Loading and Filling - Science and Art

MOHANA RAO, G*

SUMMARY

Filler pigments improves the properties of paper when used in proper proportion. Optimum filler pigment content in paper and its retention is very important both for economy and for efficient utilisation. Improved methods and use of retention aids would help in increasing the retention of filler pigments.

KEY WORDS

Loading, Ash, Pigment, Retention, Optics, Functional performance, Refractive index, Sensitive to flocculation, Physio-chemical and mechanical factors, Hydrodynamic collection, Electostatic cementation, Colloidal effect, Formation.

*Senior Chemist, The Sirpur Paper Mills Ltd., Sirpur Kaghaznagar, Andhra Pradesh.

INTRODUCTION

Swelling costs of materials, machinery and manpower, and the selling prices of finished product are not,

in agreeable proportions, these days. This is particularly so with Paper Industry. The profitability of paper industry is low comparatively—as against 9.7% of profits for industries as a whole, the profits in paper industry comes to about 3.00% (as reported by a study group few years back). Technologists in Pulp and Paper Industries are seriously concerned about it and are working to reduce the cost of production at every phase of manufacture by optimizing the conditions, primarily through improved methods and some times by installing improved equipment. "There is always a better way of doing a job" is the philosophy and Higher Productivity is what has oriented their thinking.

For instance loading and filling in paper-12 to 15% ash in paper would replace as many tons of parent pulp at approximately one third cost (at 55-60% filler retention). Filler pigments are of many kinds, some of them are very expensive. Optimum filler pigment retention is very important both for economy (lowering input values) and for effective utilization.

Understanding the phenomena of retention of fillers and their optics in paper making systems is very important (a review on the subject is necessary).

The process of adding finely devided mineral pigments to paper stock prior to the sheet formation is age old. Initially it was considered a poor practice and adulteration of paper. Soon it was discovered that the process of 'Filling' and 'Loading' is highly beneficial, since the presence of filler pigments improves the properties of paper when used in proper proportion. As a matter of fact, it is impossible to make certain grades of papers without the use of fillers. Since they increase the opacity, brightness, smoothness/finish and for excellent ink receptivity and printability. Pigment filled papers are denser, heavier and pitch trouble is less experienced in paper stocks. The papers have improved feel and appearence. Fillers, also improve absorbency of papers, decrease linting, central capillarity and porosity.

With the demand for pigment filled paper, the number of available fillers has increased drastically in the last few years, with greater optical efficiency (opacity and brightness). Talc, clay, titanium dioxide and calcium carbonate are principal filler pigments in Indian Paper Industry. Besides these Robert [1] dealt on 25 fillers and filler types that are commercially significant barium sulfate and lithopara, zinc fillers, calcium sulphate and related calcium base fillers, titanium dioxide composit fillers pigments, diatomaceous fillers, asbestos, hydrated alumina, synthetic silicas and silicates.

Earlier the fundamental parameters of selection used to be optical properties and cost. However, in addition to optics and cost, filler pigment selection is also based an functional performance with specific reference to the end use of the paper and paper Board.

Willets [2] states that a perfect filler would probably have the following characteristics.

1. It should have a reflectance of 100% in all wave lengths of light.
2. It should have a very high refractive index.
3. It should be free from grit or extraneous matter and have a partical size distribution close to 0.3 μ m, approximately half the wave lengths of visible light.
4. It should have a low specific gravity and be soft and nonabrasive.
5. It should be able to import to paper a surface capable of taking any finish from the lowest matte to the highest glass.
6. It should be chemically inert and insoluble.
7. It should be completely retained.
8. It should be reasonable in price.

Probably, a perfect filler pigment will never be available. While talc and clay are not so prohibitive in cost, Titanium Dioxide is expensive and Calcium Carbonate has its limitations, since it must be used in alkaline conditions.

FEW TYPICAL PROPERTIES OF SOME FILLER PIGMENTS [3]

	Clay	Talc.	Titanium dioxide	ppt Calcium carbonate
1. Brightness, %	75–85	Upto 90	98	95
2. Referactive index	1.56	1.57	2.55 to 2.7	1.56
3. Average particle size, μ	0.5–1.0	1–10	0.30 to 0.35	0.2–0.5
4. Valley Abrasion, Mg wire loss	15–20	——	20–30	0.6–4.0
5. Sp. Gr.	2.5–2.8	2.7	3.9–4.2	2.7–3.0
6. Solubility, gm/1000 in water	negligible.	Neg.	Neg.	0.0014
7. Solubility in dil. acid.	,,	,,	,,	Soluble

TALC

Talc, a hydrated magnesium silicate with approximate formula $H_2Mg_3(Sio_3)_4$, is the most common filler in Indian Paper Industry. It imparts a characteristic soapy and greasy feel to paper. Also it improves sheet formation.

