Physical Properties of Base Papers Used in Packaging

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SUMMARY

For converting operations, the base paper sheets should meet certain requirements of strength, structural, surface and optical properties. A few typical properties from these such as bursting strength, folding endurance, air permeability and smoothness index have been evaluated for a few types of sheets. The significance of these measurements has been discussed in relation to the functional requirements of packages using such bases.

INTRODUCTION

Packaging is one of the earliest inventions of man's primitive civilisation and the grown steadily with it. Primarily the package is an enclosure used to protect, store and transport a product but can also be used to display it and encourage its aesthetic appeal to the purchser.

The basic packaging materials fall into three types: metallic, ceramic and organic which can be further classified as being of vegetable origin such as wood, vegetable fibres, cork, rubber etc. or of synthetic materials which cover most of the plastic films, fibres and resins. Modern technology has produced composite materials which take maximum advantage of the properties of the base materials to obtain a product with combination of several properties for a particular package.

The paper web with its properties such as lightness, durability, printability, opacity, reasonable strength and good performance on converting machine is the most suitable material for packaging. Even now when there are a host of film materials competing with paper for packaging use, about 60% of world packaging is constituted of paper and its derivatives.

Paper can be defined as an interwoven mat of fibres mostly of vegetable origin formed by their felting from suspension in water. Paper boards are heavier and more rigid than paper. Usually all sheets which are greater than 12 points in gauge (0.3 mm thick) are classified as paper board. The cellophane which is a regenerated cellulose film has the same basic properties as the paper but its transparency combined with its amenability of various types of treatments and coatings has given it a place of distinction. About 100 varieties of cellophane film for various applications are known. Paper and cellophane together with polyethylene and aluminium foil constitute the four major base materials for flexible packaging.

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PHYSICAL PROPERTIES OF PAPER AND OTHER FILMS

For the converting operation the papr sheet should meet certain specifications regarding strength, structure, surface and optical properties for satisfactory performance on the machine and the end use.

The strength is evaluated by properties such as Bursting Strength, tear factor, folding endurance, tensile strength, rigidity and bonding strength.

Evaluation of structural properties is carried out by determining the basic weight, porosity or air permeability, thickness, felt and wire side, machine and cross direction and hygroexpansivity.

The surface characteristics are judged by properties such as smoothness, abrasion resistance and capacity for bonding known as surface bonding strength.

Optical properties include brightness, grass, opacity and colour. Other properties which are of interest in evaluating the base-paper are moisture content, pH of paper, bacterial sterility, flammability and resistance to aging.

In this paper an attempt has been made to illustrate the importance of evaluating these properties by taking a typical property from each group and its determination on 3-4 base papers. The properties determined were Burnt strength, Folding endurance air permeability and smoothness index.

EXPERIMENTAL

The sheets of writing paper, kraft, glassine and cellophane were conditioned for 48-hours at 60% relative humidity and 25°C temperature. The testing was carried out under uniform temperature and humidity conditions. The methods used for various tests were as follows :

TABLE—1

PHYSICAL PROPERTIES OF A FEW TYPICAL PACKAGING PAPERS

Sl. No.	Property	Kraft Paper (M.G.) Glazed	Kraft Paper (M.G.) Semiglazed	Utility Paper	Wax Coated glassine	Cello-phane
1.	Moisture, %	3.34	3.10	2.63	3.85	6.66
2.	Basis wt., g/m^2	53.5	56.5	58.0	33.5	31.5
3.	Thickness, m.m.	0.093	0.100	0.99	0.02	0.02
4.	Density, g/ml	0.576	0.565	0.64	1.675	1.580
5.	Absolute Burst resistance, $N/m^2 \times 10^5$	1.19	0.6723	1.107	1.391	2.636
6.	Relative Burst Resistance, $N/m^2 \times 10^5$	2.226	1.191	1.91	4.151	8.369
7.	Double folds, M.D.	16.1	7.13	10.43	399.4	Very high
8.	Double folds, C.D.	10.2	3.0	5.23	31.7	Very high
9.	Smoothness, Sec. Side (1)	13.25	13.68	20.2	28.43	Very high
10.	Smoothness, Sec. Side (2)	3.68	5.3	16.27	810	Very high
11.	Air permeability, ml/mt. minute	1220	1100	390	Very low	Very low

1. **BASIS WEIGHT**—Using quadrant balance and Tappi Standard Method T410-M-45.

