Global Marketing Strategies for Automotive Aluminum Sheet, Extrusion and Forged Suspension Businesses

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The need to reduce the weight of automobiles has been increasing year by year due to fuel efficiency regulations responding to environmental issues. Since the 1980s, there has been a gradual increase in the use of aluminum sheets for automotive body panels, aluminum extrusions for bumper reinforcements and door beams, and aluminum forgings for suspension parts. Aluminum has now become an indispensable automotive material. Kobe Steel has been developing business outside Japan by utilizing the material technology, production technology, and application technology for automotive parts; these technologies have been cultivated in response to the requirements of Japanese automakers. This article outlines the technological developments in each type of business, the development of production plants outside Japan, and the company's efforts to globally supply products of the same quality as those supplied in Japan.

Introduction

Regulations and assessments for the safety of automobiles have been strengthened, increasing the weight of safety members and the number of electrical components. On the other hand, fuel efficiency regulations for automobiles are becoming increasingly stringent year by year. **Fig. 1** shows the current status and future targets of fuel efficiency regulations from 2015 to 2030 in Japan, Europe, China and the United States.[1)]

With this background, automotive weight reduction and electrification have become inevitable issues, creating a new application field for aluminum alloys, which have specific gravities approximately 1/3 that of steel. Kobe Steel has been expanding this field first in Japan and is promoting expansion to other countries.

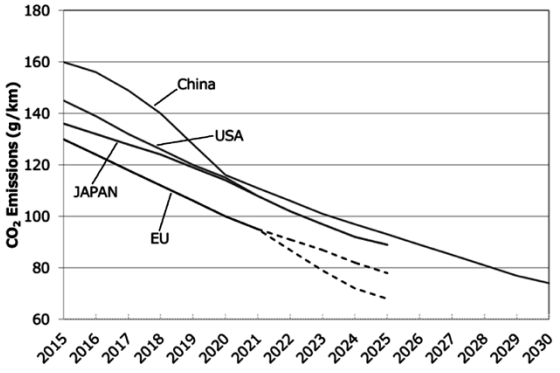

Fig. 1 Trends in strengthening of fuel efficiency and CO_2 criteria for passenger cars in Japan, Europe, China and the U.S.[1)] (Fuel efficiency criteria converted to the amount of CO_2)

This paper outlines the global business expansion of aluminum sheets, extruded material, and forged suspensions being promoted by Kobe Steel.

1. Global expansion of automotive aluminum sheets

1.1 Development of automotive aluminum sheets and application to automotive bodies

In Japan, the application of aluminum sheets to automotive body panels began in 1985 and was widely adopted by automakers in the first half of the 1990s (**Fig. 2**).[2)] During this period, effort was put into developing original Japanese alloys, and the 5000 series alloys, which possessed excellent formability and suppressed the generation of Lüders bands, were first put into practical use. In the mid-1990s, the use of aluminum panels declined for a time due to the slump in the Japanese economy, but during that period, there was no letup in the development of aluminum alloys for automotive bodies. In particular, the development of the 6000 series alloys was promoted because of their excellent bake-hardenability, i.e., their capacity for being age-hardened by the heat during the paint baking of automotive bodies.[3),4)] These 6000 series alloys became, and continue to be, the mainstream in the 2000s, when aluminum is being used full-scale in mass-produced cars.

During these years, the control on CO_2 emissions and fuel consumption became increasingly stringent in Europe and the United States, where the application of aluminum sheets to automotive bodies is progressing faster than in Japan. Accordingly, aluminum alloys for automotive bodies, such as the 6111 and 6022 alloys in North America and 6016 and 6014 alloys in Europe, were standardized. In addition, special efforts have been put into the development of application technologies involved in the use of aluminum sheets in automotive bodies, such as forming, joining, and painting.

