

Reducing Bits in Electrodeposition Process of Commercial Vehicle – A Case Study

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Abstract. Painting process is critical in commercial vehicle manufacturing process for protection and decorative. The good quality on painted body is important to reduce repair cost and achieve customer satisfaction. In order to achieve the good quality, it is important to reduce the defect at the first process in painting process which is electrodeposition process. The Pareto graph and cause and effect diagram in the seven QC tools is utilized to reduce the electrodeposition defects. The main defects in the electrodeposition process in this case study are the bits. The 55% of the bits are iron filings. The iron filings which come from the metal assembly process at the body shop are minimised by controlling the spot welding parameter, defect control and standard body cleaning process. However the iron filings are still remained on the body and carry over to the paint shop. The remained iron filings on the body are settled inside the dipping tank and removed by filtration system and magnetic separation. The implementation of filtration system and magnetic separation improved 27% of bits and reduced 42% of sanding man hour with a total saving of RM38.00 per unit.

1. Introduction

The painting process in the commercial vehicle assembly is to provide a uniform coating for the protection and decorative purpose. In order to achieve the purpose, the process is broken down into a number of different parts. These parts, or 'layers', are applied in a specific order and although the function of each 'layer' is specific it relates very closely to the others to provide the desired balance of properties [1]. The multilayer coating in the current technology are pre-treatment, electrodeposition primer, primer surfacer and wet on wet technology of top coat consist of base coat and clear coat. The function of multi layers coating were corrosion protection for primers, smoothness and chip resistance for primer surfacers and colour and weather resistance for the final top coat. The process in the Paint shop are pre-treatment and electrodeposition, sealing, electrodeposition sanding, primer coating, primer sanding and top coating. The pre-treatment of car bodies manufactured from different metal is critical for the state of the art corrosion protection and provides best adhesion for electrodeposition coating [2]. The electrodeposition (ED) process is a special coating method where ED paint dispersed in water is electrically deposited on surface of substrate to form a uniform and water-insoluble film. The main process in the electrodeposition process is the electrolysis [3] The fundamental aspect of electrodeposition is reported by Beck [4]. The electro-deposition process will form a uniform coating on the bodies for the corrosion protection. The



process started with pre-treatment process which are pre-cleaning, pre-degreasing, degreasing, water rinse, surface conditioning, phosphating, final water rinse and deionized water rinse. After the pre-treatment process, is the electrodeposition process which include of electrodeposition, ultrafiltration and final deionized water rinse. After the electrodeposition process, the coated unit will be dried by oven baking.

1.1. Quality defects

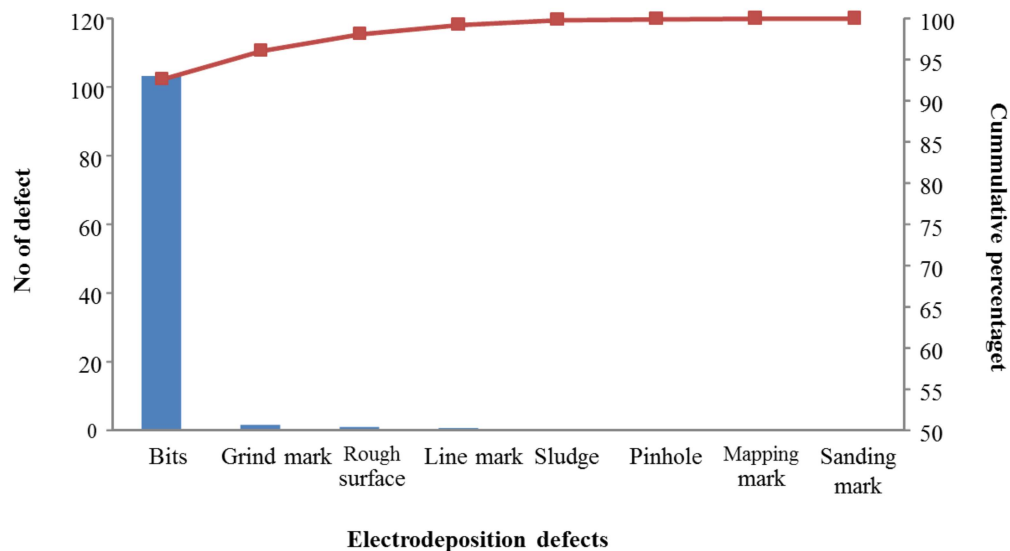
The poorly cleaned body contribute to the quality of the electrodeposited body. It is commonly known that many surface defects lie in the poorly cleaned surface after the electrodeposition process. The defected surface on the body is required to be removed by sanding before proceed to next coating which is primer coating. Since the process of sanding is costly, it is very important to provide a good quality on the surface of electrodeposited body. The good quality can be achieved by reducing the defects in the electrodeposition process. The common defects on the electrodeposited surface are bits, pinhole, cissing, sludge, grind mark and line mark. The applications of reducing defects in automotive painting process are reported in literatures. The bits problem is one of the defects discussed. The bits root cause is the accumulated dirt particle inside dipping tank. Removal of dirt particle is achieved by a set of a micro hydro cyclons combined with pressurised paper band filters and magnetic separation [2]. The common used in the industry is for the filtration system of Pre-treatment and electrodeposition is the filter bag inserted in the filter housing to remove the particles. Standard filter types are bag filters with particle retention of over than 25 or 50 μm . The polypropylene material in a needle is the common filter material. The filter bags are placed in a stainless steel basket and these are placed in stainless steel filter vessels holding two to eight such baskets. The paint flows from top to bottom under pressure which is maintained as low as possible for best filtering effect. The filters are flushed and cleaned every week. Broken filters can be identified by monitoring the pressure differences between the input and output of the filter cartridges. The cartridge has to be stopped operation and the filter bags should be replaced in cases of heavy dirt. The filter bags should be replaced to the coarser mesh-size that is $> 100\mu\text{m}$. The performance of the bag filter can be enhanced significantly by innovative application of magnetism which is magnetic pre-filters [5]. An innovative novel filter is introduced due the inefficient of the filter bag [6]. To improve the defect that occurs from the characteristic of the structure, the optimal location of supporting bonnet structure of automobile bodies is researched [7]. The quality problems are frequently occurred without proper cleaning using spray. The implementation of spray ON/OFF confirmation logic control can ensure the body passes by the proper cleaning [8].

