Role of synthetic binder in pigment coating

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SUMMARY

This paper deals with the role and importance of synthetic binders in the pigment coating. The different varieties of synthetic binders commonly used and their effect on controlling the viscosity, rheology, water release, plasticization and other properties in process of manufacture of coated papers are discussed in detail. Apart from this, merits and demerits of use of synthetic binders against natural binders e g. starch and casein are also discussed. The anticipated practical problems and at the same time various factors responsible for their efficient and effective use are incorporated in the paper.

The individual synthetic binder has certain advantages and disadvantages for its application in coating, but it cannot be judged as a separate entity. Based on overall performance of synthetic binders it has been concluded that their use will have significant impact on improvement of the coating process and final products. And this ultimately will help to cope-up the growing demand of coated papers at the same time to fulfile the need of fast developments in printing technology. However further extensive investigations are required for optimum and efficient use of these synthetic binders.

The rate of growth in the demand of pigment coated paper has exxceeded the growth rate of total paper demand in developed countries. Even in the developing country like India demand of coated paper has increased significantly in the recent years. This has motivated the technologists for carrying out extensive study in various processes, chemicals and machinery for manufacture of pigment coated paper.

Many radical changes have been made in the last decades in paper coating process. The blade coaters in the various configurations have been installed both on and off the machine. Double and triple coating using various sequences of equipment which may include size press, roll, blade and air knife has commercially employed. Novel processes such as bubble coating, pigmentless coating and dry coating have been also developed.

Apart from the development in the field of coating machines, a very fast development in printing technology has also been noticed in the recent years. And in order to run the paper on newer printing machines e g. web offset printing etc. improved quality of papers are getting higher and higher demand. These fast and significant changes in the coating machinery and process and printing technology have forced the coating technologists to make the corresponding changes in the coating colour.

The binders have become the most important ingrediant in the pigment coating. Apart from the major role of binding the pigments to the sheet, the binders play a significant role in determining the various physical properties for coating and coated papers. The coating binders are mainly classified in two categories i. e. Natural Binders and Synthetic Binders. In this paper a few aspects of use of synthetic binders are mainly discussed in detail.

BINDERS IN PAPER COATING

Natural Binders

In the initial stages of development of coating, the animal glue was the only binder used. Animal glues are natural high polymer proteins and are derived from collogen which is the protein constituents of animal skins, connective tissues and

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bones. The glues have the ability to deposit continuous viscous film from water solution and ultimately provides the strong bond upon drying. The films are soluble in water and are resistant to oil, grease and non aqueous fluids. But due to inconsistent behaviour of glue at the same time heat drying of the paper coating adversely effect the binding strength in the pigment binding. Due to these reasons other natural binders like starch and casien have replaced the animal glues.

Starch

With the development of machine coating, where quick tack free coating surface is required after application, as coated web comes into the contact of drying drums of the paper machine immediately, starches have become the dominent binders. For machine coating, high solids level of coating is preferred so as to set the coating by removal of just small quantity of water, and as it permits the drum drying in its usual manner, since starches give lower viscosity at high solids it gets preference over other binders. In order to further improve the effectivity of starches they are chemically modified e. g. dextrins, oxidized starches, enzyme-converted starches etc.

Casein

Casein was first used commercially in coating paper around 1890. The type of casein used in paper coating is precipitated by skim milk by the addition of acids to about 4.5 pH at which casein is least soluble and is isolated. In developed countries, commercial grades of casein are named usually by country of origin and by the type of acid used to precipitate casein.

The following are the main characteristics of casein desired for paper coating :

— Easy dispersion and preservation
— No colour and odors
— Pigment dispersing power
— Strong colour acceptance
— Good flow and leveling
— Strong film forming
— Strong bonding to base paper
— Good finish after calendering
— Good ink and varnish holdout

Synthetic Binders

The paper coating industry has progressed to faster machine operations with coatings at higher solids levels and with this coating technologists are also forced to review and modify accordingly the coating colour. In this respect, development of synthetic elastomeric latices as binders in paper coating formulation is of significance. Casein and proteins have been used in combination with synthetic binders for pigmented coating. But in the recent years as the world population has increased, demand for high protein foods have caused substantial increase in the price of casein and protein. At the same time, particularly in developed countries, the prices of synthetic polymers have steadily decreased and can not be considered more expensive than the protein binders. With this importance of synthetic binders has increased significantly.

