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Effect of Different Operational Techniques on Properties of Solvent Borne Paint

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Abstract

The aim of this study is to measure the impact of different manufacturing techniques on properties of solvent borne paint. Solvent borne white paint was processed as a reference coating. Enamel paint samples were prepared by three different mills, i.e., Conventional Agitator, Attritor and Basket mill. Paints were processed through mills independently having same composition. It was observed that conventional agitator resulted in high-quality product as compared to both Attritor and Basket mill. Conventional Agitator showed exceptionally good results than both other mills in terms of whiteness, wet hiding, dry hiding, and gloss. It was shown that different processing techniques had an impact on different paint properties and effect total batch processing time and time to achieve optimum dispersion.

Keywords: Agitator; Attritor; Basket Mill; Enamel; Gloss; Whiteness

Abbreviations: OEM: Original Equipment Manufacturers

Introduction

Paint consists of pigments, binders, additives, and solvent. Film forming additives are included in paints which help in the formation of paint film on a particular substrate. Paints have been used for many centuries for decorative purposes. With the passage of time, different industries developed and different uses of paints came into existence [1].

Different types of raw material are used during paint manufacturing. These include organic and inorganic pigments, different solvents, additives, and binders/ resins. color, hiding, and durability is provided by pigments. Pigments also provide weather resistance to the substrate. Some good quality pigments cover the entire color spectrum having brilliancy and hiding [1]. Vehicle consists of binder and solvent. Binders hold the pigments and fillers together and in a continuous phase. Binder also adheres them to the substrate. Resins include alkyd resin, acrylic resin, and vinyl acrylic resin [1,2].

Binder and solvents help the paints to remain in wet state. In other words, they provide aid to paints be applied on substrate. Water is the solvent in water based and emulsion paints [1,2]. Another category of paint raw materials is additives. Paint additives may include wetting agents, buffer, defoamers, rheology modifiers, biocides, surfactants, dispersing agents, etc. [2]. There are different uses of paint products. Different formulations are designed according to their use. Different paint types are decorative paints, paints for original equipment manufacturers (OEM) and special purpose coatings [3]. Approximately 50 percent of the paint factories available are present in ozone nonattainment areas [4]. In several paint factories (more than 60 percent), employment rate is quite low. They hire around 20 people. They are small units and still produce paint up to 500-gallon batches. Larger factories manufacture paint up to 3,000-gallon batches [5,6].

Paint is usually processed in a batch process. There are four stages involved in paint production [7,8,9]. These steps are Premix, Pigment grinding. Finishing, Filling and Packaging. The paint manufacturing process is summarized in figure 1. When pigments are added in the binder then the process of wetting starts [10,11]. A process of separation of solid particles (pigments and extenders) is done and this is made possible by the process of dispersion. In this process wetted particles move into the vehicle and become charged [11].

Paint is processed with different machines one of which is an attritor. An attritor consists of a tank, shaft, balls, and spokes attached to central shaft. When the shaft revolves, shear is created and balls grind and disperse the pigments. Proper dispersion

is achieved along with binder and different additives. Binder, additives, and pigments intermingle and ultimately paint is produced [10,11]. Dispersion of pigments is done very fast in an attritor as compared to a ball mill. Another advantage of attritors is that higher loading materials or high viscosity slurries are easily processed [10,11]. Scheme of flow in attritor is shown in figure 2.

