

## THE PERSPECTIVES OF RESPONDENTS TOWARD THE BEST BUILDING MATERIAL FOR MANUFACTURING DOORS AND WINDOWS IN CHINA

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### ABSTRACT

Along with the development of the construction industry, doors and windows have presented different styles. After the liberation(1949s), the wood materials were overtaken by the metal and plastic one. This paper focuses on which kind of materials is the most appropriately one to be used from the perspective of performance, energy saving, environmental protection. Some of typical enterprises were selected as sample for studying that including Conch and Dalian ShiDe and Zhong Caigroup which are the top three companies in this fields, Mingkun, Daliang, Jinglan, Huaxing etc aluminium Plants were investigated. Purposive sampling, experimental investigation, participation in allies 'meeting, literature research etc. methods were used, the methodology of combing quantitative and qualitative was adopted. The results show that, 1) the production of each ton of PVC plastic profiles saves nearly 10000 kilowatt hours of electricity compared with each ton of aluminum alloy profiles. The use of energy-saving plastic doors and windows is easier to meet the design standards for building energy efficiency. 2) Plastic profiles have good social and economic benefits, but the recycling system is not perfect.

**Keywords:** doors and windows, aluminum, and plastic, energy-saving, heating coefficient value.

### 1. INTRODUCTION

After 1949s, steel doors and windows enterprises in Shanghai, Beijing and other places have developed rapidly. In the late 1970s, with the policy of "replacing wood with steel", which set off a climax of promoting steel doors and windows. In the 1980s, the marketing share once reached 70%②. Especially in the first 20 years of the 21st century, China's real estate industry has achieved unprecedented development, and the doors and windows industry has also developed rapidly. From ordinary aluminum alloy to plastic profile, and then to broke aluminum products, the products have been upgraded step by step, At present, AL and PL are still the mainstream materials in China's doors and windows construction market③. using the PL have improved the doors and windows operational performance, huge amount of forest has protected welly and the CO<sub>2</sub> emission was reduced largely in comparison with the steel windows material. The researcher has been witnessing the development and thriving and declining of the material industry, The aim of this paper is to study the development status of doors and windows industry, to analyze the pros and cons of the popular building material for manufacturing doors and windows, to help the reader to establish the appropriate method while choosing the materials.

### 2. RESEARCH PROBLEMS

1. What are the materials currently used in manufacturing doors and windows?
2. How is the supply and demand of these materials?
3. What are the difference between the Plastic and Aluminum profiles as manufacturing doors and windows from the aspect of applied performance?
4. Are these materials safe and do not pose health hazards to users?
5. What kind of measures should be taken of the government to guide the marketing competition from aspect of society contribution?

### 3. RESEARCH OBJECTIVES

1. To explore currently used in manufacturing doors and windows, materials in China.
2. To analyze the difference between the Plastic and Aluminum profiles as manufacturing doors and windows from the aspect of applied performance.
3. To study materials safe and do not pose health hazards to users in China.
4. To guide the marketing competition from aspect of society contribution?

#### 4. SCOPE AND LIMITATION

The researcher focused on the communication with the relevant enterprise professionals, and check the relevant industry data from the industry association website, annual report from listed firms(conch)etc. Regions including Anhui, Zhejiang, Jiangsu provinces, Shanghai are the main scope which cannot stand for the whole industry in China. due to the limitations of the author, data collection and analysis and respondents' response have certain limitations, which cannot fully reflect on the real situation of the current development. And meanwhile, this paper only focused on the research on the development of companies boom and decline and market share. It excluded wide range of applications in industry and other fields, such as glass consumption, gasket and hardware consumption etc.