The synthetic binders being thermoplastic in nature, impart higher smoothness and gloss after calendering than can be obtained by starch or casein. They have got the other desirable properties to improve overall coating performance. Following types of synthetic binders are commonly used in pigment coating :

I. STYRENE-BUTADIENE LATEX

This is a major class of the pigment binding latex which is made by polymerizing concurrently at least two basic building blocks or monomers. Styrene, which when polymerized by itself gives a hard, inflexible thermoplastic polymer, and butadiene which by itself gives a soft, flexible elastic polymer. The changes in styrene-butadiene ratio have an effect on coated paper properties (Fig. 1). Normally 50 to 60% styrene content range is used for most paper coating latices as all the coated paper properties can be obtained in an acceptable range.

In the preparation of styrene-butadiene latices polymerization is usually initiated by peroxide compound such as persulfate salt. A chain transfer agent may be added to control the molecular weight of co-polymer. Buffer salt is added to control the pH. This affects the latex stability, residue and final properties such as binding power, blade runnability etc An electrolyte is used to regulate the particle size and to make the latex more fluid. A chelating agent is present to sequester for any undesirable metal ions and when the ingradiants are combined and subjected to agitation, polymerization process converts simple monomer molecules into chain like polymer molecules of very high molecular weights. In an emulsion polymerization, these chain like molecule form into colloidal particle which remain despersed in water.

Effect on Coating Colour Properties

It is to be noted that styrene-butadiene identifies a class of latex and that individual commercial product is not alike to other. Performance and properties of products are controlled by combination of starting ingredient and the conditions of

