Coating-basic fundamentals

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SUMMARY

Pigment coating to paper or board is done primarily to impove printability and appearance. It is to produce a surface which has even and controlled absorption of ink vehicles and varnishes. There have been many radical changes in paper coating in the last three decades. Most of the brush coaters have been dismantled. Air knife coaters and blade coaters of various configuration have been installed and various process changes have dictated corresponding modifications in the rheology, performance and composition of coating color. In spite of numerous changes that have taken place, the rudiments of the paper coating ' Color" remains the same namely pigments and binder plus some miscellaneous chemicals to aid disperson and modify rheological characteristics.

Paper is coated for two main basic reasons—

1. To improve those physical and chemical characteristics, many of them have surface effect which effect printability;
2. To apply a layer to the surface of base paper, the characteristics of which can be much more readily controlled to meet Printers' requirement than those of plain paper.

To appreciate why these two points are important, one must understand that paper is microscopically a very open material; it provides an active capilliary system and can produce extreme absorption effects when wet with fluid medium. Such material cannot be adequately filled by substance added in the Beaters. This is largely a question of economics because of difficulty of ensuring that the large quantity of filter which would be required is retained by the paper without vast over addition at the beaters. In any case, such a method of applying the materials would never be anything like as effective in the paper as that which applies a surface layer by coating. It is largely surface qualities we are dealing with.

Briefly then, the basic reasons for coating paper are to produce a surface which is smooth and may be rendered glossy by calendring with friction, pressure and heat. Furthermore, a surface which has even absorption and rate of absorption of ink vehicles & varnishes of which can be controlled. Such a surface will enhance the printed results and greatly help to avoid mottle & other undesirable defect. This is the basic principle but there are many other factors which contribute to large extent to printability. These will be discussed at length later.

The correct base paper is every bit as important in producing a good coated sheet as in the correct paper in producing a good printed results. I say correct in both these instances because it is not always the glossiest or the "best" looking paper which produces the best looking results and the same applies to base paper for coating. Make, look through, strength etc. are all important.

I must describe briefly some methods of coating and make-up of "color" as we call our coating mixes because the method of coating and to a far greater extent, the type of "color" used can have very great effect on printability. The method of coating may be termed as three basic "Arts" — machine coated, brush coated and cast coated. My definition of 'brush coater' is an off m/c coater which applies the wet coating to a moving web of paper by a circular brush, felt covered roll or other roll such as a rubber covered roll, the coating being afterwards evened out by brushes, air blasts or high speed rollers. The conventional brush coater which has been in use since the middle ninteenth century consists of drum which carries and supports the paper. At the beginning of operation sufficient wet color is picked up from bath by a roller and transferred to paper by a revolving circular brush or roll to give the desired dry weight. This coat highly uneven is then levelled

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out by graded, fixed or oscillating brushes. The paper is pulled constantly by a Suction table into a drying chamber where it is dried, then reeled up and calendered by pressure, heat and friction to produce the glossy coated paper which we handle every day. The calendering operation is most important and has very significant effect on paper. It densifies it, alters its caliper and especially alters its absorbency.

Another type of coated is known as air coater or air-knife coater. It is an effective single method of coating whereby excess weight of wet coating is applied to the paper surface by a roll from a bath. The excess coating is doctored off and at the same time smoothened by a strong flat jet of air. The paper thereafter being dried and calendered. This method of coating is easier to control and presents fewer obstacles at high speed, than does the conventional brush coater whose moving brushes distort or vibrate at high operation speeds. Such a coater is infinitely cheaper to maintain. But disadvantage of air doctor is that it is essentially a low solid low viscosity operation.

Another development is trailing blade coater. This consists of fairly soft rubber covered roll some 2 ft. in dia. against which there is a closely fitting through whose leading edge is a very flexible steel doctor blade. The paper is led into color trough with backside inclose contact with the rubber roll and it emerges from the color trough at a nip between the flexible doctor and the rubber backing roll. The blade thus trowels and spreads the color in one side of paper only. This is an excellent method of obtaining very complete coverage of the paper surface with very light coating.

There has been many radical changes in paper coating in last three decades. Most of brush coaters have been dismantled. Air knife coaters and blade coaters of various configurations have been installed and these various process changes have dictated corresponding modifications in the rheology, performance and composition of coating color. In spite of numerous changes that have taken place, the rudiments of the paper coating color remains the same, namely pigments and binder plus some miscelleneous chemicals to aid dispersion and modify rheological characteristics. The pigment is the major component comprising 70-90% of total dry out. The performance of specific pigment is dependent upon its inherent characteristics and the manner in which it is used. Chemical composition, particle size, particle shape, specific gravity, surface area, refractive index, brightness, absorptivity, wetability etc. are to be considered.

