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Investigation Of Mechanical Properties Of Kenaf, Hemp And E-Glass Reinforced Epoxy Composites

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Abstract

Natural fiber composites have drawn a lot of interest because of its costeffectiveness, lightweight nature, and environmental advantages.The mechanical characteristics of epoxy composites reinforced with kenaf, hemp, and E-glass fibers are examined in this work. Comparing these composites' tensile, flexural, and impact strengths is the main goal in order to assess their potential for structural uses. The hand lay-up method was used to produce the composites, and ASTMcompliant mechanical testing was then conducted.According to the findings, composites reinforced with Eglass fiber have the best mechanical strength, followed by those made of hemp and kenaf.

In contrast to synthetic alternatives, the natural fiber composites (hemp and kenaf) showed improved sustainability and a good strength-to-weight ratio.

Keywords: mechanical characteristics, epoxy composites, kenaf, hemp, eglass, and natural fibers.While E glass continues to be stronger, this study shows that kenaf and hemp fibers have the potential to be good substitutes for synthetic reinforcements in lightweight applications.

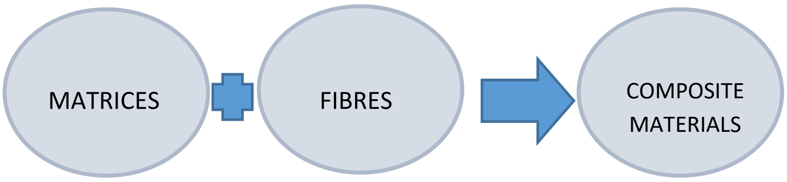
The results aid in the creation of environmentay friendly composite materials for use in engineering.

1. Introduction

In the past few decades, research and engineering interest has been shifting from monolithic materials to fiberreinforced polymeric composite materials. These composite materials (notably aramid, carbon and glass fiber reinforced plastics) now dominate the aerospace, leisure, automotive, construction and sporting industries. Glass fibers are the most widely used to reinforce plastics due to their low cost (compared to aramid and carbon) and fairly good mechanical properties. However, these fibers have serious drawbacks. The shortcomings have been highly exploited by proponents of natural fiber composites. Carbon dioxide neutrality of natural fibers is particularly attractive. Attempts have been made to use natural fiber composites in place of glass mostly in nonstructural applications. So far a good number of automotive components previously made with glass fiber composites are now being manufactured using environmentally friendly composites. The interest in natural fiber-reinforced polymer composite materials/Bio composites is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants such as flax, cotton, hemp, jute, sisal, century, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites/bio composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

1.1 Basic Composite Theory

In its most basic form a composite material is one, which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. This reinforcement is usually in fibre form.



Resin systems such as epoxies and polyesters have limited use for the manufacture of structures on their own, since their mechanical properties are not very high when compared to, for example, most metals. However, they have desirable properties, most notably their ability to be easily formed into complex shapes.

Materials such as glass, aramid and boron have extremely high tensile and compressive strength but in 'solid form' these properties are not readily apparent. This is due to the fact that when stressed, random surface flaws will cause each material to crack and fail well below its theoretical 'breaking point'. To overcome this problem, the material is produced in fibre form, so that, although the same number of random flaws will occur, they will be restricted to a small number of fibres with the remainder exhibiting the material's theoretical strength. Therefore a bundle of fibres will reflect more accurately the optimum performance of the material.It is when the resin systems are combined with reinforcing fibres such as glass, carbon and aramidthose good properties can be obtained. The resin matrix spreads the load applied to the composite between each of the individual fibres and also protects the fibres from damage caused by abrasion and impact. High strengths and stiffness, ease of molding complex shapes, high environmental resistance all coupled with low densities, make the resultant composite superior to metals for many applications.