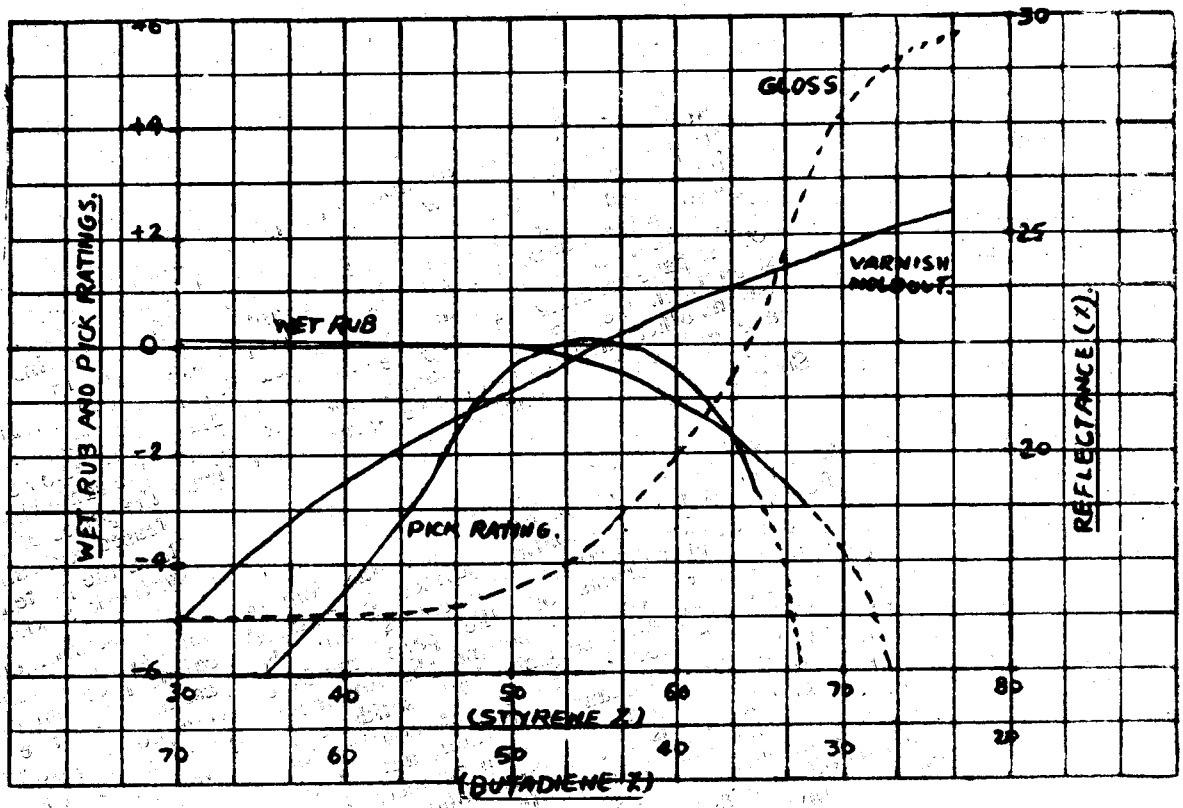

Fig. 1—Effect of Composition of Styrene-Butadiene on Properties of Paper

the polymerization. However, the main effect of use of these binders on various properties of coating colour is given below :

a) Viscosity & Rheology

The exact effects of latex addition on viscosity of coating mixture are not always predictable. This is due to number of variables such as types and number of pigments, co-binder additive, variation in pH etc. present in coating colour. In general, the replacement of casein or protein with latex allows the preparation of higher solids coating formulation. This ultimately results in the coating which are stronger and showing better picking resistance and glueability.

Latex can also change the rheological characteristics of formulation and results in improved application characteristics.

b) Temperature Stability

These latices are very stable mechanically, but they are affected to some degree by extremely high temperature. As many of these latices are powerful film formers excessive loss of water at higher temperatures, from high solid formations, may cause rapid skinning. These skins are not desperable even with high agitation. Hence, it is usually advisable to add latex when coating colour temperature is below 60°C.

c) Pigment Stability

These latices have excellent compatibility with coating pigments and other coating ingredients. However, certain specific conditions are to be maintained while using the different pigments and other ingredients. Otherwise, it will lead to incompletely dispersed or partial flocculated system which will cause running problems on coater, sticking or dusting on dryers and super-calenders

Effect on Coated Paper Properties

Most of these latices are highly individualistic in their performance and properties. However, their presence in general has significant effect on the properties and performance of dried coating. The extent of improvement will depend on the latex content of the binder.

a) Gloss and Smoothness

The thermoplastic and somewhat pressure sensitive nature of the synthetic latex usually give higher calendered gloss and smoothness than that

obtainable with natural binders. It has been observed that styrene-butadiene ratio of the latex has significant effect on gloss and smoothness development. The calendered gloss and smoothness obtained with high styrene content latices are probably due to the greater degree of thermoplasticity and correspondigly lower degree of elasticity.

b) Flexibility

Styrene-butadiene latex is a permanently flexible material which can act as plasticizer for any natural binder used in conjugation with it. This does not require moisture for flexibility. With higher flexibility of coated paper minimum will be dusting or cracking at the time of calendering, cutting and folding.

c) Gloss ink and Varnishability

Ink and varnish gloss is result of complex inter-relationships of several factors such as pigmentation, binder level, binder content, degree of migration, type of substrate, method of coating, degree of calendering and initial coating gloss. However, in general, styrene-butadiene provides significantly better gloss ink and varnish holdout than other binders.

2. POLYVINYL ACETATE

The introduction of polyvinyl acetate latex binders in paper coating was made in year 1955. The main factor for its acceptance as binder, for the coating of bleached board and folding boxboards, was its performance in producing coating with excellent gluing characteristics, high brightness and ink receptivity.

It is made by polymerization of vinyl acetate. Polymers having varying flexibility can be obtained through co-polymerization with a variety of other monomers such as vinyl esters or carboxylic acids etc. Polyvinyl acetate made by emulsion polymerization is termed as latex and it normally contains surfactants, stabilizers & catalyst. Polymerization is carried out at relatively low pressure in an oxygen free atmosphere. Important parameters are reaction rate, temperature, choice of surfactants and comonomers. These latices have generally mild odour and adjusted for nearly neutral pH by alkali prior to storage.