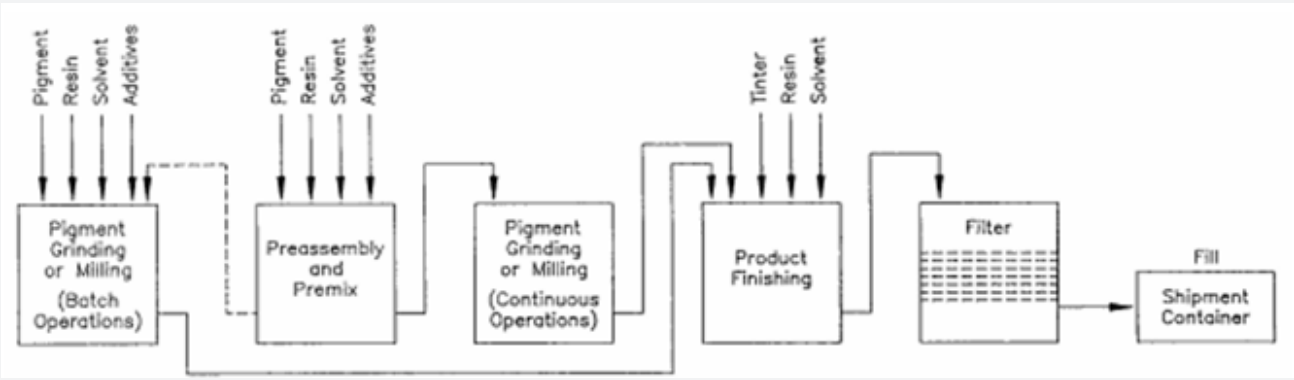

Figure 1: Paint manufacturing process.

Figure 2: Scheme of flow in attritor.

More time is required to have dispersion in ball mills. Operation in ball mill is noisy also. Agitators or High-speed dissolvers are used to process mill base and reduces time of operation in ball mill [1,10,11,12]. During batch production, these agitators are used to process the mill base in a simple, fast, and inexpensive way as compared to ball mill. In an agitator, mixing, dispersion, grinding, finishing all steps can be done effectively. Different types of agitators are shown in figure 3. A benefit associated with high-speed dissolver is that they are less expensive and they require low maintenance. Agitators cannot break hard flocculates which is a drawback in using agitators [11].

The characteristic flow in conventional agitator is shown in figure 4. Paint manufacturing dispersers are of two types, variable speed, and fixed speed dispersers. Variable speed dispersers are always preferred due to low dust creation during raw material loading. Powders are incorporated in tank at low revolution per minute due to which there is minimum dusting. After addition of additives and powders and complete wetting, revolution per minute is increased [13]. After proper dispersion of the mill base, solvent and binder are added. Binder helps to adhere the substrate and forms a durable film [11]. Scheme of flow of conventional agitator is shown in figure 5.

For color matching and to have required color, different ratios of pigments, solvents, resins, and pastes are used in the formulation [7,8]. There are two methods to fill the paint in different containers, by volume and by weight. Many paint manufacturers fill the paint containers by weight. They find it easy because density varies with foam present in paint so volume of the paint changes due to specific gravity change. Weight is independent of foam issue. Filling is done with the help of different machines and can be done manually [1,7]. Architectural paints are oil based and water-based paints. They include exterior and interior paints including varnishes, undercoats, primers, and sealers. Architectural coatings occupy largest market share.

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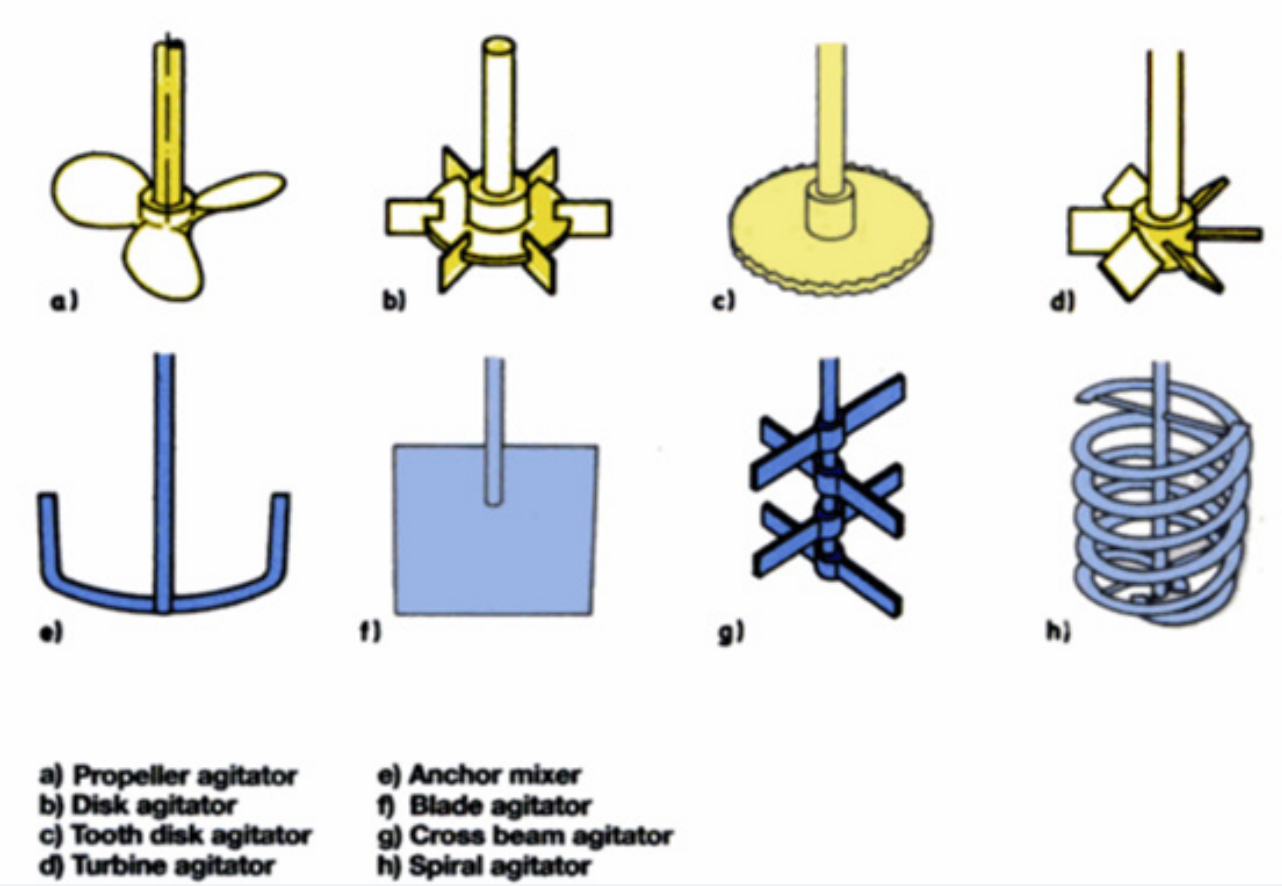

