Studies on the Varnishability of Paper and Board

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SUMMARY

Varnishing of Paper and Board is done to protect them from environmental contaminations and also for ornamentation. Physical and Chemical characteristics of papers to be varnished along with chemical composition of the varnish governs the varnishing characteristics of papers. In this paper, an attempt has been made to evaluate physical characteristics of paper such as Porosity, Smoothness, gloss and oil absorbancy with respect to its suitability for varnishing with the help of a quick drying overprint varnish.

INTRODUCTION

Varnishing of paper and board may be defined as an application of varnishing chemicals on the surface of paper or board to give them protection from environmental contaminants with an improvement to gloss. Varnishing is also done for the improvement of the functional properties of paper or board such as abrasion and chemical resistance.

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A thin layer of quick drying varnish in fluid state is applied on the surface of paper or board with the help of a varnishing machine. This thin layer of varnish is transformed into adherent resistant film after drying which protects the surface.

PHYSICO-CHEMICAL PROPERTIES OF VARNISH

Phenol formaldehyde resin or the reaction product of a resin and drying oil are dissolved in suitable solvent or dispersing agent to get a clear liquid which is known as varnish. The viscosity of the varnish fells within the range of 2 to 3 poise (1) and when it

is exposed to air in the form of a thin film, gives glossy and hard film after drying. As these are unpigmented liquids they are less resistant to light as compared to paints, enamels and pigmented lacquers, but they produce a transparent film which accentuates the textures of the surface coated. Varnishes are classified broadly into two categories :

(i) Oil Varnish and
(ii) Spirit Varnish.

OIL VARNISH

Oil varnish contain resins, drying oils, driers and thinners. Resins are used to provide the hardness, gloss and chemical resistance to the film. Commonly used resins are pure and rosin modified phenolics, copals etc. Elasticity, toughness and durability to the film are provided by drying oils. Varnish linseed oil, tung oil, dehydrated castor oil etc. are commonly used for the purpose. Dryers (Naphthanates and Octates of lead and cobalt and manganese) are used for regulating the drying of film also they catalyse the conversion of the oil to solidified from. To adjust the concentration of the varnish thinners are used. White spirit, dipentene, naphtha and xylol distillates and other petroleum hydrocarbons are used as thinners.

SPIRIT VARNISH

Spirit varnishes are solutions of resins in solvents like industrial alcohols, hydro-carbons and methylated spirit etc. Commonly used resins are shellac, soft monila, oxidized rosin, phenol, urea formaldehyde, copal esters, modified phenolics etc. Some slip additives and waxes are also present. Rosin content of the spirit varnishes are generally more than 45%.

INFLUENCING PARAMETERS BEHIND VARNISHING CHARACTERISTICS OF PAPER/BOARD

An attempt has been made in this work, to review critically the relevant literature information so as to identify the physicochemical parameters which control the varnishability of paper/board. Since varnishability is affected due to variation of properties of base paper as well as variation in coating formulation of coated paper, studies were undertaken to evaluate the varnishability characteristics with reference to

(i) Uncoated paper/boards as well as
(ii) Coated paper/boards

UNCOATED PAPER/BOARD

Varnished papers are used for a number of purposes. Requirement of base papers, which are coated with the varnish, depends upon physico-chemical properties governed by the specific treatment it reccived during preparation. Papers which are to be varnished, must possess good varnish receptivity and gloss hold out. Papers which permit the varnish to penetrate into the sheet becomes transparent and blotchy, in other words when a particular paper is said to be poor in varnishability it implies either non-uniform take up of varnish over the whole sheet surface or absorption of higher amounts of varnish as compared to minimum requirement for good varnishing. Hence optimal penetration of varnish is to be achieved by carefully controlling certain physical as well as chemical parameters of base papers. Varnished papers which are used for food closures and electrical insulations etc. are coated with Baking varnish and are baked at about 140 to 160°C for about 1 to 2 hrs. In these types of papers fiber embrittlement at elevated temperature is of paramount importance, which is governed by base paper pH[2]. Modified weller test reported by Ryan[3] as flexibility and heat resistance index test appears to be a reliable method of measurement for the specification of such papers. Experimental investigations carried out by Ryan indicate good correlationship between the Gurley density and flexibility index test, both being inversely proportional to amount of varnish absorption.

Printed papers or boards are varnished with overprint varnish where application of varnish on the surface of paper to get a particular gloss is an important factor. This is governed by the factors as mentioned below :

(i) Physical properties of papers/boards like porosity, smoothness, gloss etc.

(ii) Chemical properties of papers/boards like varnish receptivity and hold out.

(iii) Gloss imparting properties of resins used in varnish.

Conventional paper tests such as thickness, apparent density, strength, finish, water absorbency, ash and moisture etc. are carried out for almost all grades of paper. These tests indicate good amount of information with regards to certain qualities of paper, but they do not evaluate the paper with respect to its varnishability. It seems, there is no reliable standard test which can indicate varnishing characteristics of paper. Albert[4] made certain studies on the varnish penetration and found that :

(i) Varnish penetration into absorbent papers is lineerly related to the penetration of these papers by caster oil, sperm oil and some other motor oils.

(ii) Penetration of absorbent papers with a given phenolic resin varnish is inversely proportional to the viscosity of the varnish if diluted with alcohol.

While the absorbency data with regards to caster oil, sperm oil or motor oil furnish good amount of information regarding varnishing characteristics of absorbent paper, they do not correlate well with the resistance of the paper/board to oily varnishing chemicals of high viscosity.

