Importance of Shear Stress in all Types of Paper Production from Paper Mill

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ABSTRACT
It is very important to save safely long term duration of paper documents until and unless which has very high shear stress. This paper study is mainly on intention to retain long time maintenance of paper and paper products. The reinforcement to paper yields high strength of paper. The simply cutting and tearing is nothing but shear load which failure or rupture or breakage. Which materials are adding to paper as reinforcement to enhance good characteristic behavior of material paper products? By this concept we can save paper long term. Also one of the main important problem in paper mill industry is alignment of dryers which cause paper to reel properly[6]. The copper has introducing as packing material in dryers for aligning work[6]. The paper has good compressive load withstanding as well as tensile load comparatively shear load.

Keywords: *Alignment of dryers, shear stress, additives ingredients, reinforcement*

INTRODUCTION

Types of Papers

Printer Paper, Cardstock, Kraft Paper, Newsprint, Crepe Paper, Scrapbook Paper, tissue Paper, Water Color Paper, Origami Paper, Cardboard, Poster Board, Transfer Paper, Vinyl, Paper Bag, Vellum, Lined Paper, Paper Plates, Bond paper, Gloss Coated paper, Matt coated paper, Recycled paper, Silk coated paper, Uncoated paper, Watermarked paper, etc.[1-4]

Paper Formula: (C6H10O5)n. cellulose, a long chain polysaccharide, with mixed lignans and phenolics. The higher the percentage of cellulose, the better the paper, where n specifies the number of cellulose units.

Composition / Ingredients of Paper [5-10]

Cellulose fibres

It is common knowledge that paper is made of wood. Cellulose fiber occurs in many vegetable tissues, from which it can readily be extracted by mechanical or chemical means, cellulose fibres derived from wood, rags, grasses or other vegetable

Water

This may come as a surprise, but paper contains a bit of water.

Fillers

The substances are called fillers because they essentially fill the spaces between cellulose fibres. Loading or filling material such as clay, $CaCO_3$, Talc, TiO_2 etc. are used for higher brightness and better printability. Rosin, alum or combination of other chemicals is used to make paper water resistant

Chemical Additives
Adhesives are available in various types:

Natural
Starch and Dextrin
These elements come from roots, cereals, and other sources. The primary component is a polysaccharide, and when it is hydrolyzed, it produces long chain glucose units. Using various food ingredients and altering the hydrolysis process can result in distinct variants. These adhesives are primarily used in the paper sector, where they are found in products like corrugated paper and multiwall bags. In remoistenable adhesives, dry roasted starch known as dextrin is employed.

Gelatin (animal, fish, vegetable glues)
These proteins are made either by hydrolyzing soy flour or collagen, or by separating casein from skim milk. Gummed tape, textiles, and the paper industry, including book binding and case manufacture, all use animal glues made from bones and hides. Skim milk caseirs are mostly employed in wood to wood bonding. In paperbacks, soya bean glues are utilised.

Asphalt and Bitumin
Except for the bonding of coarse grade papers to generate waterproof building papers, these high fractions of crude oil are more commonly utilised as sealers than as adhesives.
Semi-synthetic

Cellulosic
Cellulose is a polymer comprised of glucosidic rings connected by oxygen that is found in the structural components of plants. Both water-soluble and solvent-soluble polymers can be produced by combining ethers and esters available in several forms, Cellulose nitrate is mostly used as a transparent, all-purpose glue for household tasks. Adhesives for paper to paper and plastic made of cellulose acetate butyrate. Methyl cellulose is used in wallpaper pastes and leather pastes to stop shrinking during drying. Low-temperature adhesives made of ethyl cellulose.

Synthetic Vinyl's
It's a line of vinyl materials that are utilised by the paper industry on a global scale. There are many different vinyl derivatives, and each one has unique characteristics. Some of the members are generated as emulsions or as solvent-soluble varieties. Wood and polyvinyl acetate are used to make paper. Applications for polyvinyl alcohol in paper.

Acrylics
Pressure-sensitive adhesives, as well as those used for flooring, paper lamination, textiles, flocking adhesives, etc., use materials similar to vinyls but made of a few distinct compositions.

