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Evaluation of Waste Powder Coatings in Home Appliances Industry

Hamid Bastani [1] - Saeed Bastani [2] - Farideh Golbabaei [3] - Majid Abbaspour [4]

1. Manajer of HSE group -MAPNA CO.- College of Environment & Energy- Azad Islamic University
2. Corrosion and Surface Coating Group- Institute Color Science and Technology
3. Health college –Tehran Medical Science University
4. College of Environment & Energy- Azad Islamic University, Science Research

Powder coatings are one type of coatings which has less pollution due the absence of solvent in its construction and therefore has been called as "environmental friendly coating".[1,2] However this type of coating has been considered as an environmental friendly coating but several causes that the most important of them is the lack of proper guiding of coatings and preparation system, have led to produce some waste in powder coatings process.[3,4]Therefore, three house hold production companies have been elected as case studies (because of the most application of powder coating in this branch of industry) to research about the above –mentioned waste materials.
This research has been done through these stages: evaluation the quantity of powder coating waste- theoretical calculation, evaluation the quantity of powder coating waste- case studies.The results shows some parameters such as dimension and size of the parts, geometrical form of the parts, situation and quality of spray process, dimension and size hung are affecting the quantity of waste in powder coating process.The waste percentage decreases when area increase, the waste percentage decreases with increase the amount of coating for each part, the waste percentage increases with increasing the amount of consumed coatings , in case of small parts with irregular geometry the percentage of waste increase , the waste percentage resulting from the hung decreases when the area of part increases, the lack of the primary maintenance (pm) program for coating system and also insufficient training of operators causes an increment in powder coatings waste.

Keywords: *waste, pollution, ecological, environmental friendly coatings, powder coatings, home appliances.*

1. Introduction

Examination of past articles and researches indicate that since powder coatings are considered environmental friendly, special study has not been conducted to estimate the amount of waste in powder coatings[5, 6, 7, 8, 9, 10]. This issue could be studied from two aspects of suppliers of powder coating technology and consumers of powder coating:
A) Manufactures of powder coating technology are mostly focused on reclamation

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systems and study different reclamation systems in terms of their advantages and disadvantages and apply the results in improving technology of powder coating production [11,12,13,14,15,16,17].

B) Consumers of powder coating have not examined the amount of wastage as a result of filters due to the existence of reclamation system in powder coating technology, and also application of modern technology, or older technology but with quality equipments with acceptable maintenance such as filter.

Since price plays an important role in selection of technology and even the type of filters in Iranian industry, inferior quality and old-technology filters substituted for superior technilogy and quality. This issue has a great impact on the rate of wastage caused by powder coating technology and the use of filters. In this regard, this project has been defined for the purpose of preventing environmental pollution caused by waste in consumption and disposal process.

2. Methods

The following steps are performed in this study:

2.1 Evaluating the quantity of powder coating waste - Theoretical Calculations

Since more than 70% of powder coatings are consumed in the home appliances industry, studies were conducted in four home appliances manufacturers.

The theoretical calculation requires the amount of used coating per piece. With regard to standards of coating usage in each piece, for instance in household production industry the thickness of coating is between 60-80 microns), the space of each piece is multiplied by thickness of coating and density of used powder to obtain the amount of powder coatings on each piece. On the other hand, the amount of used coating in specified parts was examined for a period of time and accordingly that amount was divided by the number of parts to obtain the coating on each part. The difference between the amount of coating on each part and the initial calculated amount of coating indicated the amount of waste per part.

2.2 Evaluating the quantity of powder coating waste - Case Study

The process of evaluating the coating material consumption and wastage rate in refrigerator 13, 18 and 20 feet, stove, washing machine and water heaters is described as follow.

Evaluation of wastage should be based on a method according to actual circumstances of factories to not disturbing the regular work. Thus, activities were complied with the production plan of factory in a period of time. The amount of required powder for painting of a specific part in certain period was weighed, and at the end of that period, the surplus consumed powder was weighed. The amount of consumed powder coating was found from difference of aforesaid two amounts, and by dividing it by the number of painted parts, amount of used powder coating was evaluated per part.

According to study, painting waste are in the below sections:

A: wastage caused by hangings

B: wastage caused by cabins and filters

Then, waste amount of above mentioned parts was evaluated as follows: For evaluation of waste in hangings, the number of parts in a certain period were divided into 50 courses. Cabins, filters and hangings were quietly cleaned and then the first round became started. After staining 50 pieces, line ceased, and waste in hangings

seperately were weighed and divided by 50. Then the waste amount related to hangings was determined. Next rounds make the repeatability of test possible. In respect of cabins and filters, after completion of production course, the amount of covered powder on the cabins and filters surfaces were collected and weighed. Then the total powder waste weight devided by the total number of pieces and waste related to cabins was evaluated.