Effect on Coating Colour Properties

Mechanical and chemical stability of latex are important to ensure good performance, when coating mixture is applied under conditions of high shear. For this reason, considerations in selecting the most desirable addition point include mixing intensity, coating solids, temperature, pH, viscosity of the coating in the mixer and compatibility of successive addition. The high intensity of mixing at high solids can alter the performance of latices, subject to prolonged exposure.

Effect on Coated Paper Properties

a) Glueability

The most significant advantages of PVAc-bound coating gives excellent glueability. It requires lower set time compared to other binders. The Paper coated with PVAc are free from cracks and dusting on folding

b) Gloss

PVAc permits very low viscosity/high solids mixes for the trailing blade and air-knife coaters compared to other binders. An additional gloss can be obtained by simply being able to deposit higher solids coating by using PVAc in coating colour.

c) Ink Transfer and Receptivity

For good printing surface good transfer of ink is needed in the printing nip. PVAc coating are significantly more receptive to oil absorption as measured by ink test and therefore PVAc probably has a particular advantage. With regards to a mottle free surface where oil absorption relates to ink acceptance on a printing press.

d) Varnish holdout

With uncut varnish PVAc based coatings generally have superior varnish holdout and varnish gloss.

3. ACRYLIC BINDERS

These binders are being used for many years for pigment coating. The excellent shear stability, low odour and resistance to yellowing established these binders as primary binders for the first trailing blade coatings of the board. All the members of this class display outstanding resistance to light, heat and chemical degradation.

These are produced by emulsion polymerization method. In this method, monomers are suspended as droplets in a water phase by means of an emulsifying agent. The polymerization is initiated by free radicals formed by thermal decomposition of peroxy compounds or by redox system where a reducing agent accelerates the formation of free radicals. The polymerization ratio is controlled by factors such as the number of free radicals present, concen-

tration of emulsifier and monomer and temperature. Initiater and monomer may be added by batch charge on continually through the polymerization. The emuslions used as binders for pigment coating have a high molecular weight and size of 0.05 to 0.2μm.

Effect on Coating Colour Propertics

The acrylic emulsions are non inflammable, non toxic but slighltly corressive to iron, can be used with starch without the necessity of including a protection colloid as stabilizer.

The colour containing acrylic emulsion has a considerably lower viscosity than those in which casein or unmodified starch is used alone (Fig 2). The solid content of the composition can therefore be increased as the natural binder is progressively replaced, resulting in reduced drying co sts and faster machine speed.

Effect on coated Paper Properties

a) Gloss

Acrylic binders produces much high gloss on calendering than is obtainable with the conventional binder. The thermoplastic nature of the co-polymer leads to the more effective use of heat and pressure in allowing the pigment particles to move during calendering and thus the degree of gloss increases progressively with the binder content (Fig. 3).

b) Printability

The printability of the coated papers is considerably en-hanced by incorporating acrylic binding in coating colour. The thermoplastic nature of the co-polymer leads to improved smoothness after calendering this and good ink compatibility of resin results in more uniform ink receptivity.

