UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF SPRAY PAINT PROCESS ON HIGH COSMETIC JOB

This report submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering

by

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ABSTRAK

Salutan adalah bahan pembentuk filem yang menyediakan penampilan yang menyenangkan, perlindungan kakisan dan sinar ultraungu ultraviolet. Di antara pelbagai jenis salutan, lukisan semburan kekal popularitinya kerana prestasi kualiti dan pertimbangan ekonomi. Lukisan semburan hanyalah penukaran pengisaran cat dari cat cecair ke kabus semburan di mana cat atomized digunakan pada objek yang disasarkan. Kajian tentang mengoptimumkan parameter proses lukisan semburan dilakukan untuk memproduksi aluminium kosmetik pada permukaan casting die. Ini adalah masalah perindustrian yang sebenar yang digunakan untuk Dynacast Sdn. Bhd. Terdapat banyak pemboleh ubah yang mempengaruhi prestasi semburan lukisan. Pembolehubah ini termasuk teknologi semburan cat, jenis cat, parameter proses penyediaan permukaan, dan lain-lain. Pada peringkat semasa, terdapat kekurangan pendekatan praktik yang baik untuk teknologi yang dipilih. Kerja ini berdasarkan pengalaman dan percubaan dan kesilapan. Dalam pendekatan percubaan ini, lima parameter proses penting dengan tetapan yang pelbagai dipilih. Kaedah Taguchi diguna pakai bagi hasil eksperimen yang teguh dan disebabkan oleh parameter yang berbeza-beza. Set larian dijalankan dengan empat ulangan dengan memasukkan suhu dan kelikatan sebagai bunyi. Untuk maklum balas ketebalan salutan dan pengukuran glossiness dijalankan. Ketebalan salutan Fischer digunakan untuk mengukur ketebalan salutan sementara Glossmeter digunakan untuk mengukur permukaan gloss permukaan. Berdasarkan isyarat kepada analisis nisbah bunyi, didapati bahawa jenis cat dan penyediaan yang bersesuaian adalah faktor penting untuk glossiness tertinggi dan salutan disasarkan ketebalan. Pengukuran glossiness dan ketebalan yang dioptimumkan dalam kajian ini ialah 79 GU dan 28.5μm.

ABSTRACT

Coating is a film-forming material that provides pleasing appearance, corrosion protection and block-out ultraviolet ray. Among various types of coating, spray painting remains its popularity due to the quality performance and economic consideration. Spray painting is simply the conversion of paint atomization from liquid paint into a mist of spray whereby the atomized paint is applied on a targeted object. The study on optimizing process parameters of spray painting is conducted for producinghigh cosmetic aluminium on the die casting surface. This is a real industrial problem that applied for Dynacast Sdn. Bhd. There are many variables affecting the performance of spray painting. These variables include spray paint technology, type of paints, surface preparation process parameters, etc. In current stage, there is lack of good practice approach available for the selected technology. The work is mostly based on experience and trial and error. In this experiment approach, five significant process parameters with varied settings are selected. Taguchi method is adopted for a robust experimental outcome and due to varied parameters. The set of runs were conducted with four repetitions by including temperature and viscosity as the noises. For the responses the coating thickness and glossiness measurements are conducted. Fischer coating thickness gauge is used to measure coating thickness while Glossmeter is used to measure gloss level of the surface.Based on the signal to noise ratio analysis, it is found that correspondinglytype of paint and preparation are the significant factors for highest glossiness and targeted coating thickness. The optimised glossiness and thickness measurement obtained in this study are 79 GU and 28.5μm respectively.

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LIST OF ABBREVIATIONS

ESD - Electrostatic Spray Deposition

HVLP - High Volume Low Pressure

AED - Anodic Electrocoating / Electrodeposition

CED - Cathodic Electrocoating / Electrodeposition

cfm - Cubic Feet per Minute

F - Fahrenheit

GU - Gloss unit

MPI - Master Paint Institute

OEM - Original Equipment Manufacturer's finishes

DFT - Dry Film Thickness

DOE - Design of experiment

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Coating is a film-forming material that carries many functions such as to provide pleasing appearance, corrosion protection, to block-out ultraviolet ray and so on. There are various type of coating in the industry including spray painting, powder coating, electro-coating, electrostatic coating and dip coating.Powder coating is a dry finishing process that applies electrostatic spray deposition (ESD) to transfer the powder coating onto a metal substrate. Dip coating is the immersion ofsubstrate into a liquid coating solution. The substrate is then withdrawn from the solution at a controlled speed. Coating thickness generally increases with faster withdrawal speed. The thickness is determined by the balance of forces at the stagnation point on the liquid surface. Electrostatic spray painting is a method that applies electrostatically charged to distribute the paint particles evenly and get uniform coverage.

Among various types of coating, spray painting remains a popular choice for professional craftsmen in heavy-duty industries. It provides a speedy and economical way to apply high quality paint coatings to a wide range of surfaces at a fraction of the time and cost. Spray painting systems produce a superior finish at reduced costs, with maximum utilisation of liquid painting materials. Industrial spray painting systems apply paint at different input air pressure. Paint particles in the form of tiny droplets are expelled at high pressure to produce a mirror-like finish on a variety of surfaces,

including workshop floors, marine tanks, silos, commercial roofing and aluminium die casting materials.

