SURFACE SIZING AND COATING

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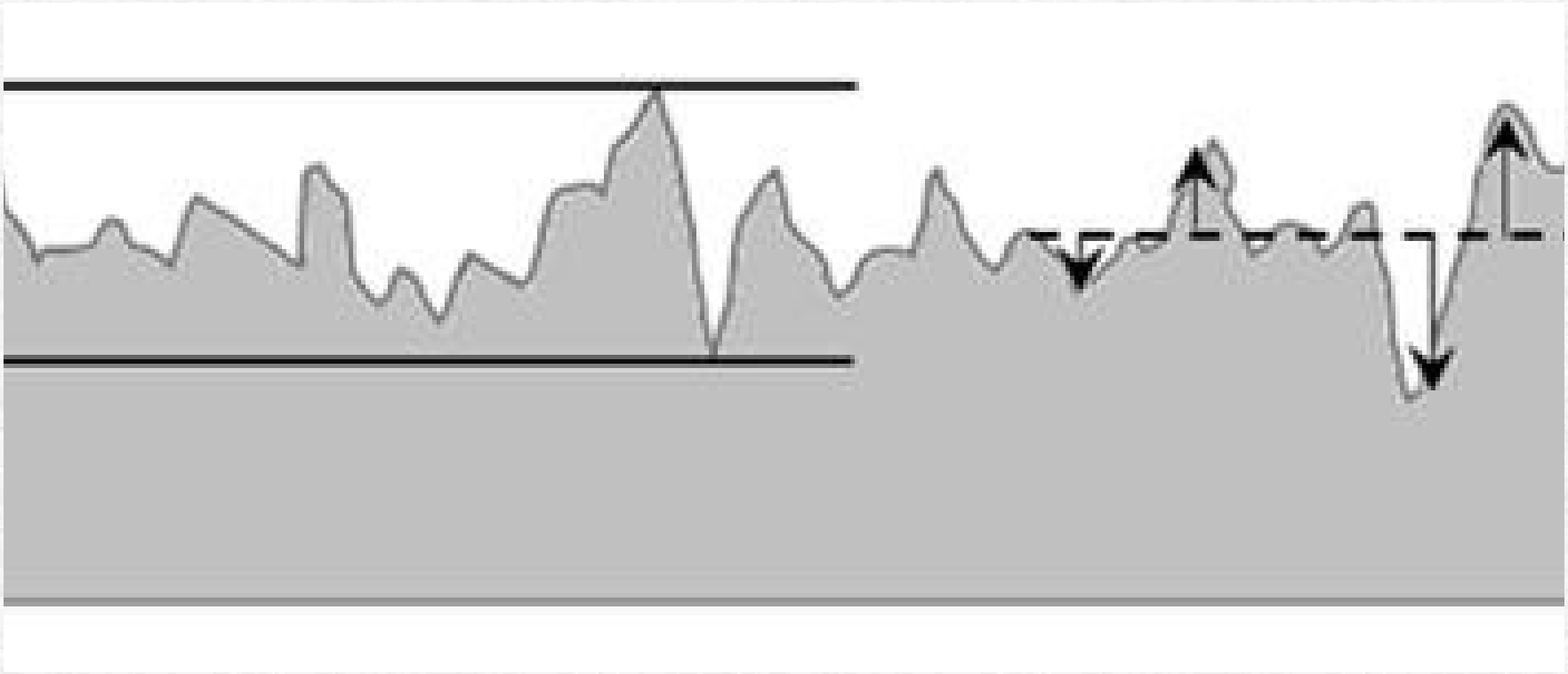
Why we Need Paper to be Surface Sized or Surface Coated?