#### 5. LITERATURE REVIEWS

1. Research on building energy consumption and material performance.

In August 2022, the Special Committee of Doors and Windows of Metal Structure Association held in Taiyuan. The report makes a detailed statistical analysis of the energy consumption and carbon emissions in the whole process of building nationwide in 2019, and concludes that 4.997 billion tons, accounting for 50.6% of China's total emissions , and the energy consumption of doors and windows accounts for 50% of the total building industry.⑧ 《The research Analysis of Frame Materials of Aluminum Alloy Doors and Windows and Plastic Steel Doors and Windows 》 By Zhao Ruoheng, Yake Architectural Design Company⑨, The author made a comparative analysis of material design from the aspects of thermal insulation performance, wind pressure strength, water and air tightness, lighting performance etc, the result shows the use of PL windows can save 5 kilowatt of electricity per day compared with AL one. The author mainly uses qualitative methods to carry out comparative analysis, and judges more through experience, without systematically describing the main differences between the two kinds of material.

2. Past researches about supply and demand of construction materials

The paper of 《Research on marketing strategy of DalianShide plastic doors and windows profile》 by the author of Yanzhuang⑩, with 10 years marketing sales working experience, most of his points are realistic, he recognized the most important factory of plastic profiles is Conch and Dalianshide and Zhongcai brand which are highly consistent to the author.but why the PL's market share have been decreasing sharply, he only analyzed from Dalianshide company that quite limited.

3. Researches about changes in materials used in construction

Research Report on doors and windows》 by Huguorui analyzed the situation from the domestic and abroad, focus on the energy saving standard implementation in different countries, in contrast with Germany and USA etc.its said the current marketing share of plastic and AL one is 35:55, some of the views the author is do agree.The building energy consumption accounts for 27.6% of the whole one in China. the doors and windows accounts for 20%-30% of the total building area⑪. the author described some key parts such as hardware etc which have vital affects to the performance .the article of 《the problems of building doors and windows industry》 by the author Hanbangshun⑫, the paper points out that in recent years, the development of China's building doors and windows industry is too fast, resulting in inconsistent product standards, and lack of supervision, which has led to the industry's evil competition. The two author's research view is more in line with the current situation, but what is the rational reason caused the situation that didn't mention.

Research Explore the mystery of European doors and windows industry》 by Mr. Zhou Weixing's article⑬,10 entrepreneurs went to Europe for a 10 days inspection tour to Germany, France and other places. they focused on window enterprises, doors and windows hardware, lock enterprises and building materials market, and comprehensively understood the market situation, development process and future trend of doors and windows industry in European, which improved the delegation's understanding of doors and windows performance, quality requirements.

In 2019, the Plastic Door and Window Committee Association released a report about the development of the PL industries. Ms.Cong JingMei (chairman), made a special report in which comprehensively analyzed the development of 28 key enterprises in the profile industry, with the domestic sales of 1.55148 million tons. Among them, the sales volume of Conch, Shide and ZhongCai are 361000 tons, 281600 tons and 217000 tons respectively, ranking the top three in the list. ⑭.the consumption of AL profiles in China came in 16.9 million tons in 2019; In 2020, the output came in 57.793 million tons⑮.The total output value of China's building door,

window and curtain wall industry in 2021 was close to 700 billion yuan. more than half of the top 100 enterprises have increased and half have decreased<sup>(16)</sup>.

## 6. RESEARCH METHODOLOGY

### Population

The Yangtze River Delta region, the total population is close to 0.22 billion which accounts for 16% of the total. As the researcher works in this field and is familiar with the market situation of PL and AL profile in China. Conch profile, Dalian Shide profile and ZhongCai profile are the largest enterprises of doors and windows materials in China, accounting for nearly 50% of the market share<sup>(14)</sup>.

### Sample and data collection methods

Based on the researcher's experience, the non-probability sampling is adopted, the top three brands in the PL industry were selected as the analysis data sources, This sampling survey is mainly conducted with the marketing and production managers in conch profiles, conducted by convenience and purposive sampling through the way of centralized interview and part of peer-to-peer exchange interview; the AL profiles were also investigated by a non-probability sampling method with more than 20 AL enterprises. The questionnaire is designed to the website by the special questionnaire APP, 115 pieces respondents took part in, this data gained just as verification, the most part of data analysis on retail market investigation were used by the HuangPai Brand questionnaires which has over 23765 respondents. The analysis of data is mainly based on the descriptive statistics with EXCEL and Python. The main analysis tool used is Pearson correlation coefficient and T-test.