Apart from Adhesives there are various chemicals used in manufacturing paper
Optical brightening agent
Paper is optically brightened to seem whiter.

Pigment
It is possible to add pigments that absorb in the yellow and red portions of the visible spectrum. The brightness of the paper will lessen as the dye absorbs light. A mixture of pigments and an optical brightening agent is frequently used to boost whiteness. Blue and violet dyes are the most frequently utilised pigments.

Retention agent
It is included to bind the paper's fillings. A polymer with many highly cationic, positively charged groups makes up this retention agent. Retention also includes a method to hasten the dewatering process in the paper's wire segment. Some of the

substances employed are polyethyleneimine and polyacrylamide.

Caustic soda

Caustic soda is added to the process of pulping fibres to raise the pH. The smoothening and swelling of the paper fibres due to the solution's increased pH aids in the grinding process.

Sizing agent

Most paper kinds require certain water resistance in their internal size in order to have a particular writing quality and/or printability. Alkyl ketene dimer (AKD) and alkenyl succinic anhydride (ASA) are the two primary chemicals utilised nowadays.

Wet strength additive

These chemicals make sure that the paper maintains its strength even when it gets wet. This is particularly crucial for tissue paper. Epichlorohydrin, melamine, urea formaldehyde, and polyimines are examples of common compounds utilised. These chemicals polymerize in the paper and create a stronger bond as a result.

Dry strength additives

Chemicals that increase paper strength in normal or non-wet conditions are also referred to as dry strengthening agents. These qualities include delamination resistance, compression strength, bursting strength, and tensile breaking strength. Cationic starch and polyacrylamide (PAM) derivatives are typical compounds employed. These dry strength additives serve as fibre binders in paper sheets, frequently with the help of aluminium ions.

Cationic starch

Cationic starch is added to wet pulp throughout the production process to increase paper strength. Useful quaternary salts include 3-chloro-2-hydroxypropyl) trimethyl ammonium chloride (CHPTAC, also known as Quat 188) and 2.3-epoxy propyl trimethyl ammonium chloride (EPTAC, also known as or Glytac Quab).

Mineral fillers

Usually found as Clay, Calcium carbonate

Coating binders

Available as Styrene butadiene latex, Styrene acrylic, dextrin, oxidized starch.

Pulping chemicals

Are used for the production of chemical pulp from wood chips, following chemicals can be used: Caustic soda, Sodium sulfide for the Kraft process, Sulfurous acid for the Sulfite process, Caustic soda, Anthraquinone for the Soda pulping.

Bleaching chemicals

Sodium dithionite, Chlorine dioxide, Hydrogen peroxide, Ozone

THE TENSILE STRENGTH

The greatest stress might cause a paper strip or sheet to break. It is among the most crucial fundamental physical characteristics of paper and paperboard. Depending on the orientation of the fibre, the tensile strength varies. Tensile strength is assessed in both machine direction (MD) and cross direction (CD) since the fibre orientation is different in each[3].

While cross direction refers to the direction that is perpendicular to the paper sheet that is running on the machine during the paper-making process, machine direction refers to the direction of the paper web that is running on the machine. In machine direction, it is higher than in cross direction. The force per unit width is used to calculate it, and the result is expressed as N/m.

The paper sheet's tensile strength was tested.

Relation of the Tensile Strength of Paper

To determine how resistant paper is to a web break, tensile strength is utilised. The key factors influencing paper's tensile strength are the fiber's strength, length, and bonding, degree of fibre refinement, and fibre direction.

The kind and quantity of fillers utilised also play a role. For various applications, including as printing, converter, and packing papers, it is an important consideration.

Tensile Index and its Calculation[3]

Tensile index is defined with tensile strength divided by basis weight and express as Nm/g.
Tensile Strength = N/m
Basis Weight = g/m2
Hence, Tensile index (TI) = (N/m)/(g/m^2) = Nm/g

Tensile Strength Test Machine

There are various kinds of tensile strength testing equipment that can be used with specimens that are either horizontally or vertically orientated. In the paper business, tensile strength testers come in five different configurations: stiff crosshead, inclined plane, hydraulic, and spring. The most popular of them is the pendulum type tensile strength test.