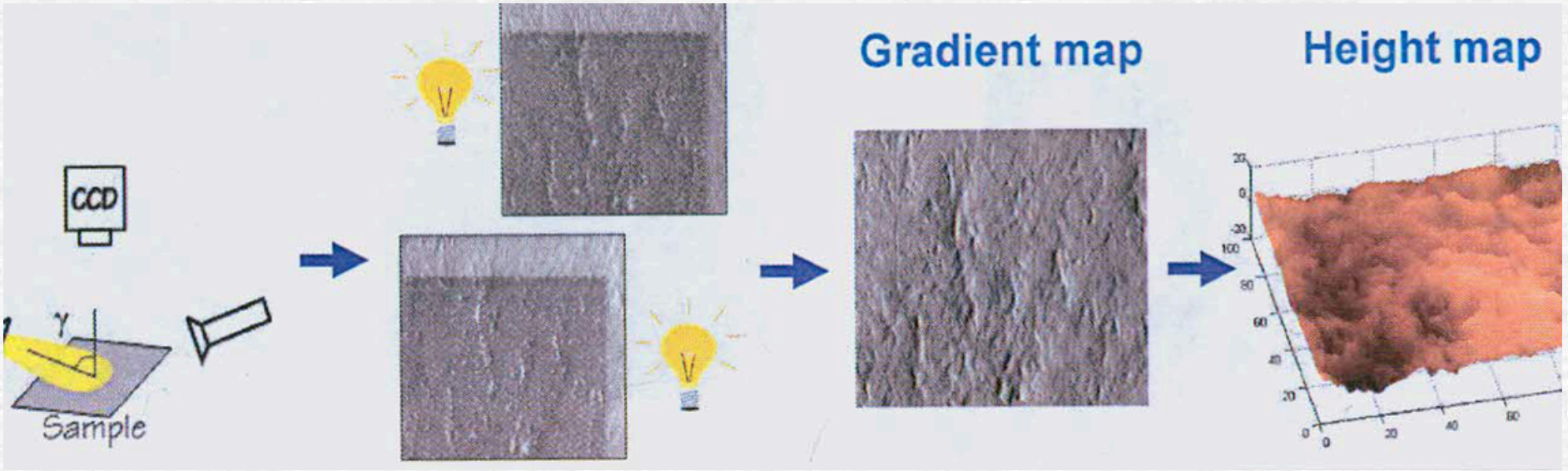
Q. What is paper ?

Ans. Paper is a porous mat of fibers of different dimensions with varying degree of agglomeration. Its surface has different voids and open areas between fibers

- When a paper surface is observed it appears to have a very smooth and flat surface, but in close up it is rough with numerous “peaks” and “valleys”.



- The surface roughness can be divided into three categories according to size: optical roughness on a length scale < 1 μm, macro-roughness on a length scale > 0.1 mm and micro-roughness at 1 – 100 μm
- In the case of coated papers, pigment surfaces form the optical roughness while the pigment shape creates the micro-roughness.
- Macro-roughness is mostly associated with the fibre structure in the paper substrate.



Since paper is needed to transmit information in graphic form, we

required paper to have even, better homogeneous, optically acceptable, continuous smooth surface with less irregular contour

that must interact with ink to provide accessible, attractive & persuasive graphical information

To Improve Printing & Appearance Properties of Paper, Paper Surface is either Surface Sized or Pigment Coated.

- Surface sizing is a paper making process that applies sizing agents to the surface of a partially dried paper web to improve its strength printability and water resistance. This process is typically performed after paper has been pressed and partially dried using a size press.
- A pigment coating is a process where an aqueous solution of pigment and a binder and a small amount of other additives are applied on paper surface either online or offline to give more uniform and more receptive surface to printing inks than the uncoated papers.

- Comparatively, coated paper is more superior quality as compared to surfaces sized paper.
- The process of surface sizing or an external sizing is different than wet and sizing or ‘Internal sizing’.
- In ‘Internal sizing’ we add the sizing chemicals (like rosin/alum, AKD, ASA) in whole pulp at wet end.
- Compared with wet end addition surface sizing provides close to 100% retention of added chemical
- Surface sizing also allows reduction or removal of chemicals from the white water to assist in environmental improvements。

Objective of Surface Sizing

- To bond the surface fibers or to increase the degree of surface fiber bonding, especially for the fibers or other elements (e.g. vessel elements) that are different to bond and thereby to pick out during printing.
- To increase the sheet's resistance to water penetration by filling in voids capillaries and small holes in paper.

Salient Feature of Surface Sizing

- Surface sizing of a sheet of paper provide resistance to penetration of liquid by reducing pore radius.
- Surface sizing give better surface properties to the sheet.
- Surface sizing improves surface strength and internal bonding strength

- Surface sizing is a key element in making an improved base stock for coating.
- In comparison to internal sizing, surface sizing provides close to 100% retention of added chemicals - reduce problems of wet end deposition and increase life of machine clothing.
- Compare to wet end sizing, surface sizing allows reduction or removal of chemical from the white water to assist in environmental improvement

Chemical Used in Surface Sizing

Starch

- Starch is most commonly used to surface sizing agent.
- A relatively low viscosity solution of 3% to 9% solids is used at size press to achieve pickup in the range of 30-50 kg. of dry starch per ton of paper produced.

