THE STATUS OF THE ALUMINUM INDUSTRY IN JAPAN

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ABSTRACT The Aluminum industry in Japan has twice experienced a fatal breakdown in the past. There are no longer any aluminum smelting industries except one. However, aluminum consumption per person has grown to be the largest in the world today. In this report, firstly, the history of the aluminum industry in Japan, such as the progress of production technology and the growth of demand, is reviewed. Then, major equipment utilized in the industry is described. Finally, the issues for future development of aluminum industry in Japan are discussed.
Keywords: Japan, aluminum industry, history, demand, equipment, technical development

1. INTRODUCTION

Although the production of aluminum raw ingot in Japan is no more than 0.5% of total demand, the growth rate of final products has always exceeded the growth of GNP. By reviewing the history of aluminum in Japan, I would like to present the status of the industry, in terms of equipment, technology, and demand. Also, I would like to address the issues for tomorrow's aluminum industry.

2. INTRODUCTORY STAGE OF ALUMINUM

It was in 1867 when the Japanese mission, that visited Napoleon III, first encountered the metal aluminum. It was 19 years earlier that the Hall-Heroult method was developed. In 1894, the Japanese army imported equipment from Germany and began production of aluminum kitchen utensils. Production of cast-aluminum initiated in 1910, die-cast in 1917, aluminum wire in 1920, foil products in 1930. The anodizing method was developed in 1929. In 1935, ultra super duralumin was developed, and based on this technology, 7000 series alloys have been contributing to aircraft industry. In the area of smelting, production technology was established in 1930. Production reached 150,000 tons per year in 1943. But it collapsed in 1945 due to defeat in World War II[1].

3. HISTORY OF THE SMELTING INDUSTRY

Fig.1 shows the aluminum raw ingot production after World War II. In 1974, production reached 1.12 million tons, which was second highest in the world. However, the smelting industry had already lost competitiveness and collapsed again. The major reason was the rapid increase of power costs due to the two oil shocks in 1973 and 1979. Also, drop in import duties made the smelting industry weak in cost competitiveness. Today, the domestic smelting business

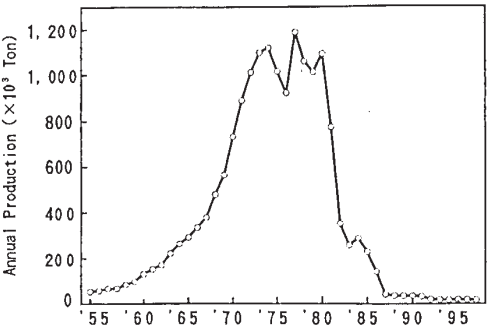

Fig.1 Aluminum Raw Ingot Prodcuction in Japan

is done only by Nippon Light Metal, which has a power supply system in house. In 1995, demand for raw ingot in Japan was 2.0 million tons out of worldwide production of 19.7 million tons.

Fig.2 shows the breakdown of aluminum raw material supply in Japan. 1.01 million tons (22.9%), including recycled ingot, out of a total 4.41 million are produced in Japan. The other 3.4 million (77.9%) are imported. Therefore the cooperation with overseas smelting plants and improvements in recycling technology are needed in the future.

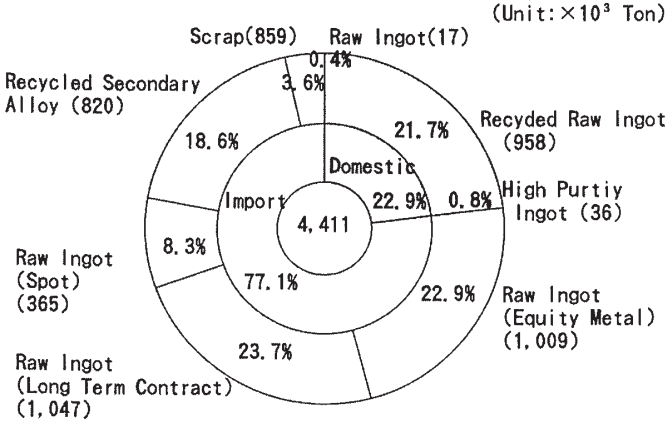

Fig.2 Aluminum Raw Material Supply(1997)

4. TREND OF DEMAND FOR ALUMINUM PRODUCTS

Fig.3 shows the total demand for aluminum products from 1950 to 1997. The growth rate of the products has always exceeded the growth of GNP. Two depressions in 1975 and in 1982 were due to the oil shocks. The depression in 1994 was due to the collapse of the bubble economy. The growth in almost all applications of aluminum products, such as buildings, cans, air conditioners, electronics, cars, trains, etc. made demand increase, and production reached 4 million tons in 1996.

