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Automated Equipment for Characterization of Web Media (COF and Stiffness Measurement)

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Abstract - The term "WEB" refers to all materials pertaining to micron-level thickness in industrial usage. These web media play a dominant role in the printing industries, chemical industries, manufacturing industries and automobile industries too. The term "Characterization" refers to all the parameters that define a web media. Some inevitable characteristics of web media include Co-efficient of friction, Stiffness of media, Absorbing capacity of media, tensile and compressive strength of media etc. Among these characteristics, Co-efficient of friction and Stiffness of web media influence an inevitable impact in designing printing machines, textile industry, chemical filtration and refinery industries. This project is aimed towards designing a compact – portable instrument that readily portrays the Static and Dynamic Co-efficient of Friction between any two web media and stiffness of the particular web media under study. This instrument is fully automated and gives the output in digital form. By this instrument, the industries relying on web media will be benefitted to a great extent.

Keywords: Web; characterization; co-efficient of friction; stiffness

1. Introduction

In today's competitive industrial scenario, intensive research is being carried out in the field of material properties and hybrid material compositions. On the other hand, use of thin flexible materials, namely Web materials like paper, sheet metal and cellulose membrane materials etc., have become inevitable in printing industries, chemical industries and automotive industries. Owing to the usage of web materials in different fields, their properties and their interaction with other materials have to be studied and analyzed in detail, so as to design the machineries and other equipments for easy handling of these materials during processing. Properties, thus measured or determined have to be compared with established standards to check their conformance. These situations demand a dedicated instrument to measure the properties of web materials accurately and precisely which proves to be industry oriented.

This paper deals with the design of an automated instrument that is used to determine the Co-efficient of Friction and Stiffness of Paper, one of the most commonly used web materials in newsprint, packaging and chemical industries. This compact – portable instrument readily portrays the Static and Dynamic Co-efficient of Friction between any two web media and stiffness of the particular web media under study. Various parameters have been considered in designing the equipment to make it simple and accurate. This paper gives detailed information about the design and applicable aspects of the equipment.

2. Problem Identification:

On a survey undertaken across the industries that are relying on web materials for their varied purposes, a bitter truth was revealed that there were no dedicated instruments to measure the properties of web materials like paper on a straight to head scale. These industries are relying on the standards prescribed by some standard organizations like TAPPI, ISO etc to cater their day-to-day research activities. These standards, do furnish accurate properties of web materials as a unique entity, but they lack in providing details about the behavior of these web materials with other materials that are operation specific. Inorder to cater these demands, the idea of designing compact automated equipment to characterize web materials was envisaged

3. Principle

3.1. Co-efficient of friction measurement

Adhering to the basic principles of Engineering Mechanics in determination of the co-efficient of friction between two bodies in equilibrium moving relative to each other, the instrument has been designed. As shown in Fig-1, when an equilibrium body of known weight at rest on a horizontal leveled surface is moved, the co-efficient of friction between the two surfaces tends to rise to a maximum level at that instant when the body is about to move. This co-efficient of friction is known as the static co-efficient of friction (μ). This can be calculated using the formula,

$$\mu = F / N$$

Where,

F=Frictional force in Newton

N=Normal Force in Newton

Here the frictional force (F) is greater than the applied force.

In similar way, the Sliding or Dynamic co-efficient of friction (μ) can be calculated using the same formula mentioned above, by substituting the varying frictional force (F) determined during the movement of the body

Here the Frictional force (F) is lesser than the applied force.

3.2. Stiffness Measurement

As we are aware of the fact that, stiffness of a body or material is defined as the resistance to deform against load, the stiffness measuring instrument has been designed adhering to this very fact. As far as the paper is concern, it is constrained to behave like a cantilever beam and it is allowed to bend under its own self-weight (basis weight). Thereby, the bending Length of the paper is determined. Hence, the stiffness of the paper is calculated using the formula,

Stiffness (S) = Basis Weight (G) * Bending Length (C)

Where,

G= Basis weight in Gram per Square Meter

C= Bending Length in Meter

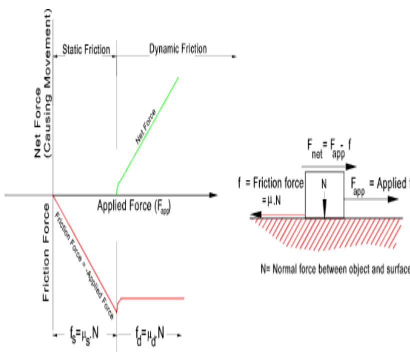

Fig. 1: Principle of COF Testing

4. Literature Survey

Clark, James d'A. Method [1], describes about testing of the folding endurance of paper. The main difference in folding endurance with the grain and across the grain is evident that sheet structure has an important bearing on this quality. However, results are influenced in varying degrees by surface treatment, such as sizing and calendaring. Some types of surface coatings affect the values, particularly when the coatings are absorbed into the fibers to the extent that they may be stiffened, softened, or otherwise altered. The effect produced by changes of fiber characteristics is illustrated by the fact that the moisture content of the paper has a much more pronounced influence on the folding endurance than on any other of the common physical tests. Because of the marked influence of atmospheric conditions, it is most important that tests are to be conducted in the prescribed manner under standard relative humidity and Temperature conditions. Since specimen is folded while under tension, the tensile strength of the paper may also have some effect on its folding properties.