STARCH

Advantages

- Economics
- Availability & variety
- Good adhesive strength per unit cost
- Good Rheology
- Ease of attaining desired viscosity
- Blends with many latexes and PVA
- Good heat and light stability (does not discolour)
- Low odours
- Good blister resistance (more than latex)
- Water receptivity (improve printing properties in web offset printing)

Disadvantages

- Binder migration (Mottle)
- Difficult to insolubilize(Low wet pick)
- Low gloss
- Film tends to be brittle (dusting & cracking at folds)
- Retrogradation – viscosity increase/decrease on storage.

Other Size Press Chemicals

- **CMC (Sodium salt of the carboxy methyl Cellulose) -** It is useful to improve grease resistance in hold out, surface strength and print gloss. The CMC solution can be used alone or in combination with starch vegetable gums or protein polymers
- **Methyl cellulose-** This helps in producing hard, flexible and continuous film which offers a good resistance to oil and greases. The methyl cellulose film is water sensitive, therefore cross linking resins are required to provide water resistance. Plasticizer (e.g serbitol) are added to improve the flexibility of the film. It is used in combination with starch

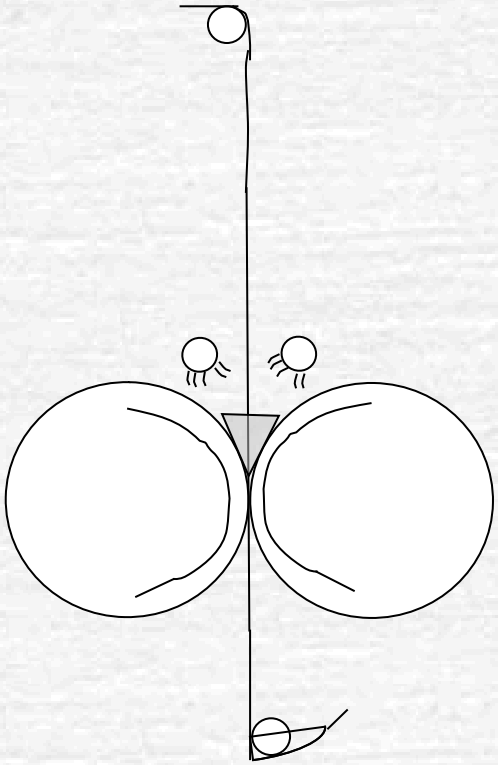
- **Polyvinyl Alcohol**- PVA is used for forming film having very high tensile strength and high degree of transparency, flexibility and oil resistance. The film has a fairly good water resistance which can be further improved by addition of the cross linking resin or an alkali stabilized colloidal silica.
- **Alginate-** They can be used alone or with a starch, casein or vegetable gums. Alginate gives high density well closed surface, which is particularly suitable for waxing base papers, gumming stock and paper board for high gloss ink printing。
- **Wax Emulsion-** Wax emulsion are used alone or with a starch to produce better finish scuffing resistance(bind loose surface fibers), water repellency, blood resistance, better foldability surface

Surface Sizing Technique

Pond Size Press-

- Horizontal
- Inclined
- Vertical
- SIM roll

Surface Sizing Techniques



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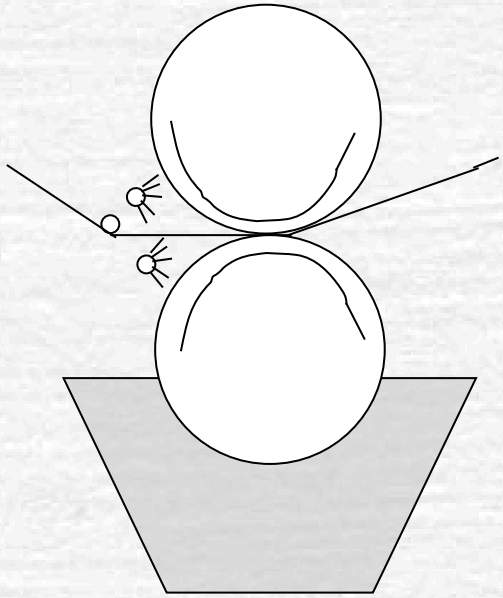

