International Conference on Mechanical, Industrial and Materials Engineering 2017 (ICMIME2017)
28-30 December, 2017, RUET, Rajshahi, Bangladesh.

Paper ID: MS-260

Investigation of Different Mechanical Properties of Commonly Available Papers

M. W. Akram, M. W. Islam, S. K. Choudhury

Department of Mechanical Engineering, Rajshahi University of Engineering & Technology,
Rajshahi-6204, Bangladesh
Email: washimruetme11@yahoo.com

Abstract

Tensile strength, Friction factor, Moisture content, Opacity, Bursting strength, Folding endurance, Hardness, Resiliency, Softness, Specific heat capacity, Ash content, Dirt content, Print quality, Printability, Pinholes, Porosity etc. are the properties which significantly affect the quality of a paper. But there is no literature available where tensile strength of paper and friction factor between paper and paper materials were measured. Apart from there is no research occurred on the collection of data about different properties of paper. Commonly available papers such as Partex, Bashundhara, Japan, Indonesia, Creative in different gram values (GSM) were used. Friction coefficient is an important factor for production of paper. Tensile strength can be used as a potential indicator of resistance to web breaking during printing. Taken all into consideration, the study would assist the researcher for further improvement of the paper quality and guide the printer operator and the consumer to select the appropriate one.

Keywords*:* Paper properties, tensile strength, friction factor, GSM (Gramm per Square Meter).

1. Introduction

Paper is a thin material formed by pressing together moist fibers of cellulose pulp derived from wood, cloths or lawns, and drying them into flexible sheets [1]. Paper is a versatile material because of it has many uses such as writing, printing, packaging, cleaning, and a number of industrial and construction processes. A chemical pulping method splits lignin from cellulose fibers for making pulp from wood which is the main component to produce paper. Lignin is dissolved in a cooking liquor, so that it may be washed from the cellulose to preserves the length of the cellulose fibers. The papers which are made from chemical pulps are also known as wood-free papers which do not contain lignin, which deteriorates over time. The bleaching operation is done on the pulp to produce a white paper which consumes 5% of the fibers. The papers which are made from cotton or other materials contained 90% cellulose, chemical pulping processes are not used in these cases [2].

To improve the printing or writing characteristics of paper, the pulps may contain not only fibers but also fillers such as chalk or china clay. Different types of additives are mixed with it for sizing purposes or applied to the paper web later in the manufacturing process. The sizing purpose is to create the accurate level of surface absorbency to suit ink or paint.

There are different properties of paper such as Physical properties (Basis weight or gram values, bulk and density, book bulk, caliper or thickness, curl, dimensional stability, hygroexpansivity, formation, friction, directionality of paper, moisture content, smoothness, roughness, conditioning of paper, sideness of paper), Optical properties (Opacity, brightness, whiteness, color, finish, fluorescence, gloss etc.), Strength properties (Bursting strength, compressibility, folding endurance, hardness, resiliency, softness, stretch, surface strength, breaking length, tensile strength, wet strength, tearing resistance, tear factor, tear index, tensile energy absorption), Electric properties (Conductance, dielectric constant or relative permittivity, dielectric strength, pH, pinholes, porosity, air resistance, permanence & durability), Thermal properties of paper (Thermal conductivity of paper, specific heat capacity of paper, water absorption), Miscellaneous properties (ash content, dirt content, print quality, printability, sizing) [3].

There are many properties of paper which are shown in the above. But, here mainly two important mechanical properties (i.e. tensile strength and static friction factor) which are necessary for our daily life are investigated.

2. Experimental details

Tensile Strength: The tensile force required to produce a rupture in a strip of paper or paperboard is known as tensile strength of paper, which is expressed in kg/cm^2. Tensile strength is the good indicator of fiber strength, fiber bonding, and fiber length. Tensile strength can be used as a potential indicator of resistance to web breaking during printing or converting [3].

Friction: Friction of paper materials can be defined as the resisting force that occurs between two paper or paperboard surfaces in contact when the surfaces are brought to slide against each other. This property is measured as a coefficient of friction, which is the ratio of the frictional force, to a force acting perpendicular to the two surfaces [3]. The static friction force is defined as the force that holds back a stationary object up to the point that it just starts to move. The initial peak force which is required to move the sled is calculated first then it is divided by the weight of the sled to calculate the static friction force [4]. The names with GSM of different paper brands which are used in this experiment can be shown in Table 1.

