Alcoa acquired the laboratory of the Aluminum Casting Co. in 1920 as payment for the debt owed on aluminum purchases made during World War I. Two metallurgists with aluminum experience came with the laboratory—Zay Jeffries and Robert Archer. During WWI, Jeffries worked on aluminum casting problems, mainly with ordinance fuses and the Liberty Aircraft Engine. Jeffries and Archer continued to make major contributions to the field of cast and forged aluminum alloys throughout the 1920s, working in the Cleveland laboratory.

With two lab facilities dedicated to research and development throughout the 1920s and 1930s, more than 20 new alloys were added to Alcoa’s product line. The first new sheet alloy—called 17S—was based on the German alloy, Duralumin. It made its debut in the 1920s and was used to build the first commercial all-metal passenger airplane in the U.S., the Ford Trimotor, with roughly 200 manufactured in the late 1920s and early 1930s. Production ceased as the Great Depression deepened and the 10-15 passenger design became cost prohibitive for commercial service.

The precipitation hardened 17S alloy also lacked sufficient corrosion resistance in a salt spray atmosphere. This problem was solved by a new process that bonded a more corrosion resistant layer of pure aluminum to both sides of the 17S sheet metal. These two layers make up about 10% of total sheet thickness. This product—named Al clad—is still used in aluminum alloy applications exposed to corrosive atmospheres.

**Alloy development**

In the 1930s, Alcoa developed a higher strength alloy called 24S. The major change from 17S to 24S involved boosting the magnesium level from 0.5% to 1.5%. This increased the design strength of 24S to 50,000 psi, from 40,000. In addition, moderate cold working, such as stretching or rolling the sheet material immediately after water quenching and then aging it, further increased 24S design strength to 57,000 psi. All of these properties could be produced with Alfred Wilm’s original room temperature treatment called natural aging. The new alloy was used to construct the first commercially successful passenger plane, the Douglas DC-3 in 1935.

Another precipitation hardening alloy system developed by Alcoa in the 1930s adds 1% magnesium, 0.6% silicon, and 0.3% copper to aluminum. This alloy—called 61S (now 6061)—is the structural material for a great tonnage of ordinary engineering applications. A number of alloys based on 6061 contain additional alloying elements and are widely available as well. These alloys are known for ease of fabrication, corrosion resistance, and low cost compared to high-strength aircraft alloys. They feature design strengths of 35,000 to 50,000 psi and have excellent characteristics for general industrial applications, such as trucks, buses, rail cars, trailer tanks, storage tanks, building construction, and light aircraft. Some of the numerous mill products made of these alloys include sheet metal, forgings, extrusions, bar, tubing, pipe, and wire.

**Aluminum for WWII**

Alloy 24S was the aluminum used for nearly all of the 300,000 planes built in the U.S. during World War II. The quantity of aluminum needed for this vast undertaking greatly exceeded the capacity of Alcoa, the only aluminum manufacturer in the country. In 1939, the U.S. produced 148,000 tons...
of aluminum, compared with 200,000 tons in Germany. Preparing for war drove the German demand. By 1943, when wartime production reached its peak, the U.S. produced 835,000 tons against 250,000 tons in Germany. In addition, Canadian production increased from 75,000 tons in 1939 to 450,000 tons in 1943. Overall production for the five war years reached 4 million tons in the U.S. and Canada versus 1.4 million tons in Germany.

To meet the increased demand, numerous aluminum plants were financed by the U.S. government, but were built and operated by Alcoa. These plants included four to produce aluminum oxide, eight to reduce the oxide to metal, and 10 to manufacture finished product. These government plants produced twice the aluminum of the Alcoa owned plants. After the war, the government plants were sold to Reynolds Metals Co. and Kaiser Aluminum and Chemical Co., ending the Alcoa monopoly that had existed since 1888. With the new aluminum industry, the old system of identifying alloys was modified. The new system used the 2000 series for aluminum-magnesium alloys. Thus, 24S became 2024 and remains a major high-strength alloy, although stronger alloys have been developed for the most critical applications.

Modern alloy introductions

Aluminum that contains zinc, magnesium, and copper was originally studied in Germany. Alloys featuring zinc as a major alloying element exhibit very high strengths, but are prone to crack under stress when exposed to corrosion. Nevertheless, research on these alloys was performed at Alcoa and the first commercial composition was 76S, used for aircraft propellers in 1940. Later, stress corrosion cracking was significantly reduced by adding small amounts of chromium to the alloy. This lead to the commercial alloy 75S (now 7075), which contains 5.5% zinc. This innovative alloy was introduced during WWII as the structural metal on Boeing’s B-29 Superfortress long-range bomber. The 75S alloy could be artificially aged to design strengths of 73,000 psi, while a modified version with 6.8% zinc (7178) introduced in 1951 can develop strengths as high as 78,000 psi.

A more recent alloy developed by Alcoa called 7055 contains 8.0% zinc, 2.3% copper, and 2.0% magnesium, and provides exceptionally high compression strength. Strength levels of 90,000 psi are achieved in plate and 97,000 psi in extrusions. This strength level is 10% higher than the best previous alloy and 25% higher than the original aluminum-zinc alloy, 7075, developed during WWII. In 2002, Alcoa received the ASM International Engineering Materials Achievement Award for the development of 7055.

These latest high-strength alloys from Alcoa are used on the Boeing 777, with the main structure of the plane constructed of two basic aluminum alloys. Because they are the most highly stressed components, the upper wings are built of 7055 alloy. The lower wings are constructed of modified versions of 2024, specifically 2224 and 2324. They have lower impurity content, which improves toughness. The fuselage is made of 2524, another version of 2024 that contains even lower levels of impurities for greater toughness.

Aluminum has come a long way since its early days of pots and pans. With the discovery of precipitation hardening as a mechanism for increasing its strength, aluminum now holds a major position in modern technology as a structural metal with unlimited use.


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