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(54) **ALMINUM ALLOY ENERGY-ABSORBING MEMBER**

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(57) **ABSTRACT**

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An aluminum alloy energy-absorbing member, which satisfies the conditions of $\alpha \geq 24$ and $(\alpha \times \sigma) \geq 6000$, wherein α (%) is the rupture elongation at a gauge distance of 5 mm, and σ (MPa) is a 0.2% proof stress value, in the extruding direction of an aluminum alloy extruded material. This is an aluminum alloy energy-absorbing member that is lightweight, high in energy absorption, adequate in required mechanical strength, and preferable as an impact-absorbing member for an automobile, and the like.

Fig. 1

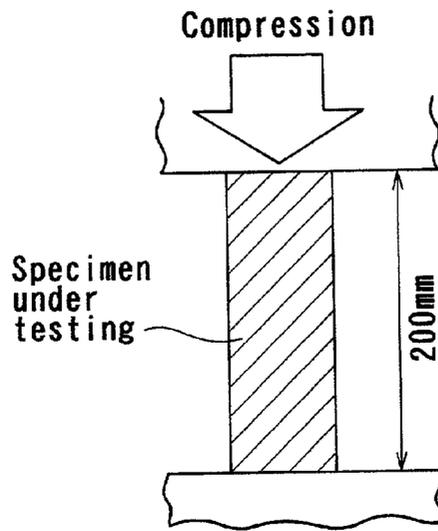
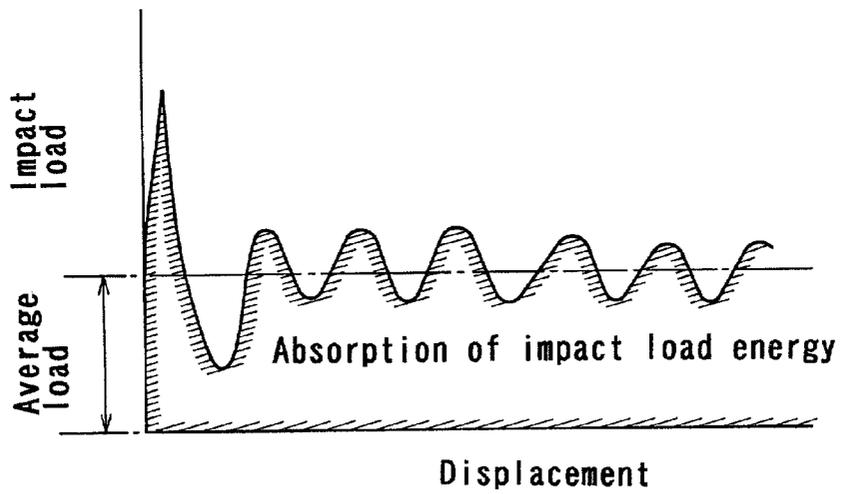


Fig. 2



ALUMINUM ALLOY ENERGY-ABSORBING MEMBER

FIELD OF THE INVENTION

[0001] The present invention relates to an energy-absorbing member composed of an aluminum alloy extruded material. More particularly, the invention relates to an energy-absorbing member preferably used as a frame material for a car body side member, for reducing the impact effect on passengers in the event of a collision of a transport vehicle, especially an automobile.

BACKGROUND OF THE INVENTION

[0002] In transport vehicles such as automobiles, recently, protection of passengers from collision impact is becoming more and more important, and in automobiles, in particular, it will become obligatory to equip them with structure and devices for protecting passengers in the event of a crash. Specifically, in the front engine section and rear trunk section of an automobile, structure and means are being devised for absorbing crash energy by accordion-like plastic deformation of structural members, such as side members, at the time of a collision. As the structural members for absorbing such crash energy, hitherto, cold-rolled steel sheets have been used, and they are assembled by press forming or spread welding.

[0003] Lately, however, from the viewpoint of environmental problems and automotive performance improvement, lightweight vehicles are demanded, and aluminum materials, which are lighter than steel sheets, are being studied to apply. As the aluminum material conforming to this purpose, an extruded material is being highly expected, because a structural member of complicated shape can be easily manufactured, and vehicle weight can be more reduced than sheet materials.