The economic situation of spray painting is the major element many company would like to adopt the process for their selected cast product. One of the common spray painting equipment is the High Volume Low Pressure (HVLP) spray gun and water paint booth. HVLP spray gun supplies air at a much lower velocity with pressure does not exceed 10 psi. Transfer efficiency can be as high as 85%.The water wash spray booth provides an extremely efficient means for removing paint particles from the exhausted air by using water as a filtration medium. It ensures proper ventilation to protect operators from fire risk and health hazard.

However, there are not enough reference and standard available for any company to apply the process. Most of them are through trials method and become *secret recipe* own by the company. Under this technology there are many areas to be explored. The area that need attention include the current spray paint technology, type of paints, spray painting procedures, process parameters in painting, coating glossiness measurement, coating defects, application of paints and process optimization in coating.Therefore, this study is taken to assist the company to produce a stable process for high quality painting.

Product with good cosmetic will be valuable for the market. There are many products require good surface finishing and excellent external appearance to increase their value. Dynacast (M) Sdn. Bhd is a global manufacturer of precision engineered metal components. The company utilize proprietary die cast and metal injection moulding technologies and offer robust solutions to many industries including automotive, consumer electronics, and healthcare.

Figure 1.1: Main entrance of Dynacast (M) Sdn. Bhd (DYNACAST, 2017)

The multi-slide die casting process uses four perpendicular slides in the tool enabling very complex and accurate castings to be produced. In some cases, up to six slides can be used at angles other than 90 degrees. This die cast tooling process is used predominantly for small zinc components; however, we developed a multi-slide die casting machine capable of casting magnesium. We have excelled at multi-slide for over 80 years and each year we continue to improve our process to create even more complex parts for our customers.
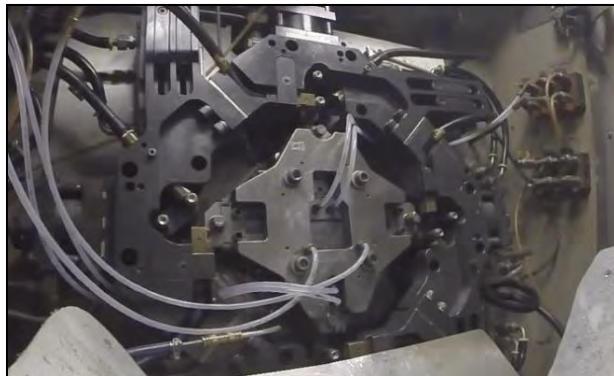
Figure 1.2: Multi-slide die casting machine (DYNACAST, 2017)

Dynacast Industrial Products produces low cost, zinc and aluminum alloy fasteners and standard components including wing nuts, cap nuts, panel nuts, conduit nuts, pallet nuts, rings, plugs, latches, connectors, anchors and inserts.

Figure 1.3: Sample die casting products of Dynacast(DYNACAST, 2017)

Using unparalleled global manufacturing and engineering resources, Dynacast Industrial Products brings value-added cost reductions to standard zinc and aluminum die-cast fasteners and standard components. Dynacast's exclusive die casting production methods assure accurate and uniform parts with smooth surfaces. Dynacast die-cast industrial products reduce costs, simplify assembly and improve both appearance and function of end-products.

1.2 Problem Statement

There are many variables affecting the performance of spray painting. These variables include spray paint technology, types of paints, surface preparation, process parameters and etc. Choosing the most suitable approach is challenging because of limited information and the task is usually based on the user experience. These are usually poorly documented. The information also treated as a secret by users as one of the basis of job securement. Wrong approach will lead to poor surface finishing and painting defects. Therefore, proper selection of approach and equipment is essential to guarantee fine surface finishing of spray painting process. In addition, this study is related to a real industry problem. Dynacast (M) Sdn. Bhd. would like to adopt spray painting as their new coating process. Therefore, there is a need to develop a standard approach and procedures to assist the company to produce a stable process for high quality coating.

1.3 Objectives

The objectives of this study are:

a. To identify the impact of the significant factors on the quality of spray painting process.
b. To optimize spray painting process using Design of Experiment (DOE) approach.
c. To recommend spray painting strategy for water paint booth in correlation to the output of process parameters.

1.4 Scope of study

The scopes of this project focus on producing surface finish with high glossiness. There are many types of paints in the industry displaying different characteristics. Some special purpose paints do not make the surface glossy. Therefore, the study will only focus on equipment and materials that produce high glossiness. This study will only conduct experiments that are supported by water paint booth and High Volume Low Pressure (HVLP) spray gun. HVLP spray gun can only support low input pressure. Painting jobs require high input pressure will not be considered. The coating material size is an apprehension as coating will be carried under the water paint booth provided. Large size of object such as automobile will not be able to fit into the spray booth. Besides that, there are five significant parameters involved in this study. They are angle of spray, distance between spray gun and substrate, atomization pressure, type of paints and surface preparation. There are many more factors that are affecting coating performance. Due to financial and time limitation, the five most significant parameters are reviewed and selected.