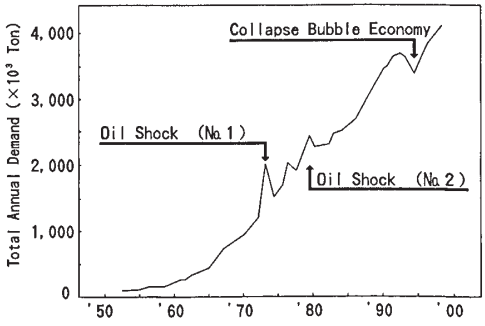

Fig.3 Growth of Aluminum Demaud

5. EQUIPMENT AND PRODUCTION IN ALUMINUM INDUSTRY

Fig.4 shows the production breakdown by product area in 1965 and 1997. During this period of 32 years, rolled, extruded and die cast products have grown remarkably.

5.1 Rolling

As to hot rolling mills, a total of 8 lines are in operation. 6 lines out of the total 8 are combination lines of both breakdown mill and finishing mill. Maximum width is 4,070mm in plate, and 2,650mm

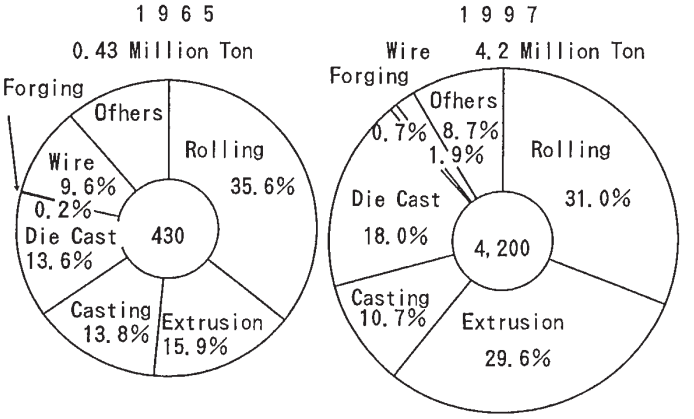

Fig.4 Growth of Aluminum Production (Breakdown)

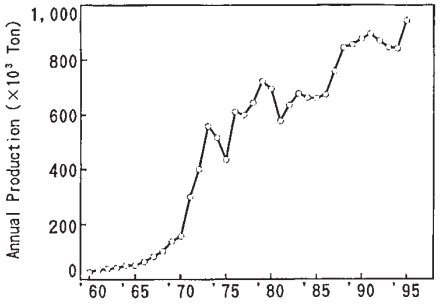

Fig.5 Growth of Rolled Products

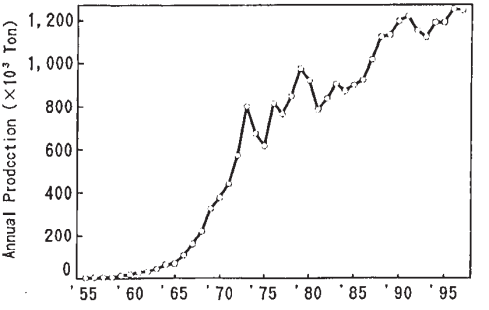

Fig.6 Growth of Extrusion Products

in coil. There are 10 continuous casting mills in addition to hot rolling mills. Regarding cold rolling mills, a total of 34 mills are installed, and 5 mills out of the 34 are two tandem mills. Maximum width is 2,650mm, maximum coil weight is 22 tons[2]. The growth of rolled products is shown in **Fig.5.** The production has grown rapidly since 1970 due to rapid growth of aluminum can stock.

5.2 Extrusion

A total of 262 extrusion presses are in operation[3]. The largest press is a 9,500 ton press that was installed in 1971. **Fig.6** shows the growth of rolled products. The figure shows a rapid increase after 1965. This was due to the growth in aluminum sash for houses. 858,000 tons (69%) out of the total 1.24 million are for sash and other construction related products. 137,000 tons (11%) are for transportation such as cars, trains. Based on the forecast that the transportation market would increase, 6 of the 4,000 to 6,000-ton class large extrusion presses were installed in 1990 to 1991.

