

EG60411 Bio-Material Science

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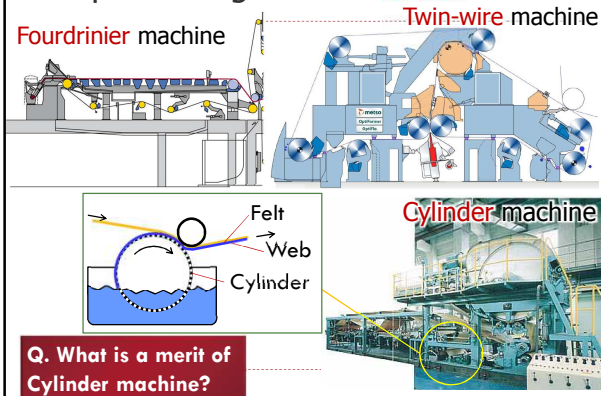
Professor, PhD, Paper Device and Eco-friendly materials

2G103, 10:10-11:25, Tuesday

Biomaterial Science (Schedule)

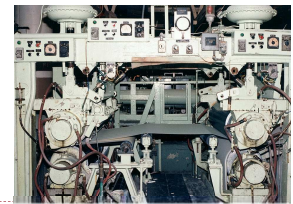
#	Date	Content
1	4/15	History of papermaking
2	4/22	Pulps – Beating and fiber properties
3	5/9, Fri	Pulps – Additives and functions
4	5/13	Papermaking processes & interfiber bonding
5	5/20	Paper– Structural and absorption properties
6	5/27	Paper– Mechanical and optical properties
7	6/3	Polysaccharide chemistry by Assoc Prof Akiko Nakagawa
8-9	6/10, 17	Pulping science and technology by Professor Hiroshi Ohi
10	6/24	Recent trend of paper science and technology

Papermaking - wire section



Papermaking – (wet) press section

- ▶ A wet web is pressed at high pressure between large rolls to squeeze out excess water.
- ▶ Water transfers to felts that sandwich the wet web.
- ▶ Pressing increases density and wet web strength.
- ▶ The common number of nips is 3 or 4.



Kodak Historical Collection #003 (1986)

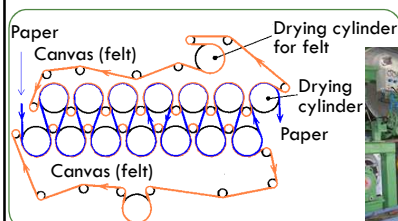
Papermaking – (wet) press section



Vietnam Paper Corporation (2014)

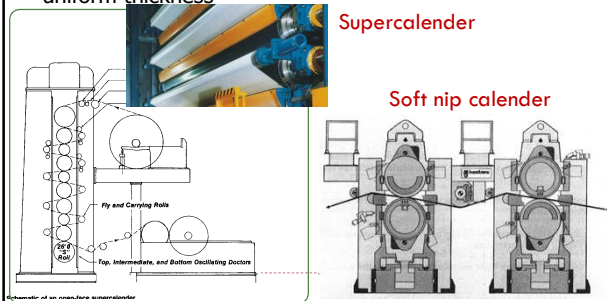
Papermaking – dryer section

- ▶ Steam-heated cylinders dry the paper with canvases.
- ▶ Free water evaporates, between fibers first, inside fibers second, and between fibrils last.
- ▶ At less than 9 % moisture content, bonding water evaporates, forming interfiber bonds.

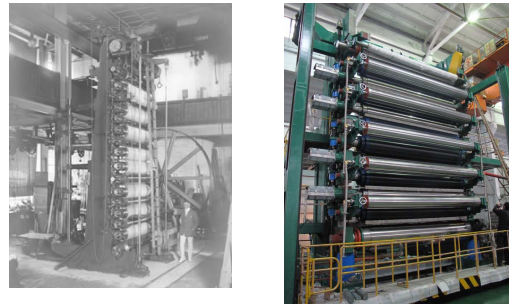


Papermaking – calender section

- ▶ A number of rolls press the passing paper.
- ▶ They make the paper surface extra smooth and glossy with friction, and provide a higher density and more uniform thickness

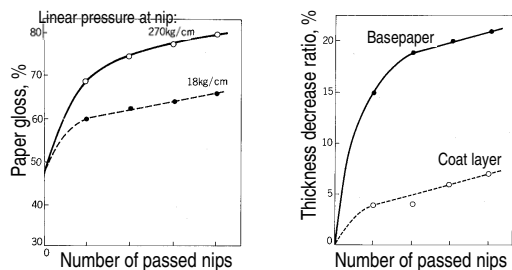


Papermaking – calender section



Papermaking – calendering effect

- ▶ Gloss improvement and compression of paper



- ▶ The number of nips is occasionally more than 10.