Table 1: Sample paper brands with GSM (gram per square meter)

120 GSM	100 GSM	80 GSM	70 GSM	65 GSM	55 GSM
Partex	Partex	Partex	Partex	Partex	Partex
Bashundhara	Bashundhara	Bashundhara	Bashundhara	Bashundhara	Bashundhara
Japan	Japan	Japan	Japan	Japan	Japan
Creative	Creative	Creative	Creative	Creative	Creative
Indonesia	Indonesia	Indonesia	Indonesia	Indonesia	SA

3. Methodology

Principle for measuring tensile strength

Specimens for the tensile test were cut by the instrument is shown in Fig. 1. ETM 50N-500N electro-mechanical desktop test machine was used to measure the tensile strength of paper which is shown in Fig. 2 and the corresponding schematic diagram of this machine is shown in Fig. 3. There are some specifications of the tensile test machine, but the most important specifications are given below:

Parameters Model: ETM 50-500N, Maximum Force: 50N; 100N; 200N; 500N, Accuracy: Class 0.5/1, Force Resolution: 1/300000 of maximum force, without step division, Force Measuring Range: 0.4%-100% FS/ 0.2%-100% FS, Force Measuring Accuracy: Within 0.5% /1% of reading, Displacement Resolution: 0.08 µm, Vertical test space: 600 mm (can be extended), Crosshead Speed Range: 0.001-500 mm/min, Dimension (L x W x H): 500 x 370 x 1160 mm, Weight: 50 kg

A certain specimen of paper was attached to the tensile test machine and the tensile force was applied to the sample. After failure for applying tensile force, the strength was measured from the computer as kg/cm^2. Paper specimens were considered as higher moisture content in the rainy season, medium moisture content in the summer season, low moisture content in the winter season and dry paper considered the specimen which was free from moisture.

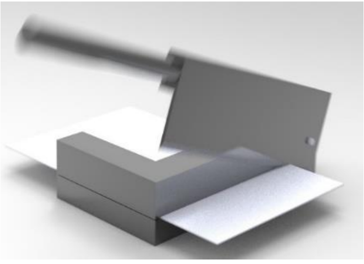

Fig. 1: Paper cutter used to cut the specimens, a slot for tensile specimen

Fig. 2: ETM 50N-500N electro-mechanical desktop test machine

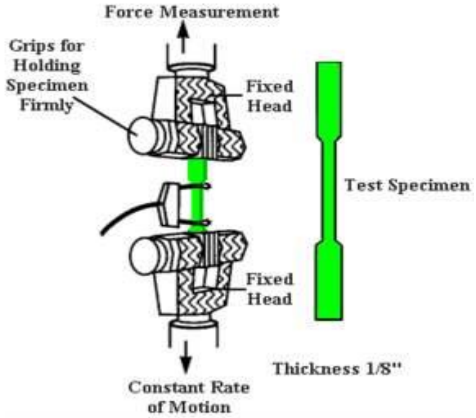

Fig. 3: Schematic diagram of tensile test machine for the paper

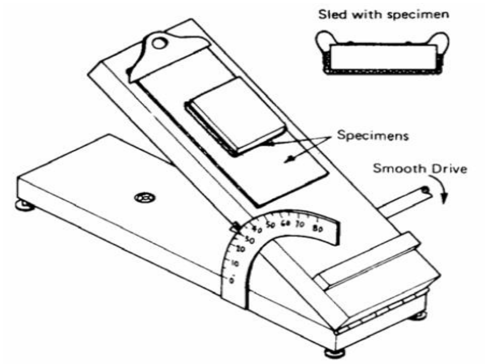

Fig. 4: Inclinometer for measuring static friction factor of paper

Principle for measuring static friction coefficient

At first, the plane was leveled so that it was horizontal when the inclinometer (Fig. 4) indicates zero degrees. The larger test specimen was mounted on the inclined plane with the surface to be tested facing upward. The other specimen was attached to the surface to be tested facing downward and rotated 90° to the direction of the specimen on the plane. There were no looseness or slack in the specimen. The sled was positioned and its test specimen on top of the other test specimen near the end of the inclined plane that was away from the hinge and stops. Dwell time was allowed of 10 s, and then the angle was increased of incline at the specified rate of 1.5 ± 0.5°/s. The incliner was stopped when the sled starts to move and permit the sled to slide to the stop. The angle was recorded at which the sled has begun its slide to the nearest 0.5°. Again after the dwell time of 10 s, the inclination was repeated to the start of sliding, let the sled come to a stop, the incline was returned to horizontal, but no record was made of the angle at which sliding begins. For the third time, the sled and specimen were carefully lifted to the starting position, it was allowed to dwell 10s and raised the incline to the inception of sliding, the angle was recorded at which sliding begins on this third slide to the nearest 0.5°. Then the next pair were placed of test specimens on the sled and inclined plane but that time the specimen was rotated 180° that had been the oriented with the MD (Machine Direction) in the direction of the slide. Then the specimen was tested as in the previous type. Then the remaining three tests were completed, the one specimen was reversed as in the previous method for each succeeding measurement.