### Research Design

This study used the mixed of quantitative and qualitative research approach utilizing a descriptive-analysis design. This specifically assess the kinds of building materials suitable for manufacturing doors and windows. The descriptive research involved the collection of data to determine the current materials available and used in manufacturing doors and windows. According to Best and Khan (2011), descriptive research describes and interprets what is. It is concerned with the conditions or relationships that exist, opinions that are held, processes that are going on, evident effects, or trends that are developing. This descriptive-analytical design involved assessing the relationships between supply and demand of materials, the manufacturing processes and cost as well as the health and safety concerns brought by the kinds of materials to be used to manufacture the doors and windows. This allowed testing of expected relationships between and among variables to make predictions.

## 6. THE RESEARCH RESULTS

### 1. The market share of AL and PL is as high as 9 to 1.

PL and AL one are just like "spear against shield" in windows building material. As the fierce competition, the phenomenon of cutting corners reflecting on the market is the bad reputation or complaints and constantly after-sales services from the customers. That is the key reason resulted in the occupation rates of PL have drop down dramatically between 2009 to 2020 which from 40% to 5%. the relationship between PL and AL profile consumption is almost like negative linear, which the Pearson Coefficient is -0.844 under the T-test value 2.71089E-06, the  $R^2$  is up to 0.762. By 2020, the consumption of AL for building was 18 million T, and the PL was 1.5 million T, the market share of aluminum alloy profiles is about 90%, basically returning to the competition pattern before 15 years ago<sup>[3]</sup> data from the appendix].

### 2. Urbanization rate is the vital factor in the development of AL industry.

Looking over the China's 20 years of rapid development, the real estate industry has driven all walks of life, From 2006 to 2021, urbanization rate has risen from 44.34% to 64.72%. The correlation coefficient between the consumption of AL building materials and its Pearson coefficients as high as 0.9811 on the premise that the T-value test is 7.23284E-08, and the correlation between the comprehensive consumption of AL and its Pearson is as high as 0.93206 on the premise that the T-value test is 3.83627E-07. On the contrary, there is a negative linear correlation between the PL and the urbanization rate, and the correlation coefficient is -0.8387 when the T-value test is 2.23009E-21. <sup>[3]</sup> data from the appendix].

3. National resident consumption index is another factor for accelerating of AL materials.

From 2006 to 2021, the per capital consumption index rose from 10500 to 38000 RMB. it almost grew in a straight line, and the model coefficient  $R^2$  reached 0.9946. The correlation between residents' consumption index and aluminum consumption level has reached 0.99 when the T-value test is  $3.872E-07$ , and relationship between building AL and residents' consumption index has reached 0.93 when the T-value test is  $7.46882E-08$ . On the contrary, with the rise of the resident consumption index, the consumption of PL has a negative linear relationship with the rise of the resident consumption index, and the correlation coefficient reaches -0.85 when the T-value test is  $2.9806E-21$ , which further proves that in the past 16 years, people's consumption ability has been improving, and they have a deeper understanding of the using and cognition of building materials, AL materials are gradually becoming the main steam of market consumption[③data from the appendix].

4. The influence of the real estate development on the material development.

According to the data of the National Bureau of Statistics, From 2017 to 2020, China's GDP increased from 78.72 trillion yuan to 91.12 trillion yuan, with a compound annual growth rate of 5.0%②.the consumption of AL profiles and the real estate investment show a strong positive linear relationship. Among them, the correlation coefficient between the overall consumption of AL profiles and the real estate development investment reaches 0.9465 when the T-value test is  $3.989E-07$ , The correlation coefficient between the consumption of building AL and the investment in real estate development reaches 0.9734 when the T-value test is  $8.298E-08$ . Especially, the building AL profiles almost maintain a direct linear relationship in real estate development. The consumption of PL has a negative linear relationship with the rise of the resident consumption index, and the correlation coefficient reaches -0.85 when the T-value test is  $2.9806E-21$ , However, the negative linear correlation coefficient between the consumption of PL and real estate development investment is also -0.8245 when the T-value test is  $9.79445E-21$ , which further confirms that, with the rapid development of China's real estate industry, the demand for high-quality door and window materials also increases, which further proves that AL profiles show an upward trend while PL show a downward trend③.