[0004] Necessary material characteristics in such an energy-absorbing member include (1) fitness for hollow extrusion, (2) adequate mechanical strength as a structural member, (3) large energy absorption upon a collision, and (4) fitness for welding.

[0005] As an energy-absorbing member made of aluminum alloy, materials having rupture elongation and local (locally-caused) elongation defined in a specified range, are proposed in JP-A-7-118782 ("JP-A" means unexamined published Japanese patent application), but the energy absorption, which is the most important characteristic for an energy-absorbing member, was not sufficient.

[0006] Among conventional aluminum alloy extruded materials, Al—Mg—Si alloy and Al—Zn—Mg alloy are known to be relatively excellent in mechanical strength and elongation, but there is the problem that their energy absorption is insufficient by only conventional extrusion.

SUMMARY OF THE INVENTION

[0007] The present invention is an aluminum alloy energy-absorbing member, which satisfies the conditions of $\alpha \geq 24$

and $(\alpha \times \sigma) \geq 6000$, wherein α (%) is the rupture elongation at a gauge distance of 5 mm, and σ (MPa) is a 0.2% proof stress value, in the extruding direction of an aluminum alloy extruded material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is an explanatory view showing a method of the compression test in the examples.

[0009] FIG. 2 is an example diagram of measurement of a displacement load curve of the compression test in the examples.

DETAILED DESCRIPTION OF THE INVENTION

[0010] The present inventors intensively investigated the energy-absorbing properties and material characteristics of aluminum alloy extruded material, and discovered that the energy absorption cannot be evaluated correctly by the combination of rupture elongation and local elongation of conventional tensile test specimens of JIS No. 13B and JIS No. 5, and that the energy absorption depends on a correlative relation between the rupture elongation at a gauge distance of 5 mm and a 0.2% proof stress value. The present invention has been accomplished based on these findings.

[0011] That is, according to the present invention there is provided: an aluminum alloy energy-absorbing member, satisfying the conditions of $\alpha \geq 24$ and $(\alpha \times \sigma) \geq 6000$, wherein α (%) is the rupture elongation at a gauge distance of 5 mm, and σ (MPa) is a 0.2% proof stress value, in the extruding direction of an aluminum alloy extruded material.

[0012] The values of α and σ in the present invention are values obtained by tensile testing at a tensile speed of 5 mm/min, using JIS No. 13B test specimens. The rupture elongation α at a gauge distance of 5 mm in the extruding direction is the value (%) expressing the rate of elongation to the initial length of 5 mm, by performing the tensile test by drawing lines at intervals of 5 mm in the vertical direction to the extruding direction in the parallel section of the specimen, and measuring the interval of the lines when the specimen is ruptured.

[0013] The energy-absorbing member of the present invention is made of an aluminum alloy extruded material. As long as the values of α and σ are as described later, the composition of the aluminum alloy is not restricted, but an Al—Mg—Si alloy or an Al—Zn—Mg alloy can be preferably used, because the mechanical strength and elongation are relatively high.

[0014] The aluminum alloy extruded material used in the energy-absorbing member of the present invention has the following values as the rupture elongation α (%) of a gauge length of 5 mm and a 0.2% proof stress value σ (MPa), in the extruding direction.

[0015] The value of α of the aluminum alloy extruded material used in the present invention is 24% or more, preferably 30% or more. If the value of α is too small, the

member is not deformed uniformly, accordion-like, when receiving an impact, and the intended energy absorption property is not obtained. The upper limit of α is generally 60% or less.

[0016] The product of α and σ ($\alpha \times \sigma$) of the aluminum alloy extruded material is 6000 or more, preferably 6500 or more. If the value of ($\alpha \times \sigma$) is too small, the energy absorption in plastic deformation of material is small, and it cannot be used as an energy-absorbing member. The upper limit of ($\alpha \times \sigma$) is generally 100000 or less.

[0017] The energy absorption property of the energy-absorbing member of the present invention is an energy-absorbing amount in compression testing of generally 10 kg·m or more, preferably 12 kg·m or more.

