New Products

Superplastic 5083 Aluminum Alloy Sheet "ALNOVI†-1" was Approved by Airbus

1. INTRODUCTION

Weight saving is the most important requirement in the area of aircraft industry. High-strength superplastic aluminum alloys such as 2004-alloy (Al-Cu system) and 7475-alloys (Al-Zn-Mg-Cu system) have long been used for aircraft components. However, following points are the shortcomings of these alloys; 1) it is very expensive to manufacture the alloy sheets, 2) solution treating and subsequent aging are indispensable for strengthening the formed products and 3) corrosion resistance and weldability are insufficient.

On the other hand, 5000-series alloys (Al-Mg system) are widely used in various applications because they have moderate strength, good corrosion resistance, favorable weldability and ease of surface treatment. The Research Laboratory in Furukawa-Sky Aluminum Co. developed "ALNOVI-1" with excellent superplasticity through optimizing the alloy composition and manufacturing processes of 5083-alloy, which has been widely used for structural materials with medium strength. Being somewhat inferior in superplasticity to conventional high-strength superplastic aluminum alloys, the "ALNOVI-1" is more advantageous in manufacturing cost and exhibits about 300 MPa in strength without heat treatment after superplastic forming. Typical applications of the "ALNOVI-1" had been automotive and building parts rather than aircraft components.

In 2001, Superform Aluminum in UK, a leading company in superplastic forming, made a prototype of landing lamp drum assembly for aircraft from the "ALNOVI-1" sheet by high-temperature blow forming. Airbus S.A.S., which has a 50 % share of the aircraft manufacturing market in the world, was very interested in the alloy sheet and appointed it as a candidate material. Then the Fukaya Works and the "ALNOVI-1" acquired the manufacturing factory and product approvals from Airbus S.A.S.

† ALNOVI is a registered trademark of Furukawa-Sky Aluminum Corp.

2. SUPERPLASTIC FORMING

2.1 Superplastic Phenomenon

While ordinary aluminum alloys elongate by less than about 100 % even when deformed at high temperatures, some materials with suitable microstructure exhibit high elongation strain ranging from several hundreds to one thousand percent when deformed under specified conditions. Such a phenomenon is called "superplasticity".

Superplastic aluminum alloys generally have very fine grain structure of about 10 μm in diameter, where the grain refinement is achieved by optimizing the kind and amount of additional elements suppressing grain growth and by controlling the thermo-mechanical process. Superplastic behavior occurs when these alloys are deformed at high temperatures of 400～550 ˚C with a relative strain rate of 10^{-4}～10^{-3}/s. Because grain boundary sliding during deformation becomes significantly activated under these conditions, these alloys exhibit an extremely large degree of ductility.

In addition, since the flow stress at high temperatures is very low due to fine grain structure, superplastic aluminum alloys can be blown-formed just like plastics with a low pressure of several atmospheres.

2.2 Features of Superplastic Forming

1) Even products which are usually formed in several parts separately can be integrally formed as a single part through superplastic forming. The single-piece forming minimizes the number of parts and joints, and thus leads to weight and cost savings.
2) Since the forming needs only the female die, investment cost for dies is reduced.
3) The high formability expands the possibility of product design.
4) Because of high temperature forming, excellent form-frozenness is given. But, it is necessary to take into account thermal contraction.
5) Superior transferability of the die surface to the metal sheet is provided.
6) Surface defects accompanied by cold press-forming such as Lüders line and surface roughening do not arise.
7) Superplastic forming takes longer time than cold press-forming. It is suitable, accordingly, not for

quantity production but for production of high-value added parts or small- to medium-lot parts ranging from 50 to 10000 pieces.

8) Cavity defects are liable to be generated by blow forming. Too much cavity decreases the static and fatigue strengths of the products.

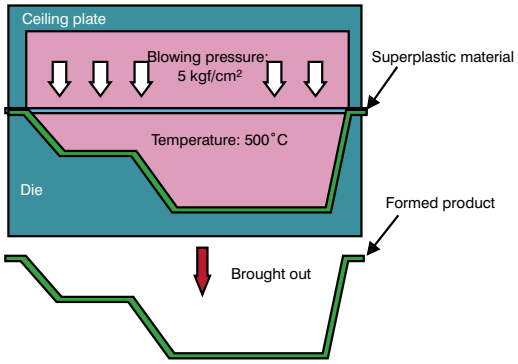

Figure 1 Illustration of typical superplastic forming.

2.3 Major Uses of ALNOVI-1 Hitherto

- Body panel and optional parts for automobiles
- Fuel tank for two-wheeled vehicles
- Leisure boat
- Floor sheet and interior panel for vehicles
- Exterior wall, interior wall, ceiling and access floor sheets for buildings
- Door, gate and fence for residence
- Casing of electronic equipment for medical applications
- Ornaments, craftworks, etc.

3. APPROVAL BY AIRBUS

In March 2002, the Fukaya Works of Furukawa-Sky Aluminum underwent a preliminary inspection. The next month, Airbus inspectors came from UK and examined the factory and quality management system officially. In June, we obtained the factory approval. We prepared a quality management manual for material production, and then acquired the material approval for “ALNOVI-1” in May 2003. In November of the year, we press released that “ALNOVI-1” was approved as a material for the landing lamp drum assembly for Airbus A330/A340.

Recently, three Japanese corporations joined the A300/A340 program, while fifteen Japanese corporations have already participated in the A380 program for an ultrahigh-capacity aircraft.

This is the first time that superplastic 5000 aluminum alloys are applied for aircraft parts, and it is expected that the demand expands during the course of strengthening the cooperative relationship between Airbus S.A.S. and Japanese corporations.

[Properties of ALNOVI-1]

Chemical compositions (mass%)

Mg	Mn	Cr	Fe	Si	Al
4.5	0.7	0.12	< 0.1	< 0.1	Bal

Mechanical properties

Tensile strength (N/mm²)	Proof strength (N/mm²)	Elongation (%)	Fatigue strength 10^7 (N/mm²)
310	160	28	150

Formability

Superplastic elongation (%)	m-value
300	0.5

[Manufacturing Limits of ALNOVI-1]

Original sheet

Thickness: 0.3~3.0 mm
Width: 2000 mm, maximum
Length: 9500 mm, maximum

* Thermal refining is usually “H18”.
* Please ask us for other sizes.

Formed product

Width: 1000 mm, maximum
Length: 2150 mm, maximum
Depth: 250 mm, maximum

* The manufacturing limits for formed products depend on the forming machine. Please ask us for details.

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