4. Results and Discussion

Tensile strength

The tensile strength of different paper brands and in different weather which are obtained in this experiment are shown graphically.

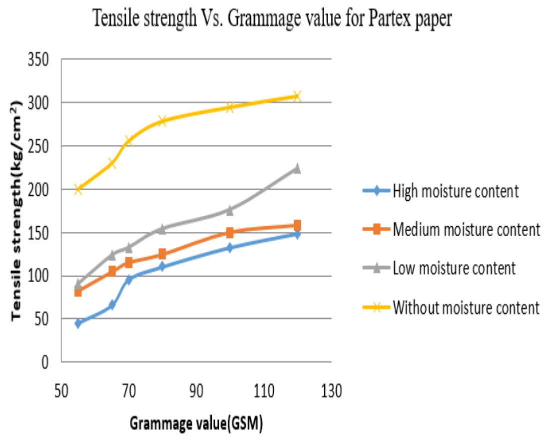

Fig. 5: Tensile strength Vs. Grammage value curves for Partex paper

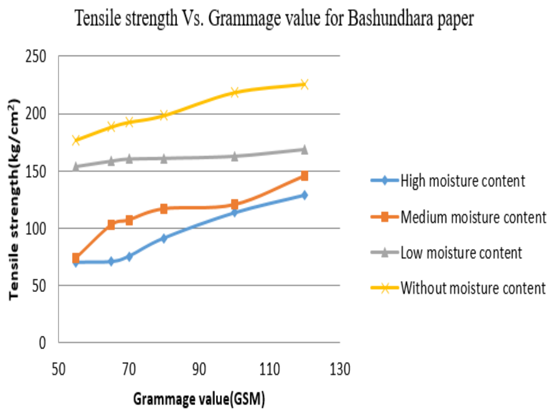

Fig. 6: Tensile strength Vs. Grammage value curves for Bashundhara paper.

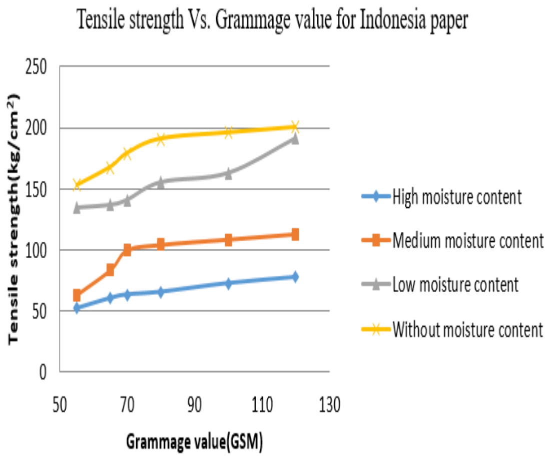

Fig. 7: Tensile strength Vs. Grammage value curves for Indonesia paper.

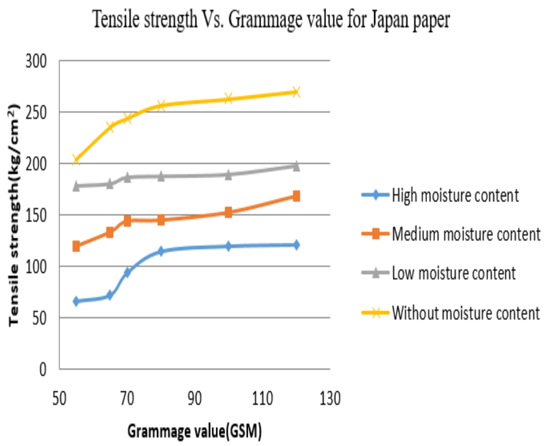

Fig. 8: Tensile strength Vs. Grammage value curves for Japan paper.

