

Chapter 3

Manufacturing Process Analysis

3. Overview of the paint manufacturing process

In this chapter, I have discussed the overview of paint manufacturing process first. Then I have summarized the tinting process for tinted products of ABC company that I use as the case study to perform my dissertation (Developing the process standard for color control in tinted products in paint manufacturing by FMEA technique)

3.1 Paint manufacturing process

Paint: The following definitions are based on ISO standard 4618/1 (Paint and Varnishes-Vocabulary- Part 1 general term) : Paint is a product, in liquid or powder form, containing pigment(s), which , when applied to a substrate , forms an opaque film having protective , decorative or specific technical properties.

The most important constituents of paints are binders, pigments and extenders, solvent/diluents/thinners and additives.

The detail of paint manufacturing process are shown as following :

3.1.1. Raw material preparation

Raw material in ABC Company classified into 2 categories. They are :

Raw material from tank farm : Normally, Tank farm is used for storage raw materials that consume in manufacturing line at high volume. These raw materials are in terms of liquid material such as binder and solvent. All of them can use be pumped directly from tank farm by pass through the pipe and controlled the accuracy by PLC (Programmable Logical Control).

Raw material from non tank farm : Normally non tank farm material are in form of powder such as pigment and extender, and in liquid form in drums that use less consumption such as binder, solvent, and additive. All of them need to prepare and weigh prior to produce the batch in production.

3.1.2. Raw material charging

Raw material will be charged step by step as the following process instruction sheet.

3.1.3 Mixing

All of raw material that charged into the batch will be stirred by dissolver blade under medium or high speed (depending on the specific speed in the process instruction sheet). The objective of this stage is to wet the pigment and extender prior to grinding. Mainly raw material in this stage consists of thickener, wetting agent, dispersing agent etc.

3.1.4. Grinding

The objectives of this process are to defloculate and deagglomerate the pigment and extender under high speed by dissolver blade. The dissolver blade can create high shear force to break down the pigment aggregate to be the particle.

3.1.5. In process quality control

It is the process control to ensure that production process lead to standard paint quality. Normally, it consists of temperature of grinding and fineness of grinding. Both of them impact to paint quality for example, high temperature impact to paint quality in terms of paint stability, while fineness of grinding affect to whiteness and fineness of paint etc. All of them will be measured and recorded.

3.1.6. Letdown stage

The remaining raw material in the formulation will be loaded into the batch. Mainly raw materials in this step consist of binder, solvent, and some additive

such as defoaming, antiskinning etc. All of them will be mixed and stirred at low to medium speed for homogeneous and it also prevents re –aggregate (flocculation) of pigment particle.

3.1.7. Final quality control inspection

After paint manufacturing process finished, it will be measured and control the quality as the specification. This step is to ensure the paint quality before reaching to customer or tinting process.

From the above process, the product can be classified into 2 categories:

1. Tinting products : These products need to be tinted and control color shade as following the standard color such as yellow, red, brown tone. They are produced from semi products as following :

- 1.1 White Base : Paint that consists of Titanium Dioxide as the main pigment in order to give whiteness and opacity.
- 1.2 Neutral Base : Paint that consists of extender only in order to reduce whiteness of white base. It is applied for medium to dark shade.
- 1.5 Colored Base : Paint that consists of color pigments to make the saturated shade. Normally, if % of total tinter is higher than 10%, color base will be produced for that color.
- 1.6 Tinter : Paint that consists of high concentration of color pigment. It is applied tinting and color adjustment.

2. Non tinted products : They are paints that do not need to work out for color adjustment for example primer, white shade. It can be filled into the packing and send to customer directly.

3.1.8 Tinting

The process is to mix all of ingredient such as white base, neutral base or color base with tinter to achieve the standard color shade. Then paint will be taken for making the color panel prior to pass through color measurement and adjustment.