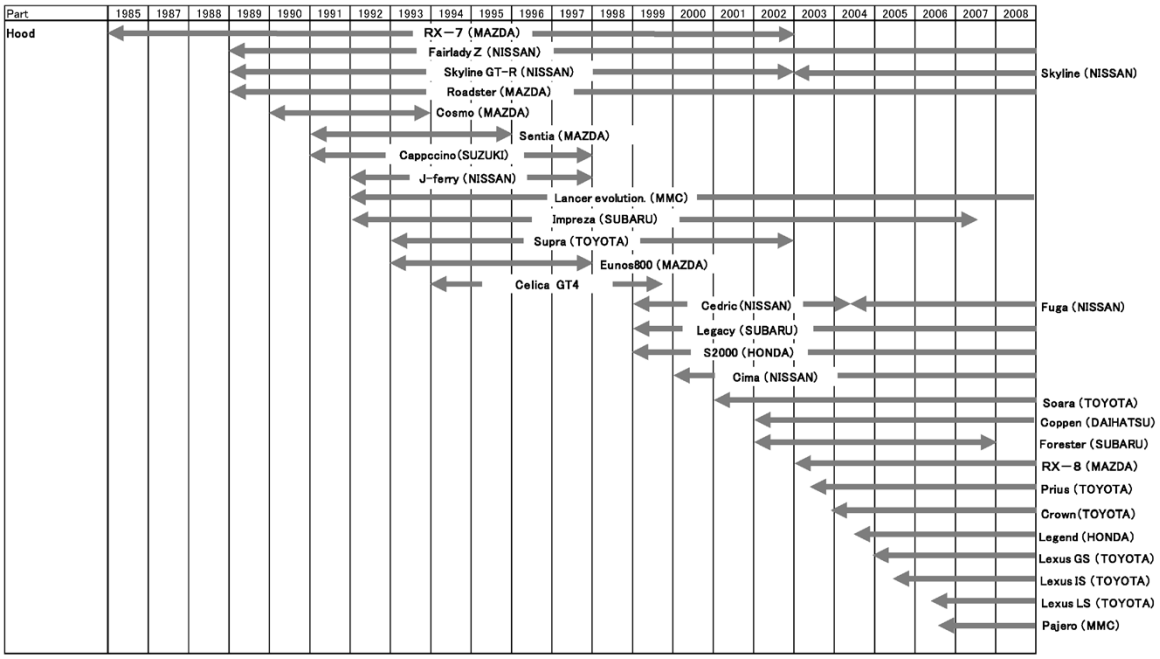

Fig. 2 Application of aluminum sheet for automotive body panels (hoods) in Japan [2)]

1.2 Kobe Steel's global development of automotive aluminum sheet technologies

As described above, the technological development and application of aluminum sheets to automotive bodies progressed more rapidly in Europe and in the United States than they did in Japan. Hence, Kobe Steel and Alcoa jointly established Kobe Alcoa Transportation Products Ltd. in Japan and Alcoa Kobe Transportation Products, Inc. in the United States to cooperate in developing technologies. These joint ventures conducted R&D and sales of automotive aluminum sheets.

The ventures were highly evaluated by automakers in Japan and the United States for setting up mutually agreed upon specifications for automotive body panel materials and establishing a system for supplying them. As for various application technologies, both of the companies have expanded the use of aluminum panels by combining the development capabilities each company has cultivated and increasing the ability to make proposals.

Later, in 2007, the joint venture was dissolved due, among other factors, to the further expansion of the automotive aluminum sheet market in Japan and in the United States. It was decided that the research and development of automotive aluminum sheets in Japan should be conducted by Kobe Steel alone.

Kobe Steel then signed a technology cooperation agreement on automotive aluminum panel materials with Hydro Aluminium Rolled Products GmbH (hereinafter referred to as "Hydro"), in 2013. This agreement is a comprehensive one, covering the licensing of technology information, intellectual properties, and production know-how, as well as related technical support. In particular, it aims to provide European automakers with materials of globally equivalent quality. This technological cooperation is ongoing and has led to the understanding of the specifications for aluminum sheets and future needs of European manufacturers in accordance with the original objectives, as well as the establishment of material development and the creation of supply systems in line with the agreement.