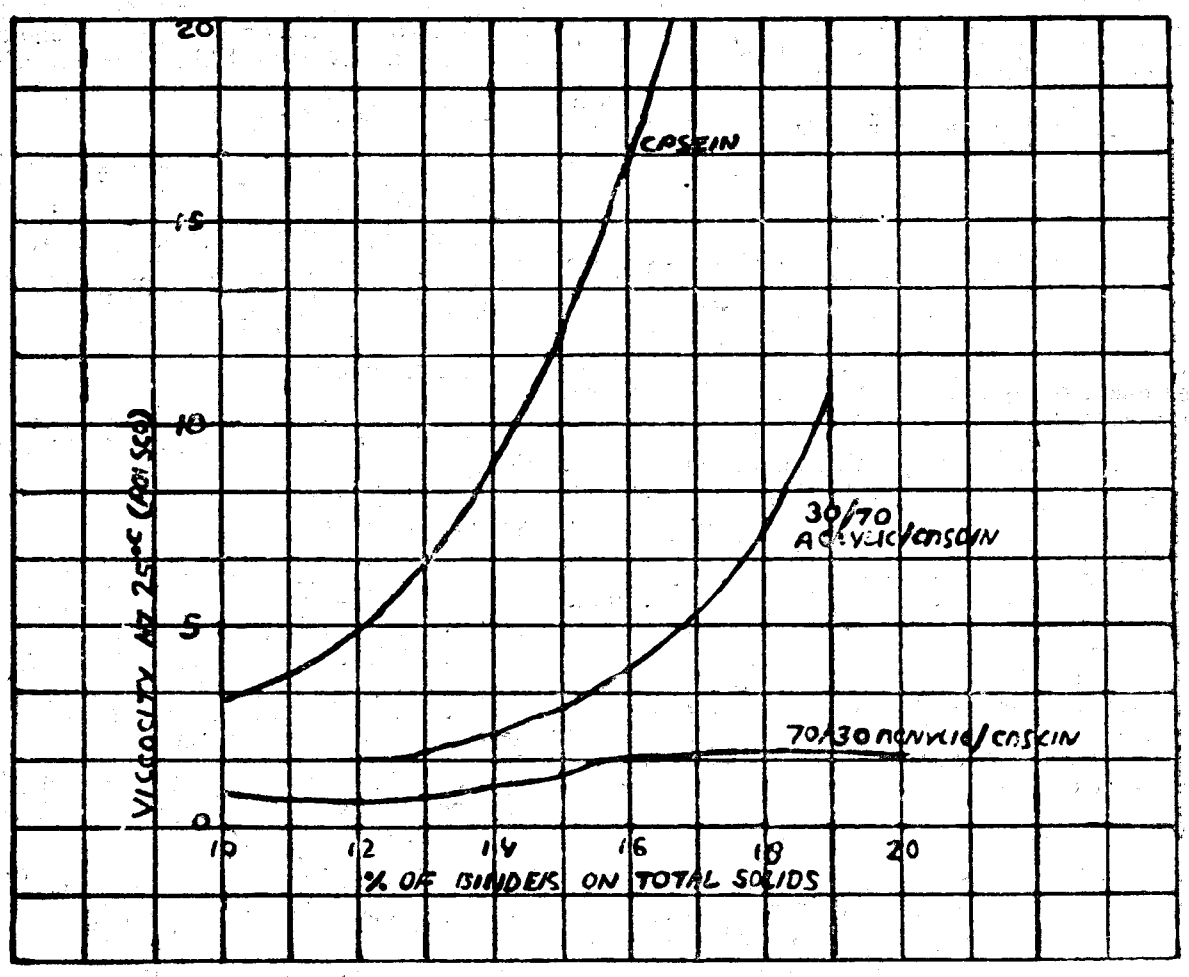

Fig. 2—Viscosities of Coating Mix At Different Binder Level

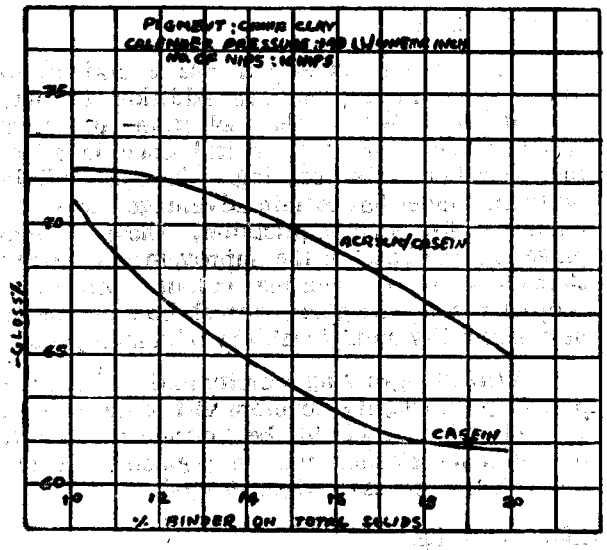

Fig. 3 – Gloss at Different Binder Level

c) Wet-Rub Resistance

It enables the papers to be produced with the wet-rub resistance required for lithographic processes without the undesirable rheological effects which generally accompany the use of auxillary materials.