1.2. Methodology

The most fundamental quality tools are called the seven quality tools – 7 QC tools. The seven QC tools are simple statistic which widely used in the manufacturing industries for solving problems and continuous improvement [9]. The seven QC tools are cause-and-effect diagram, flow chart, Pareto diagram, check sheet, control chart, histogram, and scatter plot. In this paper, the application of only two quality tools are utilized – Pareto diagram and cause-and-effect diagram. The Pareto diagram and cause-and-effect diagram are most crucial quality tools used in Japan [10]. These tools are common and essential in identification and analysis [11]. The Pareto-diagram shown on a bar graph which factors are more significant for the selected problem. The cause-and-effect diagram identifies many possible causes for an effect or problem and sort ideas into useful categories. In the cause-and –effect diagram, the causes are divided into four main categories which are man, method, machine and material.

2. Problem analysis

The defects after the electrodeposition process are detected on the coated surface after the baking process by visual inspection. The visual inspection is conducted on the coated body. Bright lights and their reflections are used to evaluate the appearance and locate any defects. The defects found are bits, grind mark, rough surface, line mark, sludge, pinhole, mapping mark and sanding mark. To identify the main problem, the defects are plotted in the chart as shows in Figure 1. Based on the chart, the main problem is the bits and covers 93 % of overall defects.



Electrodeposition defects

Figure 1. The electrodeposition defects

Therefore, bits are selected as the main defects to be solved. Bits are foreign materials found stick on the coated surface. By observing using microscope, the bit can be identified as iron filing, phosphate bits and electrodeposition paint bits. The shining and rusty is the iron filing and the whitish and powdery is phosphate bits and electrodeposition bits. The types of bits are shown in Figure 2. The bits percentage graph is explained in Figure 3. The highest percentage of bit is iron filing which covers 55% of overall bit.