Tensile index = tensile strength/grammage, quoted in Nm/g.

The area under the load/elongation curve is used to compute the tensile energy absorbed in addition to the maximum tensile load and elongation. The labour required to break the test strip is described here. The units for tensile energy absorption are J/m^2.

The paper's bursting strength indicates how much pressure it can withstand before rupturing. It is crucial for the bag paper.

Bursting strength is calculated as the greatest hydrostatic pressure necessary to burst a 1.20-inch (30.5-mm) sample by gradually increasing the pressure applied through a rubber diaphragm. TAPPI T 403 provides a description of the standards procedure as shown in Table 1.

Bursting strength depends on basis weight of paper. To normalized the bursting strength for various paper, bursting strength is reported as

Burst Index = Bursting Strength (kPa)/ Grammage (g/m^2) or
Burst Factor = Bursting Strength (g/cm^2)/ Grammage (g/m^2) or
Burst Ratio = Bursting Strength (lb/$inch^2$)/ Basis Weight (lbs/ream)

Typical Bursting Strength Values	
Grade	KPa
Coated Paper (130 g/m^2)	200-300
Coated Paper (250 g/m^2)	300-650
Bond Office/Business Paper (100 g/m^2)	250-300
Carbonless Paper (50-60 g/m^2)	150-200
Bleached Kraft (60 g/m^2)	210-260
Test Liner (186 g/m^2)	250-475

Table 1: Showing different papers strength

Elastic Modus of Paper [Table 2]

Material	Grammage g/m^2	Thickness mm	Elastic modulus E_{md} MPa	Elastic modulus E_{cd} MPa
Testliner	200	0.29	5403	1888
Kraftliner	182	0.24	7226	2553
Fluting 1	144	0.25	4716	1945
Fluting 2	123	0.19	4708	1600
Sack	68	0.09	5111	1746
paperboard	266	0.41	4922	2348
Newsprint	44	0.07	4784	1042
Copy paper	80	0.1	4558	1557

Table 2: Elastic modulus of different types of paper

Typical Bending Values [Table 3]				
Grade	Bending Moment Stiffness (mNm)		Resonance Length Stiffness (mNm)	
	MD	CD	MD	CD
Coated Paper (135 g/m^2)	65	45	1043	721
Office/Business Paper (80 g/m^2)	39	17	493	160
Carbonless Paper (46 g/m^2)	7.5	3.3	76	34

Table 3: Bending values of different types of paper

Tensile Properties of some paper grades [Table 4]								
Grade	Tensile Strength (kN/m)		Breaking Length (KM)		Stretch (%)		TEA (kJ/m2)	
	MD	CD	MD	CD	MD	CD	MD	CD
Offset (107 g/m^2)	5.6	3.2	5.3	3.1	2.5	4.1	14.9	15.8
Bond (75 g/m^2)	3.6	2.6	4.9	3.5	1.8	4.7	6.3	13.2
Newsprint (50 g/m^2)	1.8	0.9	3.7	1.8	1.1	1.4	1.8	13

Table 4: Tensile strength values of paper

Tensile Energy Absorption (TEA):

TEA is the Tensile Energy Absorption, i.e. the amount of work required to break the sheet under tension.

Tensile Index (TI) [Table 5]

It is the tensile strength in N/m divided by basis weight in g/m^2 Grammage. TI is expressed in Nm/g

Tensile Index (Nm/g) = $1000*T/R$ or $36.87*T^1/R^1$

T = Tensile Strength, kN/m

T^1= Tensile Strength, lb/inch

R = Basis Weight, g/m^2

R^1= Basis Weight, lb/1000 ft^2

Typical Tensile Index Values		
Grade	MD (Nm/g)	CD (Nm/g)
Newsprint (40 - 49g/m^2)	45 -60	-
Stationery (50-100 g/m^2)	40-70	20-40
Tracing Paper (60-110 g/m^2)	70	40
Test Liner (186 g/m^2)	175	80

Table 5: tensile values of different types of paper

Direction Z Tensile strength, also known as internal bond strength, is a measure of a board's resistance to delamination on scoring or the use of a high-tack coating in relation to glue bonding at carton side seams. In TAPPI T 541, the procedural norms are described.