3.1.9 Color control

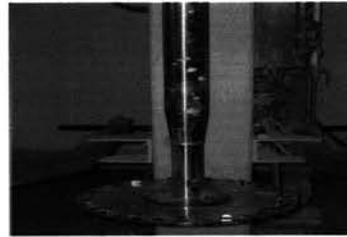
Tinted products will be measured and adjusted the color as the standard color shade. The process in step 8 and 9 will be repeated until colors achieve the target.

3.1.10 Canning

Finished paint that approved by Quality Controller will be canned as the following the weight of paint that calculated based on packing size volume.

3.1.11 Final inspection in filling line

This step is random checking the weight of paint that filled in the can to ensure the volume of packing size.



Raw material

Grinding

Letdown

Figure 3.1 : Paint manufacturing process

3.2 The process in tinting products in ABC Company

This research focuses on the tinted products in alkyd paint only. The process for tinted products can be categorized into 4 processes as following :

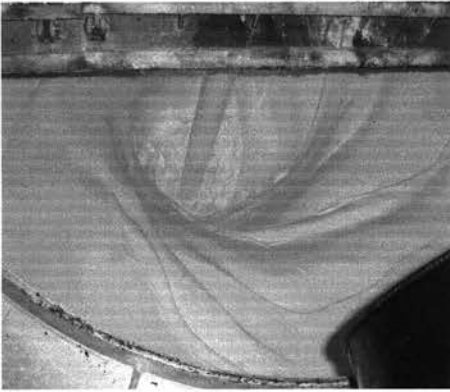
3.2.1. Raw material preparation :

Main ingredients of tinted products for alkyd bases are :

- 1.1 White Base : Paint that consists of Titanium Dioxide as the main pigment in order to give whiteness and opacity.
- 1.2 Neutral Base : Paint that consists of extender only in order to reduce whiteness of white base. It is applied for medium to dark shade.
- 1.3 Colored Base : Paint that consists of color pigments to make the saturated shade. Normally, if % of total tinter is higher than 10%, color base will be produced for that color.
- 1.4 Tinter : Paint that consists of high concentration of color pigment. It is applied tinting and color adjustment.

All of them will be produced and stored into their tanks as the stock before using. For white base and neutral base will be stored each 10000 liter in base tank, while tinter will be stored in the tinter tank 1000 liter or canister at 100 or 200 liter depending on consumption. For white and neutral base, they are controlled only physical properties as viscosity, specific gravity, fineness, drying time, and glossiness. While color strength of white base is not controlling. For

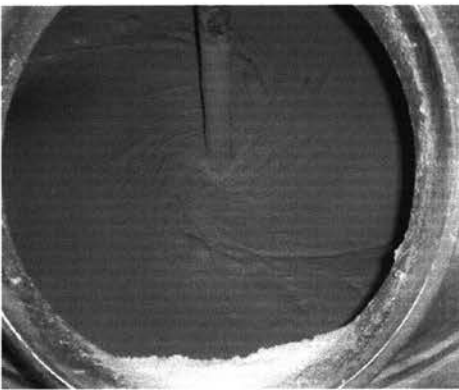
tinter, they are controlled in terms of viscosity, specific gravity, fineness, and color strength. The color strength of all of tinters are controlled at level $\pm 10\%$. So quality of all raw material will be scrutinized to find out the potential failure mode that impact to quality and color adjustment of tinted products.



White base



White base in storage tank



Neutral base



Neutral base in storage tank



Tinter



Tinter in canister

Figure 3.2 : Raw material in tinting process

3.2.2. Mixing :

Mixing is the process of tinting to create the homogenous of all of raw materials that use in tinting before measuring and adjusting the color. The process consists of tinting machine preparation, pot and tank preparation, and mixing. The point of machine design, volume of paint, speed of machine, cleanliness of tank and pot are impact to quality and color adjustment of tinted products.