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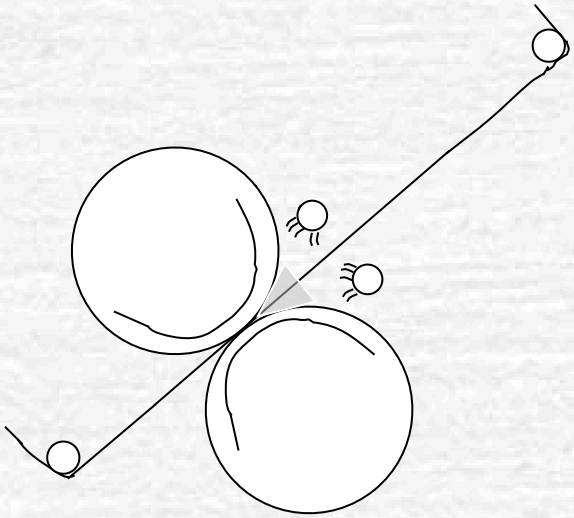
Surface Sizing Techniques



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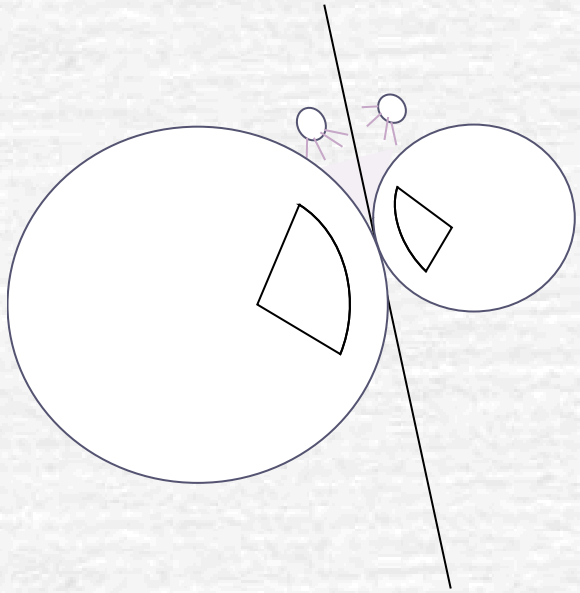

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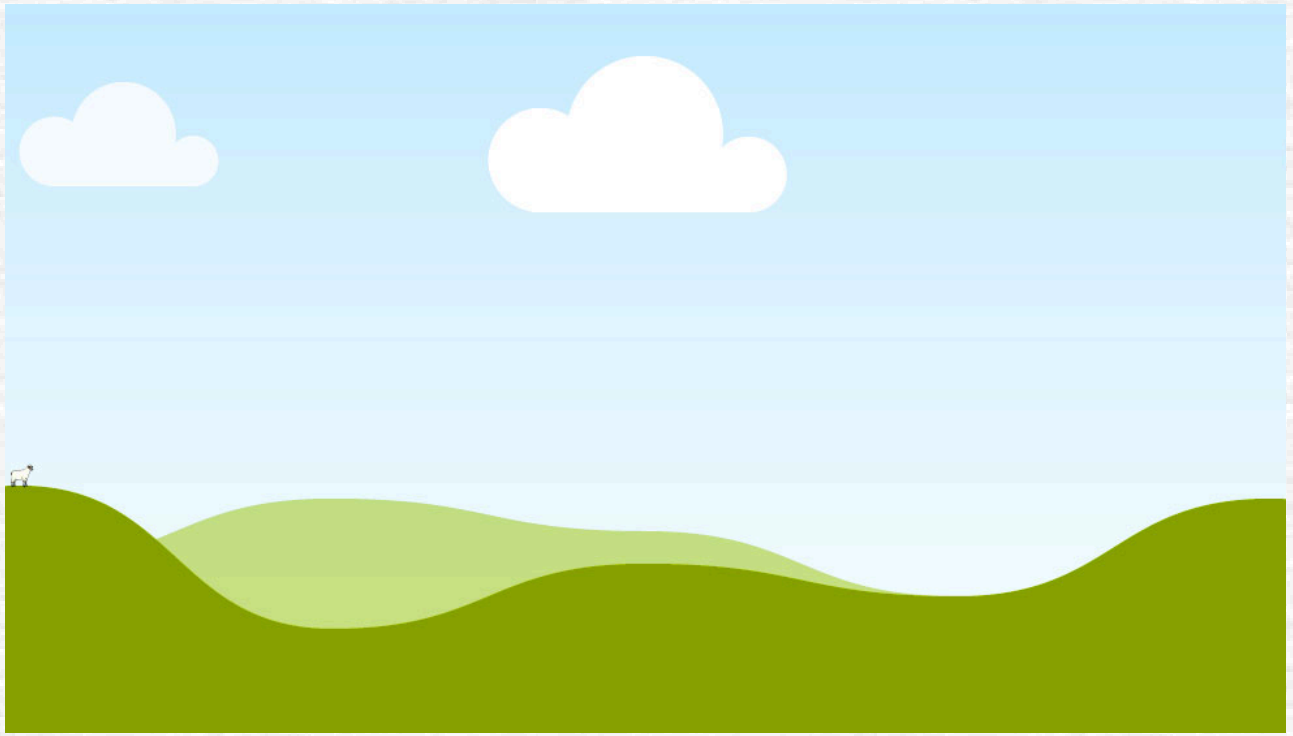
Gate Roll Size Press