European manufacturers have many technologies unique to the Continental area, such as those for the surface processing and lubricants required for automotive aluminum sheets. The fact that production technologies corresponding to these were established in a short period of time is considered to be attributable to the effective technology cooperation with Hydro. Collaboration with Hydro has further expanded into cutting-edge academic research that seeks to elucidate the aging precipitation behavior of 6000 series alloys by utilizing metallographic structure analysis technology using Kobe Steel's 3D atomic probe (3D-AP).[5), 6)]

1.3 Global development for supplying Kobe Steel's automotive aluminum sheets

Kobe Steel's global supply of automotive aluminum sheets began with exports to Korea in

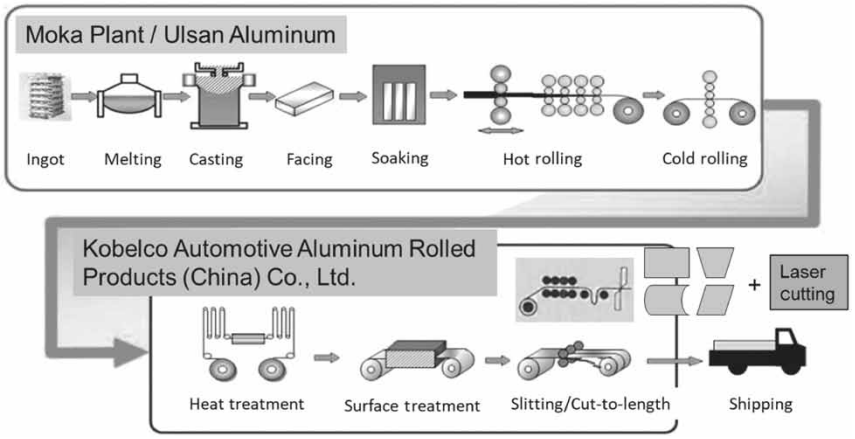

Fig. 3 Supply scheme of automotive aluminum sheet to China by Kobe steel group

2003. This was followed by exporting to China in 2008 and to North America and Australia in 2013. During the peak period, the products were supplied to six countries, and customers outside Japan accounted for the larger portion of Kobe Steel's automotive aluminum sheets. In realizing this global supply, the above-mentioned partnerships with Alcoa and Hydro helped effectively to grasp the demand early and respond to the specifications of each user. Other important points include the achievements in mass production in Japan and technology that is not limited to aluminum sheet material but extends to the application of aluminum sheets to automotive bodies.

The demand for automotive aluminum sheets continues to expand worldwide. Especially in China, now the world's largest automobile producer, it is anticipated that automotive exhaust gas regulations and fuel economy regulations will be strengthened due to environmental problems, and the demand for aluminum is expected to increase with a view to reducing the weight of automotive bodies.

Against this backdrop, Kobe Steel established Kobelco Automotive Aluminum Rolled Products (China) Co., Ltd. (hereinafter referred to as "KARP") in Tianjin, China, in 2014 and began producing automotive aluminum sheets there. KARP owns various types of equipment for the continuous heat treatment processing of cold rolled coils, the subsequent surface treatment process, and finishing processes such as slitting and shearing, and can supply aluminum panel material with the same high quality as that available in Japan. In the new scheme, Kobe Steel's Moka Plant supplies cold-rolled coils (intermediate products) to KARP, where they are heat-treated and surface-treated to be shipped as product coils. These product coils had previously been exported from Moka Plant, which has been switched to the new scheme. Combined with the parallel development of new customers, production is growing steadily. In 2017, a joint venture company, Ulsan Aluminum, Ltd., was established with Novellis Korea Limited in Korea to produce cold-rolled coils in Korea and supply them to KARP in China and Moka Plant in Japan. (**Fig. 3**).

In response to the future demand for automotive aluminum sheets, the demand being expected to grow further in China and in Japan, a stable supply of high quality aluminum sheets is secured by the expanded supply capacity; i.e., the upstream process at the 2 sites of Moka Plant and Ulsan Aluminum, and the downstream process at 2 sites, Moka Plant and KARP.

