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An Analytic Hierarchy Procedure based method for Cosmetic Design

Chih-Huang Yen*

Dr. Chih-Huang Yen, Design director , Tair Jiuh Group, Tainan, Taiwan

**Corresponding author: Dr. Chih-Huang Yen, No.7, TaFa RD., Render DIST., Tainan, Taiwan 71747*

Abstract: The circulation of global brands has become a common trend. This study proposed a method for the development of ultra thin cosmetic product to make the product size easier to circulate and with better temperature tolerance, bacteria resistance and antiknock quality. Furthermore, with this method, products are able to cater for the growing international market and also adapt to the rapidly changing fashion environment. Thus the application for ultra thin powder is characterized by small volume of a large variety production. Along with changes in fashion, automated production was used to create fashion and luxury goods suited for consumers. Moreover, it makes the products portable, and the price reasonable that meets the demand of consumers. The innovation points are as followed: 1.Formula development 2. Ultra thin aluminum plate development 3. Automated machine development 4. Ultra thin powder development.

The design of the study was used as a criterion to verify the production result while AHP method was adopted to calculate the optimal size in design target. In the final stage of the study, empirical verification is conducted. The ratio and the adjustment of formula were set to 1.mm optimization in powder pressed design; a patent in aluminum plate development was received, and an automated powder design machine was developed for mass production. For future study, evaluation can be done by the combination of AHP and ANP along with feedback of design results and repeated correction.

Keywords: ultra thin, automation, optimization, Analytic Hierarchy Procedure, AHP

1. Introduction

1.1 Motivation

Cosmetics play an important role pursuing a high degree in fashion. Similar to purchasing food, customers occasionally buy cosmetics without finish using it or make the product become overdue. If manufacturers can develop a product with the size or doze meet the need of consumers, then product competitiveness can be increased. Thus, this study based on the concept of ultra thin powder and used thin and light doze to solve the rapidly changing problem in cosmetic fashion.

1.2 Purpose

Ultra thin powder is a novel product that is never presented in the current market. In terms of the cost and the future application, ultra thin powder has all the makings of a fine product. The study aimed to reach mass production. Furthermore, ultra thin powder needs to be light and thin for the future powder case design that is portable for consumers.

A. Formula development: Through alternative testing in the primary, adjuvant and additive along with the mixture of essences and colors, material that is comparably stable and of a high degree in molecular fineness was obtained. This material is able to endure temperature changes and shock impacts, remaining completeness of the product and thus reduces risk costs.

B. Ultra thin aluminum plate development: Due to the request in ultra thin powder design, the thinnest part in the aluminum plate is only 0.2 mm which can results in shape changing or cracks during manufacturing. Therefore, high precision stamping tool is required. The company designed a 1.0 mm ultra thin aluminum plate through material choosing, stamping tool and parameters setting. Hence, a fine and delicate product is produced which also brought advantages in transportation and flexibility in design.

C. Automated machine development: Traditional production system relied on labors. This study developed an automated machine that enables automatic distinction between aluminum plates in various shapes. Furthermore, manipulators are arranged among molds for high pressure molding in placing powder automatically. Owing to the reason that an enclosed space excluded pollution from the real world, dust collecting air evacuating system is able to recycle dust and therefore reduce the cost and increase the production capacity.

D. Ultra thin powder development: Due to the reason that fashion changes rapidly and it is difficult to finish cosmetic products, the present study aimed to develop ultra thin powder with only 1 mm in width. Compared to the common 3.0 mm product, the developed product can reduce 60% powder. Therefore, it accords with the amount of powder for individual in every season. Furthermore, it is light, with a great variety, not wasteful, and the reduced price attracts consumers' interest of buying the products.