3. Result and considerations

3.1 The result of theoretical waste calculations

Tables (1-2-3-4) indicates amount of consumption and waste of powder coating in refrigerator, freezer, washing machine, stove and water heater.
In these tables consumption and waste of powder coating are calculated based on the density of 1.7gr/cm^3 and thickness of 60 microns.

Table 1: Powder coating consumption and waste in the refrigerator and freezer parts based on electrostatic

Name of manufacture: refrigerator and freezer	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (density)* (gr)	Wastages (based on density) Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Casing of 20 feet	502	3.99	407	10	6.11	16.11	4
Casing of 18 feet	242	3.96	404	10	6.06	16.06	4
Casing of 13 feet	180	3.52	359	10	5.39	15.39	4.2
Refrigerator's door 20 feet	356	0.74	76	23	1.14	23.64	31
Refrigerator's door 18 feet	250	0.8	82	23	1.23	23.73	29
Refrigerator's door feet 13	166	1.11	114	40	1.71	41.71	37
Freezer's door 20 feet	356	0.58	59	18	0.89	18.36	31
Freezer's door 18 feet	250	0.47	48	18	0.72	18.23	38
Beneath Constraint 20 feet	413	0.16	16	3.3	0.24	3.57	22
Beneath Constraint 18 feet	234	0.16	16	3.3	0.24	3.57	22
Beneath Constraint 13 feet	120	0.16	16	3.3	0.24	3.57	22
Median Beneath	486	0.11	11	2.9	0.17	3.03	28
This column was calculated based on 1.7 gr/cm^3 and thickness of 60 microns.							

Table2: Powder coating consumption and waste in the washing machine parts

Name of manufacture: washing machine twin	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (density)* (gr)	Wastages (based on density) Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Casing	162	1.91	195	11	15	26.3	13.4
Back cover	146	0.59	61	7.5	15.9	23.4	38.3
Base Connection Blades	158	0.186	19	2.1	3.5	5.6	29.4
Hose connection Piece(1)	170	0.117	12	1.3	0.9	2.2	18.3
Hose connection Piece(2)	175	0.117	12	1.3	0.9	2.2	18.3

Table3: Consumption and wastage of powder coating in stove

Name of manufacture: stove	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (density)* (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Left side of casing	156	0.588	60	8	14.1	21.7	36.1
Right side of casing	160	0.588	60	8	14.1	21.7	36.1
Stove's door	185	0.372	38	5	11.8	16.9	44.4
Dorsal	170	0.735	75	9	16	24.9	33.2
Tenacious string of double-glass	175	0.156	16	3	3.6	7	43.7

Table4: Consumption and wastage of powder coating in water heaters

Name of manufacture: water heaters	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (density)* (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Surface	154	1.07	110	8	18.2	26.4	24
Back	168	0.71	73	5	15	20.4	27.9

3.2 The Result of Case Studies

Tables (5,6,7,8) shows the rate of consumption and waste of powder coating in different parts of refrigerator and freezer,washing machines,stones,water heaters through Electrostatic study.

In this table consumption and waste are shown based on the scale measurement. Since the amount of waste of powder coating is related to hangings and cabins, the amount of waste is shown based on these two factors. Regression equation and graph of waste of powder coating are shown based on space in diagrams (1,2,3,4).

Table 5: Powder coating consumption and waste in the refrigerator and freezer parts

Name of manufacture: refrigerator and freezer	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (scale) (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Casing of 20 feet	502	3.99	460	10	5.93	16	3.4
Casing of 18 feet	242	3.96	520	10	6.71	17	3.2
Casing of 13 feet	180	3.52	430	10	5.55	16	3.6
Refrigerator's door 20 feet	356	0.74	95	22.5	1.23	24	25
Refrigerator's door 18 feet	250	0.8	100	22.5	1.29	24	24
Refrigerator's door feet 13	166	1.11	135	40	1.74	42	31
Freezer's door 20 feet	356	0.58	65	17.5	0.84	18	28
Freezer's door 18 feet	250	0.47	55	17.5	0.71	18	34
Beneath Constraint 20 feet	413	0.16	14	3.13	0.18	3.3	24
Beneath Constraint 18 feet	234	0.16	10	3.33	0.13	3.5	35
Beneath Constraint 13 feet	120	0.16	15	3.13	0.19	3.3	22
Median Beneath	486	0.11	9	2.86	0.12	3	33