5.3 Casting and Die Casting

Sand casting, metal mold casting, low pressure casting, and squeeze casting are applied generally. **Fig.7** shows die cast machine distribution by company. A total of 246 companies have 3,410 machines[4]. 0.754 million tons out of a total 1.17 million tons were die cast products in 1997. The automotive industry is a major market for die cast products.

5.4 Forging

The production of forged products was less than 31,000 tons in 1997. 18,000 tons(58%) out of 31,000 tons were for the transportation industry. In order to meet the possible increase of forged products for the automotive market, the installation of forging machines has increased since 1985. There are 858 forging machines, including three 8,000-ton presses[5].

5.5 Wire

There are 7 continuous casting mills for aluminum wire. The production of aluminum electric cable was approximately 100,000 tons during 1970s to 1987. Since then, production has reduced to 70,000 to 80,000 tons. On the other hand, the production of welding wire in 1997 was 1,255 tons.

6. MARKET TREND OF MAJOR ALUMINUM PRODUCTS

As shown in **Fig.8**, aluminum consumption per person in Japan has been the highest in the world since 1989[6]. I would like to describe the major market areas and the trends in aluminum products. **Fig.9** shows the major markets for aluminum products in 1965 and 1997. Demand in all areas has increased, and especially, in transportation, construction, and food areas have grown their share.