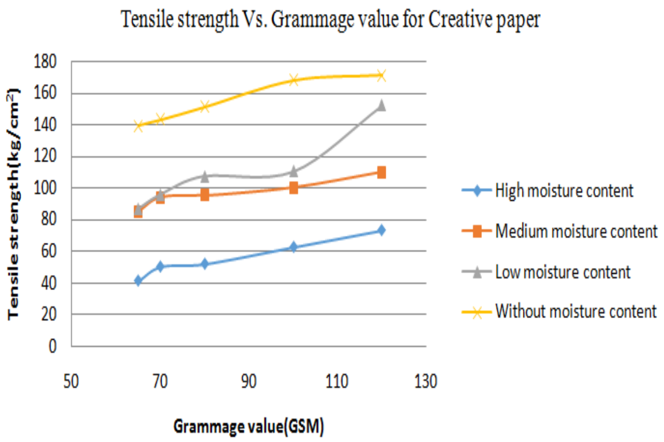

Fig. 9: Tensile strength Vs. Grammage value curves for the Creative paper.

Generally, the tensile strength of paper increases with increasing Grammage value. But in sometimes it diverges which is shown in the Fig. 5 to Fig. 9 because of raw materials used and papermaking or pulping procedure. The tensile strength also varies from one brand to another brand and the amount of moisture content which is shown by these figures also. Generally, with increasing moisture content the tensile strength decreases. From this experimental result, it may be shown that the Japan and Partex paper brand can carry more load than other paper bands. It may be concluded that the tensile strength increases with increasing Grammage value and decreases with increasing moisture content. Because with increasing

Grammage value the thickness of the paper is also increased, so tensile strength increased. But with increasing moisture content the strength of fiber of the paper material is reduced i.e. the tensile strength of the paper is reduced.

Friction factor

The obtained friction factor values for different paper brands for different weather or different moisture content are shown graphically.

The friction factor of different Grammage values and different paper brands are different which is shown by this experimental result. Fig. 10 to Fig. 14 shows the variation of friction factor with Grammage value of different paper brands and different moisture content. Measurement of the coefficient of friction has applications in packaging where a high coefficient will indicate that containers such as sacks, bags, and paperboard containers will resist sliding in unit loads or on packaging lines. This property is also important in printing papers since a specific coefficient of friction is needed so that individual sheets will slide over each other, otherwise, double press feeding may result. It may conclude that the friction factor increases with increasing moisture content because of increasing moisture content the molecular space of paper increased. Friction factor decreases with increasing Grammage value due to increasing Grammage value the molecular space decreases.

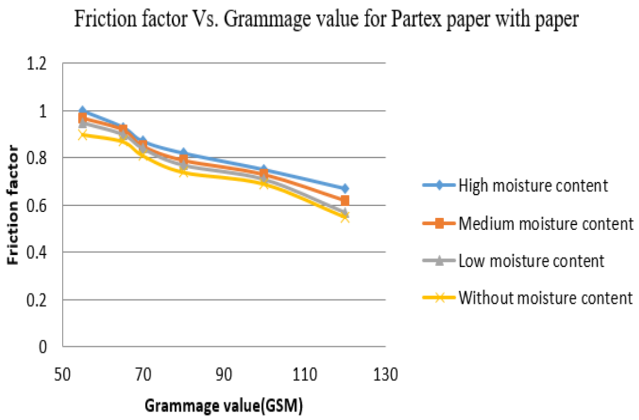

Fig. 10: Friction factor Vs. Grammage value curves for Partex paper with paper.

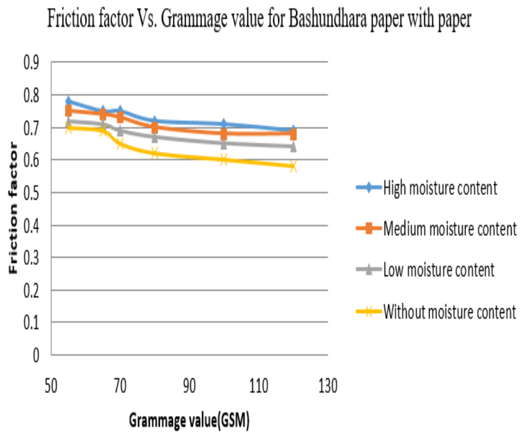

Fig. 11: Friction factor Vs. Grammage value curves for Bashundhara paper with paper.

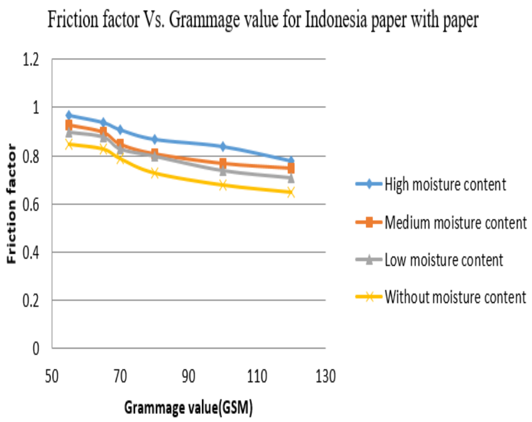

Fig. 12: Friction factor Vs. Grammage value curves for Indonesia paper with paper.