Figure 3: Different agitator types.

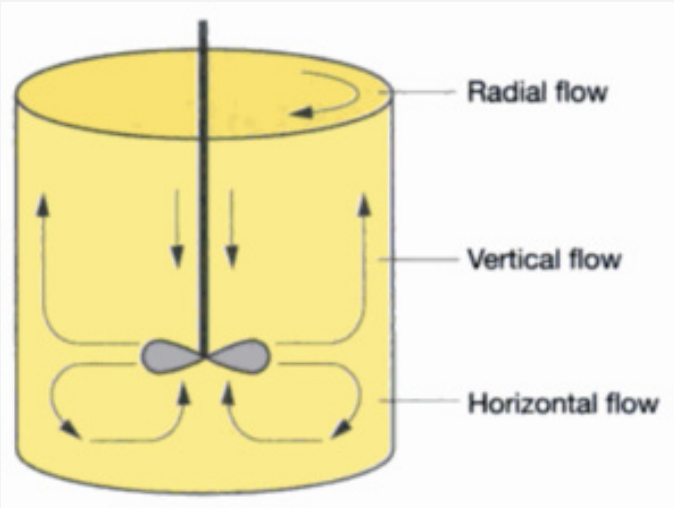

Figure 4: Characteristic flow in conventional agitator.

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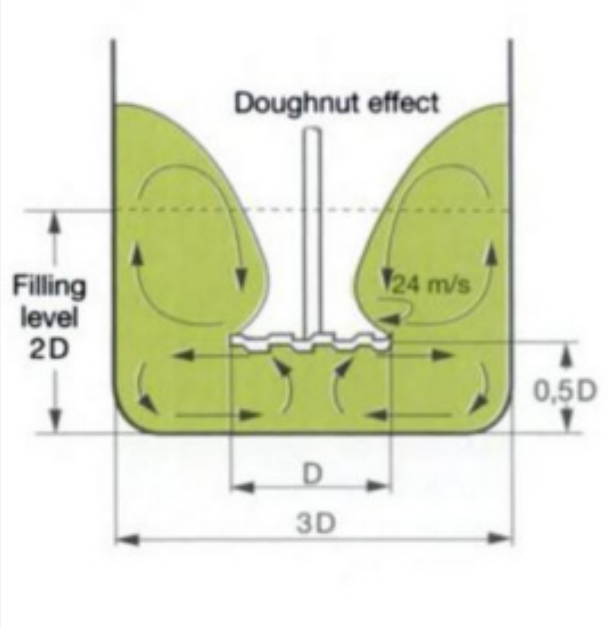

Figure 5: Scheme of flow of conventional agitator.