2. Application trends and global development of aluminum extrusions to auto parts

2.1 Trend in application of aluminum extrusions to auto parts

Aluminum extrusions have been increasingly applied since the 1960s as small cross-sectional extrusions for engine heat exchanger tubes, multi-hole profiles, etc. In the 1980s, aluminum alloys began to be applied to body structures, and extruded strips and hollow extrusions were used. In addition, they have been applied to ABS housing and collision safety members since the 1990s. In addition to lightness, aluminum extrusions can be formed into profiles with complex cross-sectional shapes having varying wall thickness distributions, which is difficult with steel, offering an effective means of reducing automotive weight.

Kobe Steel has been focusing on collision safety members such as bumper reinforcements and door beams, which have been steadily and increasingly adopted. In the future, further growth is expected in the demand for aluminum used in automotive frame members and other parts that are required to

be lighter for vehicle electrification.

2.2 Development status of aluminum extrusion alloys for automobiles

For weight reduction, aluminum extrusion alloys themselves are also required to be stronger. In Japan, the use of aluminum for bumpers began in the 1990s with a 6000 series alloy of 230 MPa proof-stress grade. Since then, the adoption of a 7000 series alloy with a proof stress exceeding 300 MPa has been in progress. To achieve further weight reduction, there has recently been a demand for 7000 series alloys with even higher strength.

High strength 7000 series alloys, however, have the problem of high susceptibility to stress corrosion cracking (hereinafter referred to as "SCC"). Hence, Kobe Steel has developed a 7000 series alloy, "7K55," that balances the trade-off characteristics of strength and SCC resistance.[7] This alloy began to be produced for Japanese manufacturers as a bumper material, and its future production at a plant outside Japan is being considered.

The demand for the weight reduction of aluminum extrusions continues, and there still is a strong need for the higher strength of the 7000 series alloys. Kobe Steel is continuing development, pursuing a balance between strength and SCC resistance.

2.3 Future development and global supply capability of automotive aluminum extrusions

Kobe Steel's extrusion business has been developed mainly by supplying aluminum extrusions to automakers in Japan. Recently, however, there have been an increasing number of cases where local production is required due to global development of the same model, multi-site production, and trade tariffs. Supply capacity in North America is often required, and Kobelco Aluminum Products & Extrusions Inc. was established with a capital of 24 million dollars in Bowling Green, Kentucky, as a manufacturing site integrating the steps from melting to processing. The first phase construction started with a processing line having a planned production capacity of 500 tonnes/month.

The plan is to begin doing business first with Japanese automakers and then with North American automakers in the future.

2.4 Business development in North America

In North America, high tensile strength steel is mainly used as the material for automobiles ranging from compact/medium-sized cars to large-sized cars. There is, however, a forecast that the adoption of aluminum will increase in response to the above-mentioned world-wide strengthening in fuel efficiency regulations. Aluminum extrusions in North America are mainly made of 6000 series alloys, and the main targets are collision safety members that require high strength.

Kobe Steel will focus on bumpers and door beams, on which the company has accumulated know-how in Japan, and make proposals on 7000 series alloy extrusions, Kobe Steel's specialty, in North America. For future targets, it is expected that the demand for materials will increase for lockers and side sills, which are structural parts of automobiles.

3. Forged aluminum suspension business

3.1 Overview of business development for forged aluminum suspensions

The use of aluminum forgings for suspension parts began in the late 1980s. Initially, they were mainly used in sports cars to improve motion performance. In recent years, they are increasingly being used in a wide range of vehicles in response to fuel and exhaust gas regulations, which have become even more stringent to address global warming, and to suppress the increase in vehicle mass due to the addition of safety equipment, among other considerations.

Kobe Steel started producing forged aluminum suspension parts in Japan in 1988. Since then, the company has responded to the growing demand while increasing its equipment capacity and improving productivity. Japanese automakers, on the other hand, have transferred their manufacturing sites to other countries and are seeking local supplies of materials with the same quality as those available in Japan. In response to such demands, Kobe Steel established manufacturing sites in North America in 2005 and in China in 2012.