2. **BURST RESISTANCE**—Mullen Burst tester and Tappi Standard Method T403-M-45 was used.

3. **FOLDING ENDURANCE**—Tappi Standard T-423-M-45. Number of double folds in both Machine and cross direction were measured Mean of 30 observations was taken.

4. **AIR PERMEABILITY**—Tappi Standard T-460-M-46. The amount of air passing through an area of 10 cm^2 of paper per minute under a pressure of 100 mm of water column was measured. Mean of 10 readings is reported.

5. **SMOOTHNESS INDEX**—The tester operates on the principle of passage of air due to pressure difference through the micro-channels in the surface of paper placed in contact with a polished glass surface. The time required for a definite amount of air to flow through these channels under a fixed air pressure was measured.

6. **MOISTURE CONTENT**—By repeated oven drying at 105°C until constant weight was obtained. Weight of water lost was calculated.

DISCUSSION OF RESULTS

The test results on these four variety of bases are given in Table-I. The significance of these tests is discussed below :

MOISTURE CONTENT—The percent moisture present in the paper affects its strength and running characteristics on machinery. It should be speeded up for a paper and measured as a routine quality control procedure. Though under the same conditions of relative humidity and temperature, the moisture retaining capacity of the base films can be different as is shown by the results.

DENSITY—The density of a paper the weight per unit volume. It is often referred to as bulk density and calculated by dividing the basic weight by thickness(2). As the density of a paper increases, the percentage of air by volume in the sheet decreases. As can be seen the glassine paper is more dense than the other types. The density of cellophane film is also high due to high secondary valency forces and the coating of rosins.

BURSTING STRENGTH—This test is a complex function of tensile strength and stretch. The fibre length and inter fibre bonding both are responsible for bursting strength. Increased fibre length gives higher bursting strength. Increase in the degree of beating also increases the bursting strength upto a certain range beyond which a decrease occurs with excessive beating. Drying conditions on the paper machine have a pronounced effect on this strength. If tension is applied on the wet sheet, the tensile strength may increase but the burst resistance decreases. The relative burst resistance obtained was as expected for various grades of paper with a high value for cellophane and low for ordinary papers.

Though it is not a fundamental test and does not make any distinction between the machine and cross direction or between the wire and the felt side of

paper, it gives a fair idea of both strength and toughness in a single test. It is of direct significance for utility of bag, wrapping papers and box boards where the paper is subjected to a stress similar to that exerted in the burst test.

FOLDING ENDURANCE—The rest measures the amount of folding the paper will endure before failure. The machine direction folding endurance is generally higher than the cross direction. though it is not always true. The results are affected by the flexing ability of the pader. As a result of increased beating Wet Pressing or other treatments if the paper becomes more brittle, the folding indurance is reduced. That is why the excess of starch or other sizing additives reduce folding.

As can be seen from the results the glassine and cellophane have good folding endurance. The increased beating in glassine is compensated by plasticizers to make it more flexible. The cellophane being regenerated cellulose film has good formation, contributing to its superior strength properties. Increased rag content of the pulp-produces paper with high folding endurance.

One special significance of this test is in evaluating aging of paper. On accelerated aging test a document paper should retain at least 50 per cent of its folding endurance.

Folding ability of boxboards is increased by using strong pulps and large amount of liner in a multiply construction.