Wholesalers and retailers are involved in selling these paints. The market share of architectural paints is around 42 percent of the total market for paints and coatings [14]. Architectural paints are also called decorative paints. Different types of paints are included in decorative paints like flat, satin, eggshell, semi-gloss, and gloss paints. Currently paint manufacturers are working on environmental aspect of paint manufacturing and different procedures and systems are being adopted by them to make environment neat and clean. These systems include environment management system during paint manufacturing [15,16]. All raw materials of paint including solids and liquids are being tested for their environmental compliance due to different environmental laws and legislations. Resin manufacturers feel many challenges due to these legislations [17,18].

Materials and Methods

The Following Instruments and Analyzers were used to Analyze Various Properties of Paint Samples:

1. Conventional Agitator, (laboratory mixer manufactured by BEVS Industrial Co. Ltd., China. Model: BEVS 2501/1)
2. Basket mill (Dispermate AE06 with the modular basket mill TML1- vacuum for product quantities up to 3 liter)
3. Spectrophotometer, model data color 110
4. Grind Gauge, sheen UK, range 0-100µm
5. Hiding Power Charts, sheen UK, Coated, 255 x 140mm
6. Automatic film applicator (manufactured by BEVS Industrial Co. Ltd., China. Model Number: BEVS1811/2)
7. Tri-Gloss master, sheen UK, angles 20-60-85°
8. Crypto meter, sheen UK, with K007 plates
9. Pyknon meter, sheen UK
10. Brookfield KU-1+ viscometer
11. Attritor, having balls diameter 6mm
12. Drying Time Recorder, Sheen UK

The following Chemicals were used in the Preparation of Paint Samples:

1. Long oil alkyd resin, oil length 70%
2. Titanium dioxide, crystal 128
3. Zinc oxide, grade 100
4. Kerosine oil
5. Long oil alkyd resin, oil length 60%
6. Cobalt octoate
7. Calcium octoate
8. Lead octoate
9. Methyl ethyl ketoxime
10. Di pentene, hydrocarbon

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Sample Preparation

Preparation of Paint Samples

Solvent borne paints were prepared using three different mills, i.e., Conventional Agitator (Figure 6), Attritor (Figure 7) and Basket mill (Figure 8). The scheme of flow of basket mill is shown in figure 9. Paints were processed through mills independently having same composition as shown in table 1. The color of all the three paint samples processed was white. The revolution per minute of conventional agitator was 1400, rpm of attritor were 300 and of basket mill were 1400.

Figure 6: Conventional Agitator.

Figure 7: An attritor.

Determination of Different Parameters

Different parameters were observed during paint samples processing as shown in table 2. It was found that raw material loading time in attritor and conventional agitator is same but half than material loading time in basket mill. Dispersion time is faster in attritor than in conventional agitator but longer in basket mill. Total processing was dramatically reduced with conventional agitator (table 2). Physical properties of paint samples like whiteness, wet hiding, dry hiding, viscosity, and gloss were also influenced by different processing techniques (table 3).

Determination of Various Properties of Paint Samples

Solvent borne paint samples so prepared were applied on hiding power charts with the help of Automatic Film Applicator following the standard ASTM D 823-95 as shown in figure 10-12.

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An instrument crypto meter was used to check the wet hiding of paint samples. Crypto meters offer a quick method to determine the wet opacity, hiding power and coverage in square meters per liter of liquid coating materials [19]. A small sample of liquid coating (approximately 4ml) was applied on the joint line of the black and white base plate, the top plate (pins facing downwards) was placed across base plate joint line the sample forms a wedge of paint, (maximum thickness nearest the pins) by sliding the plate back and forth till the sample perfectly hides both the black and the white section of the base plate. At the position of hiding a reading was observed on the engraved scale of the Base Plate, this was then converted into covering power (Square meters/liter). Top Plates (number K003.5) were offered with each of the Crypto meter products to cover a range of film thickness.

Table 1: Solvent Borne Paint composition.

Long Oil Alkyd 70%	8.8
Titanium Dioxide	19.2
Zinc Oxide	0.2
Long Oil Alkyd 60%	57.9
Kerosine	10.7
Cobalt	0.259
Calcium	0.925
Lead	0.616
Methyl Ethyl Ketoxime	0.1
Di pentene	1.3
Total	100

Figure 8: Basket Mill.