The manufacture of cast coated paper in principle is surprisingly simple. Essentially the process consists of allowing a wet plastic coating on *smooth web* of high quality stock to dry in contact with large, heated, chromium plated drum. The casting surface must be as perfect as possible to produce absolutely free from pin-holes and surface imperfections and polished to absolute mirror surface. The result is that the paper has a truly cast surface finish, reproducing faithfully the finish of casting drum. The coating, drying and finishing processes are combined in one operation. Aside from conventional operations of sorting, trimming and packing, the product is ready for use as it comes from the casting drum. Generally speaking. any subsequent operations such as calendering would only detract from inherent quality of the sheet.

The surface of cast coated paper has a beauty, smoothness and flatness which cannot be obtained by calendering or brushing or any other finishing operation This paper has not only superb beauty in itself but permits faithfully reproduction of finest halftones. The coating composition is so selected and controlled as to be highly receptive to ink.

The fact that the base has not been compressed by heavy supercalendering means that the natural resiliency of the paper has been fully reta ined. The product suggest elegance and luxury and the printed results are unsurpassed in coated papers. Its three out-standing characteristics concerns the printer. (i) The unusu al brilliance of paper. The eye catching appeal of paper must be allowed to play prominent part in the finished job, and the ink should be of transparent kind which will take full advantage of gloss. (ii) The flatness and uniformity of the surface. This means that a minimum of ink can be used to cover with consequent good image detail with fine screen. It also means minimum number of press adjustments during the run. (iii) the great versatility of paper. It is genuine all purpose paper and can be recommended for all types of printing whether it be letter press, offset or rotogravure.

Coating Color

A mineral or pigment coating mixture (traditionally called Coating color') consists of an aquous suspension of a white pigment with a water soluble or water dispensible adhesive, which adheres to the fibrous paper base when the water is removed by drying. The final coating color comprises of a number of other ingredients such as dispersing agents, levelling agents, anti-foaming agents, plasticizers, preservatives etc. resulting in a complex coating having decorative and/or function value. The exact formulation of any coating colour depends upon the desired properties in the coated

paper, coating process conditions, the base paper characteristics, economic factors etc.

The type and concentration of binder in coating formulation are primary factors that affect coating gloss. Latexes are superior to natural binders such as starch, casein etc. in gloss development. High binder concentration adversely affect gloss except in one case where increase in binder content in cast coating actually improved gloss of the coating.

Where styrene-butadiene latexes are concerned, gloss increases with styrene content in polymer.

Gloss is reflectance of a surface which is responsible for its shiny or lustrous appearance–gloss has been used as a partial indication of surface smoothenss by paper industry. Gloss has been considered a measure of good printing quality as a result many printers demand a glossy paper. On the other hand, due to glare high gloss is often associated with poor reading quality.

The minerals used in the production of coated papers may be of many kinds. Finely divided washed china clay, barium sulphate, satin white and precipitated calcium carbonate are amongst those most widely used but quantities of other minerals such as Titanium, zinc oxide etc. are also used.

Pigment particles are smaller than half tone dot and when mixed with binding material and applied to paper surface produces smooth surface for finest half tone printing. The principle function of pigments are to fill in the irregularities of papersurface and produce evenly and uniformly absorbent surface. A good pigment should possess most of the following properties:—

1. Good dispersability in water ;
2. Correct particle size distribution ;
3. High opacity power ;
4. High brightness ;
5. Low water absorption ;
6. Non abrasive qualities ;
7. Chemical inertness ;
8. Low adhesive demand ;

Clay:

Particle size is important for gloss. For coating grade clays have diameter of 2 microns or smaller. Extremely fine particles tend to increase viscosity and have higher binder demand. Higher particle size clays are seldom used because they do not finish to high gloss. Fine particle size clays are referred as coating grade clays and high brightness 90-91% range now are avilable.

Calcium Carbonate

They increase the brightness and to a lesser extent opacity and tend to produce matt finish. The affinity of Calcium Carbonate pigment for oil is relatively high and are used to control ink absorbency. A desirable effect of porous coating structure is produced which is important in papers for web offset ptg. Since it facilitates the escape of moisture from base sheet. It should be avoided in case of papers intended for varnishing.