1.3 Methodology

Designers included decision makers usually draw conclusion based on their intuitions or experience during product design or planning. This study planed to adopt a theory or a logical analysis that can be quantified and implemented design decision as the option of optimization. AHP, analytic hierarchy procedure, is a commonly used arithmetic logic. How thin the ultra aluminum plate could be was the key setting in this developmental design. Hence, AHP was implemented to obtain the value and followed by other design process.

Decision plays an important role in our daily life. In order to reduce risk and improve performance to

ensure the work to be done successfully, alternative options are offered and correlation analysis of factors that influence the options were obtained. These analysis included Multi Criteria Decision Making (2), fuzzy set theory (10), multi-attribute utility theory (11), Multi-objective optimization (12), and so on . Those present study adopted MCDM.

Multi Criteria Decision Making originated from efficient vector proposed by Koopmans (8). It is widely used in different fields for problem solving, for instance economy, engineering, management, social sciences , a bibliometric study showing their development over time, and so on (9). Among limited alternatives, Multi Criteria Decision Making can help decision makers rank and evaluate the optimal one (7).

This study introduced multi-criteria evaluation with qualitative data in multiple criteria evaluation through the use of Analytic hierarchy process (AHP).

2. Theoretical Foundation

The development of ultra thin powder is a big issue and results in the interaction among factors. AHP is a systematic method that simplifies complex problems and meanwhile establishes a hierarchical structure between factors (3). Hierarchical structure helps designers to understand alternatives, however when choosing the optimal alternative, some criteria must be followed to undergo evaluation process and finally to determine the ranking between alternatives.

2.1 Analytic hierarchy process

Analytic hierarchy process is also called AHP method, it is introduced by Thomas Saaty (4) in the 1970s. It is a systematic, and hierarchical analysis method with the combination of quantitative and qualitative data. Owing to the reason that its practicality and efficiency in dealing decision making problems, the value of AHP is soon recognized around the world. Its application is used in a great variety of decision situations .

2.2 AHP hypothesis (1)

1. A system can be broken down into different classes or components to form a network level structure.
2. Each level is assumed independent within the hierarchy.
3. The factors within each level make use of some or all the factors in the level above or assessment and evaluation.
4. Absolute scale can be converted to ratio scale in comparative assessment.
5. Regular matrix can be employed after pair wise comparison.
6. Preferential relations satisfy transitivity. Not only advantage relations satisfies transitivity. At the same time strength satisfies transitivity.
7. Owing to the reason that complete transitivity is not easy, the existence of non- transitivity is allowed. Consistency level needs to be measured in case of transitivity.

8. The degree of advantages of factors is evaluated by the Weighting Principle. Elements that appear in the class structure, regardless of their strength, are considered and assessed as a while structure.

Figure 1 shows the completely construction and each relation between the layers.