Limitation of Pond Size Press

- Suitable for slow speed machines
- Runnability problems (web breaks)
- Pond splashing problem

Pigment Coating

- A pigment coating is a process where an aqueous solution of pigment and a binder and a small amount of other additives are applied on paper surface either online or offline to give more uniform and more receptive surface to printing inks than the uncoated papers.

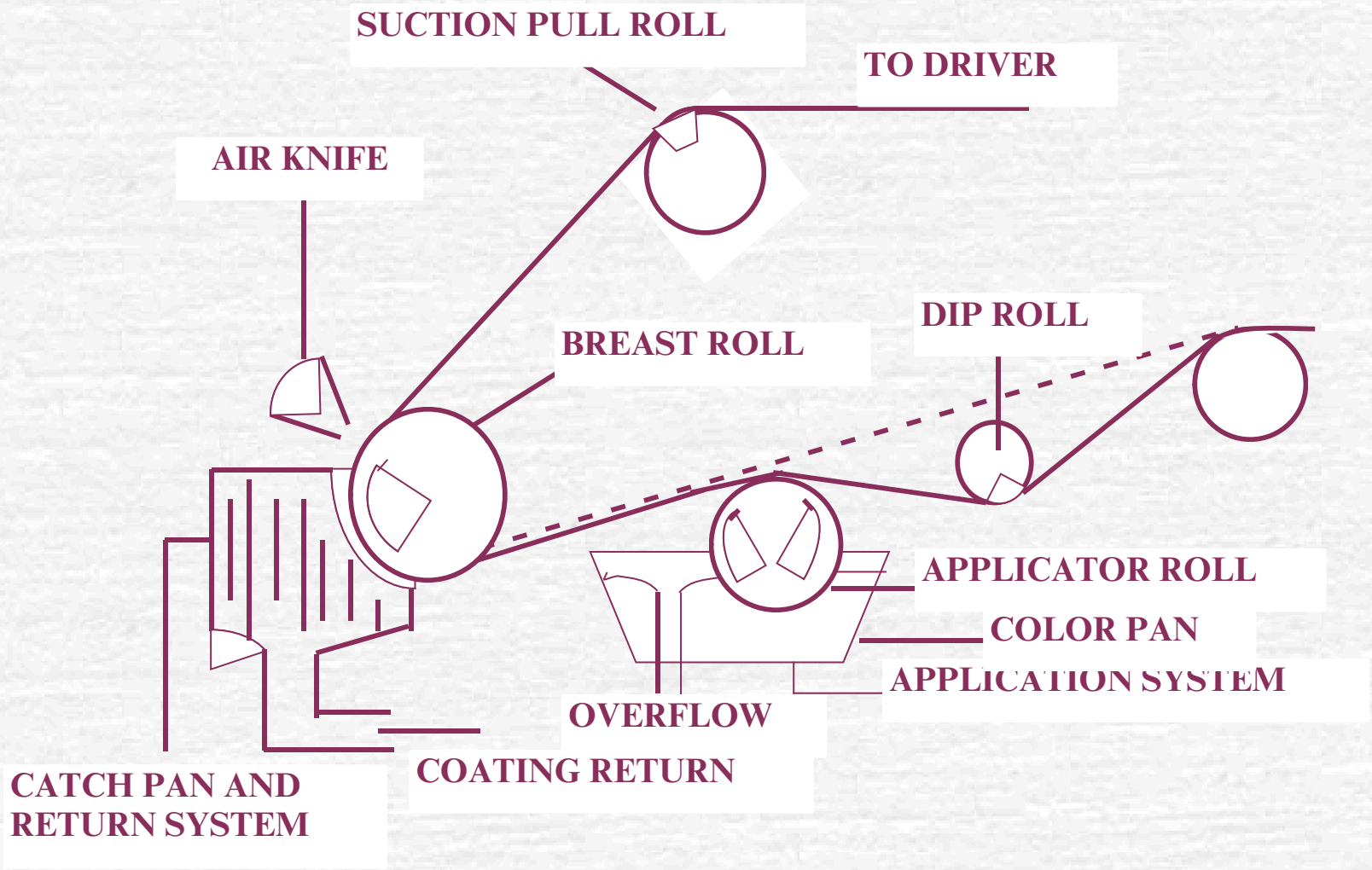
Classification of Coated Papers

- **Coated One Side (C1S) -** also called as chromo paper/board mainly used for printing lables, wrappings etc, where only the coated surface is printed.
- **Coated Two Side (C2S)** - also called art paper/board. Mainly used in magazines, papers, diaries, cover pages etc where printing on both sides is required.