5. The PL production capacity utilization rate is less than 40%.

The production capacity of PL has been developing rapidly for 20 years from 2000 to 2020, After 2015, the market share of PL has been greatly impacted by the AL profiles. Many small enterprises are gradually extinguished. It is difficult to make a comprehensive and accurate analysis, but Conch profile, Dalian Shide profile and Zhejiang Zhongcai profile are basically developing and expanding at the same time and have a high market share in China. Conch profile, as the benchmark representative of the plastic profiles firm listed. The booming and falling of its development directly reflects on the market change of PL in China between 2000 to 2020, its production and sales scale has been at the world champion level for almost 20 years consecutively, the utilization rate is almost 40% in recently years.⑭③.

6. The AL building material capacity utilization rate is less than 60%.

the author selected about 20 aluminum plants in the Yangtze River Delta region, mainly visited the main leaders of the enterprises. The scale of the plants is about 20000 to 50000 tons. Overall, the utilization rate of production capacity is about 60%, slightly higher than that of plastic profile enterprises[appendix 2- research report on the AL factories].By 2020, the market share of AL profiles is about 70%, basically returning to the competition pattern before 10 years ago⑯.

Analysis from the perspective of material characteristics and resources

1. Comparison of material thermal performance

According to the relevant data, the thermal conductivity of the two materials under the same conditions is 1250 times than that of PL⑨.thermal insulation performance is only one of the key indicators to the comprehensive performance of windows. There are various indicators such as air tightness, sound insulation, water tightness, wind pressure resistance etc. Under the same conditions, In terms of wind pressure resistance performance index, AL are optimized for PL one. In terms of air tightness and water tightness, because the processing technology of PL is high-temperature welding, and AL profiles are connected by metal screws and glue, the performance of PL windows is better than that of AL one on the whole.