Movable pot tinting



Tinting tank

Figure 3.3 : Tinting process

3.2.3 Color panel preparation :

This process is to prepare the color panel to measure the color difference with standard color that storage in terms of wavelength reflectance in the computer color matching. This stage involves with 4 processes as below :

1. Drawn down paint on paper panel :

Paint sample that taken from the batch will be drawn down on paper panel as required thickness.

2. Keep it roughly drying in drying cabinet

Color paper panel from stages 1 will be kept in drying cabinet to do roughly dry before curing in oven.

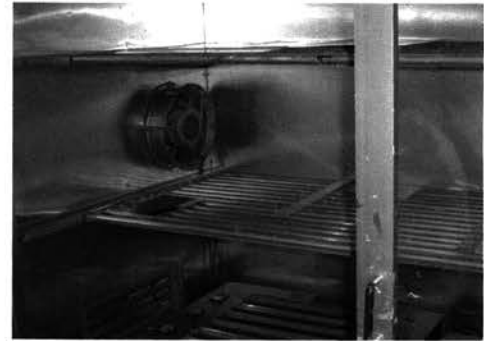
3. Curing film in oven

Color paper panel will be exposure into oven at 60 °C to curing the paint film.

4. Drying at ambient

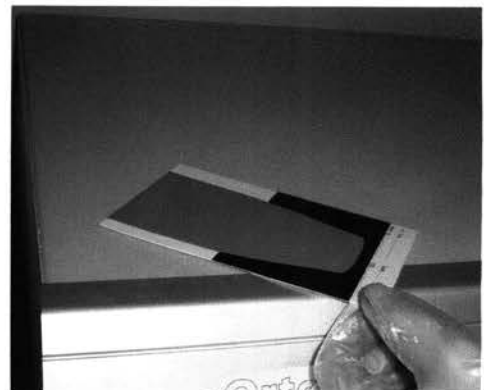
Color paper panel will be exposure with air in ambient temperature to make it cool before performing color measurement by computer color matching.

All of processes are considered as the influence to quality and color adjustment of tinted products.



Drawn down paint on paper panel

Keep it roughly drying in drying cabinet



Curing film in oven

Drying at ambient

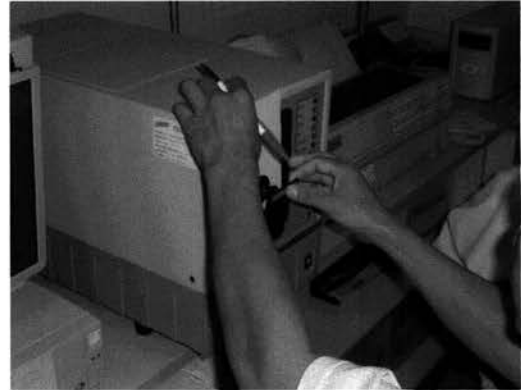
Figure 3.4 : Color panel preparation process

4. Color Measurement :

This process is to measure the difference of color shade that we are producing with the standard color. It involves with color measuring process, condition in color measuring room, and the skill of operators.



Spectrophotometer



Color measurement

Figure 3.5 : Color measurement process

Table 3.1 : The process flowchart in tinted products

Raw Material Preparation	Mixing	Color panel preparation	Color Measurement
White Base	▶	• Drawn down paint on paper panel	Measure the color difference compare with the standard shade
Neutral base	→▶ Stirring as the specific	• Keep it roughly drying in drying cabinet	
Color Base	→▶ speed and time	• Curing film in oven	
Tinter	→▶	• Drying at ambient	

3.3 The process time summary in tinting products in ABC Company

Process time for each step in tinting section for alkyd base show as following

Process	Process time (min)	Remark
1. Raw Material Preparation	25	Start from weighing of raw material until move to tinting machine
2. Mixing	30	
3. Color Panel Preparation	55	
4. Color Measurement	5	
Total Process Time	115	

Table 3.2 : The process time for each step in tinting section

It was found that cycle time for tinted product is average 115 minutes per batch.