- Paper coating operations are classified as
- **'on-machine‘**
- **'off-machine'**

indicating whether the coating is applied on the papermaking machine or apart from it in a separate operation. There are five major coating processes.

- **Size Press Coating**
- **Roll Coating**
- **Air-knife Coating**
- **Blade Coating**
- **Cast Coating**



GENERAL LAYOUT OF THE AIR KNIFE COATER

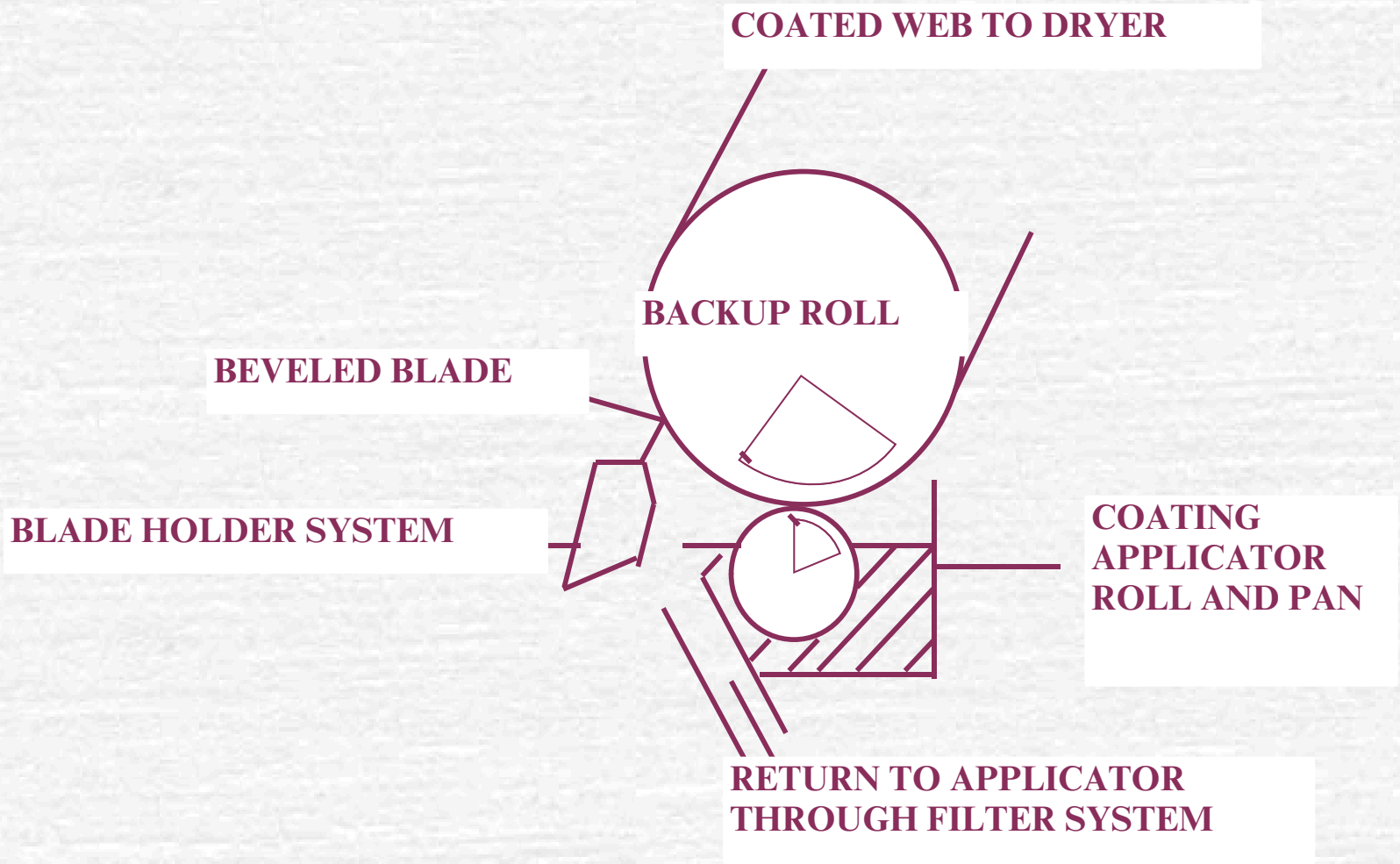
Coat weight in air knife coater is normally controlled by changing the air pressure .Other variables that control coat weight are coater speed , coating mixture solids . An increase in any of these variables will result in an increase in coat weight . The air knife can apply about 10 to 24.5 g/m2 to paper side .