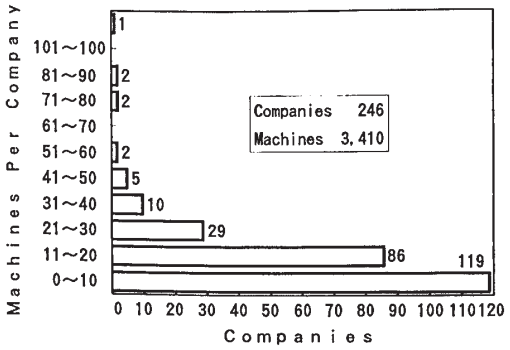

Fig.7 Die Cast Machine Distribution

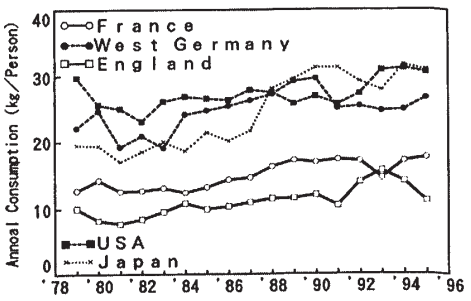

Fig.8 Aluminum Cousumption Per Person

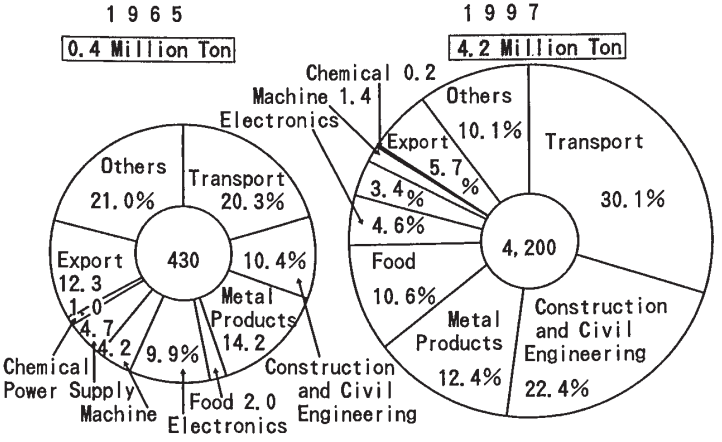

Fig.9 Growth of Aluminum Production by Market

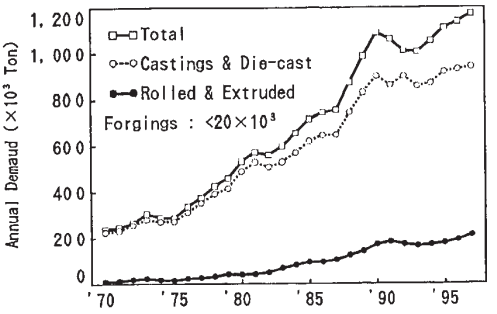

Fig.10 Growth of Aluminum for Automotive Industry

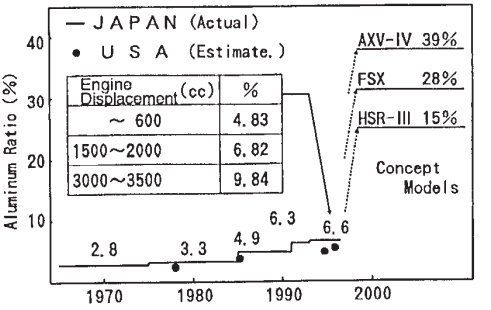

Fig.11 Aluminum Ratio in Passenger Cars

6.1 Transportation

(1) Automotive industry

Fig.10 shows the demand in the automotive market by products. In this area, 1.172 million tons, comprising 28% of total demand, was consumed in 1997. Since 1970, demand for this area has grown 490%, while growth in automobile production during the same period was 180%. Although 80% of total demand was cast products in 1997, rolled and extruded products have increased since the late 1970s. Forged products, which are applied for suspension arms and compressors, have also increased since 1985. **Fig.11** shows trends of aluminum application ratio in passenger cars[7]. A forecast of aluminum application ratio based on the concept models presented by automobile manufacturers indicates that the ratio might exceed 15% in the near future. From the point of higher energy efficiency due to lighter weight and excellent recyclability of aluminum, increasing the aluminum application ratio in automobiles is promising. However, in order to realize this with confidence, the following technical developments are the must.

1) Rolled products for panels
- Control technologies for grain size and texture. The purpose is to make material with the required characteristics for automotive panels and establish high efficiency production processes.
- Technical developments and data tables on forming, surface treatment, joining, and corrosion resistance.

2) Extrusion products
- Materials that have high strength, high energy absorption, high bending characteristics, high weldability and high surface treatability.
- Technical developments and data tables on bending and joining.

3) Forged products
- Cost reductions in forging materials and forging processes
- Low cost production processes and designing based on design-in concept

4) Cast products
- Cost reductions in squeeze casting, low pressure casting and semi solid casting
- Low cost alloy for automotive structures and large size casting to reduce parts

With regard to trucks, loading capacity has been kept low due to limitations on unit axle load, length and width. From the points of strengthened environmental controls and requirement for higher loading capacity, truck weight reduction is becoming necessary. In addition to heat exchangers, wheels and bans, aluminum has been gradually applied to bumpers, cabs, axle parts and frames. In the area of motorcycles, aluminum parts have been applied aggressively for a long time, and as many parts as possible have been changed to aluminum.

(2) Railroad cars

The first all-aluminum railroad car in Japan was made in 1962. Since then, the technology has grown. Based on operation experience, many advantages of lighter trains have been recognized such as higher speed operation without strengthen rail tracks, lower noise, and higher acceleration. The application of aluminum to cars has spread from local trains to bullet trains(shinkansen). **Fig.12** shows the growth in the production of aluminum railroad cars except new transportation system[8]. Production has been increasing since 1980 mostly because of the increase of aluminum subway cars, which get high energy savings in train operations with frequent acceleration and deceleration. In order to expedite aluminum applications to railroad cars, the following technologies have been developing.

1) Wider extrusion shapes by extended extrusion technology or weld joining
2) Practical use of vibration damping aluminum extrusion shapes. This decreases noise both inside and outside of car.
3) Extend aluminum car recycling technologies, which has begun with subway cars in Tokyo.

(3)Ocean vessels

In 1954, the first aluminum boat, which was the patrol boat "Arakaze" belonging to the Marine Safety Agency, was built. The boat utilized the alloy developed by Kobe Steel refereed to the specifications of the UK. **Fig.13** shows the number of aluminum boats produced. In order to reduce building costs, the production technology of wide π section has been developing. The advantages of aluminum boats are recognized as follows.

