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Indian Commercial Paints—Consistency and Other Related Properties

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Data on flow properties of Indian Paints have not been systematically determined. This paper describes the flow properties together with other related properties of some commercial paints available in the country.

Specifications for paints usually include limits of consistency as determined by the usual viscosimeter or flow cup. This aspect of control of quality of paints is currently engaging a number of testing laboratories in India. The plastic viscosity data presented in the preliminary investigation in this paper have been obtained by using rotational type of viscosimeter; and efflux type viscosimeters have been used to measure the consistency in arbitrary units. The investigation has been carried out on a variety of commercial paints both interior and exterior, wall paint, etc. It is hoped that such data when corroborated by other research workers in the field, will serve as a basis for revising the test for consistency in the existing Indian Standard Methods of Test for Ready Mixed Paints and Enamels (IS : 101-1950).

This paper is published with a view to increasing the awareness of the consumer regarding the quality characteristics he should expect from a particular paint — *Ed.*

INTRODUCTION

CONSISTENCY is that property of a material by virtue of which it resists permanent change of shape, and is defined by the complete force-flow relation. This is the widely accepted definition of consistency as given by Bingham[1], covering both the Newtonian and the non-Newtonian liquids. Paints belong to that class of non-Newtonians which exhibit plastic flow and hence, unlike Newtonians, their consistency cannot be measured by a single numerical quantity but is described by two independent variables (plastic viscosity and yield value), each of which must be evaluated to give a complete picture of the flow characteristics. In the Indian Standard Methods of Test for Ready Mixed Paints and Enamels (IS: 101-1950), the clause covering consistency is as follows:

> '7.4 **Consistency** — The material shall be in such a condition that stirring easily produces a smooth and uniform paint suitable for application by the method specified in the detailed standard'.

This definition appears to be empirical, it does not suggest any instrument for the measurement of consistency. In this connection it may be mentioned that although the American Society for Testing Materials (ASTM) have not given the limits of consistency of paints, they have specified the use of the rotational type of viscosimeter (Stormer viscosimeter)* for its measurement and have also recommended the use of the Ford viscosity cup†. Data on flow properties of foreign commercial paints are available in the literature, but no such data, as far as is known, is available on Indian commercial paints. In the present work, the flow properties together with other related properties of some commercial paints have been investigated with a view to collecting factual data.

*ASTM D 562-47 Method of Test for Consistency of Exterior House Paints and Enamel-Type Paints.

†ASTM D 1200-54 Method of Test for Viscosity of Paints, Varnishes, and Lacquers by Ford Viscosity Cup.

EXPERIMENTAL

Two methods for the measurement of consistency, viz, the single point and the multiple point methods of measurements, are in vogue. The relative merits and demerits, as well as the arguments for and against either method, have been elaborately dealt with by Green[2]. The different instruments, used for consistency measurements of paints, can be grouped under two heads: (1) the efflux type and (2) the rotational, viscosimeters. Out of the two widely used efflux type instruments — the flow cup (Ford cup) and the Gardner mobilometer, the former, though found good for control purposes in many factories, is unsatisfactory, as it affords only a single point measurement. However, with the Gardner mobilometer, a consistency curve can be prepared by adopting the multiple point method and the uniformity of consistency of paints can be investigated by the nature of the curve — its linearity indicating the uniformity of consistency. The Stormer and MacMichael viscosimeters are two examples of the rotational type of instruments. By adopting the multiple point method, the double consistency curve can be prepared, and the consistency characteristics can be evaluated from the hysteresis loop. In the present investigation, the consistency curves have been prepared by using Gardner mobilometer and the double consistency curves by using the MacMichael viscosimeter.

In order to carry out this study, samples of commonly used commercial ready mixed household paints were obtained from leading Indian paint manufacturers (five firms). The samples investigated consisted of a variety of paints ranging from matt to high gloss finish, paints for wood work and steel, for interior and exterior use; wall paints, etc. The shades of the samples were green, grey, white, buff, chocolate and red.

TESTING OF SAMPLES

The following tests were carried out on all the samples.

Flow Properties

a) *Single Consistency Curves*—The mobility of the samples was measured by the Gardner mobilometer at 25° ± 0·5°C in seconds. The time for travel of 10 cm under 100 g load was noted. (This is one mode of expressing the mobility, in arbitrary units.) Next, the time for 10 cm travel under different loads was determined, and the results expressed as time-load curves. Figures 1, 2 and 3 show the single consistency curves for three groups of paints.

b) *Double Consistency Curves* — The double consistency curves were

prepared by the Pryce-Jones[3] method using the MacMichael viscosimeter.

