Image Analysis - An Appropriate Tool for Examination of the Aging of Natural Fibers

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ABSTRACT
Engineering materials can be broadly classified as natural and man made materials. The Man made materials like steel, plastic excellent mechanical properties, but not easily disposable after use. Natural materials like wood, fibers like cotton, jute, hemp etc, can also be used as engineering materials for suitable applications. They have comparable mechanical properties with man made materials. Natural fibers are advantageous in easy disposing after use, no release of CO_2 production for their manufacture but they absorb CO_2 in photosynthesis; they increase the employability of rural farmers. Natural fibers are widely used to make natural composite materials, hybrid composite materials, ropes, threads and textiles. Natural fibers are hydrophilic in nature, they absorb moisture. In rainy season they absorb moisture and loose strength. The fibers also be affected by atmospheric and environmental conditions. Bacteria and fungus will attack on the fiber and degrade them.

By these processes the fiber becomes weak and becomes useless for engineering applications. To avoid the catastrophic failure of an engineering component made of wood, the natural fiber be examined at macroscopic and microscopic levels. The macroscopic observations made by naked eye and microscopic observations may be done by microscope, more sophistically SEM Scanning Electron Microscope. The surface of the material can be observed and percentage of the decayed area can be found. The image analysis gives accurate measurements and also performs the required calculations. A number of Image analysis software is available in market used for medical and engineering applications.

In this paper the applications of Image analysis to examine natural fibers is explained with illustrations. When the fiber is found to be decayed, the component can be replaced by a new one to avoid failure. The damaged fiber will also change its color and texture, the change in color can be easily found by Image analysis.

General Terms
Natural Materials, Aging, Image, Natural Fibers, SEM

Key words
Engineering materials, natural fibers, fungus, decay of natural fiber, Image analysis. Microscopic and macroscopic observations.

1. INTRODUCTION

The main basic elements in the universe are Carbon, Hydrogen and Oxygen. They are main components of hydro carbons and carbohydrates. The carbohydrates are useful in the form of food. The plants and its parts are being used as food, they are carbohydrates. They have cellulose, hemicelluloses, pectin, lignin and waxes. The plant fibers are also considered as an important food. The plant fibers will also serve as an engineering material.

Now a day more focus is given to the production the natural composites. To produce natural composite materials, natural fibers like flax, hemp, jute, coir etc are widely used as a reinforcing material. The resins like Urea formaldehyde are used to bind the fibers together.

The natural cellulose fibers are also used to make paper, ropes etc. one of the important application of the fibers is to make composite materials. The physical and chemical properties of the natural fibers are important while electing the natural fibers. There are few properties that can be known just by appearance. Like its diameter, color, shape, surface finish, fungal infection.

By magnifying it, we can identify its structure and surface easily. To analyze by images, it is advisable to use any soft wares. There are many types of software are available in the market for image analysis, they are called image analysis soft wares. Many of them can be downloaded freely or can use trail versions.

The image analysis software has tools like thickness measurement, angle measurements, color distribution etc. the images of natural fibers can be analyzed by these soft wares to know its properties. In this paper the SEM (Scanning Electron microscope) images are taken and analyzed by image analysis soft wares

The natural fibers on exposure to atmosphere i.e. sun, light, heat and moisture they loose color. The change in color can be an indication to decay in strength. The simplest example is that the paper changes its color in course of time.

As an example:
The newly formed mango leaves are in purple color, as the age increase the color changes to green, The leaves of more than a year are in thick green color. The dead leaves change their color to brown as shown in the figure 1.

Fig 1: Mango leaves of various ages

The flower in white color, as their age increases the color changes to pure white. As shown in the figure 2, when the flower is about to decay the color of petals is faded and it changes to black. A dead petal changes the color to black.

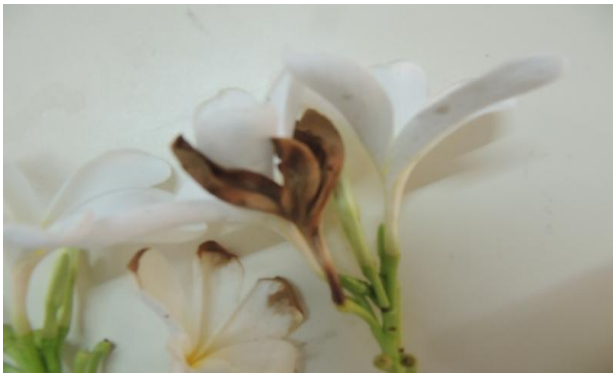

Fig: 2: Flowers of various ages

As shown in the figure 3, the Jute fiber is in brown color, as their age increases the color changes to pale brown. When its is affected by fungus its color changes to black. The jute fiber is coated with starch to accelerate the action of fungus.