[0018] If necessary, by adjusting the composition of the aluminum alloy, or adjusting the heat treatment condition, the aluminum alloy extruded material having such values of α and σ can be obtained. The method of adjustment varies with the composition of the alloy to be used, and if the value of α is too small, for example, it is adjusted by heat treatment. If the value of ($\alpha \times \sigma$) is too small, it may be adjusted by adding an element for increasing the mechanical strength, or by changing the aging condition.

[0019] By using the aluminum alloy extruded material adjusted to such values of α and σ , an energy-absorbing material that prevents a decrease of the energy-absorbing amount while maintaining the necessary characteristics such as mechanical strength, can be obtained.

[0020] The shape and size of the energy-absorbing member of the present invention are not particularly restricted, and it may be properly used as a member necessary for absorbing energy, for example, at a crash. Specifically, in an automobile, for example, it is preferably used as a member for lessening the impact effect on passengers in the event of a collision. It may be used as a frame material for a side member, and a bumper beam material, and the like.

[0021] The energy-absorbing member of the present invention is made of a lightweight aluminum alloy, and it has high energy absorption while satisfying the necessary mechanical strength and the like as a structural member. Therefore, the present invention is very useful as an impact-absorbing member for an automobile and the like.

[0022] The present invention is described in more detail based on the following examples and comparative examples, but the invention is not limited to those.

EXAMPLES

Examples 1 to 9, Comparative Examples 1 to 4

[0023] Each of alloys having the composition shown in Table 1 was melted and casted into a billet of 220 mm in diameter, then the billet was homogenized for 2 to 8 hours at 470 to 580° C., and extruded into a square form with a cross inside, with one side of 100 mm and a wall thickness of 2.5 mm. Further, as shown in Table 2, the thus-obtained extruded material was fan-cooled right after extrusion, and aged, to obtain a T5 tempered material (which is referred to as "air-cooled" in Table 2), or the material was held at a temperature of 470 to 520° C. for 40 minutes, cooled in water, and aged, to obtain a T6 tempered material (which is referred to as "water-cooled" in Table 2), and the following tests were conducted.

(1) Tensile Test

[0024] Each of the materials was cut into a JIS No. 13B test specimen, lines were drawn at intervals of 5 mm in the vertical direction to the extruding direction in the parallel section of the specimen, and the test was conducted at a tensile speed of 5 mm/min.

[0025] The elongation α (%) after rupture in the parallel section of 5 mm, the 0.2% proof stress value σ (MPa), and the tensile strength (MPa) were measured, and the results are shown in Table 2.

[0026] Tensile strength of 150 MPa or more is sufficient for use as a structural member of an automobile.

[0027] Separately, each of the materials was cut into a JIS No. 13B test specimen, and the tensile test was conducted in the same manner as in the above, except that the gauge length was changed to 50 mm-interval, and the overall elongation (ϵ (%)) of each specimen was measured.

[0028] The results are also shown in Table 2.

(2) Compression Test

[0029] As shown in FIG. 1, a shaped specimen of 300 mm in length was loaded at a compressive speed of 10 mm/min, and the energy-absorbing amount was determined from the load, which was applied from the start of compression until compressive deformation of 100 mm, and the amount of deformation. An example of measurement of a displacement load curve in the compression test is given in FIG. 2. The obtained energy-absorbing amount is shown in Table 2.

TABLE 1

Alloy No.	Composition (wt %) (balance Al)									Remarks
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Zr	Ti	
1	0.48	0.17	—	—	0.5	—	—	—	0.02	JIS 6063
2	0.35	0.19	—	—	0.48	—	—	—	0.02	JIS 6063
3	0.51	0.18	0.09	0.08	0.6	0.02	—	0.03	0.01	JIS 6N01
4	0.7	0.22	0.08	0.09	0.72	0.02	0.01	0.03	0.02	JIS 6N01
5	0.71	0.23	0.25	0.06	1.11	0.23	—	—	0.01	JIS 6061