Herbert F. Schiefer method [2], has shown that the principle of the heavy elastica (including both the heart-loop and the cantilever methods) is valid for determination of stiffness if the material does not have a static electric charge. Although higher stiffness can be obtained at the expense of more weight, the investigation showed that the rigidity can increase more rapidly than the weight. Compared with the Echo I material, the laminates had the highest efficiencies of the materials that were tested. A comparison between the flexural stiffness determined by a standard stiffness tester and that determined by the heavy-elastica method revealed that the results of the two methods correlated to the utmost extent and the elastica method was the more sensitive method.

Sharman [3] measured the stiffness of paper with a pendulum damped by a flexing paper ring and defined stiffness as the bending moment per unit width that produces unit curvature. He pointed out, however, that the modulus of elasticity has different values in various directions in the sheet of paper, and that it is necessary to evaluate the stiffness for machine direction, and the stiffness for cross direction.

Frederick. T. Carson and Venon Worthington [4], describes an instrument to determine the stiffness of paper. Here the specimen is bent through a given angle and the bending moment is measured as the torque in two lengths of piano wire, between which the clamp that holds the specimen is suspended. Stiffness of paper is defined as the bending moment per unit of width of specimen producing unit curvature. This quantity was evaluated for eight types of paper, for various lengths and widths of specimen, and for bending angles from 5° to 30°. The stiffness value for a given specimen remained substantially constant when the width and bending angle were varied, but increased somewhat as the length of the specimen was increased.

Abbott [5] measured the stiffness of fabrics, which had been rated subjectively by experts, by means of several methods and found that measurements made with an apparatus similar to that of Schiefer [2] and expressed as flexural rigidity, agreed best with the subjective ranking.

5. Construction and Technical Specifications

5.1. Components for Co-efficient of Friction Tester

- stepper motor with gear (12v stepper motor with pinion PCD of 20mm and 40 teeth (0.5 module))
- Rack and Pinion Drive (Rack with 0.5 module)
- Moving tray made of acrylic (9cm*8cm*2cm)
- standard slet or weight (500g) – Mild steel
- Plastic ‘C’ channel rails – (24cm*10mm)
- inelastic string – Brass string
- machined acrylic base- (30cm*15cm*2cm)
- strain gauge transducer (Range = 2 N to 9 N)

- Microprocessor 8085 Coupled With Integrator and Relay Circuit Board

5.2. Components for Stiffness Tester

- Transparent Acrylic Board (28cm *15cm * 1cm)
- Milky Acrylic Board (28cm *15cm *1cm)
- Acrylic Platform (Top) (11cm * 13cm * 1cm)
- Calibrated Scale (15cm)
- Straight Line I/R Sensor (12v, Range 10cm)
- Stepper Motor – 12v & 15 degree step angle
- Compression Spring (OD 17mm, Wire Diameter - 0.7mm)
- Microprocessor 8085 Coupled With Integrator And Relay Circuit Board

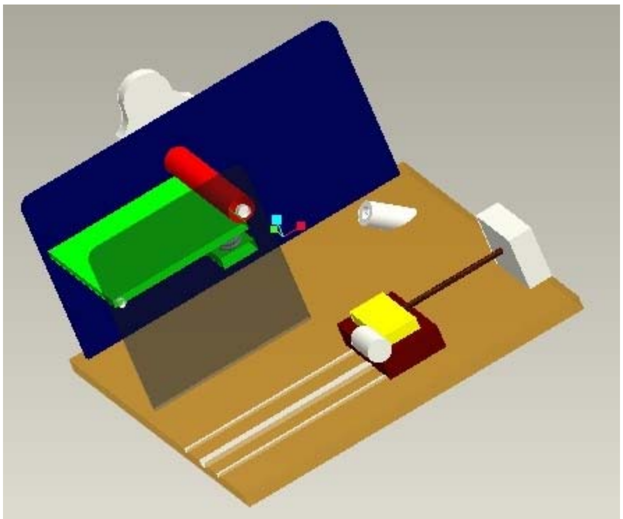

Fig. 2 : CAD Model of the Equipment (COF Side)