1.2 Classification of Composites

Today, the most common man-made composites can be divided into three main groups:

a. Polymer Matrix Composites (PMC's)

These are the most common and will be discussed here. Also known as FRP - Fibre Reinforced Polymers (or Plastics) - these materials use a polymer-based resin as the matrix, and a variety of fibres such as glass, carbon and aramid as the reinforcement.

b. Metal Matrix Composites (MMC's)

Increasingly found in the automotive industry, these materials use a metal such as aluminum as the matrix, and reinforce it with fibres, or particles, such as silicon carbide.

c. Ceramic Matrix Composites (CMC's)

Used in very high temperature environments, these materials use a ceramic as the matrix and reinforce it with short fibres, or whiskers such as those made from silicon carbide and boron nitride

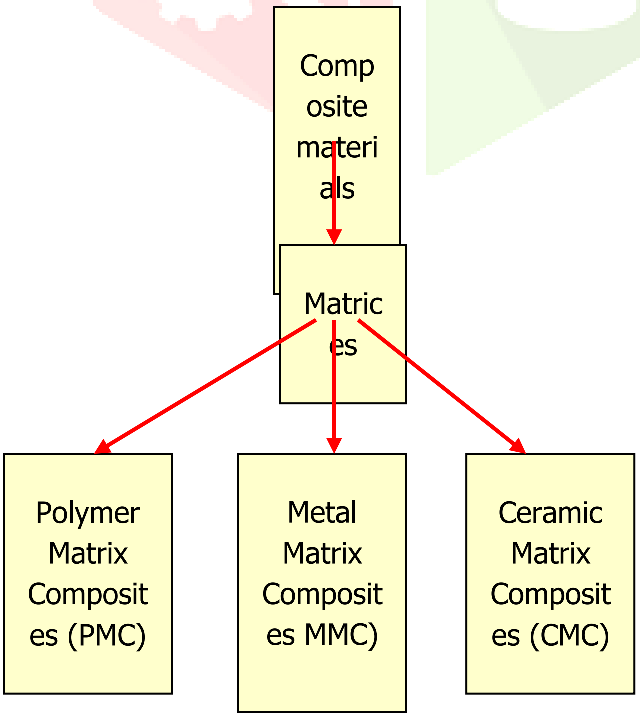


Fig 1.1Classifications of Composites.

1.3 Introduction to Materials of Composite

Kenaf:

Kenaf is scientifically known as Hibiscus cannabinus and is closely related to cotton and jute . This is because the crystalline cellulose contentand micro fibril angles of the two fibers are fairly similar. Kenaf is cultivated for its fiber and is well suited in India, Bangladesh, United States of America, Indonesia, Malaysia, South Africa, Vietnam, Thailand, parts of Africa, and in specific parts of south-east Europe. China also has actively developed this plant and is now one of the largest kenaf producers in the world. Recently, kenaf in Malaysia has been identified as one of the potential natural raw fibers to replace tobacco in manufacturing a multitude of products for the construction, automotive, textile and advanced technology sectors.

Hemp:

Hemp fibers are finding increasing use as reinforcements in composite materials, often replacing glass fibers. Found in the bast of hemp plant, these fibers have specific strength and stiffness that are comparable to those of glass fibers, cost effective and easy to process and recycle. Hemp fibers find applications in,

- Used in production of Automobile parts.
- Used as building construction product.
- Hemp ceramic composites are used as tails.
- Can be used for sporting goods, musical instruments, luggage, etc.

E glass fiber:

E–Glass comprises of one of the most important class of reinforcement especially used in polymer composites. It has low thermal coefficient, low dielectric coefficient and high electrical resistance. Its properties depend on additives and curing agents.

E Glass fibre is available in the following forms:

a. Strand - a compactly associated bundle of filaments. Strands are rarely seen commercially and are usually twisted together to give yarns.

b. Yarns - A closely associated bundle of twisted filaments or strands. Each filament diameter in a yarn is the same, and is usually between 4-13μm. Yarns have varying weights described by their 'texes' (the weight in grams of 1000 linear metres) or denier (the weight in lbs of 10,000 yards), with the typical text range usually being between 5 and 400.

c. Roving'sa loosely associated bundle of untwisted filaments or strands. Each filament diameter in a roving is the same, and is usually between 13-24μm. Rovings also have varying weights and the texes range is usually between 300 and 4800. Where filaments are gathered together directly after the melting process, the resultant fibre bundle is known as a direct roving. Several strands can also be brought together separately after manufacture of the glass, to give what is known as an assembled roving.