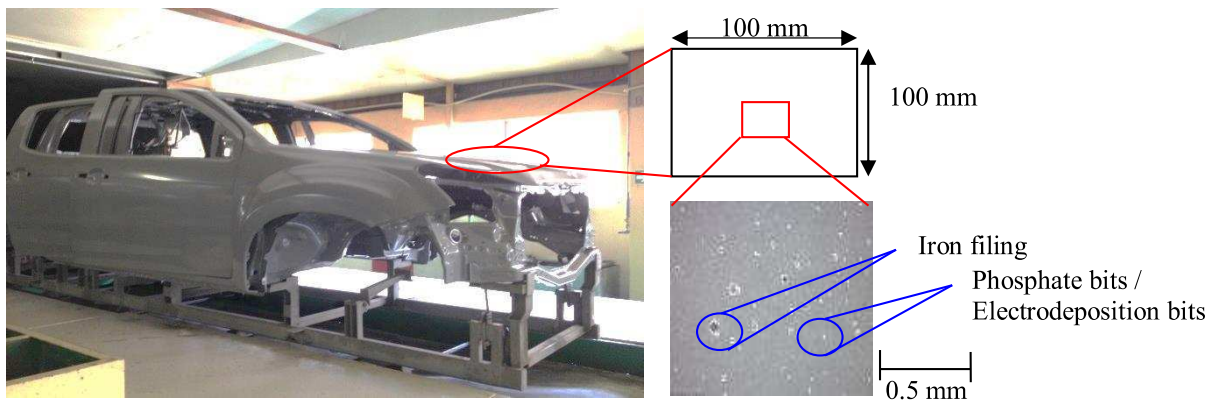


Figure 2: Type of bits on unit

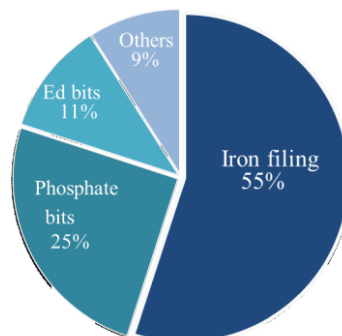


Figure 3: Iron filings on body in white

The iron filings come from the body assembly at the Body shop. The iron filings are produce during the spot welding, welding, grinding, and sanding process for the assembly of the metal part. The iron filings found in body in white is shown in Figure 4.



Figure 4: Iron filings on body in white

The bits root cause is analysed using Ishikawa diagram as shown in Figure 5. The analysis is divided into four main factors which are man, method, machine and material.

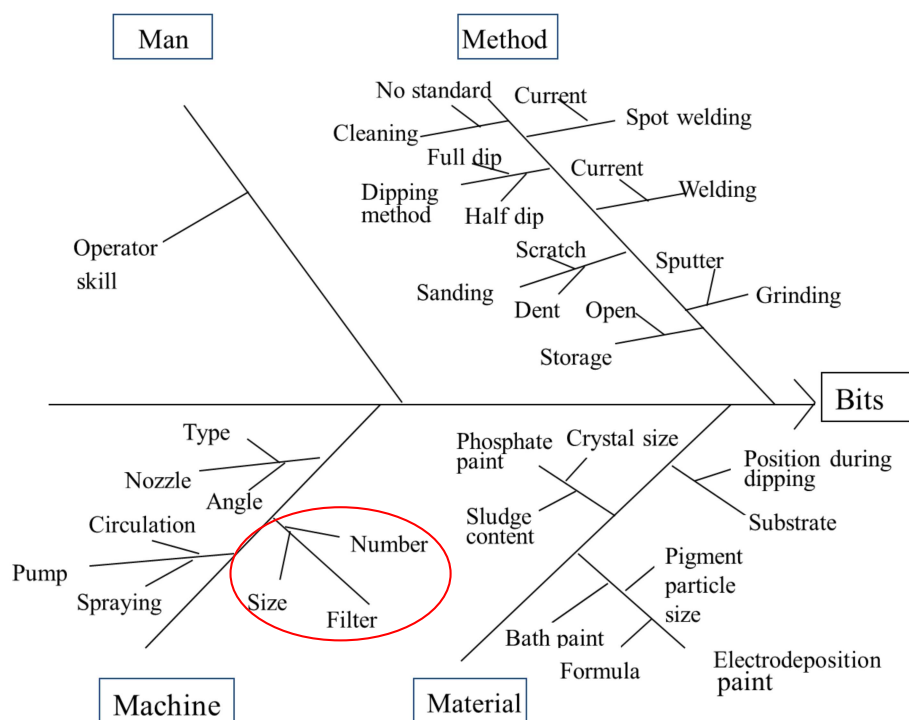


Figure 5: Bits root cause analysis

2.1. Man

For the man factor, the operator skill for the spot welding, welding, grinding, and sanding process influenced the amount of the iron filing. The operator skill is controlled by skill chart and is evaluated each month. For the welding operation only the skilled operator with certificate is allow to do the welding process.