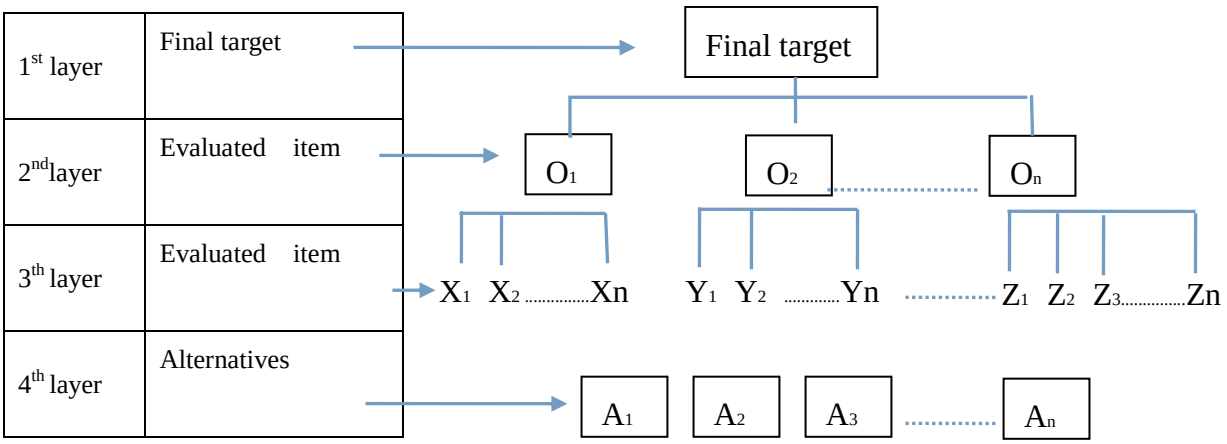


Figure 1. AHP hierarchy structure

3. Implementation method and procedure

3.1 Research design and procedure to outline the configuration of this study, the research and design process is presented in Figure 2.

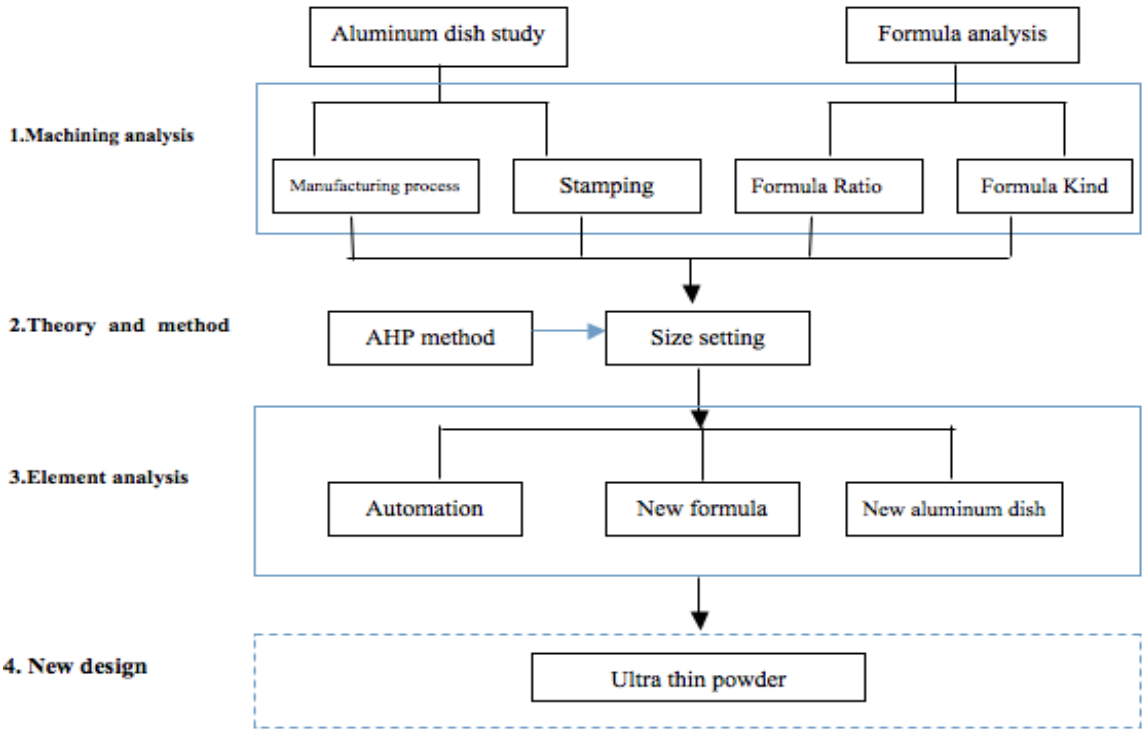
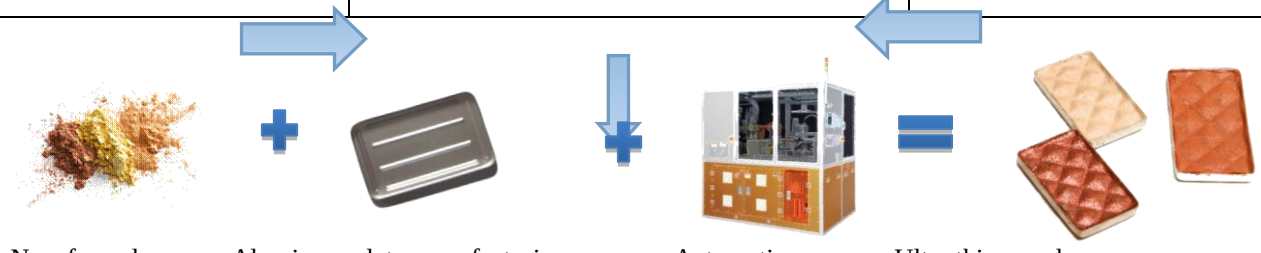