Tensile strength at zero span (paper): This gives a sense of the tensile strength of the fibre, not the bonding strength.

The gauge length of the tensile strength measuring device is adjusted to zero, ensuring that fibre rapture is the only mode of failure. It is measured using a paper strip, however the key factor is pulp quality.

Comparison of Individual Fiber Strength, Zero Span Tensile strength and Tensile Strength of Handsheets. [Table 6]					
Fiber Type	Average Fiber Length (mm)	Tensile Strength of Hand sheet (MPa)	Zero-Span Tensile Strength (MPa)	Fiber Strength (MPa)	Ratio of Zero-Span to Fiber strength
Douglas Fir (Unbeaten)	3.7	78	257	627	0.410
Southern Pine (Beaten)	3.3	83	207	590	0.351
Sweetgum (Beaten)	1.7	46	227	526	0.432
Sweetgum (Unbeaten)	1.7	8	217	665	0326

Table 6. Strength comparison values of different types of paper

ELECTRIC PROPERTIES OF PAPER

Paper is utilized for a variety of electric applications, including cable wrapping and capacitor dielectric media. The following electric properties are important for paper to be used in electrical applications.

Conductance

Electrical conductivity is the capacity of a material to convey the progression of an electric flow (a progression of electrons). Paper is named awful guide or cover[7]

Dielectric Constant or Relative Permittivity

It is the ratio of the permittivity of a substance to that of free space or vacuum. The dielectric constant of paper varies from 2 to 5.

Dielectric Strength [Table 7]
Dielectric strength of an insulating material is the maximum electric field strength that it can withstand intrinsically without breaking down. Dielectric strength of Waxed paper is 40-60 Million Volt/m or 40-60 KV/mm. For a paper of 0.1mm thick, the dielectric strength will be 4-6KV.

Dielectric Properties of Cellulose and Paper					
Sample	Dielectric Constant	Power Factor	Resistivity (Ohms/cm)	Dielectric Strength	Density
100% Cellulose	8.1	-	10^18	250x10^5	1.56
Paper	1.2 -4.0	0.001-0.002	10^18	2x10^5	0.2 - 1.2