1) High stability and high safety
2)Stable draught because of less corrosion loss than steel boats and no weight increase by water absorption as in FRP boats.
3) High loading capacity
4) High speed and high energy saving
5) Recycleability

(4) Aircraft and Space industry

Until early the 1940s, Japan had one of the most advanced aircraft industries. Although the aircraft industry collapsed in 1945, there are technologies such as the development of the YS11, subcontracting for Boeing, the development of the MH2000 helicopter, and the launching 10-ton class satellites. All aluminum products for

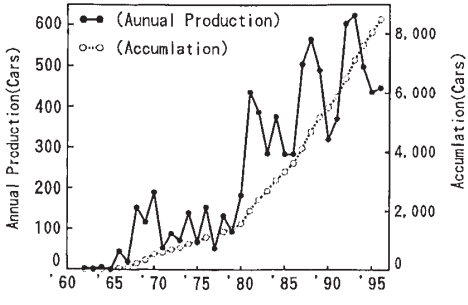

Fig.12 Growth of Aluminum Railroad Cars

the aircraft and space industries can be supplied in Japan. However, the market is very limited.

6.2 CONSTRUCTION INDUSTRY

(1) Houses

Aluminum sash, which allowed houses that used to made of wood and paper, to be built airtight, and spread rapidly. Following aluminum sash, air conditioners have became common. Lifestyle in Japanese houses has become very comfortable. The first generation of aluminum sash protected people from rain and wind, while the second generation offered heat and noise insulation.

(2) Buildings and Factories

The Kasumigaseki building, which was the first high rise building after the lifting of height bans in this earthquake-prone country, was constructed in 1968, and aluminum curtain wall was adopted to the building. In this area, the direction of development has advanced from offering just color and durability considering city view to surface treatment technologies that offer anti-mold and dirt prevention.

Recently, the application of aluminum roof to factories and warehouses has begun. For these applications, technical data for durability, maintenance, fire prevention, heat and noise insulation, and construction has been developing.

(3) Civil engineering

In 1961, the first all aluminum bridge, the "Kinkei-bridge", was constructed. It has proven that there are no problems with corrosion or fatigue in this application. A portion of water gates and power supply towers, also utilize aluminum.

6.3 FOOD INDUSTRY

Fig.14 shows aluminum demand in the food industry. 95% of total demand is for can stock. During this 32 years period from 1965 to 1997, aluminum demand grew almost 200 times, driven especially by the introduction of two-peace aluminum can, which was introduced in1971. In the worldwide can market in 1997, the ratio of aluminum can is 100% in America, 48% in Europe, 42% in Japan and 80% worldwide. Aluminum cans in Japan are expected to increase to 65%. Because of the effort to implement aluminum recycling in this industry, the UBC return ratio has increased since 1991 and reached 70% in 1996. The actual can to can recycling ratio has also reached 70% recently.

6.4 ELECTRONICS INDUSTRY

Aluminum is highly adaptable in electronics parts applications due to such characteristics as light weight, corrosion resistance, non magnetization, electromagnetic shield, thermal conductivity, electro conductivity, and optical characteristics. Aluminum has been applied in magnetic disks, copy drums, VTR heads, casings for Li-ion batteries, heat sinks, and precision positioning devices. Fin stocks for air conditioners and lithograph sheet materials are categorized in this market, too. The worldwide magnetic disk market has been growing rapidly[9], and technical requirements for the accuracy of configurations, dimensions, and surface quality have become stricter. Therefore, especially in this market, it is imperative to catch technical information proactively and to respond quickly. Target materials for semiconductors and liquid crystals, vacuum chambers are growing as new markets for aluminum.