Advantages : Brightness, Opacity & high oil absorbency

Disadvantages : Does not finish to high gloss. Generally used 20-30 % of pigment in System. Large quantities can be troublesome in full finish printing.

Sat in White

Satin white is a reaction product of lime and alum and is found usefull in formulations for enamels because of its high brightness and ease of calendering to high gloss. Due to its high adhesive demand it is generally not used as sole pigment. In addition coating colours containing satin white with proteinacous binders tend to thicken on standing and also coagulate any latex that may be present. Its major use is in photographic papers where chemical purity is essential.

T_1O_2 :

It has high refractive index and therefore increases opacity and brightness. It has high binding power and even after waxing retains high degree of opacity. Both anatase and rutile forms of titanium find application in coating. Rutile grade has yellowish cast compared to bluish cast for anatase grades. If fluorescent dues are used, rutile grade should be avoided since they have high absorption in ultraviolet range and therefore reduce the effectiveness of fluorescent dyes. In general anatase grade will be economical for high brightness and high opacity whereas rutile will be more efficient for coating which will be partially or fully impregnated by oiling, waxing or varnishing.

Plastic Pigment :

The thermoplastic nature of plastic pigment easily produce high gloss papers of premium. Plastic pigments should be regarded as a family of hard, finely divided polymers. By varying the composition of particle size, a large number of different products can be made to meet specific needs of paper coating industry. For example, the 5 microns plastic pigment is designed to balance opacity, brightness and gloss. The 2 microns particle size grade opti-

mises gloss at slight sacrifice in opacity and brightness and 1.2microns enhances gloss ink and varnish hold out. All grades improve printing performance.

These are some of brief characteristics of minerals used in coating colour and their effectiveness in coated paper is described. The mineral matters are mixed with an adhesive to bind them to the paper surface. The function of adhesives in fluid or semi-fluid coating colour is to help carry pigments in dispersed condition, to govern or influence the flow behaviour. In dried coating the adhesive produces cohesion between individual pigment particles as well as adhesive between paper base and dried layer of coating. Finally, type of adhesive, the ratio of adhesive to coating pigment control the degree of absorption of printing ink and varnish in converting operations.

It should have high binding strength and good colour and produce coating surface which is highly receptive to printing ink. Offset printing requires high binder level to resist the pull of tracky inks used in the process. Letter press does not require as much binder because inks are less tracky Rotogravure would require the lowest binder level because the inks are fluid and have relatively little tack.

The binders mostly in use being casein, starches, various proteins such as Soyabean protein and various types of latics, Polymer dispersons have now gained a firm foot hold due to following reasons—

1. The film formed by polymer dispersons are flexible and extensively insoluble in water.
2. Favourable processing properties if coating color is low viscosity and high solid content.
3. Consistency and reproducibility of the properties of Polymer dispersions.

Primarily combinations of polymer dispersons and water—soluble natural binders are used. Water soluble binders are vegetable glue–Casein protein and starch and also include polyVinyl alcohal and carboxymethyl cellulose. In using binder combination it must be borne in mind that water soluble binders have great influence in rheological properties of coating colour while the polymer dispersions have only little influence in this respect.

The binder component which determines the coating colour concentration and pigment binding effect can be regarded as main binder and while the component which mainly has an influence on the rheological properties is often regarded as the co-binder. Today function of cobinder is usually fulfilled by water soluble binder. The flow properties of colour and properties of resultant coating are dependent on interplay between main binder and co-binder.

The viscosity of colour is not only influenced by type and amount of binder but also to a great extent by pH and solid content of coating colour. Following relationship can be observed :—

1. **Pick Strength** : The pick strength increases with binder proportion and amount of natural binder used.
2. **Oil receptivity & Oil absorbency** : The ink receptivity decreased with increasing binder proportion.
3. **Gloss** : The synthetic binders always have a gloss improving effect.
4. **Wet rub resistance** : It improves by addition of polymer dispersions.

Sole binders are increasingly replacing the conventional combination of Polymer and water soluble binder because of ease in preparing colour formulations and other advantages such as—

i) Lower viscosity of coating colour :

ii) High solid content and good flow behaviour :

iii) Improvement in coating properties i. e. pick strength, smoothness, water resistance, compressibility and flexibility.