Table 7. Dielectric values of different types of paper

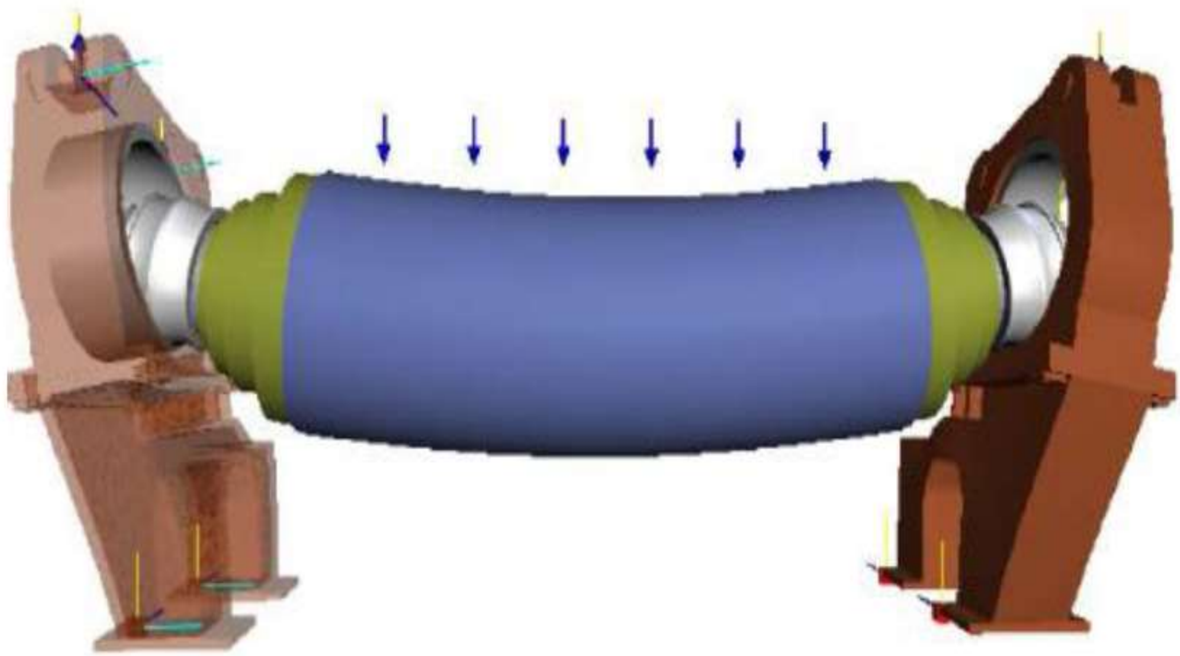

Fig. 1: *Mis-Alignment of dryer[6].*

ALIGNMENT OF DRYER [Figure 1]
Here the alignment material is copper used after alignment on dryers smooth operation will be obtained[6]. Smooth paper finish will obtain from alignment work .There are no problems like paper wrapping one over other will occur. All dryers will work properly after alignment. Cheap packing material will available. Less man power and semi-skilled workers will be preferable[6]

REINFORCEMENT MATERIAL IN PAPER
Poly (butylene adipate terephthalate)-PBAT and polylactide-PLA compositesas reinforcing material yielding maximum strength of 120 MPa and a tensile modulus of 10.2 GPa.
Plastic is plied top ply and bottom ply to opposition to rupture of paper.

An average shear strength of 2.52 MPa with a standard deviation of 84% of the mean, it is found shear strength values between 3.20 and 13.4 MPa, with an average of 8.12 MPa.

Refining is mechanical beating of pulp is a common procedure that is used in paper-making to improve the mechanical properties of the materials. Reinforced polypropylene composites with MAPP as a coupling agent.

DIFFERENT FORCES STRESS DISTRIBUTION IMAGES AND SEM VIEWS OF PAPERS [Figure 2-13]

