasses looks different over the other sun glasses in the market as it gives a fashion look as well which is attractive [33]. Figure 6 shows a back case of a cell phone which is made from composite material. The colors can be added to give a flashy attractive look [34]. People tend to make the cigarette rolls by themselves at home which requires a

roller to make a cylindrical shape of the cigarette and here the roller machine is made of composite material [35]. Figure 8 shows the body of a guitar which is made of composite material [36]. Figure 9 shows a pen case which is made of composite material and its currently trending in gift shops to engrave a name on it as stylished pen to give it as birthday or occasional event presents [37]. Hendry Ford was the first person to implement the hemp fiber polyethylene composite material where specially the bumpers, hoods, frames, doors were made. Figure 10 shows a duo mode (sports and general-purpose) car where the doors and bumpers are made from composite material. These are the common applications which are currently used. From the literature point of view, noting the mechanical properties, composite material can be used to make study tables, small chairs for decorations, laptop keyboard surfaces, toys, house indoor applications such as switch boards, etc. Due to its less overall tensile strength property compared to non-bio fibrous composite materials, it cannot be used in aerospace sector, or in most of automobile, industrial equipment etc. The mechanical properties can be improved by focusing more on the treatments of hemp fiber in case to increase the tensile strength, young's modulus, etc. The cost of hemp is 0.6 – 0.65 $/lb and HDPE are 0.38 – 0.46 $/lb which shows how efficient it is when it comes to the cost.

V. Merits and Demerits

Various research over hemp fiber polyethylene composite materials have been conducted and will be carried in future in search of increasing the mechanical properties of the composite materials. Any product which is being produced or manufactured have a motto to use it for some specific application. They all have some advantages and disadvantages which is quite common in almost all products. Improving them each time is what the research is focused up on. Coming to the hemp fiber and polyethylene composite material, the advantages is observed more than the disadvantages. The product made from this composite material varies since the fiber volume fracture is an important factor. Considering the average properties as observed by above literature review, the advantages and disadvantages are mentioned below,

- It is observed that the average temperature resistant is between -5° to 85ºC, where most of the applications mentioned above are favourable but this also indicates that the products cannot withstand high temperature levels.
- Average Tensile Strength is about 60.2 MPa which is not bad for manufacturing most of the applications but when it comes to competitive filed, the numbers seem to be less.
- Less cost and weight due to the availability and production of hemp fiber and polyethylene.
- Eco-friendly or reusable (recycled).
- Depending on the type of soil, time duration varies for the bio-degradable factor but it's a plus point that the composite material can be naturally degraded which implies less pollution.
- Due to the restrictions of harvesting the hemp in most regions of the world, government clearance certificate or permission is required.
- Water absorption factor is less since the matrix material is a plastic.

VI. Conclusion

The composite materials have increased in its demand due to its cost-to-weight ratio and desirable mechanical properties. Trend moves toward using bio-fibers or natural fibers extracted from hemp. The hemp harvesting and production does not require special attention but the only problem is getting clearance from the government to grow and harvest the hemp since the same species of hemp plant produces marijuana which is considered as illegal to grow due to its violent usage and effects on human health. The polyethylene is one of the most widely used plastic on the planet. The quantity wise both hemp fiber and polyethylene materials will not be an issue. More over the prices range between 0.6 – 065 $/lb for the hemp fiber and 0.38 – 0.46 $/lb for the polyethylene materials. Various coupling agents were treated such as NaOH, Silane, MA and MAPE to hemp fibers before reinforcing it to the polyethylene in which the results show increase in tensile strength. The manufacturing techniques include vacuum infusion, compression and injection moulding, and, pultrusion and extrusion techniques. The tensile strength from the various tests and experiments conducted by the literature survey journals and research articles shows on an average for 20:80% and 40:60% hemp fiber and polyethylene volume fraction show good overall tensile strength achieving up to 60.2 MPa of tensile strength. Moreover, the composite material is bio-degradable and recycled. The future scope plays a major role as the quality of hemp harvesting can be improved using latest technologies over traditional methods. Treating the hemp fiber with various coupling agents shows improvement in overall tensile strength where the research must be carried further in conducting test over new coupling agents. The application wise though it is widely used in many products, it should improve a lot by upgrading and converting existing products by testing the mechanical properties of the materials.

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