2. METHODOLOGY FOR PREPERATION OF LAMINATES BY HAND LAYUP TECHNIQUE

2.1 Hand layup technique:

Hand lay-up technique is the simplest method of composite processing. Theinfrastructuralrequirement for this method is also minimal. The processing steps are quite simple.

2.2 Wet Lay-up/Hand Lay-up

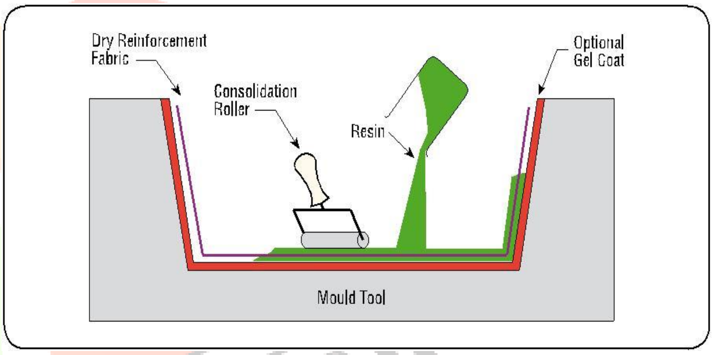


Fig 4.1: Hand layup

Description

Resins are impregnated by hand into fibres which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

Main Advantages:

i) Widely used for many years.
ii) Simple principles to teach.
iii) Low cost tooling, if room-temperature cure resins are used.
iv) Wide choice of suppliers and material types.

v) Higher fibre contents and longer fibres than with spray lay-up.

Main Disadvantages:

i) Resin mixing, laminate resin contents, and laminate quality are very dependent on the skills of laminators. Low resin content laminates cannot usually be achieved without the incorporation of excessive quantities of voids.

ii) Health and safety considerations of resins. The lower molecular weights of hand lay-up resins generally mean that they have the potential to be more harmful than higher molecular weight products. The lower viscosity of the resins also means that they have an increased tendency to penetrate clothing etc.

iii) Limiting airborne styrene concentrations to legislated levels from polyesters and vinylesters is becoming increasingly hard without expensive extraction systems.

iv) Resins need to be low in viscosity to be workable by hand. This generally compromises their mechanical/thermal properties due to the need for high diluents/styrene levels.

2 .3 Typical Applications:

- Standard wind-turbine blades
- Production boats,
- Architectural mouldings...etc.,

Requirements:

- Open mould Die
- Epoxy resin : epoxy lapox L-12
- Hemp and Kenaf fibre
- E-glass fibre
- K-6 Hardener
- Wax
- Weighing machine
- Thinner
- Glass rods to stir and beakers
- Leveller

2.4 Step by step procedure of fabricating laminates:

1. The laminates are prepared by using the hand – layup method.

2. In this method we can use the hand roller and measure biker, steel rule, gloves, scissors, and also one hacksaw blade is used to cut the laminates with required shape after making the laminate.

3. The square shape cavity is also used to prepare the laminates.

4 .Take the square shape cavity on a smooth surface, and apply wax as the releasing agent at the bottom of the cavity, then take the resin and mixed it with hardener with 1:10 and apply the resin in the cavity and in the next step one layer of fiber is applied on the resin wait 5to 10minutes.and again apply the resin on the fiber again wait 5minutes

. 5. This process is continuing up to the desired thickness.

6. After preparing the laminates some amount of weight is placed on the laminates.

7. The weight is placed on that cavity is up to 24hrs.

8. After 24hrs the lamina is chemically reacted with hardener and epoxy then it can be solidified. Vacuum bagging has been done.

9. Repeat the above steps and prepare 3 samples of laminates.

10. Cut the laminates as per the ASTM standard dimensions thenthe laminates which are prepared are given for various

tests like tensile test,flexural and hardness test.

