An Innovative Integrated Jute Grading Instrument

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The quality parameters of jute fibres are key factors in its utilization and fixing the prices. During the marketing of jute fibre, price is usually fixed on the basis of rough subjective judgment of the fibre quality and the assessment of quality of fibre may vary from grader to grader. Six quality parameters of jute fibres are considered for the assessment of the quality and grading of fibres. These parameters are strength, root content, defects, fineness colour and bulk density. Grading of jute fibre by hand & eye method is very difficult for a farmer because there are different sub-groups for each parameter. So the growers are deprived by the purchaser due to their inability to grade the product. Therefore, keeping the interest of the farmers and traders in mind, an automated integrated jute grading instrument has been developed. This instrument is easy to operate and gives reliable results comparable to those obtained from the existing instruments.

Keywords: Jute, Grading, Integrated, Automatic

Introduction

Traditionally, India and Bangladesh are the largest producers of jute in the world. Jute, being one of the foreign exchange earners, has a very important role in Indian economy. The quality however is not uniform and varies from place to place according to the nature of soil, climatic conditions, type of water used for retting purposes and care taken in subsequent processes. This lack of uniformity in quality has led to the classification and grading of jute using a score card system of grading that aims at eliminating personal bias as far as practicable. Relative weightage is given to each physical parameter by standard scoring system and the grade of fibre is determined by total score of the six parameters. “Hand & Eye” method is generally used in the market for assessment of the quality and grading of fibres. This method is subjective and assessment may vary from grader to grader. To eliminate this error, there are grading instruments based on individual parameter operated either manually or electronically. For example, Bundle Strength Tester for strength estimation, Air Flow Finessness Meter for fineness measurement, Colour Meter for colour estimation and Bulk Density Meter for density estimation. These instruments, however, take enough time to assess the corresponding grading parameters. To improve upon it, an automated jute grading instrument has been developed. In this automated grading instrument all the measurement organs have been incorporated for measurement of strength, fineness, colour and defects present in percentage. Initially the set of fibre under test is placed on the conveyor belt which carries the test set of fibre to the image grabber unit. In this area the image is taken by a high capacity camera. From the image and with the help of a developed program the fibre colour with respect to the whiteness index, fineness of the fibre in tex and defects present in % is computed. From the number of fibres present per mm width, fineness is calculated and the average fineness of the fibre was determined from the obtained values. Similarly, for defect percentage images from three positions of the jute reed are taken and colour value relative to white is measured. After obtaining these three parameters a definite part of the fibre sample is placed to the strength checker unit. Here the jaws of the clamp hold the fibre and pull. These jaw set is being operated with a permanent magnet gear motor set which is fed with a ramp type unidirectional voltage, thus producing a uniformly linear increasing torque in the motor shaft. At the moment of break of the fibre, its current input will be reduced to a very small value instantly. This is the indication of break of fibre. At this point, the output voltage from the load cell indicates the breaking strength of the fibre in other scale. The bulk density is measured by measuring the slope of the fibre coming out from the tray using a set of sensors. The Root

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content part is assessed manually by measuring the length percentage. All these data are sent to the control unit where the grade of the fibre is obtained. Keeping this situation in the background, the user-friendly integrated jute grading system has been developed to simplify the existing system to make it easy, attractive and popular among the farmers.

**Materials and methods**

Randomly selected 20 jute reeds from bale samples were required to perform the test. The new developed automatic grading instrument is basically an integrated system, consisting of hardware and software units. There are four input units present which measure the strength, fineness, defects percentage and colour parameters for grading. The Root Content part is to be entered manually. For strength, fibres are broken with the help of a mechanical unit and its value is calculated using the developed programme for this purpose. A roughly fixed weight of the samples is taken and accordingly the strength is determined and sent to the control unit. The outputs from other three units to obtain colour, fineness and defect percentage are obtained and sent to the control unit from where the results are displayed. This has been shown in Figure 1. However, there is a restriction since the image processing technique is used before acquiring the image, the fibre should be of scannable type, i.e. it should be of laminar type, as far as possible. So, to make the fibres scannable, flow of jute input is to be passed through a fibre pre-processing unit.

**Pre-processor unit**

A pre-processor unit has been developed using specially designed set of rollers and driven by a gear motor set. Initially the jute fibre under test is placed on the conveyer belt evenly and uniformly. When the system will be in a running condition, the fibre would come under the camera unit in almost laminar form. Photograph is taken at this stage of operation to find the percentage variation in colour, fineness and defects.

![Fig. 1 — Block diagram of the developed system](image)