4. POLYVINYL ALCOHOL

Polyvinyl alcohol is an unusually strong resin and displays excellent adhesive strength in bonding to the pigments, cellulose and other polar surfaces. It is an excellent film former and is by nature resistant to wetting by oils, grease and organic liquids. Due to all these advantages the use of this binder is restricted due to its high price compared to natural binder as well as other binders at the same time undesirable rheology in coating mixtures at high shear rates.

COMPARISION OF SYNTHETIC AND NATURAL BINDERS

The various advantages and disadvantages of use of synthetic binders are discussed earlier. However, in general the effectivity of synthetic binders compared to natural binders are given below :

	Synthetic Binders	Natural Binders
1.	These binders can be used as such as recieved and do not require cooking.	Starch and other natural binders require cooking with dissolving chemical.
2.	Lowers the viscosity of coating colour so that higher solids can be used. This complies the requirement of new developments in coating machinery.	Protein binders tend to increase the viscosity hence do not permit the use of higher solids in coating colour.
3.	Due to the thermoplastic nature dusting on supercalender is reduced and coating is more flexible.	Starch and proteins tend to give hard brittle films which are not continuous, it is difficult to get high finish by calendering, cracking and flanking occur when paper is folded.
4.	Wet rub resistance for offset paper increases with their use.	Wet rub resistance is poor in coated paper.
5.	Due to better film formation tendency varnish holdout is very good with most of the binders.	Comparitively poor varnish holdout.
6.	Gloss and smoothness are easily obtained during calendering.	Difficult to get high gloss and smoothness during calendering.
7.	Paper coated one side have tendency for less curling due to better dimensional stability.	The dimensional stability is poor and papers coated one side have tendency to curl.

The following problems have been encountered while using synthetic binders :

1. The brightness and opacity tends to decrease on heavy calendering. This is because of thermoplastic nature.
2. The surface exposed to air forms skin and has tendency to yellow on ageing.
3. The costs of synthetic binders are very high in our country which affects adversely overall economy of coating particularly when they are used in higher proportions.
4. These binders have very poor water holding properties which ultimately creates problem of binder migration. In fact binder migration term is applied to movement or redistribution of binders within the coating layer after the layer is applied to the moving web. This may ultimatly cause the serious visible defects such as dryer streaks, surface and ink mottle.
5. Too high proportion of synthetic binders in the colour gives sheet which is limp, hence these binders can not be used as sole binder.

DEVELOPMENT IN SYNTHETIC BINDERS

Competition is very tough in synthetic binder sector and developments are being steadily made, since no single product can answer all requirements. There has been much work done to modify the latex to over-come the various problems mentioned above.

The effects have been made to develop Acrylic/ Vinyl acetate binders which are alkali reactive. These dispersion polymers swell well under alkaline conditions and this swelling action yields thixotropic and pseudoplastic flow properties Because of their desirable rheological and water holding properties these binders can be used as sole binder. These binders can also be used in combination with other binders thus providing the paper manufacturers a high degree of latitude in formulation.

Recently the modification of styrene-butadiene latex has also been reported. A range of alkaline thickenable carboxylated styrene-butadiene has been developed, which give better binding performance.

A new coating binder carboxytated polyvinyl acetate, particularly for wet-offset paper has been developed which is high blister resistance, so that it can be calendered at increased humidity, thereby giving improved smoothness and gloss.

CONCLUSION

The pigment binder performs several important function in coating process in addition to binding the pigment. Hence, the selection of pigment binder is one of the most critical aspect in selecting the ingredients for coating. Though individual synthetic binder has certain advantages and disadsvantages for any application, these should be judged on the basis of the improvements gained in characterstics of coating colour, process and properties such as gloss, varnish holdout, smoothness, flexibility and glueability of coated paper.

With the growing scarcity and price hike of protein products, the development of more effective synthetic binders should be considered for their optimum and efficient use in pigment coating to improve the process and paper quality.

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