In the present investigation wire No. 34, with 1 cm dia plunger submerged to a depth of 3 cm was used. All measurements were carried out at 25°±0·5°C. For two samples (No. 4 & 8) showing higher viscosity, wire No. 30 was used in place of wire No. 34. For this reason the values for these samples have not been taken into consideration either in preparing the hysteresis loops or in comparing the results with other samples. The speed of the cup was varied from 10 to 40 RPM. The hysteresis loops were prepared by plotting RPM against deflections. Hysteresis loops for different groups of paints are shown in Fig 4, 5, 6 and 7. The intercept made by the down curve multiplied by the instrument constant gives the yield value of the sample.

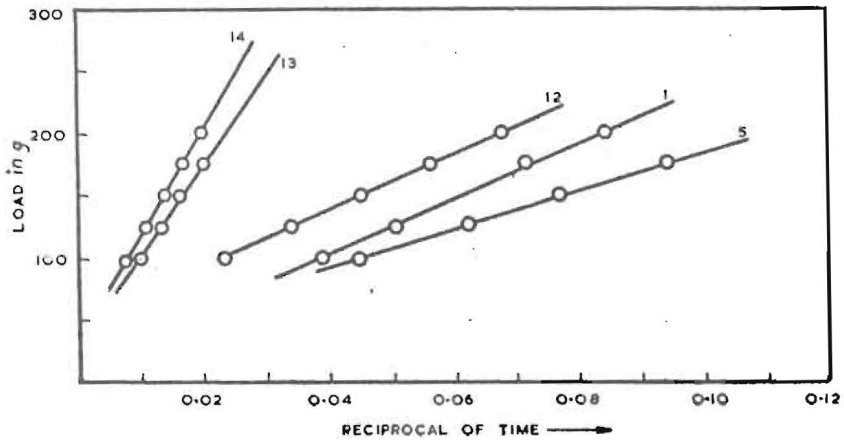

Fig 1 Consistency Curves of Green Paints

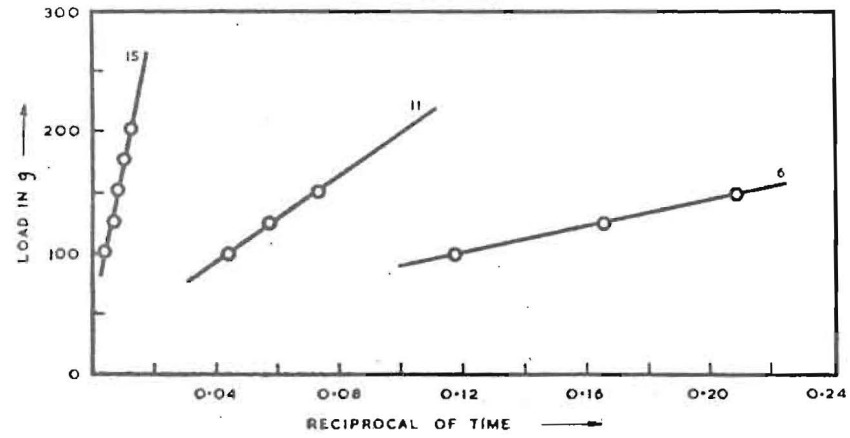

Fig 2 Consistency Curves of Grey Paints

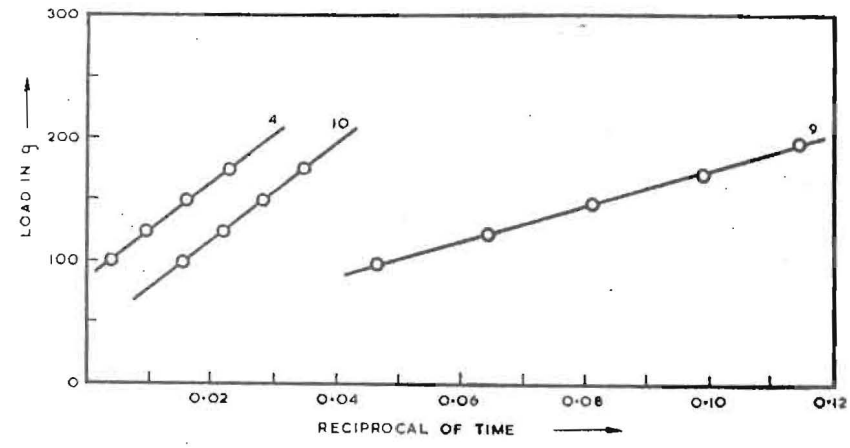

Fig 3 Consistency Curves of White Paints

Other Properties

Pigment and Oil Content — These were determined by the method given in IS: 101-1950

Gloss — 60-deg specular gloss was measured by the gloss-meter and the samples classified as high gloss, semi-gloss and egg-shell finish in accordance with ASTM D523-51T Method of Test for Specular Gloss (*Tentative*).

