Tensile and Fatigue Properties of Aluminum Alloy Sheet 6022

M.Z. Wang and M.E. Kassner

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Tensile and fatigue tests were performed on aluminum alloy 6022 T4E29 and T6 sheet specimens in ambient air. The tensile and fatigue properties were compared with other commercial aluminum alloys. The results showed that 6022 alloy has high fatigue strength and good ductility with moderate tensile strength.

Keywords aluminum alloy 6022, fatigue, mechanical properties

1. Introduction

The 6022 aluminum alloy was developed in the late 1980s by Alcoa (Pittsburgh, PA) and has 0.8-1.5% Si; 0.45-0.7% Mg; and some other elements such as Zn, Cu, Mn, Fe, Ti, and Cr. It was designed to overcome some of the earlier 5XXX and 6XXX alloy problems relating to Luders bands. However, probably as a result of its relatively recent use, there are less mechanical data available, especially fatigue properties. Zhao and Lee[1] conducted three-point bending (reversed deformation) tests on 6022-T4 aluminum sheets to obtain materials parameters to simulate draw-bend deformation. Taleff et al.[2] reported the tensile ductility and creep behavior of several commercial aluminum alloys, including 6022-T4 aluminum sheets, at elevated temperatures. Miao and Laughlin[3,4] investigated the effects of Cu content and aging treatments on the precipitation characteristics and age-hardening behavior in 6022 aluminum sheets. This article reports the tensile and fatigue properties of aluminum alloy 6022 sheets, in both T4E29 and T6 conditions.

2. Experimental Procedure

The aluminum alloy 6022 sheet (thickness = 1 mm) was provided by Freightliner (Portland, OR) in the T4E29 condition. After machining, one-half of the specimens remained in the as-received (T4E29) condition, and another half were aged at 177 °C for 30 min and then air cooled (T6). This simulated a paint bake cycle in automotive applications and is consistent with the aging procedure reported previously.[3] All the specimens were cut along the longitudinal direction (rolling direction). The dimensions of fatigue specimens (smooth, $k_t = 1$) were according to ASTM E466-96 and are illustrated in Fig. 1, with a gauge section of 12.7 mm in length, 5.08 mm in width, and 1 mm in thickness, and with a blending fillet radius of 40.6 mm. The tensile specimens had a gauge length of 20.3 mm and a blending fillet radius of about 6.4 mm.

Three specimens were tensile tested in an Instron 4505 machine at room temperature at an approximate strain rate of $5 \times 10^{-4} \cdot s^{-1}$ each for the T4E29 and T6 conditions.

The fatigue specimens were polished with SiC paper from 320 to 1000 grit and then tension-tension tested in an Instron 8501 servohydraulic machine in ambient air with load control of 5 Hz (or 20 Hz if greater than 10^6 cycles) and stress ratio (R) = 0.1. The chemical composition of this alloy is listed in Table 1. It is noted the Si content is slightly lower than 0.8% (the lower limit of the Aluminum Association[6]).

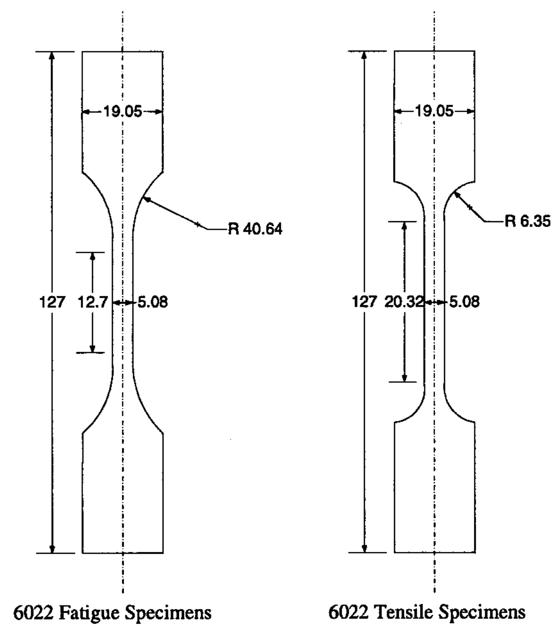

Fig. 1 Schematic of fatigue and tensile specimens of the 6022 sheet (thickness = 1 mm)

M.Z. Wang and **M.E. Kassner,** Department of Mechanical Engineering, Oregon State University, Corvallis, OR 97331. Contact e-mail: kassner@engr.orst.edu.

Table 1 Chemical Composition of Aluminum Alloy 6022 Sheet

Element	Si	Mg	Cu	Fe	Mn	Cr	Ni	Zn	Ti	V	B	Ga
Wt.%	0.75	0.57	0.08	0.12	0.08	0.02	0.003	0.008	0.019	0.008	0.0003	0.012

Table 2 Tensile Properties (a) and Fatigue Limit (b) of Aluminum Alloy 6022 Sheet

Specimen	$\sigma_{y,0.2\%}$, MPa	σ_{UTS}, MPa	Elongation, %	R.A., %	Fatigue Limit, MPa
6022 T4E29	160	271	28	41	198
6022 T6	232	317	22	29	230

(a) Average value based on three tests.
(b) Estimated minimum fatigue limit at 10^8 cycles, $R = 0.1$.