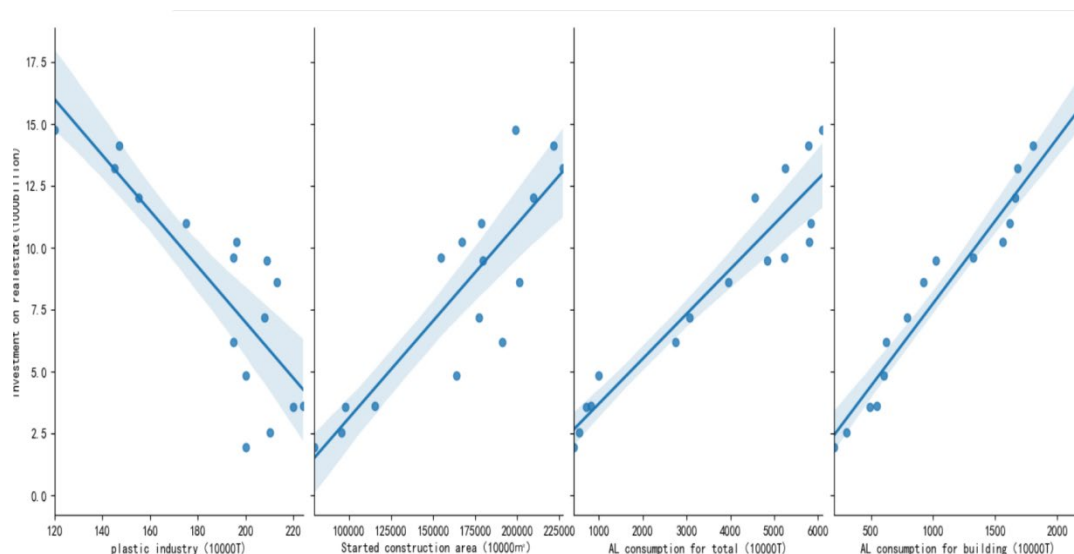


Figure 1 Comparison of material thermal performance

## 2. Comparison of Electricity consumption during production

Both PL and AL materials have similar sources and need to be extracted through mining and processing. From June 2021 to December 2021, the author focused on the Yingde conch profiles for experimental data collection. The base has a production capacity of 40000 tons of PL and 30000 AL. It mainly collects the energy consumption in the two material production processes after the raw materials entered. It showed that the electricity power consumption of AL processing is about 270kWh higher than that of PL. AL also has natural gas consumption generally 30m<sup>3</sup>/ that is ignored in this paper. Both are calculated from the beginning of ore mining. Producing 1 ton PL can save about 10000 kWh of electricity than AL [23] (photo detailed), it means that the cost of AL profiles is higher than PL approximately 7000RMB per unit, also means 1.23T standard coal and 9.97 T CO<sub>2</sub> would be saved [23].

## 3. Comparison of the operation and recycling characteristics

**Factors affect the performance:** The quality of doors and windows is not only related to the processing technology, but also closely related to hardware accessories. According to the survey data released by Huangpai Doors and Windows [24], glass, hardware and sealing materials are the main factors in the quality complaint link which accounting for 90%. The second is the quality complaints in the design process of materials, accounting for 81.5%. **Health and environmental protection:** the surface treatment process of AL is relatively complex. There are two common processes: spraying and oxidation. Among them, the process contains certain heavy metals such as fluorine and chromium, and acidic materials. This is also why a large number of wastewater are re-generated in the production process of AL; but PL one, PVC raw materials are mainly used certain auxiliary raw materials are formulated as additives. At present, most of them are environmentally friendly, and the surface treatment method is co-extrusion and film coating. No pollutants are produced in the process, and the process water source is mainly recycled. **Sound insulation performance:** In general, under the same conditions, the sound insulation effect of PL one is more better than ordinary AL doors and windows. The broken aluminum doors and windows are similar to those of plastic profile doors and windows. The air sound insulation reaches about 30-40db decreased [appendix5-photo shows the insulation level].

### Comparison of processing costs:

Under the same energy-saving coefficient with an energy-saving K value of 2.0 for PL and AL doors and windows, and other supporting materials are the same, the price of AL doors and windows is about 30% higher than that of PL one. Generally, the price of PL doors and windows is 600 yuan / m<sup>2</sup>, and the AL is 800 yuan / m<sup>2</sup> [appendix -investigation with zhejiangjianye company about the price].

## 4. The comparison of raw material resource analysis

By the end of 2019, the total capacity of PVC in China had reached about 25.18 million tons, 25.68 million tons in 2021. It can be seen that plastic doors and windows account for only 16% of the overall consumption [25]. In 2020, China's electrolytic AL output up to 37 million tons, In 2021, electrolytic AL output was 38.53 million

tons, with a year-on-year increase of 3.91%. In 2020, China imported 1.06 million tons of electrolytic AL, an increase of 1323% compared with 2019; The growing trade deficit of electrolytic AL products forces us to upgrade the AL industry, strengthen the development of high-end electrolytic AL products. China has relatively rich PVC resources. The use of PL profiles not only meets the performance requirements of windows, but also has a high degree of compatibility with the country's long-term energy conservation strategy, A large amount of aluminum resources should not be wasted on building doors and windows materials[26].

#### **Analyzing from the retail markets.**

1. The consumers are young and easy to accept new things. According to the author's and HuangPai Brand door and window survey report, in 2022, the consumers of doors and windows mainly focus between 19-39 years old, and young and middle-aged people will become the mainstream, with men accounting for 59%. the average annual income of the survey population is between 300000 and 500000RMB, accounting for 59%, mainly concentrated in the first and second and third tier cities. Among them, the income of 100000 to 300000 RMB people accounts for 23%[24].