Fig 2.4 Fabrication Process

Figure 1 shows the problem geometry considered in the presented study. It consists of arectangular slab shaped electronic board of dimensions L×W. There are three identicalembedded discrete heat sources of dimensions $L_h \times L_h$ in this slab. The heat sources areprovided along the vertical central axis of the slab, as shown. There is one heat source at thegeometric center of the plate, while the other two heat sources are symmetrically located oneither side of it. The bottom most heat source and top most heat source are at a distance L/8from the corresponding horizontal boundaries of the rectangular slab. There is a uniformvolumetric heat generation at the rate q_vW/m^3 in each heat source. The thermal conductivityand surface emissivity of the rectangular slab are, respectively, k and ε.

The heat generated in the three heat sources is initially conducted along and across theelectronic board, before getting dissipated from the boundaries of the device by combinedconvection and radiation. The cooling medium is air at temperature T∞, while the convectionheat transfer coefficient is h W/m^2 K. The governing equations for temperature distribution inthe entire computational domain are obtained by making energy balance between the heatgenerated, conducted, convected and radiated. For example, the governing equation for all theinterior nodes of each of the three discrete heat sources, upon energy balance, turns out to be:

3. TESTS ON COMPOSITE FIBERS

3.1 TENSILE TEST:

In a broad sense, tensile test is a measurement of the ability of a material to withstand forces that tend to pull it apart and to what extent the material stretches before breaking.

The material is cut into specimen for tensile testing as per ASTMD638-10 specifications. The tensile strength of the specimen is determined using UTM tensile tester. The samples were tested .The tensile test determines the overall strength of the given object. In a tensile test, the object fitted between two grippers at either end then slowly pulled apart until it breaks. A tensile provides vital information related to a product's durability including yield point, tensile strength.