1.5 Significant and importance of the study

1.5.1 Function

The intention with spray painting is to protect the metal surface from corrosion and, at the same time, obtain the required degree of cosmetic finish for the object. The ability of the paint coating to prevent corrosion depends on its anti-corrosive

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pigments and its adhesion to the substrate. Often the protective properties are a combination of the above factors.

1.5.2 Operation

Spray painting requires some basic equipment including the spray booth and spray paint gun.In this project, I am provided with water spray booth and High Volume Low Pressure (HVLP) spray gun.
The Spray Systems Water wash Spray Booth provides an extremely efficient means for removing paint particles from the exhausted air by using water as a filtration medium. Water wash booths are utilized for high volume paint usage. In addition, water wash booths handle a larger variety of paints as compared to dry filter booths, with a wider range of viscosities and drying speeds. Water wash booths are favoured by all health, fire and building codes.

HVLP spray guns utilise a High Volume of air at a Low pneumatic Pressure in order to transfer paint or other fluids to a surface. The integrated turbine is similar to types used in vacuum cleaners, but rather than sucking in air, it blows warm air with the liquid towards the substrate. HVLP is often the preferred choice for painting metal mainly because it has a higher transference rate than older technological spray painting systems. Transfer efficiency is defined as the percentage of paint leaving the gun that result in coating the intended surface rather than being dissipated into the air.

The aim of any spray gun is to atomise liquid which effectively breaks it up into tiny particles, so this paint atomisation simply converts liquid paint into a mist of spray. As a rule, the smaller the droplet size, the more uniform the coating. Factors influencing the size of the liquid droplets and the effectiveness of atomisation include the size of the spray gun tip and level of air pressure.

Proper atomisation is essential for achieving a good finish when re-spraying architectural metalwork. Poor atomisation will lead to a number of problems such a coating that resembles orange peel or an uneven surface. When used by experienced

sprayers, HVLP guns are an impressive way of covering a multitude of surfaces ranging from cars to the metal framework on shop fronts.

CHAPTER 2

LITERATURE REVIEW

2.1 Spray Paint Technology

2.1.1 Dip Coating

Dip coating as shown in Figure 2.1 is a simple and traditional method of painting industrial goods. It is easy to operate. The operation has low capital cost. It also provides much higher material yield when compared with spray coating. The process applies the principle of the adhesion properties of viscous paints on the objects to be painted. In contrast, dip coating has its   disadvantages. One of them is the lack of processing window with regard to film thicknesses and the defects associated with it. The defects include runs and blisters. Dip coating also require some costs and the need for special precautionary measures to avoid explosions or fires when using solvent-borne paints. Thus, very few cases where water-based dip coats are nowpractically used in the conventional style industry. There are people attempt to replace water by trichloroethylene. However, the attempt did not succeed for the time being in overcoming all the challenges associated with the process. The good news is that the tendency to run was cut down and a greater uniformity of film thickness is achieved. Since the dip coating is associated with fire risk, thus it was the occupational health and safety reasons

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need to be mentioned to ensure people do not miss-operate and causes bad incident to happen.
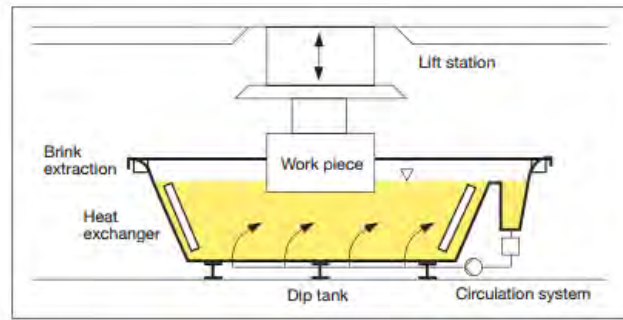

Figure 2.1: Process scheme of conventional dip coating(Artur Goldschmidt et al.,2003)

In dip coating, there are two ways of immersions; the workpiece is immersed either in a batch or continuous process. Dip coating as shown in Figure 2.1 usually applies low viscous paint. Workpiece will be removed and pass through a draining section, conveyed to the oven. Draining process is combined with evaporation of the solvents, has to last long enough to ensure that there are no surface defects such as blisters, pin-holing or runs. Some dip coating applying water-based paint require a sufficiently long blow-drying zone, which is usually heated in addition, to make sure workpiece is totally dried. Although all the optimizations have been implemented, it is impossible to achieve uniform film thicknesses on every part of the workpiece. Furthermore, the paint still tends to run especially when the paint viscosity is too low. The paint would run away from edges, and these are the drawbacks of conventional dip coating with water-based paints. The disadvantages of conventional dip coating become particularly apparent with complex objects which include cavities. During the evaporation phase and the subsequent heating in the oven, a saturated vapour atmosphere is filling up the cavities through which air cannot pass. Thus, it is possible for the fresh paint film to be washed off again by condensationbecause of the slower heating of the cooler parts of the workpiece. The consequence of this is an incalculable weakening of the cavity protection which is impossible to monitor.