Drying Time — The drying time was measured by using a circular drying time recorder. Several stages of drying, viz, the surface, set-to-touch and the hard dry time, can be recorded — e.g., in Fig 8 and 9 the various stages of drying for sample numbers 11 and 1 respectively are shown.

Surface Tension — This was measured by the Dunoüy's Tensiometer.

Brushability and Levelling — Qualitative evaluation of these properties by brushing and samples reported as good, fair and poor.

DISCUSSION OF RESULTS

The test results are given in Table I.

Flow Properties — In general the plastic viscosity of the samples, with one exception (sample 4), was found to be less than 4·0 poises, and the yield values less than 400 dynes per sq cm, with two exceptions, namely samples No. 4, paint for timber, and No. 8, a flat wall paint. Fisher[4], in a similar work, has reported the plastic viscosities to be less than 4·0 poises with an occasional exception. The results of the report of an extended investigation[5] give the limits of plastic viscosities as 0·9 to 5·0 poises with one exception, and yield values less than 500 dynes per sq cm, except for a flat paint which had a yield value of 1,300 dynes per sq cm.

Figures 1, 2 and 3 show that the consistency curves are straight lines thereby showing the linearity of the curve of efflux volume versus shearing stress. These results are similar to those obtained by other workers.

The hysteresis loops for the various samples as given in Fig 4, 5, 6 and 7 show normal behaviour, whereas loop 6 in Fig 5 shows abnormal behaviour. Sample No. 3, Fig 4 (a flat wall paint) shows no thixotropy, whereas such a paint should possess thixotropy. It is also interesting to note that this sample possesses the lowest yield value in the group of flat paints.

In accordance with ASTM D 523-51T, samples of paints can be classified on the basis of gloss, as shown in Table II. The plastic viscosities, yield values and thixotropy ratings are also summarized in the table. (The exceptions have been omitted). High glossy enamels with low pigment content showed slight thixotropy and low yield values. Fisher[4] also reports high gloss enamels with low pigment content showing no thixotropy or very slight thixotropy and possessing lowest yield values.

Since only three wall paints (egg shell finish) were examined, the results on these have not been summarized in the table. These have plastic viscosity ranging from 1·6 to 3·96 poises and yield value 61·26 to 87·52 dynes per sq cm, with one exception (sample No. 8) in which case the value was found to be nearing 1,500 dynes per sq cm. The corresponding thixotropic values ranged from nil to a marked degree.

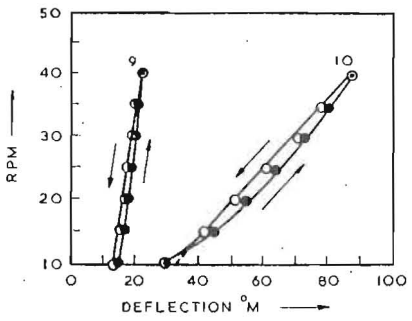

Fig 6 Thixotropic Hysteresis Loops of White Paints

Sample No. 3 showed no thixotropy at all (refer the coincidence of the up-curve and the down-curve in Fig 4).

For convenience of discussion the paint samples have been grouped according to their shades. From Fig 1 relating to green paints it is seen that samples No. 1, 5 and 12 recommended for use on timber, are less viscous than samples No. 13 and 14 meant for use on steel. This observation is also corroborated by the hysteresis loops (*see* Fig 7) for these samlpes. Sample No. 14 shows maximum thixotropy and samples No. 1, 5 and 12 show practically the same thixotropy.