Talc frequently contain relatively coarse material and varies greatly in Calcium content. High Calcium talcs are whitest, but calcium is harmful to sizing and certain dyestuffs.

CLAY

Clay meets most of the requirements of a good filler pigment, except high refractive index and hence best preferred. Water washed clays are very good, for their fine color and particle size. Air separated clays are cheaper than water washed clays.

TITANIUM DIOXIDE

Titanium dioxide is the most expensive filler pigment, but ranks more important among the pigments. Only a fraction as much titanium pigment as clay is needed to produce the same opacity particularly in light weight papers. According to Robert Mays, titanium dioxide is sensitive to flocculation into dense aggregates in filler applications, hence it is not possible to maintain optimum spacing of the titanium dioxide particles in sheet. However, it has been possible to improve the scattering power of titanium dioxde in combination with spacer or extender pigments. By combining titanium dioxide with extender fillers, it is possible to maintain the filler cost at reasonable level, in the manufacture of speciality papers.

CALCIUM CARBONATE

Precipitated calcium carbonate is high in purity, brightness and has controlled particle size, shape and is less abrasive. Though calcium carbonate is a very good filler pigment, its use has been limited due to its high reactivity with acid furnishes. Precipitated calcium carbonate is the primary filler in Cigarette Papers, where particle size is critical in order to regulate burning rate.

STRENGTH PROPERTIES

Dispite their beneficial effects, filler pigments impair strength properties of paper. The mechanism is to a great extent unknown. Schott ([4]) observed at a certain level of filling with clay, breaking length, tensile strength and burst factors fell by 5–10% and tear factor and wet breaking length increases by 20–30%. The loss of strength of properties occur presumbly;

(a) If the adhesion between filler particle and cellulose fibre were weaker than the adhesion between two cellulose fibres, particles caught in the area of contact between two fibres will reduce the strenght of that interfibre bond,

(b) Alternately, the particles might reduce the bonded area of paper by interfering with fibre shrinkage and matting during drying; or

(c) Filler particles, by preferentially absorbing hemicellulose might prevent these materials from strengthing the web.

Talc does not reduce strength as much as clay and titanium pigments has little or no effect when used upto 6%. However, great many varieties of paper can be manufactured at 12–15% ash on paper, provided the bleached white pulp possess viscosity around 10 c.p. (0.5%, C.E.D.) while meeting the Indian Standard Specifications.

RETENTION

Efficient utilization of filler pigments is most important. Casey ([5]) gave excellent review of filler retention.

The mechanism of filler retention depends on a combination of physio-chemical and mechanical factors which play an important part not only in holding the filler in the web but in efficient white water recovery and reuse.

In the colloidal or coflocculation theory, where the filler particles and fibres coflocculate under the influence of long range surface forces and the particles are then held to the fibre surface by similar force. If only fibre and filler are present in the stock going to wire, the retention is mechanical, because both fibre and filler carry the same negative charge. There will be no electrostatic cementation, flocculation or coflocculation.

Dale ([6]) studied the importance of Colloidal forces in the retention of titanium dioxide pigment particles. He noted that pre-sheet formation retention is of major importance in pigment retention. Presheet formation retention and retention of free particles during sheet formation are both found to be the functions of an apparent hydrodynamic collection efficiency.

RETENTION AIDS

Solid particles are retained by mechanical filteration of particles by the fibre mat. The filteration can be made more efficient by co-flocculation of the particles upon the fibers with the help of retention aids.

Alum is the oldest retention aid. Its action is similar to that of most of the highly cationic starches, high molecular weight polymers ([7]). All these have a colloidal effect on the filler resulting in improved

retention of filler pigments. In addition, these cationic agents tend to act as a positively charged electrostatic cement, binding negatively charged filler to negatively charged fibre. Britt, K.M. ([8]) made specific study in this regard, on the effect of surface change of Zeta potential.

EXPERIMENTAL

With the increasing use of titanium dioxide in various grades of papers and boards (in our mills), particularly in light weight papers and board liner furnishes, where the head box and vat consistencies are low, we are posed with the retention problem of this expensive pigment. After a great deal of study we broke through in our endeavour and improved the retention of titanium dioxide by about 35 % (as mentioned earlier this is mainly through improved methods).

Further overall retention of little over 10 percent has been achieved in the case of the other filler pigments also using a certain very effective retention aid at a throw away price. However, retention aids must be cautiously used with thorough knowledge. Unless used judiciously they tend to floc the whole system adversly affecting the sheet formation. In case of excessive flocculation, the filler pigments are apt to loose optical efficiency, too.

CONCLUSION

It is important to understand the functional performance of filler pigments, before they are choosen for use, keeping the end use of product in view.

A study of pre-sheet formation phenomena of filler pigment particles in very necessary for effective utilization and optimum retention.

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