Fig: 3: Jute fiber indicating the change in color due to fungus.

From these examples, the color can definitely be used to indicate the age of the natural materials.

2. SEM IMAGES

The scanning electron microscope images can be used to study the fibers in nano scale also. This SEM image gives the clear picture of the fibers when they are fractured. The effect of alkali treatment can be seen in these SEM images. The bonding between the fiber and the resin matrix can also be analyzed by the images. The surface defects, surface texture of natural fiber can bee seen by SEM.

When the images are taken from SEM, they can be used for analysis. The image analyzing software has measuring tools. The linear distances can be measured easily. Like radius of a curve, thickness, etc can be measured. The angle measurements can also be done. Calculations like areas, color distribution etc can be done easily by this image analyzing software.

3. LITERATURE REVIEW

K. Qi, C. J. Lupton, F. A. Pfeiffer, and D. L. Minikhiem [1] in the paper titled "Evaluation of the Optical Fibre Diameter Analyser (OFDA) for Measuring Fiber Diameter Parameters of Sheep and Goats" explained the working of Optical fiber diameter analyzer, which by taking the image automatically and determines the fiber diameter. Alexander Bismarck et al [2] had explained that the SEM image at 1000 X magnification can give clear surface morphology of natural fibers. Fei Liu, Junshu Wu, Kunfeng Chen and Dongfeng Xue in the paper [3] "Morphology Study by Using Scanning Electron Microscopy " explained the limitations of optical microscopes and suggested to use the SEM Scanning electron microscopes to the uninstructed objects.

S.L. Favarat, T. A. Ganzerli, A. G. V. de Carvalho Neto, O. R. R. F. da Silva, E. Radovanovic [4] had explained various methods of pretreatment of fiber to be followed in preparation of samples to take SEM images, Infrared spectroscopy (FTIR-HATR and 13C Magic Angle Spinning Magnetic Resonance Spectroscopy (13C MAS NMR) in their paper "Chemical, morphological and mechanical analysis of sisal fiber-reinforced recycled high-density polyethylene composites . Nur Hafizah Bt Abd Khalid, Jamaludin Mohamad Yatim and Wan Aizan Wan Abdul Rahman in the paper titled [5] "Temperature Effects on Tensile Properties of Kenaf bast Fiber "explained that the cross section of fiber is not circular and it is in irregular shape. They followed ASTM D2130-90 standard test to determine the fiber diameter.

Gilberto [6] found length of lingocellulosic fibers by using Morfi analyses with TECHPAP LB Morfi equipment. Gary Chinga-Carrasco [7] found the cross sectional area of kraft pulp fibers and explained how to reduce noise in the images by using Image J program . Susheel Kalia et al [8] by using a combination of microscopic techniques with image analysis found the information about cellulose nano fibers, they found that the cotton nano fiber had length of 85-225 nm, with a diameter of 6-18 nm. (2011).
Gary Chinga-Carrasco et al [9] noticed that due to technical advances of novel microscopic techniques, the computerized image analysis give more details in 2D and 3Dimages . Heidi Peltola et al [10] found that , the diameter and the lengths can be found accurately with image analysis , the volume fractions in a composite can be found easily by image analysis. P. Poza et

al [11] noticed that the microstructure of natural materials can be found accurately by image analysis. P.J. Herrera-Franco [12] found that the fiber and matrix adhesion can be found by the SEM image analysis.

4. THE CONVENTIONAL METHODS OF MEASURING NATURAL FIBERS

Conventional tools used to measure the fibers are scale, vernier calipers' and micrometer. The least count of ordinary scale is 1mm, vernier calipers' is 0.1mm and micrometer is 0.01mm. these conventional instruments can't be used to measure the natural fibers because of the reason is that, the size of natural fiber is in the order of micro meter to nano meter. To measure the dimensions by these instruments a force is needed to be applied on the natural fibers. After taking the measurements the fibers may not be useful in engineering applications, because of cracks on their surface due to force applied on them. So use of conventional measuring instruments for natural fibers is not suitable and do not give correct results.

5. IMAGE ANALYZING SOFTWARES

There are many types of software, available now a days, to analyze the images. Here we discuss one software namely " Bersoft image measurement 8.0 trial version "

5.1 To find Various Measurements

Open the SEM image in Bersoft image analyzer and set the magnification factor such a way that the image magnification factor exactly matches with Bersoft image analyzer.