2.2. Method

The factors involving method which produce the iron filings at the body shop are spot welding, welding, sanding and grinding process. The spot welding and welding process is the step to assemble the metal parts to build a

complete body. Spot welding gun and welding machine are used during the process. Portable hand grinder is used in the grinding process to grind the sputter that produced during the spot welding process. Finally, in order to produce a smooth and good surface for a good quality for the next painting process, defects such as dent and scratches on unit are sanding using the sanding machine. It is very important to minimise the iron filings at the body shop during these processes to minimise the iron filings to the paint shop. The generation of iron filing from the spot welding process and welding process is controlled by periodical checking of the current parameter once in three months. For the sanding and grinding process, the defects such as sputter, dent, and scratch are controlled to reduce the iron filings. A cleaning method is established to clean the body from the iron filings before delivery to paint shop. The body is vacuumed with high pressure vacuum and clean with sew rag. The body is store at the white body storage (WBS) after completed the cleaning process. To prevent the accumulation of iron filing inside body during storage, the buffer quantity at WBS is controlled. However, there are remaining iron filings on the body. The remained iron filings are carry over to the paint shop. The remained iron filings on the body are settled inside the dipping tanks during the pre-treatment and electrodeposition process. The dipping methods are half dip or full dip.

2.3. Machine

The machine factors are inclusive of filter, pump and nozzle. The iron filings removal inside tank is depended on the filter size and number. The carry over foreign materials must be reduced by the filtration system. The pump is involving the workability of spraying pump and circulation pump. The spraying nozzle type determined the spraying efficiency on the body whereas the spraying angle ensured the nozzle is sprayed at the correct angle to remove the iron filings on the body.

2.4. Material

For the material factor, the substrate, electrodeposition paint and phosphate paint are the factors which contribute to the bits. The electrodeposition paint root causes are paint formula, bath paint and pigment particle size. The paint formula is the paint formulation inclusive resin composition, ash content and additive. The solid content, pH and bath temperature are the factors involving bath paint. These parameters are controlled within standard specification provided by the paint supplier. The paint supplier will provide weekly report of the parameter control. The grinding condition effect the pigment particle size. The phosphate paint factors are the sludge and crystal size. The phosphate sludge is generated after the chemical reaction with body and is filtered by filtration system. The substrate position during dipping also influenced the bits count on unit.

For initial countermeasure, it is propose to remove the iron filings inside the dipping tank by filtration system and magnetic separation. For filtration system, smaller size filter is used to trap the iron filing and magnet bar utilizes in magnetic separation to attract the iron filings. By using these two countermeasures, the amount of iron filings inside dipping tank is expected to be reduced.

3. Experimental conditions

A filtration system is installed at the dipping tank to trap the iron filings inside the dipping tank. There are ten dipping tanks for the Pre-treatment and electrodeposition process. The filters are installed at the Pre-treatment tanks consist of circulation and spraying system. The circulation system is for the liquid circulation inside tank where the body is dipped into it. The spraying system is located upper of the spraying tank to rinse the body after the dipping process. The size and quantity of filters installed are described in Table 1.

Table 1. Filter quantity and filter size for dedicated tank

Tank No and Name	Spraying filter		Circulation filter	
	Quantity (unit)	Filter size (micron)	Quantity (unit)	Filter size (micron)
1. Pre degreasing	2	25	8	50
2. Degreasing	2	25	8	50
3. Water Rinsing	2	25	3	50
4. Surface conditioning	2	25	3	50
6. Water Rinsing 2	2	25	3	50

The material of the filter is the nylon and can be washed and re-used for repeat filtration. The filter bags are placed in stainless steel basket and are placed inside stainless steel filter vessel. Magnets with 9000 gauss strength are inserted inside each of the filter bag to capture the iron filing by magnetic separation. The filtration system is shown in Figure 6. The numbers of bits are counted on roof, bonnet and door surface after the oven baking.



Figure 6: Filtration system with filter bag and magnet

4. Results and discussion

The iron filings were trapped inside filter after installation of the filtration system. The trapped iron filing inside filter bag is shown in Figure 7.



Figure 7: Iron collection inside filter bag

The quantity of bits on the coated surface is shown in Figure 8. The amount of bits which can be seen and feel by hand are counted in a 100 millimetres square outside of the coated body. The measurement is taken at three surface areas. The surface areas are divided into three sections which are roof surface, bonnet surface and door surface. The number of bits count before the experimental are recorded and presented as in Figure 10. The bits count on the roof surface, bonnet surface and door surface is 58, 45, and 7 respectively. Most of the bits are accumulated on the roof area as compare to door and bonnet due to different of the surface orientation. The roof is in horizontal orientation compared to the bonnet which in 25° and door is in vertical orientation.