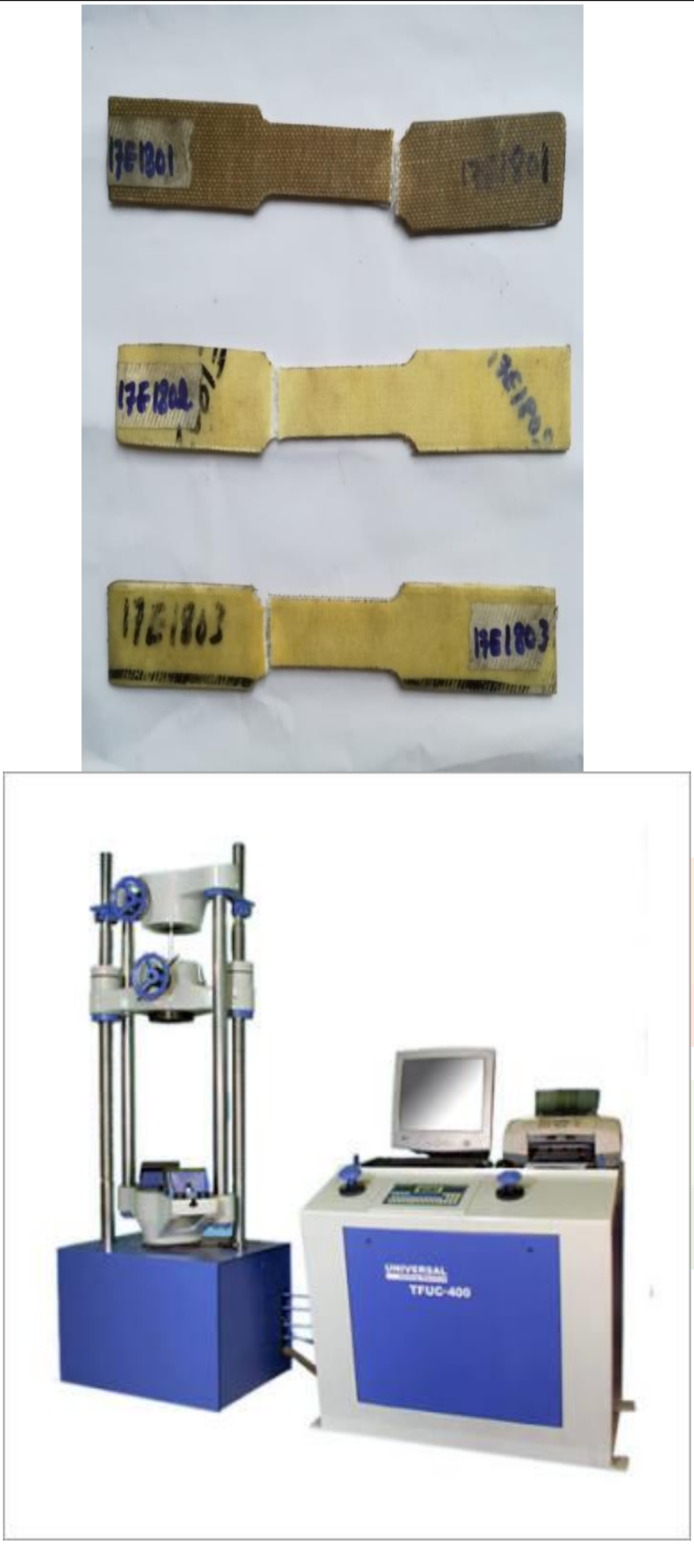


Fig 3.1 Test Specimen & Testing Machine (UTM)

3.2 FLEXURAL TEST:

Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen.Flexural testing is used to determine the flex or bending properties of a materialThe flexural test measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment. The test will be conducted as per ASTM D790.

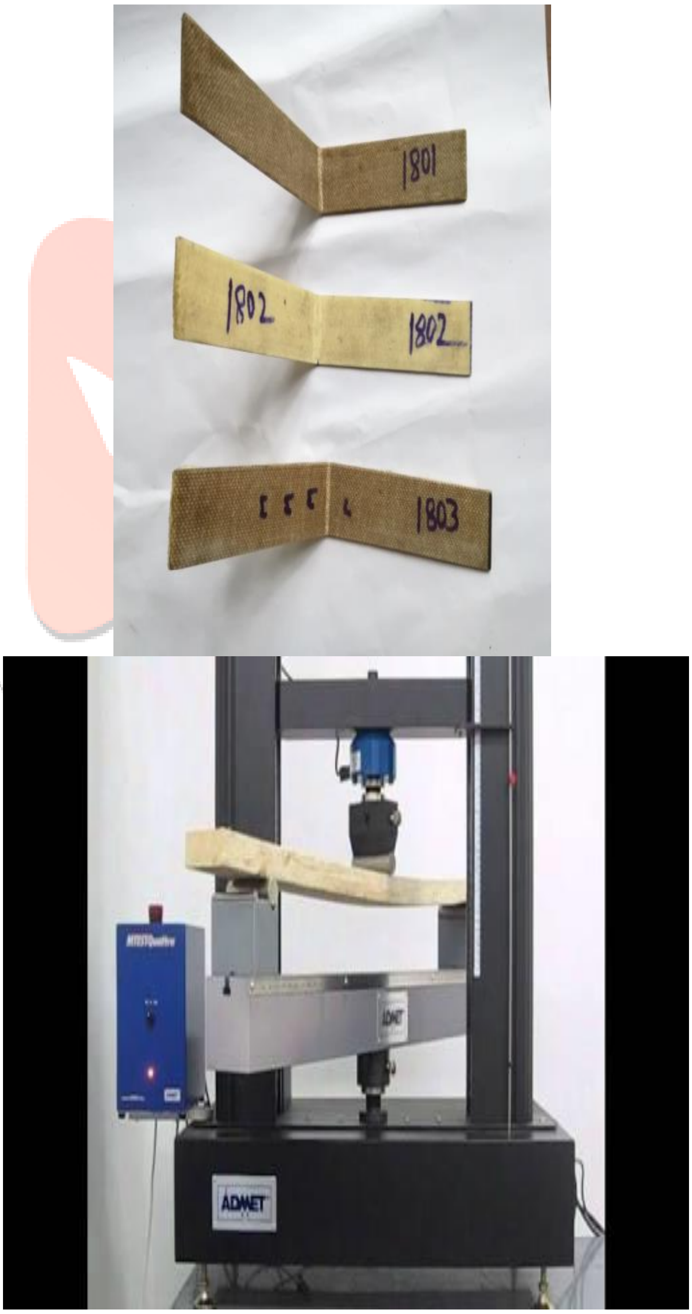


Fig 3.2 Test Specimen & Flexural Testing Machine

3.3 HARDNESS:

Hardness is a characteristic of a material. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material. Indentation hardness value is obtained by measuring the depth or the area of the indentation.