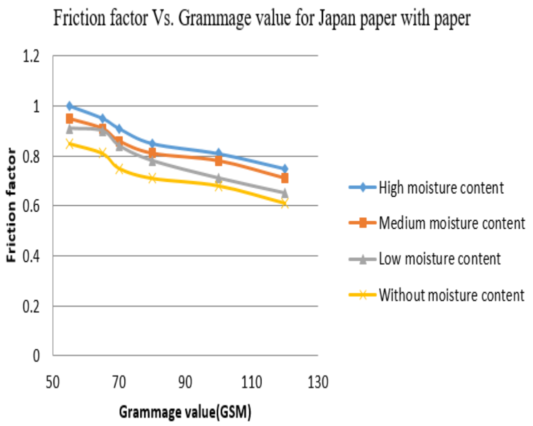

Fig. 13: Friction factor Vs. Grammage value curves for Japan paper with paper.

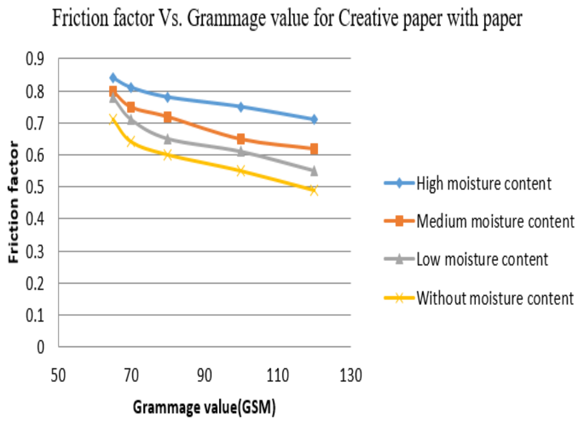

Fig. 14: Friction factor Vs. Grammage value curves for Creative paper with paper.

During the converting and end-use of almost every paper product, friction is very important [5]. For example, high friction is crucial for sack paper and linerboard in corrugated containers during transportation and storage [6], for controlling the paper roll behavior and for good run ability of the paper in a printing press [5]. The reliability of copiers and printers [7] as well as the suspension from currency bills from automatic teller machines [8] depend on a constant level of friction between the paper sheets during sheet-feeding. Low paper-paper friction and low paper-metal friction are required for example during the corrugating of fluting [5].

5. Conclusions

The tensile strength and friction factor of different Grammage values of papers and different brands with different moisture content are obtained by this experiment. Tensile strength increases with increasing Grammage value and decreases with increasing moisture content. It also varies from one paper brand to another paper brand. It may be concluded that Japan and Partex paper brand can carry more load than other paper brands. The maximum values of tensile strength at high, medium and low moisture content are 148.75 kg/cm^2, 168.75 kg/cm^2 and 223.61 kg/cm^2. On the other hand, the minimum tensile strength for high, medium and low moisture content is 41.39 kg/cm^2, 63 kg/cm^2 and 87 kg/cm^2. It may be also concluded that the friction factor increases with increasing moisture content and decreases with increasing Grammage value.

Another property of paper such as breaking length, opacity, folding endurance, pH, thermal and electrical conductivity and calorific value may be measured. The name of different papers which are commonly used for different purposes is known by this experiment. Tensile strength can be used as a potential indicator of resistance to web breaking during printing. Taken all into consideration, the study would assist the researcher for further improvement of the paper quality and guide the printer operator and the consumer to select the appropriate one.

6. Acknowledgement

The authors would like to facilitate their sincere gratitude and honor to their supervisor Dr. Sirajul Karim Choudhury, Professor, Department of Mechanical Engineering, Rajshahi University of Engineering & Technology for his proper guidance, valuable advice, encouragement and supplying with informative materials collected from various renowned journals that helped them a lot to carry out this work in scheduled time. Grateful acknowledgments are due to the technicians and laboratory attendants of the Metrology Laboratory, Machine Shop, Wood Shop, Heat Engine Laboratory, Welding and Sheet Metal Shops and Material Science Laboratory of Rajshahi University for their assistance and co-operation in carrying out the study in various ways.
May Allah bless and reward all of them

7. References

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