2. Sound and thermal insulation are also the key factors in the selection.

consumers introduced the main problems of the doors and windows used in their homes, such as poor sound insulation, heat insulation, which accounting for 62% and 52% respectively, and loose parts and adhesive strips accounting for 42%. It can be seen that sound insulation, heat insulation and air tightness are the pain points of the use of doors and windows. Among them, the quality of glass, hardware fittings and sealing material accounts for 90%, and the design of window frame profiles and window types accounts for 81.5%[24].

3. China's energy-saving standards have broad room for progress.

According to the survey data, 48% of the people do not know about low-power windows and doors, and 36% of the people know some of them. It can be seen that the current awareness of low energy consumption doors and windows is low. In the 23765 questionnaires collected this time, 85.5% of consumers are willing to give priority to low-energy windows and doors when replacing windows and doors [24]. In 2021, the Energy Consumption Special Committee of China Building Energy Conservation Association released the Research Report, which the total carbon emissions of China's "whole building process" in 2019, which was 4.997 billion tons, accounting for 50.6% of the total national carbon emissions that year. The energy consumption of doors and windows accounted for about 50% of the building energy consumption [8]. most of the provinces implemented energy efficiency standards for doors and windows are 65%. Only North and Northeast China are located in relatively cold regions standards have been raised to about 75%. [appendix 3 -2021 【29】 ].

4. Consumers and manufacturer are paying more attention to the good brand.

The author investigated Zhejiang Jianye, Wuhu Xinye Ankang, Shandong Jijing, and Wuhu Conch System Windows and Doors Company. they all chosen to transform to the retail and configured high-end automated production lines, For example, Wuhu Xinye Ankang has invested 10 Million RMB to introduce a full set of AL doors and windows production line from Germany, and putted it into operation in October 2022[27]. This is also the first fully automated doors and windows processing automation production line in the AL door and window industry. Mr. Ding Shiming, the president of ZhejiangJianye Group, He believed that, there were more than 40000 doors and windows factories in China, 99% of them had backward product technology, low production efficiency, and high production costs. 99% of the products do not meet the requirements of green energy conservation. This is also why he invested about 10 million RMB in 2020 and also introduced a full set of automatic production lines from Germany. [28]

#### **7. CONCLUSION**

1. Promote the using of energy-saving plastic doors and windows to save social resources. To sum up, the production of each ton of PVC plastic profiles saves nearly 10000 kilowatt hours of electricity compared with each ton of aluminum alloy profiles. The use of energy-saving plastic doors and windows is easier to meet the design standards for building energy efficiency.

2. Encourage and support large enterprises to establish a sound ecological chain recycling system. plastic profile profiles have good social and economic benefits, but the recycling system is not perfect. When the secondary windows are replaced or installed, garbage pollution is likely to occur. The government should encourage and support large enterprises to integrate excess capacity resources through technological upgrading and transformation, with the help of the digital advantages of the industrial Internet platform and improve the ecological recycling system of the industrial chain, The environmental protection and ecological industrial chain system of plastic profile doors and windows is really achieved.

## 8. DISCUSSION

This paper analyzed the industrial development in the past 16 years, the advantages, and disadvantages of the two materials from the perspectives of the PL and AL products, social resource consumption, environmental emissions, and recycling. It is suggested that the country vigorously promote the use of energy-saving doors and windows and improve the standards. As the author has been working in doors and windows enterprises for a long time, in view of his limited level of research and analysis, some materials and data analysis have some inaccuracies. Many of them also cite second-hand data, which can only give readers a perceptual understanding of the development of China's doors and windows materials industry in the current era. Many in-depth topics, such as how to formulate standards and how to supervise, also put forward shallow ideas. Sincerely welcome readers to correct and guide.

## APPENDIX

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16. Mr. Li Fuchen, President of Aluminum Door, Window and Curtain Wall Branch of China Building Metal Structure Association, made the 《Work Report on Aluminum Door》, Window and Curtain Wall Industry
17. CONCH profiles exhibition hall, some data and windows development history introduction were used in this paper, more detail described in the photo.
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