The characteristics of other binders are as—

Casein : Good filming properties. Easily dissolved and handled good adhesive strength. Good pigment binding properties. Low specific gravity. Good adhesion to paper. Water proof fairly readily. Good calender finish.

Disadvantages : Characteristic odour. Foaming tendency, Fluctuation in cost. Susceptibility to insect infection. Susceptibility to spoilage. Brittleness and poor folding characteristics.

Glue :

Advantages : Good filming properties, Good adhesion to paper. Good pigment binding capacity. Easily dissolved & handled.

Disadvantages : Relatively high cost for glue. Water sensitive susceptible to spoilage. Brittle and folds poorly. Low solid content—18-20% at usable viscosity. Fluctuative in cost. Distinctive odour sometimes imparted to paper.

Starch :

Advantages : Does not impart colour to coating.

No. colour low cost. High solids solution can be obtained. Readily available. Dries easily.

Disadvantages : Poor adhesive strength than casein or glue. Water sensitive. Tends to dust on Calender. Does not produce high gloss on calendering adhesive properties are not additive when combined with casein.

Soya protein :

Advantages : Uniform cost and quality. Resistance to inset infection. Adhesive strength comparable to that of casein. Produces fluid coated colours.

Disadvantages : Colour darker than casein. normally requires more alkali than casein. Tendency to foam. Loss of strength when blended with other adhesive.

Polyvinyl Alcohol :

Disadvantages : Excellent colour. Excellent adhesive power. Can be water proofed. Coating flows readily. No cutting agent required for solubility. Good film forming properties. Forms flexible films. No loss of adhesive power when solution is stored.

Disadvantages : High cost. Low solid content at usable viscosity. Water sensitive unless water proofed.

CARBONY-METHYL-CELLULOSE :

Advantages : Excellent film former. Colourless odorless. Good adhesive to paper. Non toxic. Easily dissolved and handled. No alkali needed to solubilize. Good adhesive to paper.

Disadvantages : Difficult to water proof. Relative poor pigment bonding capacity. High cost. Low solid content at usable viscosity. Water sensitive.

AUXILLIARY INGREDIENTS OF COATING COLOUR

Commercial coating colours usually contain a number of minor ingredients, in addition to the adhesive & pigment, which are added for certain special effects. Among the material which may be added are the following :—

1. Dye stuff—to give desired shade.
2. Wax emulsions—to increase water repellency, to improve flexibility, to raise the gloss to reduce dusting during calendering.
3. Foam reducers—e g. Pine Oil, silicon oils, octyl alcohol etc.
4. Levelling agent—e.g. sulfonated oils, calcium stearate etc.
5. Dispensing agents—e.g. various phosphates etc.
6. Plasticizers or softening agent—e.g. Glycerine etc.
7. Water proofing agent—e.g. Urea Formaldihyde resins, Glycol, Formaldehyde resins, Glycol, Formaldehyde Ammonia resins.
8. Preservative-Borax etc.

COMMON COATING PROBLEMS :

1. **Specks** : Specks in the coating are due to improper filteration of coating solution.
2. **Streaks** : Streaks in a coloured coating can be traced to insufficient mixing or to selective settling after mixing. Excessive viscosity, which results in an uneven flow on coating machine is also a possible source of this defect.
3. **Scratches** : Scratches are based by particles under the knife or on the rolls of coaters. They are more likely to occur on Air knife type coaters, due to small clearances involved.
4. **Bubbles** : These may be caused by the air entrapped in solution by too rapid drying with excessive temperature & by the pin-holes in paper which may release air when coating solution is applied.
5. **Curling** : It may be caused by very low moisture content in the paper. Another cause is insufficient plasticizer in the formula which results in excessive shrinkage on drying.
6. **Blocking** : It is the term applied to sticking of coated side to the adjascent uncoated side in roll of paper or in a pile of sheets. It is caused by trackiness resulting from an overplasticized film.
7. **Blackening** : Blackening is a phenomenon resulting in excessive loss of brightness. It is caused by shifting of the coating during calendering, resulting in the formation of ridges & valleys in the final coating. High moisture content of the coated paper at the time of calendering, cause blackening.
8. **Fish eyes** : This may occur due to high fat content of casein being used as a binder.

Approximately 90% of all paper is printed by some means or other. The proper paper for a given printing depends upon the type of printing process, the type & method of drying the ink. Printability is dependent upon the optical, as well as the mechanical properties of paper. It depends on properties such as uniformity, ink receiptivity, com-

pressibility, smoothness, opacity and surface strength or resistance to pick and pH of paper. The various properties which effect printability are as under.