For example, if the scale line on SEM image shows 50 micrometer, by measuring it with Bersoft image analyzer, the line should indicated 50 micrometer only

5.2 To find Distance

Click the icon distance in the application window

Click on the first point and drag the mouse to the next point then click again,. The distance will be displayed. With this you can measure distances like diameter, length, depth, radius, curved length

5.3 To find Area

To find area of rectangle click the rectangle icon in the application window. Then take the cursor in to the picture, draw the rectangle where you want to measure after drawing the rectangle, the area will be displayed in it. Similarly, to measure the area of circle / ellipse follow the same procedure. to measure the area of the irregular shape, there is an icon for free hand curves then click, it draw the shape where you want to measure the area, after finishing the drawing i. e. closing the irregular figure , the result area will be displayed on it.

6. PROCEDURE TO USE BERSOFT IMAGE MEASUREMENT

6.1 The areas of the irregular projected portions on the fibers

To find the areas of projected portions on the fiber, the projections on the surface of fibers are un cleaned waxes present on the fibers.

Bunches of the fibers were taken by SEM image and the projected portions on the fiber were calculated by a free hand curve. When curve forms a closed figure the area will be indicated on it.. On a fiber there may be few projections as shown in the figure 4.The values are shown in table 1.

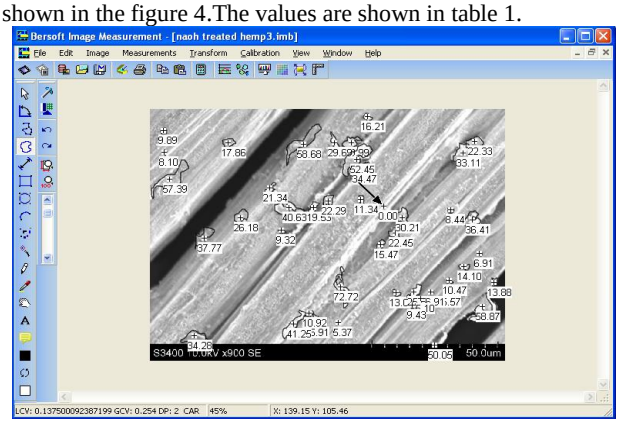

Fig 4. To find areas of projected portions on the NaOH treated Hemp fiber

6.2 To find the area of the fiber effected by fungus, bacteria

The decay by fungus generally starts on the surface of natural fiber and extends into the fiber. The effaced surface will be a regular geometrical shape like circle or ellipse. The effect of the fungus depends on the natural fiber , its bread, composition, exposure to atmospheric conditions like moisture, temperature, humidity and time of exposure.

The area of fungal action is found by drawing a circle or an ellipse on it with a tool in the software. Then the area is automatically displayed on it. The total decayed area by fungus can be found by summing up them. Thus the percentage of decay can be found. The SEM images of the Hemp and jute fibers are given in fig 6 and fig 7. The fungal effected regions of fibers are indicated by a circle. The calculations are done similar to explanation given to find areas of irregular projected portions. Here commands like circle , ellipse can be used directly in the software. In figure 6, there are 4 fibers in a bunch, fiber number 1 and 4 are not affected by the fungus. The fiber number 2 is affected at 2 regions and fiber number 3 is affected at 5 regions.

In figure 7, there are 6 fibers are examined by SEM, fiber number 1, 5 and 6 are not affected by fungus. Fiber number 2 is affected at 4 regions, fiber number 3 affected at 23 regions and fiber number 4 affected at 2 regions. The values are shown in table 2 and table 3.

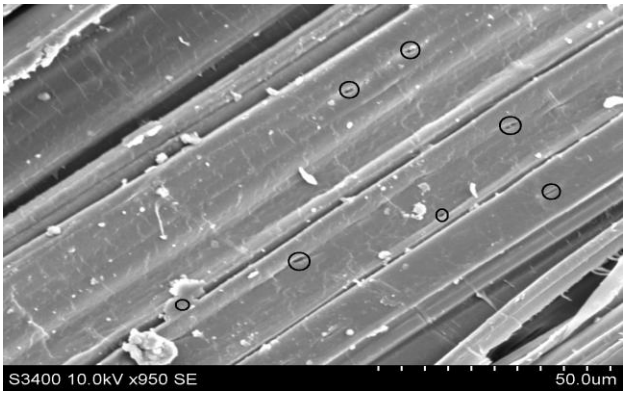

Fig: 6: Hemp fiber affected by fungus

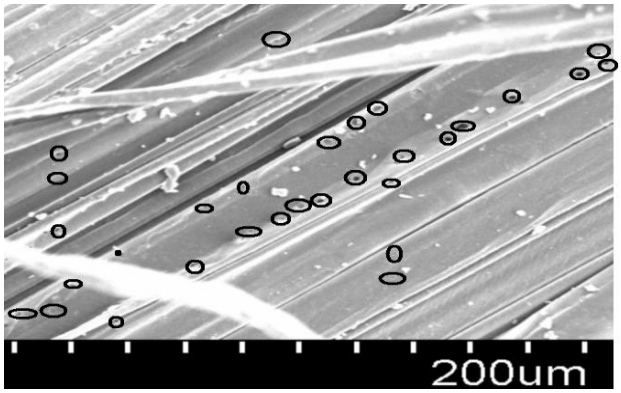

Fig:7: Jute Fiber affected by fungus

7. OBSERVATIONS

Table 1: To find the diameter of the fibers in a bunch of NaOH treated Flax (All Dimensions are in micrometer)