TABLE 1-continued

Alloy No.	Composition (wt %) (balance Al)									Remarks
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Zr	Ti	
6	0.09	0.22	0.08	0.12	0.73	0.02	5.54	0.18	0.02	JIS 7003
7	0.1	0.23	0.09	0.42	1.37	0.01	4.48	0.17	0.01	JIS 7N01
8	0.88	0.17	0.53	0.11	0.72	0.08	—	—	0.03	—

[0030]

TABLE 2

No.	Alloy No.	Hardening condition	Aging condition						Tensile		Energy absorption
			Temperature °C.	Time hr	α %	σ MPa	$\alpha \times \sigma$	ϵ %	$\epsilon \times \sigma$	strength MPa	
Example 1	1	Air-cooled	200	2	42	198	8316	16.6	3287	230	13.9
Example 2	2	Air-cooled	180	10	34	196	6664	13.2	2587	217	13.4
Example 3	3	Air-cooled	190	1	36	176	6336	15.8	2781	236	12.4
Example 4	3	Water-cooled	160	8	28	244	6832	12.2	2977	269	16.2
Example 5	4	Air-cooled	180	6	26	249	6474	14.4	3586	277	16.5
Example 6	6	Air-cooled	150	12	36	262	9432	17	4454	314	16.6
Example 7	7	Air-cooled	120	24	30	315	9450	17	5355	357	17.2
Example 8	5	Water-cooled	—	—	52	147	7644	18.2	2675	238	12.3
Example 9	3	Air-cooled	—	—	48	134	6432	16.8	2251	225	12.2
Comparative Example 1	5	Water-cooled	170	10	20	329	6580	10	3290	341	7
Comparative Example 2	4	Air-cooled	210	6	28	203	5684	13.4	2720	244	8.4
Comparative Example 3	7	Air-cooled	—	—	22	241	5302	18.2	4386	361	9.3
Comparative Example 4	8	Air cooled	—	—	34	147	4998	13.6	1999	268	9.8

(Note)

 α : Rupture elongation at a gauge length of 5 mm σ : 0.2% proof stress ϵ : Overall elongation at a gauge length of 50 mm

[0031] As is apparent from Table 2, in Examples 1 to 9 according to the present invention, a quite large energy-absorbing amount was obtained while maintaining the necessary material strength. Contrary to the above, sufficient energy absorption was not obtained in Comparative Examples 1 to 4, in which $\alpha < 24\%$ and/or $(\alpha \times \sigma) < 6000$.

[0032] When the rupture elongation (α) and the value ($\alpha \times \sigma$) were within the range defined in the present invention, an excellent energy-absorbing characteristics were obtained.

[0033] By contrast, if evaluated by the overall elongation (ϵ) instead of the rupture elongation (α), it is understood that no correlative relation was recognized at all between the magnitude of energy absorption and overall elongation (ϵ) or ($\epsilon \times \sigma$). That is, the rupture elongation (α) and overall elongation (ϵ) have different meanings as physical properties (value), and the overall elongation (ϵ) cannot be used instead of the rupture elongation (α) as a parameter of the energy-absorbing characteristic. More specifically, different from the rupture elongation (ϵ) of the very narrow gauge length of 5 mm defined in the present invention, the overall elongation (α) at the gauge length of 50 mm employed conventionally in the evaluation could not be used as a means for defining

or evaluating the energy-absorbing characteristic, or for defining or evaluating the material excellent in compression (crushing) buckling resistance as an automotive structural member.

[0034] Having described our invention as related to the present embodiments, it is our intention that the invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

What is claimed is:

1. An aluminum alloy energy-absorbing member, satisfying the conditions of $\alpha \geq 24$ and $(\alpha \times \sigma) \geq 6000$, wherein α (%) is the rupture elongation at a gauge distance of 5 mm, and σ (MPa) is a 0.2% proof stress value, in the extruding direction of an aluminum alloy extruded material.

2. The aluminum alloy energy-absorbing member as claimed in claim 1, wherein the aluminum alloy is an Al—Mg—Si alloy or an Al—Zn—Mg alloy.

3. The aluminum alloy energy-absorbing member as claimed in claim 1, which is used as a frame material for a side member, or a bumper beam material.

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