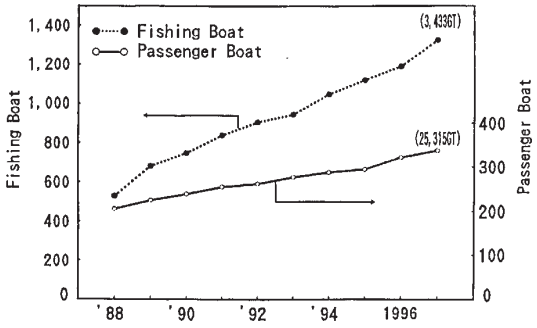

Fig.13 Number of Aluminum Boats

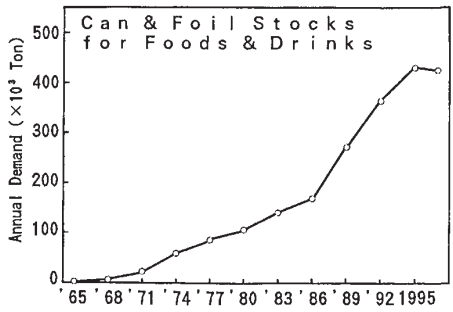

Fig.14 Growth of Aluminum in Food, Beverage Market

7. ISSUES

7.1 Raw Materials

In the Japanese aluminum industry, which has no electro-chemical smelting, recycling is a major issue. Although scrap recycling has been progressing, scrap from automobiles and construction materials will increase in the future. The technology to remove impurities and inclusions from recycled metal at high yields has been developing as a national project. In the future, it will be necessary to establish a recycling system in society and to develop the technology to separate aluminum from other scrap materials.

7.2 Melting and Casting

Some time ago, improvements in the technology to remove impurities led to the production of aluminum lens casings for camera. Later, tube filters were developed to refine can stock and disk materials to meet market requirements. Thus, in Japan, the technology to refine molten metal has advanced substantially. These technologies have been applied in foil stocks and lithograph materials. In the future, much more advanced technology to remove impurities will be needed. Also, the technology to control the distribution of finer intermetallic compounds will be essential. At the same time, from the point of environmental protection, the technology to reuse dross has been developing, as one of "zero emission"[10].

In casting, thin slab continuous casting technology will be an issue in the future.

7.3 Rolling

Because of more precise profile control at rolling has been required, the development in this area must be continued. Hot rolling is most essential in the control of metallurgical structure. Technologies that control texture and grain size to be more highly uniform and finer, must be required. In order to make automotive panel material with formability superior to steel, more precise control of texture is needed. The precise texture control will be the target.

7.4 Extrusion

The development of die designing based on the finite element method and cooling rate control technology has progressed. For automotive frame material, improvements in dimensional accuracy and energy absorption properties are needed. Also, in vibration damping extrusion products for cars or

highways, more advanced damping properties and cost reduction are needed.

7.5 Casting and Forging

More advanced designing based on the finite element method will be important for increasing use in the automotive market. At the same time, more weight reduction in combination with alloy development and designing is needed. Alloy development can be independent from current aircraft alloy specifications.

7.6 Heat Treatment

One of the major issues in this area is to combine heat treatment and hot processing such as hot rolling, extrusion and hot forging. This enables the utilization of energy from hot processing. Material design that improves its properties utilizing customer's heat treatment may be extended. This is already being done with some can stocks and heat exchangers.

7.7 Forming and Joining

There are many issues in this area such as forming for automotive panel, bending for automotive frame, welding, hydroforming, and mechanical joining.

7.8 Surface Treatment

The surface treatment technology for "Pre-coated Fins" for air conditioners was developed in Japan. In accordance with the diversified requirements in the air conditioner market, pre-coating technology needs to be further advanced. In the automotive industry, the surface treatment technologies that have been developed for steel products will be applied to aluminum. In addition to coating technology, the development of surface treatment that is suitable for customer's process such as coating, forming and joining will be a major issue.

7.9 Numerical Analysis Technology

Numerical analysis technology will become more important in almost all areas to provide improvements in productivity, quality, designing and the development of new application or market for aluminum. Software development that meets the characteristics of aluminum is essential.

7.10 Multi Functional Material

In the past, multi-functional materials such as aluminum honey comb, vibration damping shapes, vibration damping sheet and pre-coated fins have been developed. In the future, it will be important to advance these functions and to develop new functions that enable the development of new applications.

7.11 Environment and Health

Following ISO9000 authorization, to be authorized to ISO14000 will be a major issue. In this field, there are so many issues such as pollution control, CO_2 gas reduction, a factory waste reduction. Regarding the issue of aluminum being implicated with Alzheimer's disease, social recognition that aluminum has nothing to do with the disease has been obtained. This is the result of the "International Health Forum" sponsored by the Health Committee, which is one activity of the aluminum industry operates from a position of fairness and neutrality. As a manufacturing industry, further advanced

activities related to various health issues will be needed.

8. SUMMARY

The Aluminum industry in Japan is basically a complete processing business with the exclusion of smelting. Therefore added value is small. Also, price is decreasing rapidly. Needless to say, technical development for cost reduction is important. However, in order to make the aluminum industry the business that is worthy of world top aluminum consumption per person, increasing value by adding new functions and higher utilization by developing new application are our direction.

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