The Vickers hardness test method, also referred to as a micro hardness test method, is mostly used for small parts, thin sections, or case depth work. The Vickers method is based on an optical measurement system

Fig 3.3Test Specimen & Vickers Hardness Testing Machine.

4. RESULTS AND DISCUSSION

4.1 Tensile Test Report:

1. Combination No 1:**Hemp-E glass-Hemp**, 3 mm Thk

Test reference : ASTM D638

Initial width : 19.08 mm

Gauge length: 50 mm

Peak load : 9.28 kNLoad at yield : 8.68 mm

Maximum C.H. Travel :8.4 mm C.H Travel at yield : 8.0 mm

Tensile Strength : 162.12 N/mm2

Yield stress : 151.64 N/mm2

Load at break : 9.28 kN

C.H Travelat break : 8.40 mm

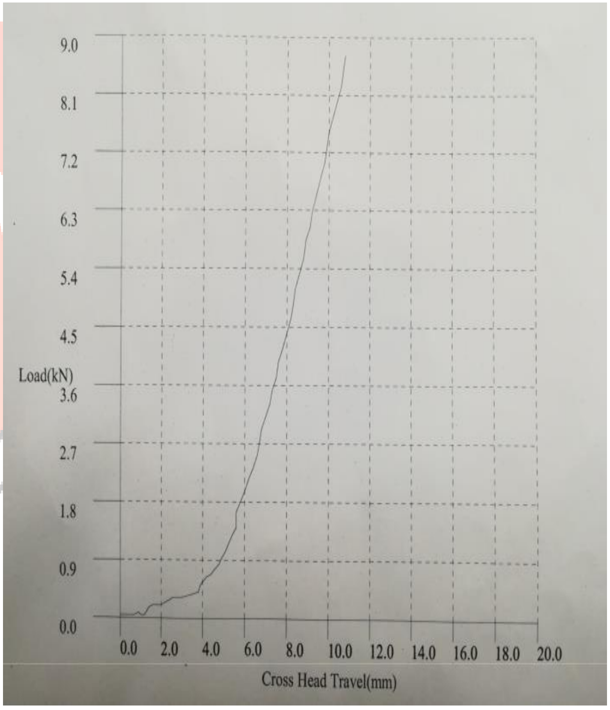


Fig 6.1 Graph: Load v/s Cross head travel

5. CONCLUSION

These experimental investigation of mechanical behaviour of Kenaf , E-Glass and Hemp fibres reinforced epoxy composites leads to following conclusions.

- This work shows that successful fabrications of Kenaf, E-Glass and Hemp fibres reinforced epoxy composites of 3 mm thickness is possible by simple hand lay-up technique.

- The tensile strength of H-E-H (162.12 N/mm2) is 0.08% greater than that of K-E-K (161.99 N/mm2) combination. The tensile strength of K-E-H (152.58 N/mm2) is 5.8% & 5.88% lesser than the K-E-K and H-E-H respectively.
- The yield strength of H-E-H (151.64 N/mm2) is 1.88% greater than that of K-E-K (148.84 N/mm2) combination. The tensile strength of K-E-H (139.98 N/mm2) is 5.95% &7.68% lesser than the K-E-K and H-E-H respectively.

  Hence H-E-H combination has better Tensile and yield properties.
- The flexural strength of H-E-H (6.347N/mm2) is 16.16 % and 35.64 % that of K-E-K (5.464 N/mm2) and K-E-H (4.679 N/mm2) respectively.

  Hence H-E-H combination has better Flexural properties.
- The K-E-H(VH 0.1, 22) combination has better Hardness thanK-E-K(VH 0.1, 20) and H-E-H(VH 0.1, 18) combination.

  Hence we can conclude that K-E-H is harder than the other two combinations.

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