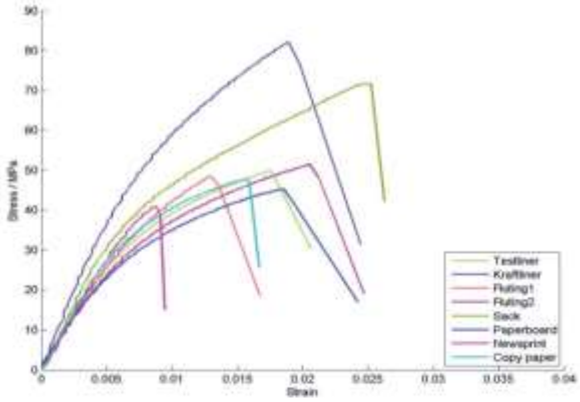

Fig. 2: *Graph of stress strain of different paper.*

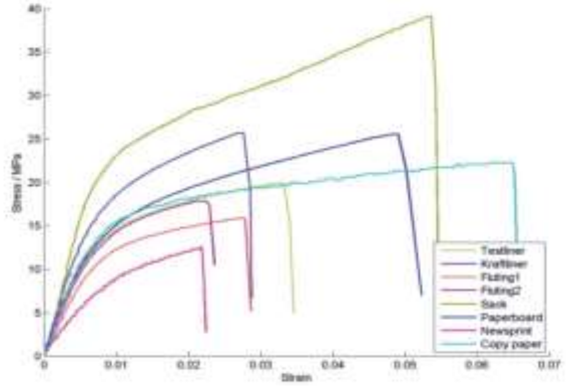

Fig. 3: *Graph of stress strain of different papers.*

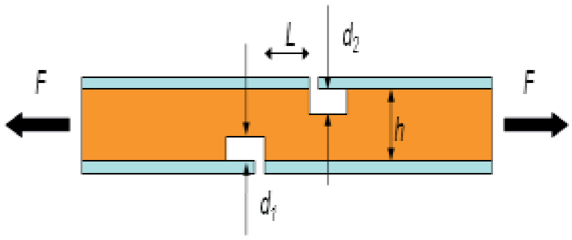

Fig. 4: *Tensile test of cracked notch paper*

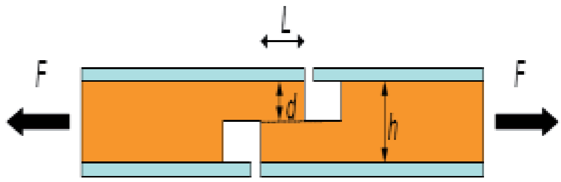

Fig. 5: *Tensile test of cracked notch paper*

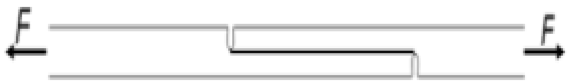

Fig. 6: *2D view of notched paper force*

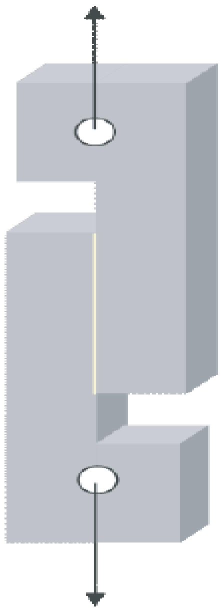

Fig. 7: *3D view of notched paper force*

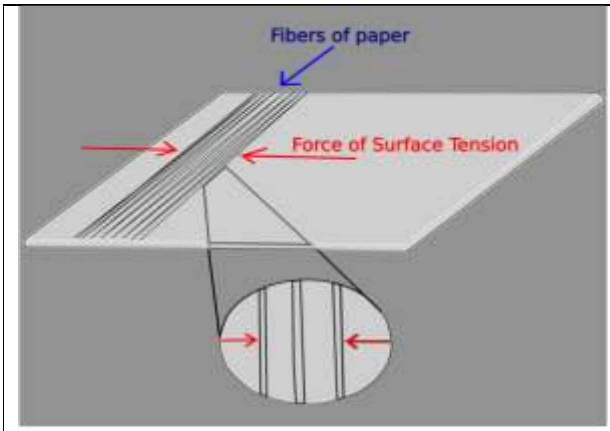

Fig. 8: *3d view of forces on paper*

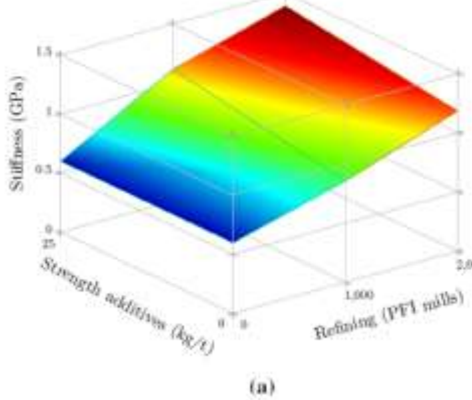

Fig. 9: *Refinig analysis of paper*

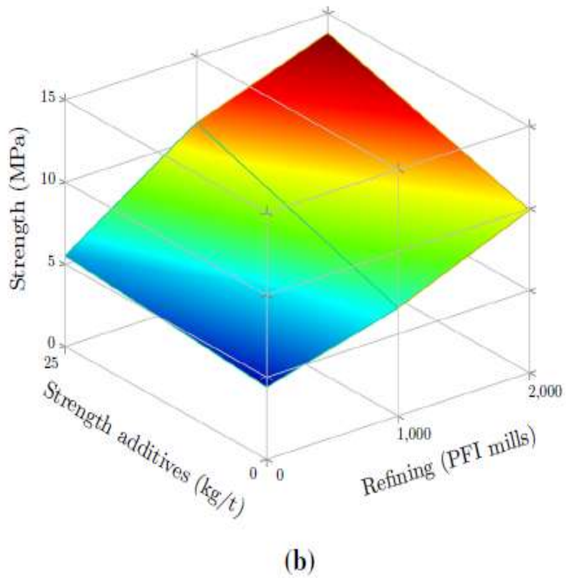

Fig. 10: *Refinig analysis of paper*

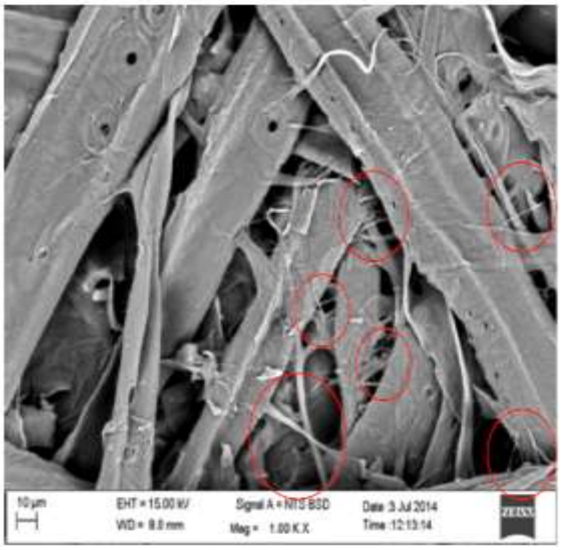

Fig. 11: *SEM view of paper*

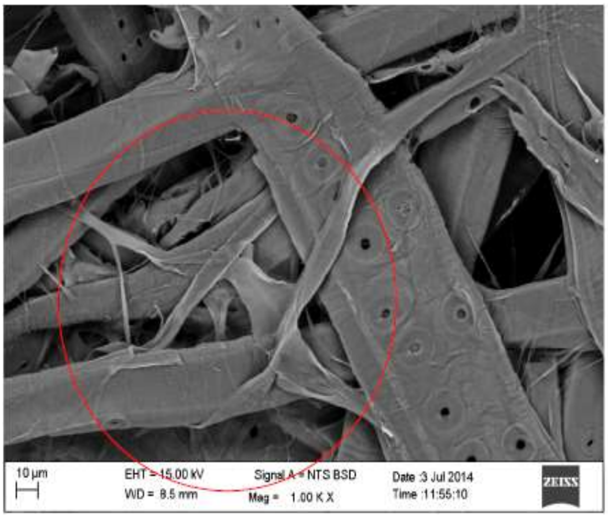

Fig. 12: *SEM view of paper*

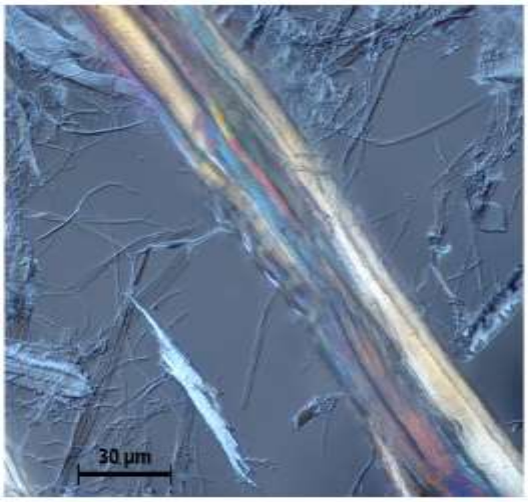

Fig. 13: *SEM view of paper*

CONCLUSION

Here the alignment material is copper used after alignment on dryers smooth operation will be obtained [6]. Smooth paper finish will obtain from alignment work .There are no problems like paper wrapping one over other will occur.

All dryers will work properly after alignment. Cheap packing material will available. Less man power and semi-skilled workers will be preferable [6].The paper has good compressive load withstanding as well as tensile load comparatively shear load. As reinforcement to enhance good characteristic behavior of material paper products. .

Cellulose fiber occurs in many vegetable tissues, from which it can readily be extracted by mechanical or chemical means, cellulose fibres derived from wood, rags, grasses or other vegetable.

The density of the sheet can affect the extent of modification in the elastic modulus and strength caused by refining. Improving bonding between fibers and forming the load-carrying bridges between the fibers. The reasons behind the improved bonding have been discussed in various contexts. For example, fines have small sizes, and good swelling and chemical compatibility, and thus can fill the gap or openings between fibers at the bond locations

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