Figure 2. Research design process

Based on manufacturing procedure and product value in the future market, a research design process with analysis and concept combination was adopted. Table 1. indicates 4 key points in this paper: new formula, aluminum plate, automation and ultra thin powder.

Table 1. The concept of product development

Industry status	Advantage in new product	Future trend
1.Powder preservation easily influenced by the environment 2.Manufacturing 3mm powder 3.Disadvantage in long distance transportation 4. High labor needs and limit the	1. Temperature tolerance, bacteria resistance 2.With low preservative and heavy metal 3. Fit personal need in every season, not wasteful 4.Ultra thin, easy for storage and transportation 5. Machine replaces traditional labor 6. With dust collecting and recycling system	1.High prospect in Reasonable price market 2.Fast flow in global market 3.Short in fashion circulation 4.Product towards multifunctional development



New formula Aluminum plate manufacturing Automation Ultra thin powder

3.2 Design object with AHP application

Designers proposed 4 thicknesses for the powder:

1.0mm, 1.5mm, 1.9mm and 2.2mm.The evaluation criteria for choosing the idea thickness include aluminum plate shape, powder formula and automatic powder pressed design. The 4 proposed thicknesses are evaluated with the AHP technology, and the evaluation processes and shown in Figure 3&4.

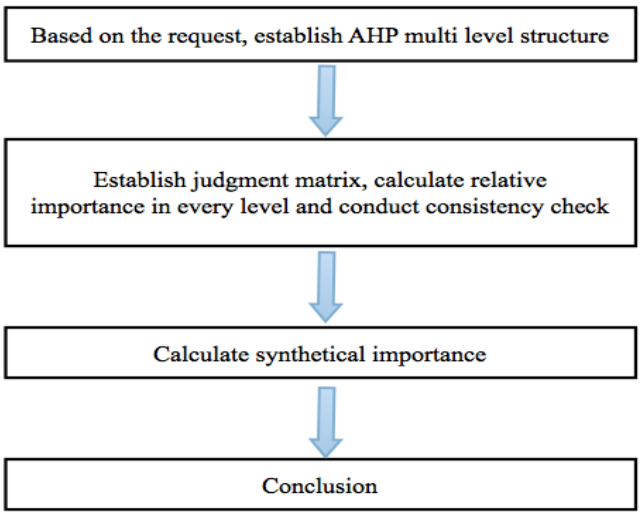


Figure 3. The process for evaluating the required thickness.