1. Ability of paper to be fed to the printing unit & delivered in flat condition.
2. Ability to maintain its dimensions within such limits as will permit good colour register.
3. Adequate pick resistance.
4. Ability to receive an acceptable ink impression.
5. Freedom from anything that can adversely affect the printing elements namely the offset blanket & plate.
6. Freedom from anything that can interfere with proper functioning of the ink.
7. Water resistance of coated surface,

Now after evaluating various properties of pigments and binder we come to very important aspect i.e. Printing which dictates coating formulation.

Letter Press Ptg : Process transfers relatively heavy layer of ink to paper. It is not necessary to use highly pigmented, heavy bodied ink. Medium pick resistance is required. However, increasing surface strength by use of higher and/or more efficient adhesive effect on ink transfer. Alkaline paper surface is desirable as the ink dries by oxidation.

Flexographic Printing : Process similar to letter press using plant of rubber with raised surface. The inks are dried in oven. The ink used is less tacky-surface requirement are not critical. Similarly pH requirement not critical unless pH sensitive dyes are used.

Offset : Ink transfer through blanket on paper is relatively thin, about half the thickness of corresponding ink film of letter press process. Therefore, it is necessary to use heavy bodies inks. Hence higher surface strength of paper is required and it also should exhibit adequate surface strength when damp. Actual level of strength required depends on specific print job involved. Printing large solid areas result in more stress than printing type matter only. Multicolour printing requires the use of inks with decreasing tacks for successive colours to give proper ink trapping in over a lapping areas.

Gravure Ptg. : The plate of gravure process has an image engraved in the form of cells recessed into the metal. These cells are filled with ink which is then transferred to the paper by direct contact. The quality of gravure ptg. requires adequate and uniform transfer of ink from recesses to the paper and therefore paper qualities are critical. The prime importance is smoothness of paper so that perfect contact is made with each cell. By making light contact around each cell, a vacuum is created when paper separates from plate and the ink is sucked out. Further paper should be absorbent so that gravure inks which are of fluid nature should be absorbed by paper. Coating must be formulated for correct level of absorbency. Solvent based gravure inks does not require sheet with high surface strength. However, paper should have lowest possible abrasive characteristics to avoid rapid wear of printing plates. Wear of printing plate will change the printing effectiveness and also scratches on plate will spoil printing results.

SCREEN PTG.: The ink is transferred through the open mesh of screen whose non-image area has been blocked out. Silk is common material used for this printing method and relatively heavy layers of ink are transferred in screen ptg. This together with flexibility of screen make unimportant the texture of surface to be printed. The heavy layer of ink will dry slowly so that paper has to be passed through heating unit. All the drying process make it important that paper should have dimensional stability and good oil hold out characteristics.

VARNISHING : Papers are varnished to increase the gloss and scuff resistance. Four techniques are used to achieve varnish hold out. Coat must be sufficiently high to ensure coverage of base stock to prevent penetration of varnish. Since many organic binders resist solvent absorption, coating to be varnished have relatively high binder level and have many points higher wax pick tests. Better varnish hold out can be achieved with fine particle size coating than coarses grades. Finally carefully controlled redistribution of adhesive in wet layer during drying is important. It is desirable to cause some adhesive to migrate to the surface. Since this will improve solvent hold out, on the other hand no point in the body of coating should be depleted to the level where coating will split under stresses applied during printing.

In the last I would like to enumerate the different uses of coated papers :

Uses of Coated Papers

Coated papers find a wide range of uses. A brief list of uses & fields of application of coated papers is given as under—

1. **Printing Trade**
   - — Catalogue covers
   - — Menu covers
   - — Advertising literature
   - — Greeting cards

2.	**Packaging**	— Box covers — Containers & Bags — Labels.
3.	**Display**	— Window, counter & booth displays.
4.	**House Hold**	— Shelf papers, lining for drawers Water proof table covers — Washable window shades — Washable wall papers — Lamp shades
5.	**Imitation leather on Paper base**	— Brief cases & bags — Photograph alums & scrap book covers — Novelty items such as combs cases etc
6.	**Industrial uses**	— Gaskets for special application — Electrical insulation — Adhesive papers.
7.	**Specialities papers**	— Special photographic paper; mica coated papers, laminescent papers, NCR papers, metallic papers.

This list is by no means complete, but serves to illustrate the wide variety of uses of coated papers.