S.N. of fibers	Diameters at different location 1 in microns			Average diameter of each fiber
	1	2	3	
1	18.22	18.43	16.64	17.76
2	7.44	7.88	9.58	8.30
3	17.13	18.83	18.87	18.28
4	15.26	17.4	17.11	16.59
5	17.65	18.93	17.68	18.09
6	9.47	10.11	12.09	6.33
7	8.26	9.05	6.54	5.96
8	14.56	14.24	13.68	10.62
	Average diameter of 8 fibers			12.74
	Mean Deviation			4.94
	Standard Deviation			5.48

Table 2 : To find Areas of projections on the NaOH treated Hemp fiber (in sq micrometer)

S.N.	loctions	Area of projections on Fibers 1 to 5 in sq micrometer				
1.		1	2	3	4	5
2.	1	9.89	37.77	19.65	41.25	9.43
3.	2	8.10	34.28	22.29	10.92	13.05
4.	3	57.39	26.18	11.34	5.91	91.57
5.	4	17.86	21.34	34.47	5.37	10.47
6.	5		58.68	52.45	72.72	14.10
7.	6		9.32	16.21	15.47	6.91
8.	7		40.63		22.45	13.88
9.	8		22.29		30.21	58.87
10	9		29.69		50.05	
	Sum	93.24	280.18	156.41	254.35	218.28
	Area of fiber	1586.0	4210.5	8036.1	9111.30	4122.7

Table 3 : The area affected by fungus on the surface of Hemp fiber (in sq micrometer)

S.N.	locations	Area of projections on Fibers 1 to 4 in sq micrometer			
		1	2	3	4
1	1		15	28	
2	2		18	24	
3	3			16	
4	4			26	
5	5			12	
6	6				
7	Sum		33	106	
8	Area of fiber	1350	4500	4200	1250

8. RESULTS

8.1. The Average Diameter of the Fibers

The average diameter of the fiber is 12.74 micrometer

8.2 The Projections on the Surface

Number of the projected portions on the fiber 37 on five fibers
Minimum area of projected surface = 5.37 sq micrometer
Maximum area of projected surface = 91.57 sq micrometer
The percentage of projections on the fiber = 3.70
Sum of the projected area on the fibers =1002.46 sq micro meter
Total area of the fiber = 27066.77 sq micro meter
The percentage of projections on the fiber = 3.70

8.3 The Area Affected by Fungus on the Surface of Hemp

Number of the holes on the fiber4 on five fibers
Sum of the area of holes on the fibers in the bunch = 139 sq micro meter
Total area of the fiber = 11300 sq micro meter
The percentage of holes on the fiber = 1.23

8.4. The Area Affected by Fungus on the Surface of Jute

Number of the holes on the fibers (29 on six fibers)
Sum of the area of holes on the fibers in the bunch = 1020 sq microm
Total area of the fiber = 3900
The percentage of holes on the fiber = 2.615

9. CONCLUSIONS

1. The decayed area on the natural hemp fiber is 1.23 %, so its age may be about 2 Years; hence this fiber has to be replaced.
2. The decayed area on the Jute fiber is 2.65 %, so its age may be about 3 years; hence the fiber has to be replaced.
3. As soon as the holes are formed on the fiber, it can't carry a load. The hole makes the fibers to fail on application of the load. So the fiber has to replace.
4. The original and change in color of natural fiber can be easily identified by image analysis, image analysis gives the frequency

of the color. The frequencies can be useful to make ageing model.

5. By the image analysis, the measurements can be made in nanometers also. Image analysis will give accurate measurements. The sensitivity is very high with this Image analysis.

5. The image analysis will give measurements by analyzing the images only; with out touching the fibers, so fibers will not undergo any contact or forces. So in the fiber no forces will be developed, scratches will not be formed on its surface.

10. LIMITATIONS OF THE STUDY

The image analyzing software is only a tool. They will not give any conclusions. To get conclusions and to analyze, knowledge about the fibers and their mechanics is necessary.

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