According to experimental investigations carried out by Horsey[5] it is possible to have considerable difference in oil resistance between samples when tested with high viscosity oils, but little difference when tested with low viscosity oils. These investigations indicate the need for standardization of

oil absorbancy test with different oils, depending upon viscosity range of varnishing chemicals used.

A sheet of paper or board may be considered as a capillary system of interconnecting pores, which consists of interfiber as well as intrafiber pores.

During its penetration, the fluid applied on the paper surface, must pass through this system of capillary pores. There is a pronounced effect on capillary suction due to changes in pore diameter, and consequently porosity is an important factor controlling the penetration of varnishing fluid to paper surface. It is reported(6) that a variation in pore diameter between 1 and 30 microns is equivalent to variation of capillary suction from 3,000 to 100 cm of water pressure at zero contact angle.

The thickness of paper/board is another factor which determines the time required to penetrate completely through the paper. Larocque(7) reported that the resistance of paper to penetration of oily vehicle varies as the square of the sheet thickness.

With the help of washburn's equition which governs the law of fluid flow through the cabillary tubes, the phenomenon, penetration of varnish into the surface of paper/board may be expected to follow the following equation :

$$l^2 = \frac{r\,\sigma\,\mathrm{Cos}\theta\, t}{2\mu} \quad \ldots\ldots\ldots\ldots (1)$$

where l = depth of liquid penetration, cm
r = pore readius, cm
σ = surface tension of petrating liquid, dynes/cm
θ = Contact angle
t = time of penetration, sec, and
μ = Cofficient of viscosity of liquid, poises

The equation (1) on differential form, is equal to

$$\frac{dl}{dt} = \left(\frac{\sigma}{\mu}\right)\left(\frac{r}{1}\right)\mathrm{Cos}\theta \quad \text{——————} (2)$$

Of the five variables, which determine the rate of penetration of varnish into paper surface, two (surface tension and viscosity of the penetrating fluid) are fixed by varnish, while the variables (radius and length of the pore) are governed by the Paper Makers product i.e. substance value, deasity, porosity etc. of the base paper. $\mathrm{Cos}\theta$ is determined by the degree of sizing of the uncoated base paper or coating formulations of coated base paper.

The equation (1) after rearrangement becomes :

$$\frac{1}{r} = \frac{\sigma\,\mathrm{Cos}\theta}{2\mu}\,\frac{t}{l^2} \quad \text{——————} (3)$$

If the type of varnish and the grade of base paper is kept constant i.e. if σ, μ and $\mathrm{Cos}\theta$ are kept unchanged, the equation is converted into the following form :

$$\frac{1}{r} = K\frac{t}{l^2} \quad \text{——————} (4)$$

where K = constant $= \dfrac{\sigma\,\mathrm{Cos}\theta}{2\mu}$

Assuming porosity of paper sheet be proportional to its effective pore radius, the following expression is obtained from equation (4) :

$$G = KK^1\, t/t^2 \quad \text{——————} (5)$$

where K^1 = proportionality constant
G = Gurley density

Equation (5) indicate, that, for a particular type of base paper (coated or uncoated) and varnishing chemicals, there is a linear correlationship between Gurley density and degree of penetration of varnishing fluid. Validity of this linear relationship has been substantiated by the experimental investivations carried out by Albert(4) who obtained linear data for paper having gurley air resistance between 10 to 150 seconds.

COATED PAPER/BOARD

Most of the coated papers or boards are varnished with overprint varnish. In these papers, type and amount of pigments and binder used for coating governs the varnishing characteristics. Moloney(8) Woodward(9) stal, Lyons(10) indicated the importance of particle size of clays for the production of varnish resistant coatings and showed that, clay finer than 2 microns in diameter produced paper coatings having greater gloss and hiding power with fewer surface voids, than larger particle size clays. Rice(11) presented data indicating beneficial effect of Titanium dioxide and optimal level of adhesive addition for the production of high varnished brightened paper, Hall etal(12) reported pronounced receptivity of calcium carbonate (precipitated grade) towards printing ink and varnish due to its organophilic character.

CONCLUSION

Scanning of literature in the field indicates insignificant amount of informations relating to optimal operational data of the base paper for the improvement of varnishability of the paper or board. Most of the reported literature is confined to the effect of particle size in coating formulation and there is scanty published work in the field of base paper analysis with regards to varnishing characteristics.

Therefore, there is a strong need to initiate investigations in the field of varnishability of paper and board with the following objectives :

(i) To identify the fonctional parameters of the base paper.

(ii) To evaluate the optimal range of the influencing parameters of the base paper, which control the varnishability of paper.

(iii) To optimize the coating formulation with particular reference to varnishability of the paper.

Based on the literature survey and its critical assessment, the following conclusions may be made :

a. Overprint varnishing characteristics of paper or board is not directly related to the physical characteristics of base paper like moisture, pH and strength etc.

b. Physical factors of base paper such as porosity, smoothness and gloss are the controlling factors and accordingly must be maintained within optimal range for the improvement of Overprint varnishing characteristics.

c. Receptivity of base paper with respect to absorption of varnishing chemicals as well as its resistance to higher penetration is correlated to Gurley density within certain operational range.

d. For paper coated with baking varnish and heat resistance index in conjunction with Gurley density and pH value, gives reliable indication with respect to its actual performance during varnishing.

e. Oil absorbency of base paper may be utilized as an indication of varnishing characteristics of paper/board.

f. Size and nature of the pigment in coating formulations offers pronounced effect on the requirement of adhesive, development of opacity, gloss and consequently varnishability of coated paper.

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