Table 3 Typical Tensile Properties and Fatigue Limit of Several Commercial Aluminum Sheet Alloys (Major Effects Are Bold)

Alloy	Temper	$\sigma_{y,0.2\%}$, MPa	σ_{UTS}, MPa	Elongation, %	Fatigue Limit, MPa
5052	O	90	195	25	110 (a)[5]
5052	H38	255	290	7	140 (a)[5]
5182	O	138	276	25	138 (a),(b)[5,7]
5182	H34	283	338	10	
6005	T5	241	262	8-10	minimum 97 (a)[5]
6009	T4	131	234	24	159 (b)[7], 117 (c)[5]
6009	T6	324	345	12	166 (b),(d)[7]
6010	T4	186	296	23	
6010	T6	372	386	11	145 (b),(d)[7]
6022	**T4E29**	160	271	28	198 (e)
6022	**T6**	232	317	22	230 (e)

(a) At 5×10^8 cycles, R.R. Moore type rotating beam test.
(b) At 10^7 cycles, $R = 0.1$ axial test.
(c) At 10^7 cycles, sheet flexural specimens.
(d) T62 temper.
(e) This study.

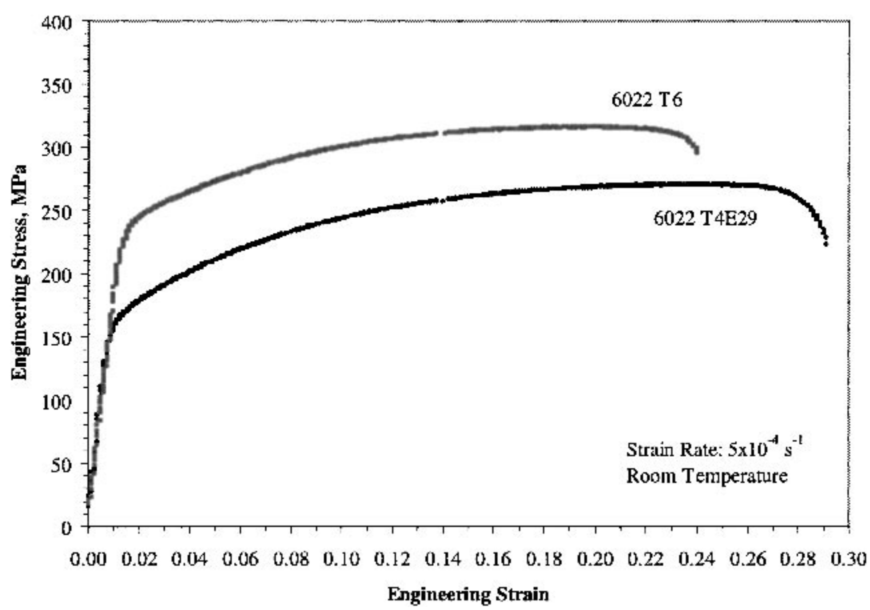

Fig. 2 Typical tensile behavior of 6022 T4E29 and T6 sheets

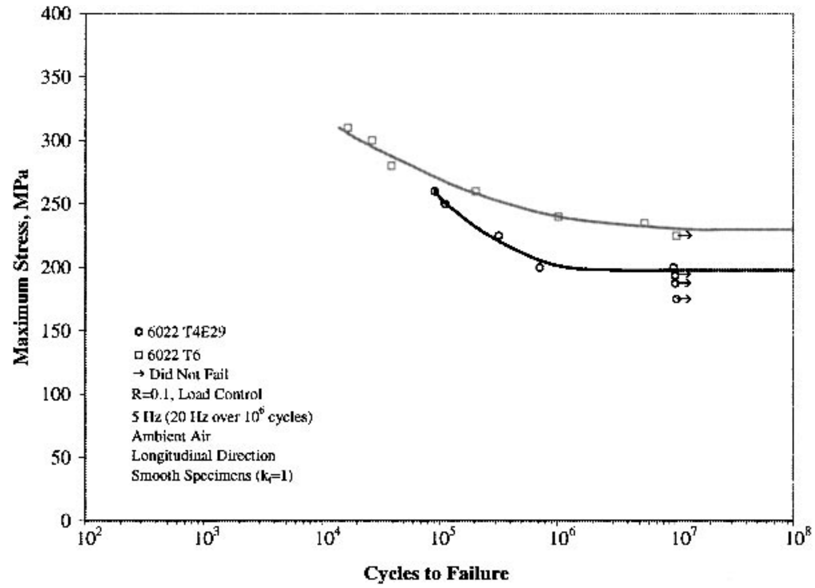

Fig. 3 S-N Curves of 6022 T4E29 and T6 sheets

3. Results and Discussion

Table 2 and Fig. 2 and 3 provide the tensile and fatigue properties for 6022 in both T4E29 and T6 conditions. The tensile curves were highly reproducible, and the S-N curves evidenced relatively small scatter.

Compared with the T4E29 condition, the T6 age treatment obviously increased the tensile strength and fatigue strength, particularly in the high-cycle region of over 10^6 cycles and still exhibited good ductility, although it was decreased.

Table 3 listed several aluminum alloys used in automobile applications and their typical tensile properties and fatigue limit.[5,7] It can be observed that the 6022 alloy has medium tensile strength but good ductility and high fatigue limit for both T4E29 and T6 tempers.

4. Conclusions

The tensile and fatigue properties of aluminum alloy 6022 T4E29 and T6 sheet specimens were tested and compared with those of other aluminum alloys. The results showed the 6022 alloy has high fatigue strength and good ductility with moderate tensile strength.

Acknowledgments

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