**Strength checker unit for fibre bundle**

The ability of the fibres to resist strain to the limit of rupture is called the strength of the fibre. The strength is measured as the breaking load of the fibre sample under test divided by the linear density of the unstrained fibre and is called its tenacity. This is expressed in gm per tex. For determining strength, bundle strength tester is used. For this, sample needs to be prepared, weight has to be measured and calculation was required following breaking the fibre. The average of breaking load was taken for randomly chosen 16 bundles. This is a time consuming process. But automated integrated instrument measured the strength automatically, so the time taken was less. In this case 3 iterations were considered. A robotic arrangement has been designed for bundle strength measurement. Arrangement is made in such a fashion that the fibre bundle goes straight to the designed slot automatically; the jaws hold the fibre bundle tightly and pulls it until it breaks. A dedicated memory unit has been provided in the instrument to store the Breaking Load (in Kgf) and tenacity of the fibre under test (gm/ Tex). The data is stored in the dedicated non-volatile memory unit. A set of specially designed jaws has been developed to hold the fibre sample in two ends. A dc gear motor has been used to open and hold the grips. Another gear motor has been used to move the jaws in constant velocity motion. Very sensitive active transducer has used to measure the breaking strength of the jute fibre under test. Basically a ramp type dc voltage is applied to the gear motor so that it can produce a linear value of torque in the shaft of the gear motor. It pulls the fibre sample under test at linear and constant velocity. The breaking point is observed from the rate of change of current (di) with respect to time (dt) i.e. di/dt value of the current intake of that motor. At the point of break of the fibre bundle, the rate of change of current with respect to time will be a negative maximum. At this point of time the voltage obtained from the sensitive load cell indicates the breaking strength of the fibre at a different scale. The signal is passed to the control unit through a differential amplifier to remove spurious noise signal.

**Colour measurement**

Colour represents the property of a fibre, which distinguishes it in terms of appearance as redness, yellowness, greyness, etc. In case of jute, it is largely dependent on retting conditions, water used and washing made. In case of hand and eye method of grading, the colour is obtained from the past experience.
of the grader, thus it is error prone. In precision measurement system, dedicated instruments are used which are very costly. In NIRJAF Colour & Lustre Meter has been developed in the laboratory before six decades. That instrument has photo cells and after receiving the specular & diffused reflection, colour is measured relative to a white surface. A new method has been developed to find the colour of jute and allied fibres using the image processing system accurately and economically. With the instrument developed in the present study, the image of the jute and allied fibre sample is procured. Initially a very expensive image grabber system was used for grabbing the images of test samples. Keeping in mind to develop the economical system, the method was scaled down to scanned images using a normally easily available type scanner. At first, the colour matrix of the test sample is developed by decomposing the colour components of each pixel to its equivalent RGB form. These components are being checked using a newly developed rule-based algorithm and from the built-in look up matrix to find the colour value in terms of the whiteness index value.

**Fineness measurement**

The fineness is a measure of the diameter (width) or weight per unit length of fibre filament. It is a genetic property and also depends on plant age at harvest. Fineness can be estimated using the air-flow fineness measuring instrument. Finer fibre shows better spinning quality. For measurement of fineness of the jute fibre, the fibres are aligned in a way that there is no overlapping and gaps present between them, as far as possible. Then the number of fibres along the width is calculated from the obtained image from where number of fibres per mm is computed. This value is calibrated with the known tex value of the fibre. Using this process over numerous samples, an empirical formula has been developed which gives the direct value of fineness in tex.

**Density measurement**

Weight per unit volume of fibre considering all air space in the fibre is the measure of density. The density is determined by the bulk density measuring instrument taking the fibre samples from the middle region of bulk. The sample that is compact and weighty is graded as ‘heavy body’ and loose and less weighty one is ‘medium body’ shown in the instrument. Heavy bodied sample generally spin into good quality yarn. A hardware/software unit finds the bulk density of the jute sample under test. Sensors are used at the end. When the fibres are coming out after test the sensors feels the heavy bodied or medium bodied nature and accordingly send the message to the central unit.

**Defects percentage measurement**

Factors causing serious or partial damage to the quality of fibre are commonly known as defects. To compute the defects present in percentage using image processing, the colour gradient i.e the ratio of change of colour (dc) to the incremental distance (dx) i.e. dc/dx over a particular focus area of fibre is evaluated. Thus by calculating the total area under defects and comparing it with the total area under focus, the percentage of defect is achieved. As the complete instrument takes three snaps from three places of the sample, an average value will be given.

**Root content measurement**

The hard barky region at the lower end of the reed is called root. The roots are cut at the mill before processing of fibre and in commerce they are known as ‘Cuttings’. Cutting the root portion from the weighted samples gives the percentage of root content by weight basis. Presently problem is encountered in the measurement of root content in-situ in the instrument developed in this study. For that, the root content value is supplied from outside console manually. When the camera scanner scans the fibre it includes root content from the console and defects at a time. Figure 2 shows a photograph of the complete instrument.

**Results and Discussion**

The results of different parameters are given in Table 1. From the table it appears that the results received from the integrated jute grading instrument are at par with test results of individual instruments. To perform a test in different instruments, it takes a lot of time for sample preparation, measuring weight and calculation. But in the integrated jute grading instrument,
instrument there is no need of sample preparation but requires only feeding of the samples in the conveyor belt. When the instrument is switched on, the different parameters will be tested and recorded automatically. As because the grading is done by score marks basis as per BIS standard (IS 271-2003) for each parameter, the score marks are assigned automatically and is displayed in the LCD display board along with the grade obtained of the fibre.

Conclusions
As this is a completely automatic instrument, no manual exercise is required to run the instrument. As no sample preparation is required, it is quite fast and efficient. Also, there is no scope present for manual manipulation.

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References
2 Bureau of Indian Standard (BIS) for Tossa jute IS:271-2003
5 Chakravarti A C, A photoelectric meter to measure brightness, colour and lustre of flat surface, Invention Intelligence, 8, (1973), 261.