Table6: Powder coating consumption and waste in the washing machine parts

Name of manufacture: washing machine twin	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (scale) (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Casing	162	1.91	235	11.3	14.2	25.5	10.8
Back cover	146	0.59	73	7.5	15.2	22.7	31
Base Connection Blades	158	0.186	24	2.1	3.3	5.4	22.5
Hose connection Piece(1)	170	0.117	7.5	1.3	1.1	2.4	32
Hose connection Piece(2)	175	0.117	7.5	1.3	1.1	2.4	32

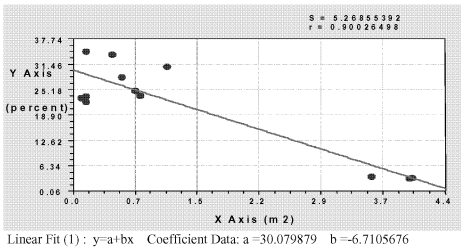
Table7: *Powder* coating consumption and wastage in stove

Name of manufacture: stove	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (scale) (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Left side of casing	156	0.588	72	7.6	13.2	20.8	28.8
Right side of casing	160	0.588	72	7.6	13.2	20.8	28.8
Stove's door	185	0.372	43	5.1	11.3	16.4	38.1
Dorsal	170	0.735	98	8.9	15.1	24	24.4
Tenacious string of double-glass	175	0.156	18	3.4	3.1	6.5	36.1

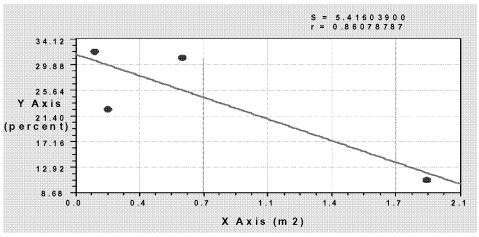
Table8: Powder coating consumption and wastage in water heaters

Name of manufacture: water heaters	Number of Production (Weekly)	Piese Space (M2)	Rate of Consumption (scale) (gr)	Wastages (based on density)			
				Weight (gr)			Precent
Name of piece				Hanging	Cabin	Sum	
Surface	154	1.07	123	8.2	19.1	27.3	22.1
Back	168	0.71	85	5.4	14.5	19.9	23.4

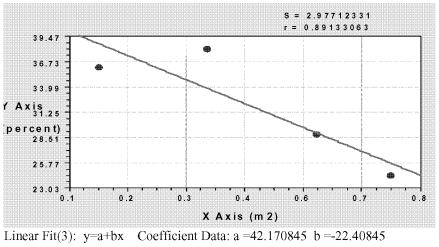
Diagrams :Regression equation and graph percentage of waste of powder coating in the refrigerator and freezer(1), washing machines(2),stoves(3),water heaters(4) parts based on space



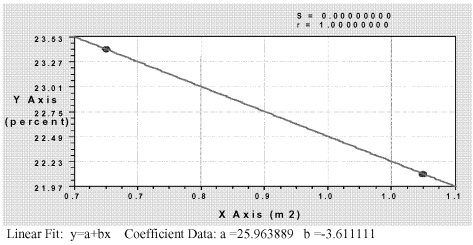
Linear Fit (1) : y=a+bx Coefficient Data: a =30.079879 b =-6.7105676



Linear Fit(2): y=a+bx Coefficient Data: a =31.700366 b =-10.343092



Linear Fit(3): y=a+bx Coefficient Data: a =42.170845 b =-22.40845



Linear Fit: y=a+bx Coefficient Data: a =25.963889 b =-3.611111

4. Conclusion

Based on survey results and examination of reasons of Powder coating waste, following conclusions obtained are:

Applying superior reclamation technology will result in reduction of waste percentage and increase the percentage of recycling efficiency. Designing the appropriate hangings complying with pieces type decreases the amount of waste due to hangings. The use of quality filters reduces the percent of waste caused by filters and increases the recycling efficiency. Performing a primary maintenance program (PM) for coating system prevents re-work and decreases the amount of waste. Different and non-equal conditions for spraying various parts with different sizes decrease the waste percentage. Controling preparation stage prevents re-working and decreases the amount of waste. Controling conditions of the coating chamber reduces the amount of waste percentage due to cabin. Selecting proper powder coatings and making conditions suitable for maintaining powder decrease the amount of waste. Training operators prevents re-work and decreases the amount of waste. Percent rate of waste deccreases when the area of part increases, $r = 0.912$. Percent rate of waste deccreases when the consumed amount of coating for each piece increases, $r = 0.905$. Percentage rate of waste in small pieces with irregular geometric shape increases, $r = 0.920$. And with increase of pieces space, the percentage of waste in hanging reduces, $r = 0.891$. Amount of waste increases when the amount of coating increases, $r = 0.886$.

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