3.2 Features of forged aluminum suspension parts

An example of suspension members is shown in **Fig. 4**.[8] Suspensions are important security components, connecting automotive bodies and tires; they correspond to the legs of human bodies. These parts require high strength along with high reliability, and greatly affect motion performance and ride quality. From the latter viewpoint, it is important to balance the so-called "sprung mass,"

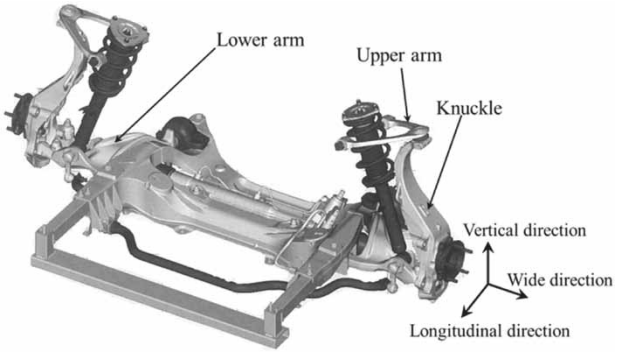

Fig. 4 Example of suspension members (front suspension structure of double wishbone type)[8)]

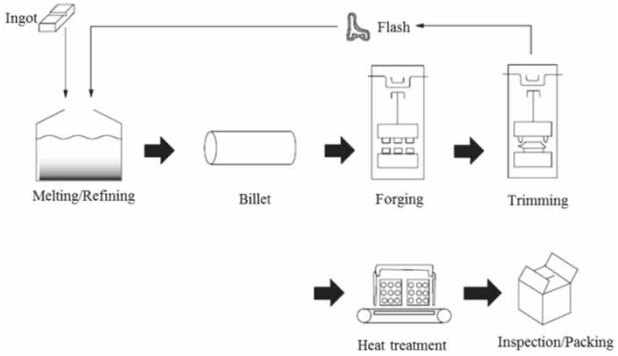

Fig. 5 Integrated production system for forged suspension of aluminum alloy in Kobe Steel [9)]

including the mass of a body and frame, and "unsprung mass," including the mass of the tires and suspension arms. For mere weight reduction, lowering the weight of the body, which makes up most of the automotive weight, has the greatest effect; however, there is a concern that the mere reduction of the body weight may result in an improper mass balance and deterioration of the ride quality. For this reason, in order to maintain auto performance, the weight reduction of the suspension, an unsprung component, is also necessary to lowering the weight of an automobile.

Given this backdrop, suspension members are being changed from conventional cast iron or press-formed sheet steel to aluminum alloys. Applicable aluminum products include forged products, cast products, press-formed sheet products, and aluminum extruded products. Aluminum forgings, having strength greater than that of aluminum castings, can achieve more pronounced weight reduction. In addition, because they have degrees of shape freedom higher than those of press-formed products, Kobe Steel believes that forged aluminum products are the best fit for suspension members.

3.3 Features of Kobe Steel's technology

Kobe Steel, anticipating the expanded use of forged aluminum suspension, started production in Japan in 1988, and continued to improve the product after introducing dedicated equipment in the early 1990s. Kobe Steel's production lines have a casting line for producing billets, the stock material for forging, adjacent to the aluminum forging line. Thus, the company has established an integrated production system for forged aluminum products from forging stock to finished forgings, which offers the greatest advantage. A schematic diagram of this integrated production system is shown in **Fig. 5**.[9)] The integrated production system has realized cost reduction by the complete recycling of forging burrs, reduction of lead time by decreased material transportation, and unified management including quality and production, thus enabling highly efficient production.

Other major advantages of Kobe Steel include its design technology for proposing lighter shapes and development technology for providing materials with higher strength.

3.4 Business development outside Japan

As the number of automobiles sold in Japan has peaked, Japanese automakers have moved their production sites outside Japan. Also, since forged aluminum products are increasingly adopted for global platform vehicles produced and sold in multiple countries/regions, the local procurement of forged aluminum suspension parts has become increasingly desirable.