Advantages

- Applicability to wide range of raw stocks and coating condition , uniformly coat rough stock also
- No scratches
- Low mottle on printing .
- Easily adjustable for changes in web widths , viscosity and solid contents of coating mixture .

Disadvantages

- It is low viscosity and low solids operation . Normal coating solids range from 30 to 50 % , average is 45% .
- Higher drying cost due to low solids .
- Cleaning , compressing and cooling of air increases the cost Plugging of air slit .
- Foam generation



Inverted Blade Coater Using Flooded Nip

- Blade coating is now the dominant form of coating.
- Blade coaters produce a high quality coated surface, which is due to the absence of the film-split pattern that is characteristic of roll-coated papers.
- Carry complete coating coverage.
- Minimum coating penetrated into web .
- Application of pre-metered coating film so that least amount of blade pressure is needed.
- There are a number of variations of coaters using this principle. Champion Rod Coater, Champflex Coater, Puddle-type Blade Coater, Bill Blade Coater, Bent Blade Coater etc.

Cast Coating

- It is used to produce ultrahigh-finish pigment- coated papers.
- It involves bringing a wet, plastic coated surface into contact with a non-adhering surface with a high finish then rendering the coating non-plastic, and there after removing the coated paper from the non-adhering surface.
- The final coated surface mirrors the finish of the highly polished drying surface, thus eliminating the need for super-calendering and maintaining high bulk and ink absorbency of sheet.

Properties of Pigment Coated Papers

Brightness

- Factors influence brightness are the pigments, binders, and additives and their % in coating formulation.
- Fine particle size, high brightness clay, calcium carbonate, aluminum trihydrate, satin white, and titanium dioxide contribute to high brightness.
- Synthetic binders produce- higher brightness than the natural binders;
- low binder levels enhance brightness.
- Additives such as the natural gums and starches have a minor, but negative, effect on brightness.

- Opacity
- Smoothness
- Ink Receptivity
- Pick Strength
- Other Properties like Foldability, Wet-Pick Resistance, Blister Resistance, Permanence (or Resistance to Aging)

Components of Coated Papers

- Base paper or raw stock
- Pigment
- Binder

Base Paper

- The base paper is the most important component in determining the quality of coated paper.
- The properties of prime importance are uniformity, formation, porosity, resiliency, strength moisture, brightness, opacity, finish and surface smoothness.
- Furnish for the raw stock varies, 20-50% long fibre, 40-70% short fibre or mechanical fibre, and 10-15% pigment filler.
- The strength of the raw stock is responsible for most of the strength of the final coated sheet.

Pigment

- Pigments forms the major part of coting color formulation.
- About 80% of total weight is pigment.
- Main pigments for coating by far is Kaolin or China clay,calcium carbonate, titanium dioxide, aluminum trihydrate, amorphous silicas and silicates, satin white, talc, zinc oxide, barium sulphate, and plastic pigments.

Pigment	Chemical Composition	Most Particles (μm)	Particle Shape	Density (kg/dm³)	Refractive Index	ISO % Brightness
Kaolin Clay	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	0.3-5	Hexagonal platy	2.58	1.56	80-90
GCC [3]	CaCO3, $MgCO_3$ (2-3%)	0.7-2	Cubic, prismatic, platy	2.7	1.56-1.65	87-97
Talcum	$MgO \cdot 4SiO_2 \cdot 2H_2O$	0.3-5	Platy	2.7	1.57	85-90
Gypsum	$CaSO_4 \cdot 2H_2O$	0.2-2	Roundish	2.3	1.52	92-94
Titanium dioxide • Anatase • rutile	TIO_2 TIO_2	0.2-0.5 0.2-0.5	Rodlike Rounddish	3.9 4.2	2.55 2.70	98-99 97-98
PCC[b]	$CaCO_3$	0.1-1.0	Variable, usually rodlike	2.7	1.59	96-99
Calcined Kaolin	$Al_2O_3 \cdot 2SiO_2$	0.7 (median)	Aggregated plates	2.69	1.56	93
Plastic pigment • solid	Polystyrene most common	0.1-0.5 0.4-1.0	Spherical Spherical	1.05 0.6-0.9	1.59 1.59	93-94 93-94

Binders

- Water soluble colloids such as starch, protein, and polyvinyl alcohol.
- Aqueous emulsions of synthetic polymers such as styrene butadiene, poly acrylate and polyvinyl acetate.