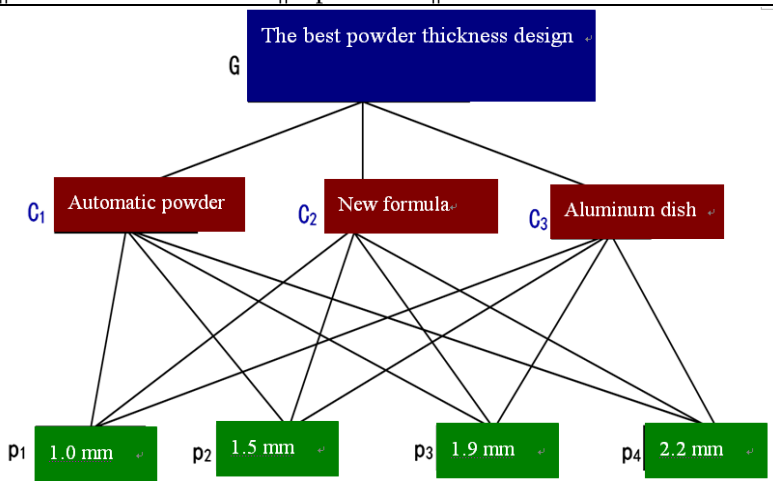


Figure 4. The hierarchy structure for evaluating the best powder thickness.

The corresponding codes used in this study are shown in Table 2.,

Table2. Calculation code and representative meaning

Calculation code	Representative meaning
C1	Automated powder pressed
C2	Formula
C3	Aluminum plate
p1	Powder with 1.0mm thickness
p2	Powder with 1.5mm thickness
p3	Powder with 1.9mm thickness
p4	Powder with 2.2mm thickness

Table 3 shows the relative importance for the 4 different powder sites based on the three evaluation parameters. From the result, it can be concluded that choosing 1.0mm powder is the best alternative.

Table 3.The importance of the powder thickness measured with the given parameters.

C_i / p_j	C_1	C_2	C_3	W_i
	0.258	0.636	0.106	
p_1	0.258×0.217 =0.056	0.636×0.569 =0.362	0.106×0.25 =0.027	0.44
p_2	0.258×0.584 =0.151	0.636×0.067 =0.043	0.106×0.549 =0.058	0.252
p_3	0.258×0.065 =0.017	0.636×0.266 =0.169	0.106×0.075 =0.008	0.194
p_4	0.258×0.135 =0.035	0.636×0.099 =0.063	0.106×0.127 =0.013	0.11

4.Case study

Before this study, products in the market were being analyzed. The powder that was used by a large amount of consumers was selected as the target in the study. Then, design and make formula for the target, powder, which is the primary concern of the study. Then, technology of in the study was being evaluated. Market, products and manufacturing were set as the main focus of the study, and feasibility is also being investigated. Finally, drat plan was generated.

The development of powder seems to be simple and not complicated, however many aspects are involved. First, ratio and formula of the powder material plays an essential role that influence whether the material can become powder or not. Furthermore, stability is also an aspect that needs to be concerned after manufacturing. Second, although metal stamping is a mature technology, the selection of aluminum, the thickness of the metal, and the application of stamping technology to metal are all key points that relate to producing a successful aluminum plate. Finally, owing to the reason that the study aimed to reach high precision in manufacturing, and traditional labor processing cannot control the yield rate in production; hence, the development of automatic powder pressed is of importance. The development process was drawn as Figure 5. With the Ishikawa diagram, it could be more clear and easy to be understood.