In Fig 2 relating to grey paints, curves No. 6, 11 and 15 show no similarity amongst themselves. This may be due to the fact that these paints are manufactured by different firms and are used for different substracts in daily use. A glance at Fig 5 shows that sample No. 15 possesses maximum thixotropy in this

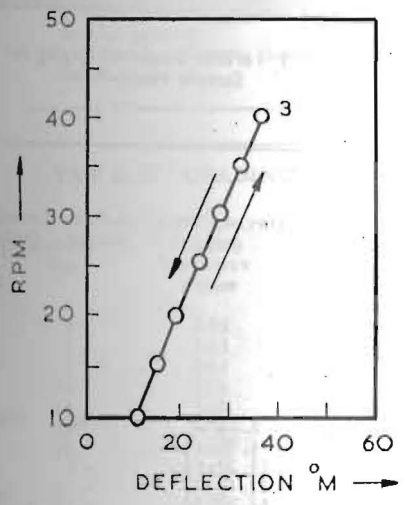

Fig 4 Thixotropic Hysteresis Loop

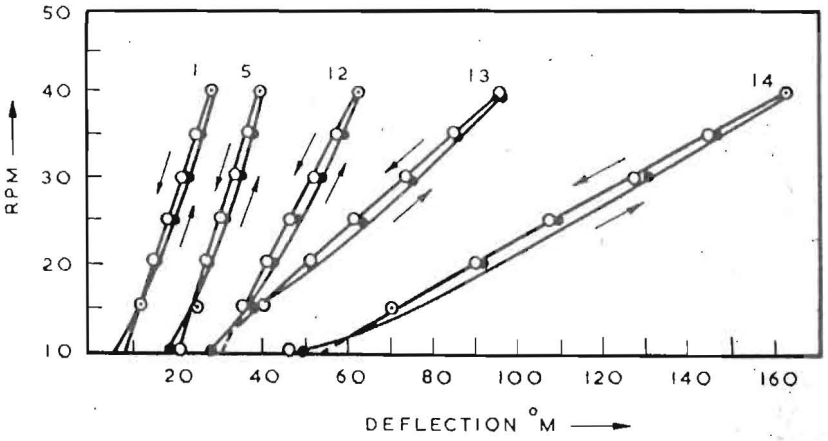

Fig 7 Thixotropic Hysteresis Loops of Green Paints

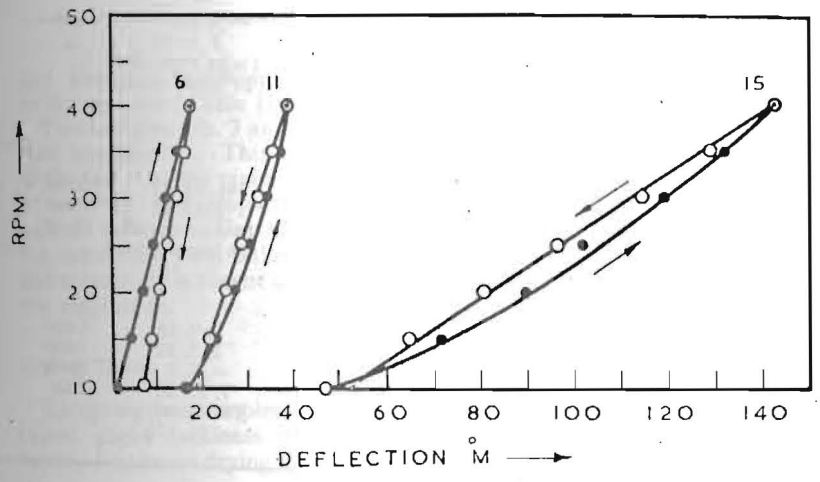

Fig 5 Thixotropic Hysteresis Loops of Grey Paints

group of paints. Although sample No. 6 has good brushability and levelling properties, yet its hysteresis loop is a departure from the normal and it is difficult to explain this.

Amongst white paints (Fig 3) sample No. 9 has the lowest viscosity. The hysteresis loops for these paints are shown in Fig 6, from which it is evident that sample No. 10 (exterior paint) is more thixotropic than sample No. 9 (interior paint). The hysteresis loops for sample No. 4 have been omitted for reasons given in the experimental portion.

The consistency is influenced by pigment content. In general the samples had a creamy consistency with 2 or 3 exceptions wherein the

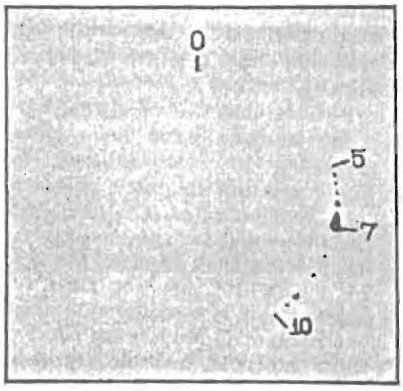

Fig 8 Various Stages of Drying for Sample Number 11

pigment particles either appeared not to have been sufficiently reduced in size, or probably poorly wetted, which resulted in showing the pigment particles as grains during and after applications of the sample.