Against this backdrop, and to meet the worldwide demand for forged aluminum products, Kobe Steel has developed technologies for further sales expansion and, in 2005, began production in North America and China to establish a system for supplying suspension parts of the same quality on a global scale. The history of technology development and global expansion is shown in **Fig. 6**.[10)] Kobe Steel's past business development can be divided into the following three phases:

I. Establishment of technology in Japan (1988-)
Establishing an integrated production system to efficiently produce forged aluminum suspension parts and a system for proposing shapes suitable for weight reduction to expand sales.

II. Technological evolution and expansion in North America (2005-)
For the purpose of increasing orders outside Japan, further development of design technology for weight reduction, development of high strength alloys, and establishment of technology for producing stable quality to achieve the same quality abroad as that

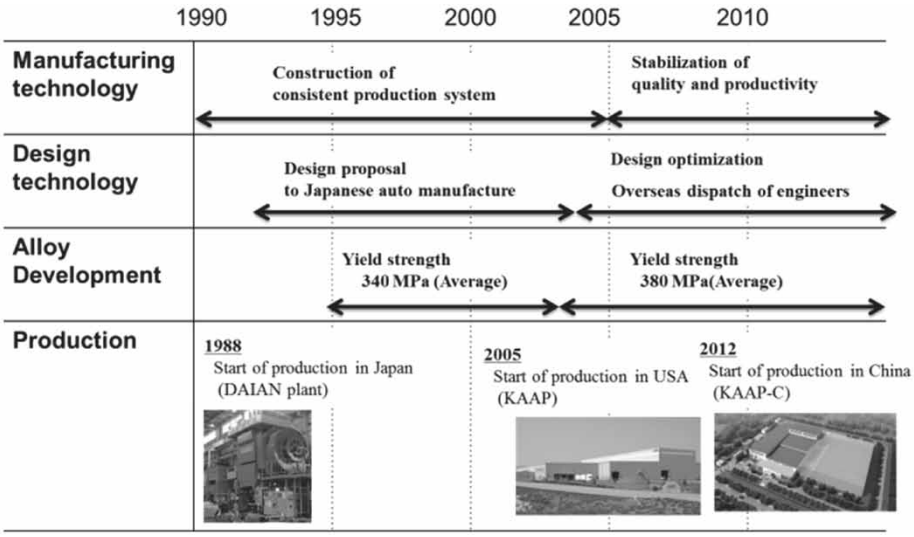

Fig. 6 History of technology development and global expansion of forged suspension of aluminum alloy in Kobe Steel[10)]

Table 1 Annual production capacity of each plant

Plant	Annual production capacity (pcs/y)
Daian (Japan)	4,000,000
KAAP (USA)	7,000,000
KAAP-C (China)	2,000,000
Ttotal	13,000,000

achieved in Japan

III. Expansion into China and response to global vehicles (2012-)
Expansion of sales in China and to globally-produced vehicles based on stable production utilizing the knowledge of global plant establishment acquired through the North American plant

In particular, in Phase II, which was the first global expansion, automation technologies were developed to enable stable production even by local workers with little experience. As a result, it became possible to stably produce products of the same quality as those made in Japan. These technologies were also exploited when entering China in Phase III.

Since then, the facilities have been expanded along with the increasing demand. **Table 1** shows the actual production capacity at each site. The total production capacity has reached 13 million parts a year at the three sites in Japan, the U.S., and China. In North America, where the sales ratio of large vehicles is relatively high, there is a strong demand for weight reduction, and thus aluminum forgings are prevailing faster. As a result of intensive facility expansion, the plant currently has a capacity of 7 million parts per year, accounting for 53% of the total capacity. Kobe Steel will continue to consider increasing capacity as demand increases.

Conclusions

This paper has explained Kobe Steel's business development in the fields of aluminum sheets, extrusions, forged suspensions in the global market of automobiles, where significant expansion is expected in the future. Among automotive aluminum materials, these three products have different technology trends and market characteristics, and business development will proceed in accordance with the situation. In these businesses, Kobe Steel will strive to focus on ensuring quality first and be worthy of the customers' trust.

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