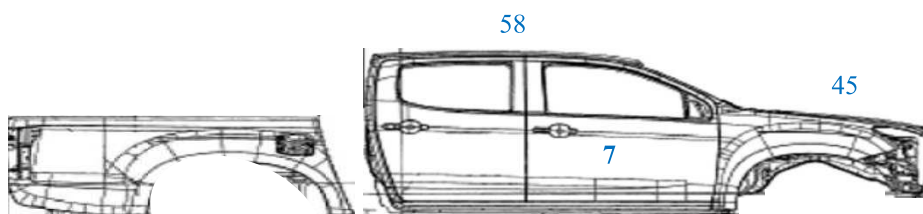


Figure 8. The number of bits count on unit before experimental

The bits count is improved 25%, 27%, and 29% at roof, bonnet and door surface respectively after filtration system and magnetic separation. Details of bits count comparison before and after installation of filtration and magnetic separation is illustrated in Figure 9.

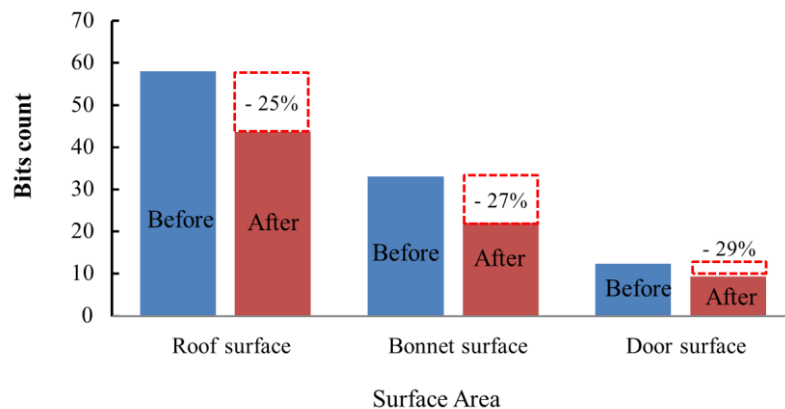
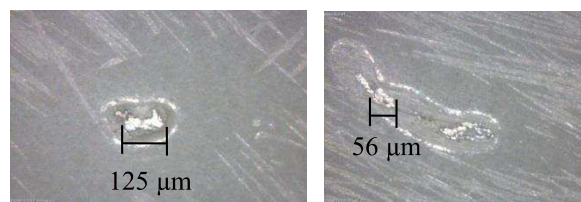


Figure 9: Comparison of bits count before and after filtration and magnetic separation

Before the application of the filter, iron filing size more than $125\ \mu\text{m}$ is found on the coated surface. However with the filter application, the size of iron filing detected on surface area is smaller. The maximum size of iron filing left on the surface area is $56\ \mu\text{m}$. The filter is effective in trapping the iron filing bigger than $59\ \mu\text{m}$. The iron filings sizes more than $89\ \mu\text{m}$ escaped and the sizes less than $56\ \mu\text{m}$ remained and stick on unit. The size of bits is identified by microscope as shown in Figure 10.



a) Before ($> 125\ \mu$)

b) After ($< 56\ \mu$)

Figure 10: Bits size on unit

By applying the filtration and magnetic separation into the dipping tank, the rework activity such as sanding on surface area is reduced. These contribute to the reduction of man hour, manpower and sanding disc consumption. The reduction items are explained in Table 2.

Table 2. The reduction items before and after application of filtration and magnetic separation

Item	Before	After
Manpower	8 person	6 person
Man hour	0.45	0.26
Sanding disc consumption	8 pieces	5 pieces

The man hour reduced from 0.45 to 0.26 and manpower reduced from 8 person to 6 person. The sanding disc consumption for sanding activity also reduced from 8 to 5 pieces per unit. By translating these figures into cost, this activity contribute to the saving RM 3.00 on sanding disc consumption and RM 35.00 on man hour cost.

5. Conclusion

The main defect on the electrodeposited surface is the bits. The major contribution of the bits is iron filing generated from welding, sanding, grinding, and spot welding process at body shop during the metal assembly process. The iron filings are carry over to paint shop and accumulated inside dipping tank. By introducing the filtration and magnetic separation into the Pre-treatment system has successfully reduced the iron filing inside tank. The number of bits improved 25%, 27%, 29% on roof surface, bonnet surface and door surface respectively. The numbers of bits improved 27% in average. The sanding man hour used to improve the electrodeposited surface is reduced by 42% and a total saving of RM38.00 per unit achieved.

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