Binders

1. **STARCHES**
   - **Enzyme converted**
   - Thermal chemical converted
   - Oxidized (chlorinated)
   - Hydroxyethyl ether
   - Others (acetate, cyroethyl, cationic, thin boiling)
2. **PROTEINS**
   - **Soybean extract**
   - Casein (from skim milk)
   - Others (Animal glue, gelatin)

3. SYNTHETIC LATEXES

These are suspensions of 100 to 200 nm particles in water. These commonly used latexes are—

- Styrene butadiene polymer
- Vinyl acetate polymer
- Acrylic polymer
- Alkali sensitive latexes (swollen by dilute alkalis)
- Latex starch solution

4. SYNTHETIC SOLUBLE BINDERS

- Polyvinyl alcohol
- Carboxymethyl cellulose

STARCH

Advantages

- Economics
- Availability & variety
- Good adhesive strength per unit cost
- Good Rheology
- Ease of attaining desired viscosity
- Blends with many latexes and PVA
- Good heat and light stability (does not discolour)
- Low odours
- Good blister resistance (more than latex)
- Water receptivity (improve printing properties in web offset printing)

Disadvantages

- Binder migration (Mottle)
- Difficult to insolubilize(Low wet pick)
- Low gloss
- Film tends to be brittle (dusting & cracking at folds)
- Retrogradation – viscosity increase/decrease on storage.

Comparison of Different Modified Starches in Coating

Property	Enzyme Converted	Thermal	Oxidized	Ethylated
Viscosity stability	Fair	Fair	Excellent	Good
Binding capacity	Fair	Good	Good	Excellent
Colour	Good	Fair	Good	Excellent
Economy	Excellent	Excellent	Good	Fair
Pigment dispersion	Poor	Poor	Excellent	Poor

Protein

Advantages

- Excellent glueability
- High stiffness
- High opacity
- Excellent binding strength
- Excellent runnability on coating machine
- Improves stability and water retention of high latex level coating
- Good dispersing agents for pigments
- Adds blocking resistance

Disadvantages

- High viscosity of liquid coating at high solids
- Brittle films
- Foam stabilized in coating
- Odour
- Low gloss coating
- Low brightness coating
- Cost
- Must be cooked with alkali to prepare

Styrene Butadiene Latex (Carbohydrate)

Advantages

- Excellent overall properties
- Gloss ink holdouts
- Bonding strength
- Wet rub and abrasion resistance
- Gloss

Disadvantages

- Glueability
- Blistering tendencies
- Odour
- Mottle

Polyvinyl Acetate Latexes (Co-polymers)

Advantages

- Brightness and brightness stability
- Stiffness
- Blistering resistance
- Hydrophilic

Disadvantages

- Ink holdout
- White pitch
- Low binding strength

Acrylic Latex

Advantages

- Excellent overall properties
- Excellent runnability
- Brightness and brightness stabilities.

Disadvantages

- Very high cost

Ranking of Different Binders as per their Binding Performance Per Unit Cost

Binder	Rank
Starch	1
S. B Latex	2
Protein	3
Acrylic Latex	3
PVAC Latex	4
PV Alcohol	5

Different Binder Dosages for Different Purposes

Printing Method	Sheet Requirement	Binder (Solid per 100 part pigment)
Sheet offset (Tackiest oxidizing type printing ink)	High gloss Good water resistance High gloss ink holdout High picking	14-20 (Latex exceed 50% with co-binder starch, casein)
Web offset (Heatset ink)	Dry & Wet pick resistance lesser than sheet offset	12-80 (Latex is 25-35%)
Sheet letterpress (Less tacky ink)	Wet pick resistance not required	8-16
Web letterpress	---	10-16
Rotogravure (Fluid ink)	No pick resistance	7-12 (Starch as main binder alongwith small latexes)

ADDITIVES

These additives include

- Deformers,
- Lubricants,
- Wax emulsions,
- Preservatives,
- Flow modifiers,
- In solubilizers.

Generally most additives are used in small amounts and rarely exceed 5% of the coating solids.

THANKS