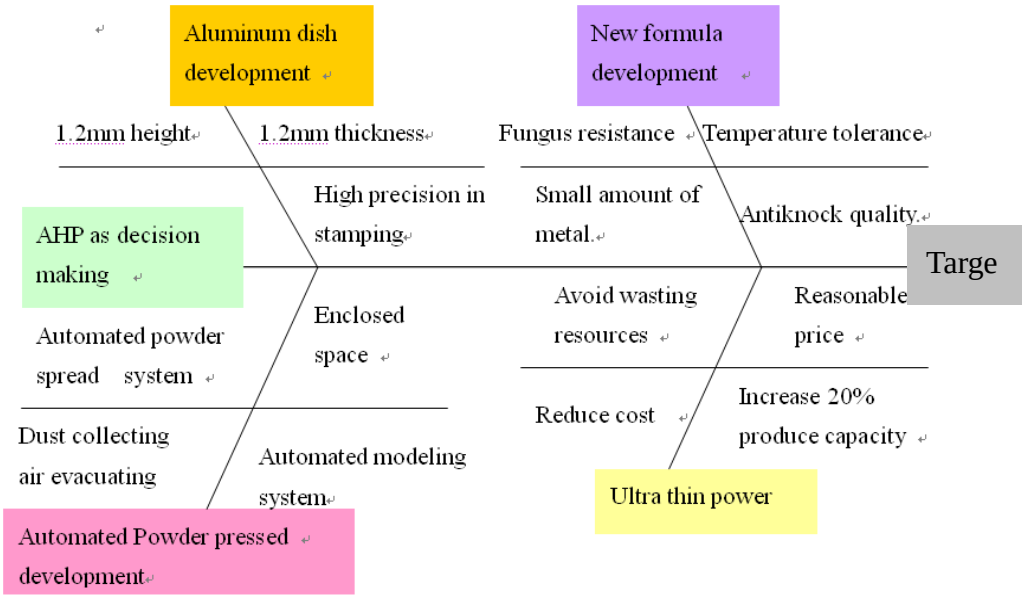


Figure 5. Ishikawa diagram of research developmental process

4.1 Innovation point in research plan

A. Development of high stability formula

After powder with 1.0mm thickness was deduced from AHP method, powder formula needs to be reproduced. The solutions for solving the problems encountered in the development process are listed in Table 4.

Table 4. Correspondence solution in formula development

	Problem	**Innovative formula solutions**
	Low temperature tolerance, and easily deteriorate	High temperature tolerance
	Low polymerism and easily broken	Increase polymerism in the powder
	A large amount ofpreservative is used to prevent product from being rotten	Increase resistance to bacteria
	To reach cosmetic result, heavy metal elements are added	Reduce the amount of heavy metal

Increase polymerism in the powder: Different from traditional high pressure stamping, through the control of molecular weight and application in manufacturing, polymerism is used as binding material to increase polymerism in the powder. High resistance to bacteria: Cosmetics has the nutrient that microbes need. Therefore, it easily gets infected by microbes. The mixing effect of the formula brings two advantages: fewer amounts but high efficiency.

High temperature tolerance: The formula has inert element, and often it does not react with other substances. Hence, when temperature changes, products with the innovative formula do not get deterioration easily.

B. The development of light aluminum plate

The solutions for solving the problems encountered in the development process are listed in Table 5.

Table 5. Correspondence table of solution in light aluminum plate development

	Problem	**Solutions**	
		0.2 mm thickness	**1.0 mm height**
	Thickness between 0.25~0.3 mm	Stretching technology, design setting in Radius reinforcement and stamping power are used. Avoid broken on the sides and corners during processing.	The new powder is of 1mm thickness, which is half thick of the common size. It can be applied to thin, multilayer and special shaped products.
	3 mm aluminum plate is easy for manufacturing		
	Regulated size of aluminum plate product design		
	Low precision, high allowable value		

C. Application of the designed product

For the thinner plate, developed the container as shown in Figure 6. It shows the design difference from the traditional one.

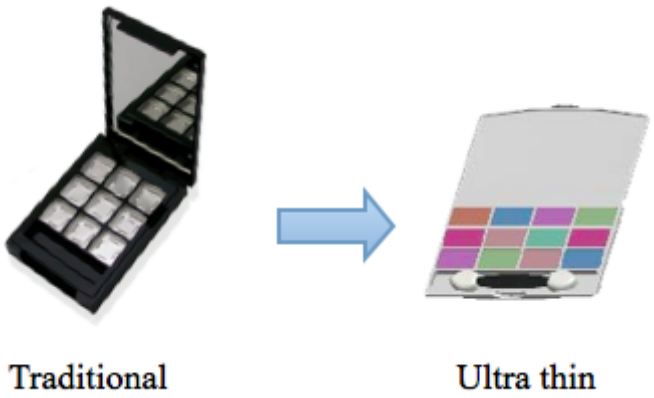


Figure 6. The container developed for the thinner plate

D. Stamping model design

The bottom of the stamping model has a flange with 3mm thickness and a cutting edge punch oriented design. This can avoid stretch punch deformation and locating problem. From Figure 7, one can see the difference between the developed thinner case and the traditional one. Because the innovation help the production, it also got new style paten in Taiwan.