Levelling Qualities and Brushability

On the basis of the extent of thixotropy (area of the hysteresis loops) and levelling performance the samples can be divided into three distinct groups showing good, fair and poor levelling properties. In Table III the samples have been arranged in the descending order of the area of the loops (as judged visually), i.e., the hysteresis loop has the largest area for sample No. 15 and no area for sample No. 3. In each group, the levelling performance follows the descending order of thixotropic gradings. This shows that the grading of the samples on the basis of levelling qualities follows the order of the area of the hysteresis loops (extent of thixotropy) in that particular group.

In Table IV the samples have been graded on the basis of plastic viscosity. It is observed that there is no correlation between the yield values, the plastic viscosities and the levelling qualities of the samples. Similar findings have been reported by Williamson and co-workers[6].

Out of the 16 samples investigated only two samples, No. 3 and 9, showed poor levelling qualities. This may be due to the very slight or no thixotropy coupled with low yield values.

Enamels were found to have acceptable brushing properties. In general, samples between plastic viscosity range of 2·2 to 3·63 poises showed good brushability. From Table IV, it is seen that the gradings of the samples on the basis of brushability follow the order of plastic viscosity. No relation was found to exist between brushability performance and the yield values (Table IV

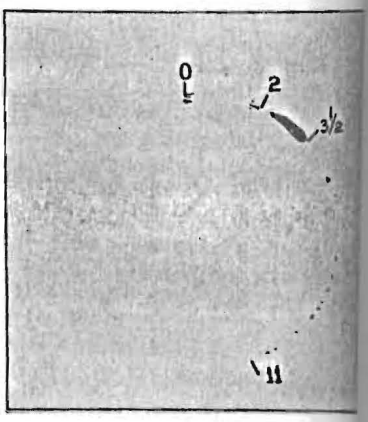

Fig 9 Various Stages of Drying for Sample Number 1

TABLE I TEST RESULTS

Firm No.	Sample No.	60-Degree Specular Gloss	Plastic Viscosity Poises	Mobilometer Reading for 100 g Load Seconds	Yield Value dynes/cm²	Pigment in the Sample Percent	Oil in the Sample Percent	Surface Tension dynes/cm	Drying Time (hr)	Brushability	Levelling Quality
					Greens						
I	1	79·0	3·63	24·5	55·23	27·72	42·31	28·2	2, 3½, 11	Good	Good
II	5	77·0	2·20	22·5	128·86	67·80	30·59	35·6	4½, 7½, 12½	,,	
IV	12	76·0	2·34	32·5	187·12	70·48	21·01	34·3	1½, 2½, 8	,,	
IV	13	72·0	3·59	98·5	181·08	72·65	26·61	36·1	2½, 4½, 12	,,	
V	14	40·0	3·59	123·0	318·35	83·83	15·31	36·3	6½, 7½, 10	,,	Fair
					Greys						
II	6	83·0	—	8·5	—	55·74	39·76	31·2	—, 3, 7½	Good	Good
III	11	84·0	2·58	22·5	107·14	38·32	37·61	33·8	5, 6, 10	,,	
V	15	62·0	3·45	242·0	333·87	85·45	14·15	41·4	Tacky even after 24 hours drying	,,	Fair
					Whites						
II	4	88·5	7·41	252·5	787·25	70·50	29·01	36·5	4½, 8½, 11	Good	Good
III	9	4·0	1·83	11·9	87·52	72·12	11·45	32·3	½, 12, 15	Poor	Poor
III	10	87·0	3·35	67·5	199·18	60·43	31·90	33·3	Tacky even after 24 hours drying	Good	Fair
					Miscellaneous						
I	2	54·0	3·61	62·5	169·43	42·99	31·67	32·6	6, 9, 16	Good	Fair
I	3	5·0	3·95	4·8	61·26	68·00	26·10	29·4	2, 3, 12	Poor	Poor
II	7	51·0	3·12	7·0	132·79	63·20	30·24	32·1	—, 3, 8	Good	Good
III	8	5·0	1·62	179·5	1 449·25	79·50	—	—	7, 15, 30 (minutes)	Fair	Poor
V	16	82·0	2·22	62·2	242·95	73·75	26·15	40·2	—, 6½, 17½	,,	