Q. Why is it as many as 10 although only 3 or 4 for wet press?

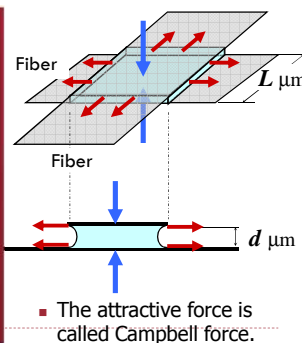
Types of chemical bond

- ▶ **Ionic bond** = a chemical bond in which two ions are joined together because one has a positive charge and the other a negative charge
- ▶ **Covalent bond** = a chemical bond in which two atoms share one or more pairs of electrons that hold them together (ca. 500 kJ/mol)
- ▶ **Hydrogen bond** = a weak connection that is formed between an atom of hydrogen (= a gas) and an atom of another substance such as oxygen or nitrogen (= a gas) (10~40 kJ/mol)
- ▶ **Van der Waals forces** = the relatively weak attractive forces that act on neutral atoms and molecules and that arise because of the electric polarization induced in each of the particles by the presence of other particles
- ▶ **Dipolar bond (coordination bond)**
- ▶ **Metallic bond**

Inter-fiber bond

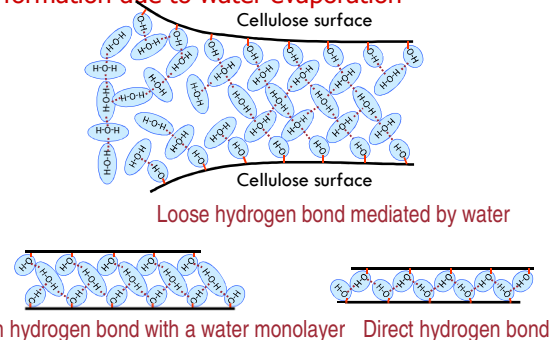
- ▶ Effect of water on interfiber bond formation

Q. Suppose two crossing flat fibers with the square, length L on a side at the crossing point. As they dry and the interfiber distance d comes to 1 mm, How much contraction stress develops between the two fibers?



Inter-fiber bond

- ▶ Interfiber approach and hydrogen bond formation due to water evaporation



Inter-fiber bond

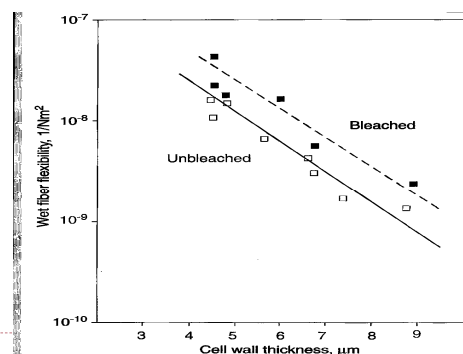
► Evidence of hydrogen bond

- When paper mass was measured after allowing to stand in deuterium water (D_2O) vapor until saturation, 0.5 to 2.0 % of hydrogen of all the hydroxyl groups was not replaced with deuterium. This ratio corresponds to the percentage of hydrogen bonded hydroxyl groups.
- Energy required for tensile breakage was calculated. 19 kJ/mol (equivalent to hydrogen bond energy)
- Strength decreased with acetylation of carboxyl groups **Cell-OH \rightarrow Cell-O-C-CH₃**



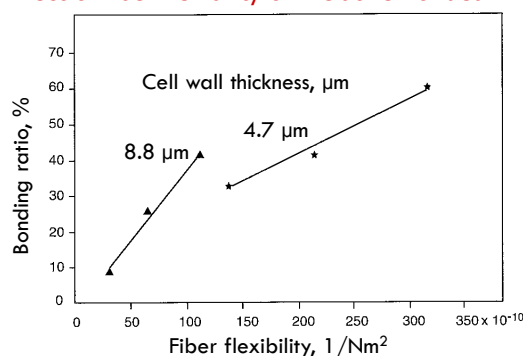
Inter-fiber bond

► Effect of **cell wall thickness** on **wet fiber flexibility**

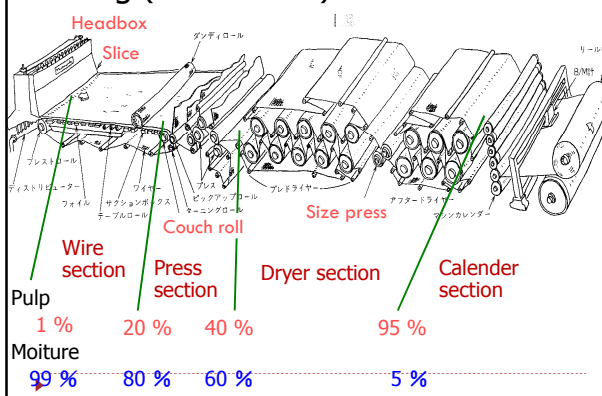


Inter-fiber bond

► Effect of fiber flexibility on Relative Bonded Area



Forming (Wire section) – Moisture content



Post-forming – Size press

► Sizing

- ▶ Internal sizing- addition to pulp slurry
- ▶ External (surface) sizing – application to surface

► What is surface sizing (size press)?

- The treatment for providing water-resistant property to paper by application of starch solution etc.
- Other than starch, carboxymethyl cellulose, polyvinyl alcohol, polyacrylamide etc. are applied. Strong water-repellency is not required.

- Advantages over internal sizing

- ▶ 100% retained. No deposit on walls of former or froth

Post-forming — Size press

- Purpose and effect

- ▶ Picking prevention in offset printing
- ▶ Ink jet printability to prevent bleeding