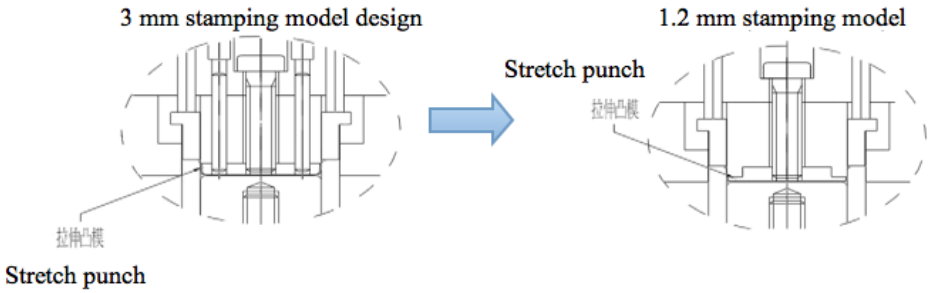


Figure 7. Innovation in comparison of stamping model design

D. Development of automated powder pressing

The solutions for solving the problems encountered in the development process are listed in Table 6. The concepts for the solutions are briefly described as follow.

Produced in enclosed space results in pollution exclusion: an enclosed space was adopted, thus dust-free the monitoring along with machine supplementary in powder and aluminum plate, and the pollution can be completely excluded. Therefore, the cosmetics that applied to consumer's faces are safe.

Air evacuating system dust collecting can recycle 95% of powder: Through the unique air evacuating system for

dust collecting , spreading power device and the design of jack stack and air suction pipe, redundant power can be recycled and reused. This can reduce wastage during powder production.

Table 6. Correspondence table of solution in automated powder pressing development

	Problem	**Solutions**
	Traditional processing is easily polluted by external substances	Produced in enclosed space results in pollution exclusion
	High error rate in manual work	Filling powder by machine has a high precision rate about 99%
	Semi-automated production needs huge manpower	Reduce labor, and increase 200% capacity
	Floating power is not easy to recycle	Air evacuating system for dust collecting can recycle 95% of powder

5.Results and discussion

The powder in the current market that used by a large amount of consumers was selected as the investigation target for the study. In which, the designing and making formula for the powder was the primary concern of this study. Technology for solving the problem was also evaluated. Market, products and manufacturing process were set as the main focus of the study, and the feasibility was also the examined.

There are many aspects were involved. First, the ratio and formula of the powder material plays an essential role that influenced whether the material could become powder or not. Furthermore, the stability was also an aspect that needed to be concerned after manufacturing. Second, although metal stamping is a mature technology, the selection of aluminum, the thickness of the metal, and the application of stamping technology to metal were all key points that related to producing a successful aluminum plate. Finally, owing to the reason that the study aimed to reach high precision in manufacturing, and traditional labor processing cannot control the yield rate in production; the development of automatic powder pressed was of importance.

Furthermore, the study had a theoretical foundation in the developmental design. Hence, a more complete procedure was seen in the study. For the future study, product verification and design can be developed. For instance, ANP method can be adopted in formula mixture and ratio; AHP and ANP can both be applied to the development and evaluation in product design.

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Dr. Chih-Huang Yen is design director in Tair Jiuh Enterprise., co. (Taiwan) for cosmetic industry since 2010. He spent about 11 years in SAGA Company (France) as a R&D manager did watch & jewelry design and development since 1999 . His major research interests include application of fuzzy set theory on product design, concurrent engineering in product design, computer-aided design, applying neural network, genetic algorithm, and gray theory to product design, color planning for product design, heat transfer analysis, and application of reverse engineering in product design.