3.4 The current problem in tinting products in ABC Company

From the paint manufacturing, tinting process is the part of manufacturing line that creates the value of products. At the present, it takes at least 2-3 times for color correction. This leads to waste time and it also impact to productivity in production line. The problem can identify in each process as following :

Table 3.3 : Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : **Raw Material Preparation**

Activities/Inspected Results	Area	Input	Output	Aspect
1. White Base Preparation	Tinting Section	White base	Uncontrolled color strength of white base	Deviation of color strength in each batch impact to color adjustment
		White base	Long drying time white base	Color deviation due to non fully curing film
		White base	Different whiteness of white base in each batch	Tinted color deviation
		White base	Low hiding power of white base in each batch	Tinted color deviation
2. Neutral Base Preparation	Tinting Section	Neutral base	Clearness of neutral base in each batch are different	Tinted color deviation
		Neutral base	Long drying time neutral base	Color deviation due to non fully curing film
3. Tinter Preparation	Tinting Section	Tinter	Too board standard of color strength control level	Tinted color deviation
4. White base/Neutral base storage	Tinting Section	White base	White base settling	It impacts both quality and color deviation
		White base/Neutral base	Skinning of white base and neutral base	It impacts to fineness and color deviation
		White base	Color strength changing after storage	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Raw Material Preparation

Activities/Inspected Results	Area	Input	Output	Aspect
5. Tinter storage	Tinting Section	Tinter	Settling of tinter	Deviation of color strength in tinter
		Tinter	Dry skinning tinter	It impacts to quality in terms of fineness and color strength
		Tinter	Color strength changing after storage	Tinted color deviation
6. White/Neutral Base/ Tinter weighing	Tinting Section	White Base/ Neutral Base/ Tinter	Error of weighing in white base/ neutral base/ tinter	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Mixing

Activities/Inspected Results	Area	Input	Output	Aspect
1. Tinting machine preparation	Tinting Section	Blade propeller	Blade that contaminated with some paint or waste thinner	Tinted color deviation
		Blade propeller design	Low mixing efficiency of propeller Consequently, inhomogeneous paint	Tinted color deviation
		Level of propeller	Level of propeller does not suit with the level of paint volume	Paint contain high bubble, and Inhomogeneous
2. Container for tinter weighing preparation	Tinting Section	Pot 200 Ltr, Gallon container	Pot, Gallon container that contaminated with some tinter	Tinted color deviation
3. Pot, Tank for tinting preparation	Tinting Section	Pot, Tank	Pot, tank that contaminated with some paint or waste thinner	Tinted color deviation
		Pot	Some waste thinner and paint leave in the valve	Tinted color deviation
4. Mixing Process	Tinting Section	Speed of Impeller	Low speed of impeller Consequently, inhomogeneous paint	Tinted color deviation
		Level of propeller	The impeller level is nearly the same level of paint. So it can create high bubble in paint.	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Mixing

Activities/Inspected Results	Area	Input	Output	Aspect
4. Mixing Process	Tinting Section	Level of propeller	The impeller level is lower than level of paint. So it can make paint inhomogeneous.	Tinted color deviation
		Volume of paint in tinting machine	Level of paint is the same level of propeller. So it can create high bubble in paint.	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Color panel preparation

Activities/Inspected Results	Area	Input	Output	Aspect
1. Make the draw down panel as the specification	Laboratory	Paint	High bubble with in paint	Tinted color deviation
		Paint	Low hiding power of paint	It can not measure color
		Paint	Paint is floating	Tinted color deviation
		Paint	Paint has some skinning	It impacts to quality in terms of fineness and color shade.
		Glass plate for underlying to draw down	Rough surface of glass plate, It make the paint film does not smooth.	Tinted color deviation
		Glass plate for underlying to draw down	Uncleanness glass plate, It make the paint film does not smooth.	Tinted color deviation
		Paper for underlying to draw down	Wrinkle paper, It make the paint film does not smooth.	Tinted color deviation
		Film applicator	Inaccuracy applicator	Tinted color deviation
		Film applicator	Dirty film applicator	Tinted color deviation
		Draw down procedure	Film is thicker than standard, So it can make film wrinkle.	Tinted color deviation
		Draw down procedure	Film is less than standard, So it can make film low hiding.	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Color panel preparation