SMOOTHNESS INDEX—This test gives an indication of the surface of the paper. It is essential to keep a uniform pressure for all measurements. Increased beating of the stock as for glassine paper increases the smoothness. Factors such as sizing, calendering, short fibre content and thinness of fibres help to improve the smoothness.

Some minimum degree of smoothness in necessary for printing. It is also a factor in laminating the papers. Smoothness requirements vary with the end use of paper. For example, the papers used in sorting machine needs a certain amount of slip for easy processing whereas the shipping bags need some roughness to achieve non-skid characteristics. The two sidedness of the paper is very evident from the results. The difference in the smoothness of two sides is quite marked in case of waxed glass ine. It can be seen that the papers with high sheet density have generally a higher smoothness.

AIR PERMEABILITY—This test depends upon the size, shape and distribution of pores or air passage within the sheet structure. The test is useful for bag paper which should be able to displace the air quickly when the bag is filled to prevent bursting during filling. It can also be used to give an approximate indication of the permability of paper to other fluids such as oil and other organic liquid. The impregnating qualities of papers for saturation with coating agents, ink penetration and spreading in printing papers and filtering characteristics of papers are same if the other areas in which this test can be helpful.

It is found that the cellophane and glassine have very low air peremability and so are very useful bases for packaging. The advantage of having high permeability in kraft papers has been mentioned above. The writing paper (utility) has an intermidiate range of air permeability.

The water vapour permeability (W V P) is of particular significance to packaging papers. Many items need a packaging through which the moisture vapour should not enter from the atmosphere and spoil the contents. In other cases the moisture content of the package should not be lost by evaporation. Either way a barrier film effective to stop float of moisture vapour will have to be used.

Cellophane which is formed as a cellulosic film and is highly impermeable to air is not a barrier to water vapour. This is due to hygroscopic nature of the cellulose. The water (SPADEO) on the surface radily migrates through the cellulose structure and will thus diffuse to the opposite side, if the realitive humidity is less on that side.

The water vapour barrier properties are imparted to the cellulosic bases by impregnation with wax or coating of hydrophobic solids such as resins, latex or asphalt. Lamination with films such as polyethylene, vinyl polymers or aluminium is another common method to achieve the same.

TABLE—II

WATER VAPOUR PERMEABILITY OF A FEW PACKAGING MATERIALS* ([2,4,5])

Material	Thickness in mil.	W V P in g/m²/24 hours at 38°C, 90% R.H.
Polyethylene	1	18
Polypropylene	1	11
Polyvinylidene chloride	1	3
Polyvinyl chloride	1	16
Polystyrene	1	100
Polyamide	1	extremely high
Polyester (Mylar)	1	21
Rubber Hydrochloride (Pliofilm)	1	15
Aluminium foil	0.7	0.8
Cellophane (Moisture proof)	1	11
Paper + barrier films		
Glassine + Paraffin Wax	—	1.1
Kraft + Polyethlene	—	18.7
Kraft + asphalt + Kraft	—	39

* Data collected from various sources.

In Table-II some of the common bases used for achieving moisture barrier properties and their values for this property have been summarised. It can be seen that vinyl films are of comparable water permeability except polyvinylidene chloride (PVDC) for which the moisture vapour transmission is low. A coating of paraffin wax or glassine gives a material why very low rate of moisture vapour transmission.

Uncoated cellophane film is flexible strong, transparent and grease proof. It is also highly permeable to water vapour. A moisture proof coating such as cellulose nitrate on both the sides greatly reduces the permeability to water vapour but for high barrier packages a PVDC coating is preferred(3). A composite paper of kraft and asphalt paper gives reasonable barrier to water but not to water vapours.

It is well known that a great variety of paper grade and products derived from them are used in the field of packaging. The products may differ from each other very slightly or the difference may be great and obvious. The identification and characterisation of these differences is based on physical properties, the evaluation of which can lead to most economic and optimum use of these products.

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