TABLE II CLASSIFICATION OF PAINTS ON THE BASIS OF GLOSS

Class of Paints	Plastic Viscosity poises	Yield Value dynes/cm²	Thixotropy
High gloss			
a) Enamels	2·58 to 3·63	55·23 to 107·14	Slight
b) Oil paints	2·2 to 3·59	181·08 to 242·95	Slight to marked
c) Semi gloss oil paints	3·1 to 3·59	132·79 to 333·87	,,

TABLE III GROUPING OF SAMPLES ACCORDING TO THIXOTROPY AND LEVELLING PERFORMANCE

Thixotropy Grading (Descending Order)	Sample No.	Levelling Quality	Brushability
1	15	Fair	Good
2	14	,,	,,
3	10	,,	,,
4	2	,,	Fair
5	16	,,	Good
6	12	Good	,,
7	11	,,	,,
8	5	,,	,,
9	13	,,	,,
10	1	,,	,,
11	7	,,	,,
12	9	Poor	Poor
13	3	,,	,,

Note 1 — Sample No. 4 & 8 have been omitted for reasons given in the experimental portion.

Note 2 — Sample No. 6 is omitted as its hysteresis loop showed an abnormal behaviour.

TABLE IV GRADING OF SAMPLES ON THE BASIS OF PLASTIC VISCOSITY

Sample No.	Plastic Viscosity Poises	Yield Value dynes/cm²	Brushability	Levelling Quality
3	3·95	61·26	Poor	Poor
1	3·63	55·23	Good	Good
2	3·61	169·43	,,	Fair
13	3·59	181·08	,,	Good
14	3·59	318·35	,,	Fair
15	3·45	333·87	,,	,,
10	3·35	199·18	,,	,,
7	3·10	132·79	,,	Good
11	2·58	107·14	,,	,,
12	2·34	187·12	,,	,,
16	2·20	242·86	Fair	Fair
5	2·20	128·86	Good	Good
9	1·83	87·52	Poor	Poor

and also the thixotropic gradings of the samples (Table III).

Two samples, No. 3 and 9, showed poor brushability. This may be due to the fact that the pigment-oil ratio is too high, the proportion of the volatile solvent is also high and at the same time yield values are low, and thixotropy is absent or is of very low magnitude.

Drying Time

Excepting two samples, which retained slight tackiness even after twenty-four hours drying under laboratory conditions, all other samples were found to be hard dry within 11 to 18 hours. Figures 8 and 9, relating to sample No. 11 and 1 respectively, show the arc pattern scribed by the loaded pin of the recorder giving the set-to-touch, dust-free and hard dry time as 5, 7, 10 hours and 2, 3½, 11 hours, respectively. Other samples gave similar results with some exceptions [samples No. 5, 6 and 16 (Table 1)]. In the first phase of drying, the liquid is sufficiently mobile and hence flows back into the channel cut by the loaded pin. In the exceptions mentioned above, the behaviour was different, i.e., the liquid from the surroundings did not flow back into the channel. This may probably be due to the rapid fall of yield value. The result is that in such cases the recording of the set-to-touch time becomes difficult.

SUMMARY

With one exception, the plastic viscosity was found to be between 1·6 to 4·0 poises and the yield values were less than 400 dynes per sq cm, with two exceptions. The consistency of the samples was found to be uniform. As expected, a straight line relation of curve of the efflux volume versus shearing stress is also observed. All the samples with one exception were found to possess thixotropy. One wall paint was found to possess no thixotropy and this sample also showed poor brushability and levelling qualities. One sample (No. 6) showed abnormal behaviour when its hysteresis loop was prepared.

It was observed that, on the basis of thixotropy, the samples could be divided into distinct groups in respect of good, fair and poor levelling qualities. The gradings of the samples in respect of levelling qualities followed the thixotropy rating in each group. No relation was found to exist between the yield values, plastic viscosities and levelling performance.

The grading of the samples in respect of brushability followed the order of plastic viscosity with an occasional exception. Samples between the plastic viscosity range of 2·2 to 3·6 poises (medium range) showed good brushability. Brushability was not found to be dependent on yield values or on the extent of thixotropy.

The use of MacMichael viscosimeter (rotational viscosimeter) was found to be an advantage in finding out the plastic viscosity. The use of mobilometer is also recommended if the object is to compare the sample against the approved sample and to find out whether the consistency is uniform.

However, the main emphasis, in this investigation, was to find out the flow characteristics and other related properties of commercial ready mixed paints as manufactured in India and to collect a factual data thereon.

In an extended investigation an attempt will be made to find out the limits of consistency of paints manufactured to Indian Standard

Specifications, and suggest suitable methods and instruments best suited to our conditions.

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