Activities/Inspected Results	Area	Input	Output	Aspect
2. Keep it in drying cabinet	Laboratory	Draw down panel	Draw down panel that keeps in drying cabinet less than standard time. It makes film wrinkle.	Tinted color deviation
		Draw down panel and drying cabinet	Dust on draw down panel	Tinted color deviation
		Drying cabinet	Color panel is lower drying than standard.	It can not measure the color.
3. Curing film in the oven	Laboratory	Draw down panel and oven	Non fully dry panel	Tinted color deviation
		Draw down panel and oven	Wrinkle film panel	Tinted color deviation
		Draw down panel and oven	Yellowing film panel	Tinted color deviation
4. Drying at ambient	Laboratory	Draw down panel	High temp draw down panel	Tinted color deviation

Problem identification in tinted alkyd paint in terms of quality and color adjustment

Process : Color measurement

Activities/Inspected Results	Area	Input	Output	Aspect
1. Color measurement	Laboratory	Color panel	Wrinkle film panel	Tinted color deviation
			Low hiding power film panel	Tinted color deviation
			Yellowing film panel	Tinted color deviation
			Non fully drying panel	Tinted color deviation
			Color floating on film panel	Tinted color deviation
		Color eye	ΔE does not reach standard	Tinted color deviation
			Inaccuracy of color eye	Tinted color deviation

3.5 Historical data collection in tinted alkyd products in ABC Company

The historical data prior to start the research has been collected for 1 year. It starts from January 2002. The index that used for evaluation in this research is amount of correction, and cycle process time in tinting section as stated in Chapter 1. The reason is that it can reflect the actual effectiveness of improvement in the operation. The research focuses on 18 shades of alkyd products that cover 80% of tinted alkyd product in ABC Company. The data show as following :

Product Code	Product Name	Total Batches	Amount Correction time			Average Process time (min)
			1 time	2 times	3 times	
245125	GE: Island Green	7	0	7	0	230
245315	GE : Pacific Blue	11	1	9	1	230
245702	GE : Pastel Green	6	0	5	1	249
245940	GE : Royal Blue	5	0	3	2	276
245M05	GE : Grey	10	4	5	1	207
248T03	JG : Custard Cream	6	0	5	1	249
3524810B	JG : Early Rain	8	0	7	1	245
3524880T	JG : Oak	9	4	4	1	214
248R45	JG : Gaily Blue	7	3	4	0	181
3524870A	JG : Smoke Grey	8	4	4	0	173
3524860H	JG : Dusky Green	10	2	8	0	207
3524850T	JG : Pacific Blue	14	0	10	4	263
3524850K	JG : Dazzle Blue	5	0	2	3	299
3524810I	JG : Peppermint	9	0	9	0	230
3524810F	JG : Mellow Yellow	7	0	6	1	247
3524810L	JG : Ivory Bisque	11	0	8	3	262
3524853C	JG : Baby Blue	3	0	3	0	345
248R10	JG : Blue Sapphire	3	0	0	3	235
Total		139	18	99	22	233

Table 3.4 : Historical data collection in tinted alkyd products in terms of amount correction and average process time prior to implement FMEA

From the above data, it was found that only 13% of total batches could achieve right first time for color control, while 87% need more than 1 time for color adjustment. Moreover, total process time for tinting is average 233 min per batch that is longer than standard process time in tinting section. It impacts directly to productivity in the ABC Company. This research have been introduced the FMEA technique to define, identifies, and eliminates the problem in tinted alkyd products in the ABC Company.