ASTM D2457 test was followed to test the gloss or sheen of paint samples with the help of Tri-Gloss master equipment. The values of paint dry hiding were determined with the help of spectrophotometer data color 110. To find out drying time of latex paint samples, drying time recorder was used. Standard test ASTM D1084 was followed to measure viscosities of samples by using Brookfield KU-1+ viscometer. Densities of the paint samples were determined using Pykno meter following the standard ASTM D1475. Dispersion of paint samples were determined by using gring gauge. The results so obtained are summarized in table 3.

Discussion and Results

Solvent borne paint processed through conventional agitator showed better results in terms of whiteness, wet hiding, dry hiding, and gloss compared to the paint processed through attritor or basket mill (table 3). It could be observed from figure (10-12) that opacity of paint is most in conventional agitator paint, less in basket mill paint and least in attritor paint. Also, solvent borne paint sample made with conventional agitator showed better results during paint production in terms of reducing loading time, dispersion time and total processing times (table 2).

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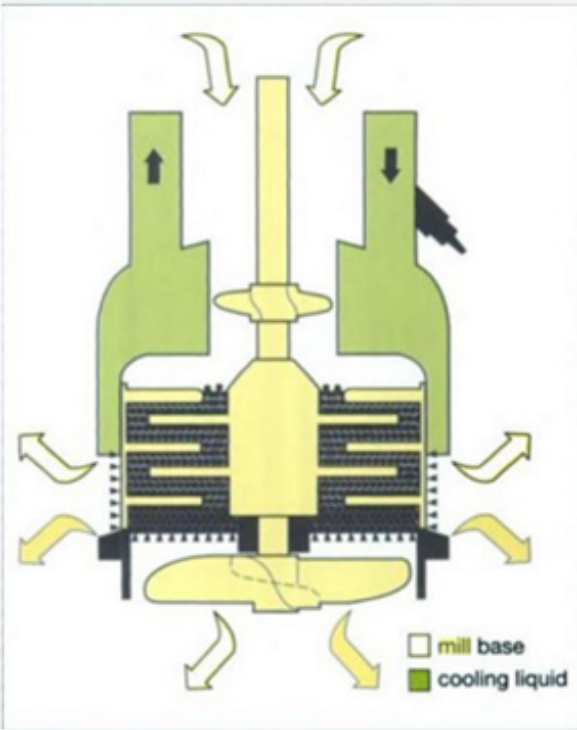

Figure 9: Scheme of flow of basket mill.

Figure 10: Comparison of solvent borne paints processed through basket mill and agitator.

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Table 2: Different Parameters during paint samples production.

Parameters	Conventional Agitator	Attritor	Basket Mill
Loading Time	5 min	5 min	10 min
Dispersion/Grind Time	10 min	10 min	20 min
Dispersion	10 microns	10 microns	10 microns
Total Processing Time	20 min	30 min	35 min

Conclusion

Based on results and experiments, it is concluded that by using different operational techniques, solvent borne paint showed variant results. Three mills were compared i.e., agitator, basket mill and attritor. Among all three mills, agitator showed excellent results. When solvent borne white paint is processed through conventional agitator, better results are obtained in terms of wet hiding, whiteness, gloss, dry opacity (table 3) and (figure 10-12), reduced loading time, early dispersion time and low processing times (Table 2).

Figure 11: Comparison of solvent borne paints processed through basket mill and attritor.

Table 3: Specifications of paint samples processed through Basket Mill, Attritor and Conventional Agitator.

Specifications	White		
	Conventional Agitator	Attritor	Basket Mill
Viscosity	99 ku	86 ku	81 ku
Density	1.076 gm / cm^3	1.08 gm / cm^3	1.066 gm / cm^3
Dispersion	10 microns	10 microns	10 microns
Wet Hiding	8 # 3.5	9 # 3.5	9 # 3.5
Dry Hiding	81.97	78.78	81.33

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Whiteness			
At Black	88.59	84.74	86.43
At White	79.93	77.06	77.69
Drying Time	5 hrs 30 min	5 hrs 30 min	5 hrs 30 min
Gloss			
At 20^0	80	76	78
AT 60^0	93	90	92
At 85^0	120	111	121
Spectrophotometer Values			
L	94.48	93.75	94.51
a	-1.02	-0.84	-1.05
b	1.7	1.89	2.18

Figure 12: Comparison of solvent borne paints processed through attritor and agitator.

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