5.3. Construction of Co-efficient of friction Tester

As seen in fig-2, the co-efficient of friction tester is constructed in the following way

- Grooves have been provided on the acrylic base to fix the rack and rails of required length

  The acrylic tray is fitted on to the rails and the tray bears the stepper motor with its pinion meshed with the rack that is fixed on the base plate
- The stepper motor is connected with microprocessor and integrator circuit to stop it and start it whenever required
- A standard weight or slet of about 500g is tied to a inelastic string and is connected to the strain gauge transducer

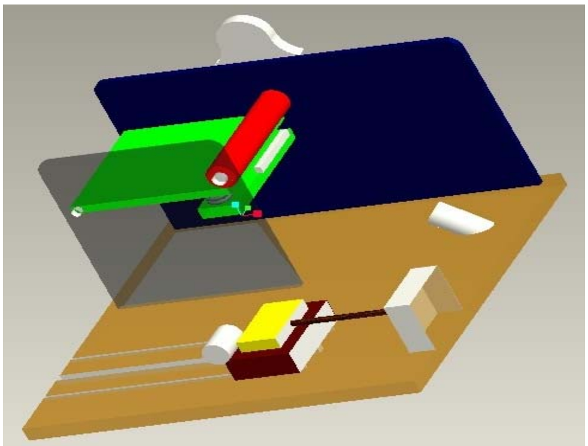

Fig. 3- CAD Model of Instrument (Stiffness side)

5.4. Construction of Stiffness Tester

As seen in Fig-3,

- The milky acrylic board and the transparent acrylic board are erected on the base with 11cm width in between
- The acrylic platform is placed in between the acrylic plates
- One end of the acrylic platform is fixed with compression springs against the down block and another end is pivoted
- The rollers are fixed on the shaft that is connected to the stepper motor
- The IR sensor and the receiver are placed at an angle of 41.5 degree

5.5. Working of the COF Tester

- When the switch is ON, the acrylic tray moves forward through rack and pinion drive
- The standard weight below which the paper sample is stuck is placed on the tray and is tied to the strain gauge transducer
- The material against which the COF is to be determined is placed on the tray
- When the tray moves, the standard weight is also pulled along with the tray
- The pulling force is sensed through the strain gauge transducer
- The pulling force sensed is entered into micro-processor and the results are interpreted in digital form that gives the static co-efficient of friction as sited in section III (A)
- For determining dynamic co-efficient of friction, the tray is allowed to move to the entire length of the base and the force reading from the transducer is noted for every 5mm displacement of the tray
- The force reading inferred is then substituted in the formula and the average co-efficient of friction is considered to be the dynamic co-efficient of friction.

5.6. Working of Stiffness Tester

- The paper sample is placed on the acrylic platform by pressing the platform against the springs as it is pivoted on the other side
- After placing the paper, the acrylic platform is released such that it fixes against the roller tightly
- Now the stepper motor is switched ON and the paper is allowed to move forward on the platform like a paper rolling inside a printer
- The paper moves forward and deforms due to its self- weight after some particular length and cuts the infrared beam that is inclined at 41.5 degree.
- Once the paper cuts the beam, the Stepper motor is stopped by means of a microprocessor and integrator circuit.
- Now the bending length is noted on the calibrated scale that is being fixed near the acrylic platform
- Thus, the stiffness of the sample is constituted based on the formula given in section III (B).

6. Advantages

1. The instrument is compact and portable
2. The instrument is simple in construction
3. It is easy to operate
4. The instrument can be automated with greatest accuracy and reliability
5. The instrument can also be extended for characterization of other web materials also.

7. Conclusion

The instrument proves to be a useful tool to all industries relying on web materials and this technology can also be extended to other web materials with little modifications. This instrument will definitely be a boon to related industries and research can also be extended in characterizing other materials in the easiest possible way.

8. References

[1] James d'A. Clark, "Determining the rigidity, stiffness and softness of paper", paper trade journal, volume 100, TS169 (March 28, 1935)

[2] Herbert .F. Scheifer, The Flexometer, an instrument for measuring the flexural rigidity of cloth and similar materials, BS Research Journal, volume 647, (1933)

[3] C.F.Sharman, the stiffness of paper, Pro.tech.sec paper makers Association of Great Britain and Ireland, Volume 23, (Dec 1942)

[4] Frederick T. Carson and Venon Worthington, Evaluating the Wearing quality of currency paper, Research Journal NBS, volume-26(1941)

[5] N.J.Habbot , The Measurement of Stiffness in textile fabrics and thin plastics, ASTM Bulletin.No.176, TP190 (September 1951)