Development of Vanadium Free Beta-Titanium Alloy

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Daido’s titanium alloys

**Alloy developed by Daido**

**Consumer**
- DAT5(6Al-4V)
- DAT51(22V-4Al)
- DAT15G(15V-3Cr-3Sn-3Al)
- DAT55G(15V-6Cr-4Al)

**Medical**
- DT2, DT4(CP-Ti)
- DAT5E(6Al-4V ELI)
- DAT67(6Al-7Nb)

**Aerospace**
- DAT5(6Al-4V)
- DAT54(6Al-4Sn-4Zr-3Mo-1Nb-0.4Si-0.06C)

**Automobile**
- DAT52F(3Al-2V-REM-S)
- DAT5M(6Al-4V-Fe)
- DAT62M(6Al-2Sn-4Zr-2Mo-S)
- DAT54

**PPC-VAR process**

**Levitation process**
Excellent cold formability beta titanium alloy, DAT51(Ti-22V-4Al).

Daido’s titanium alloys for consumer products:

- DAT5(6Al-4V)
- **DAT51(22V-4Al)**
- DAT15G(15V-3Cr-3Sn-3Al)
- **DAT55G(15V-6Cr-4Al)**
High strength beta titanium alloy, DAT55G (Ti-15V-6Cr-4Al).

Daido’s titanium alloys for consumer products

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High strength beta titanium alloy, DAT55G (Ti-15V-6Cr-4Al).

Daido’s titanium alloys for consumer products
Price of vanadium raw material (ferro-vanadium:FV)

The fluctuation of the price.

ref. Metal Bulletin
Alloy design

Development of beta titanium alloys for stable price

For consumer products

CATi : Ti-13Cr-1Fe-3Al

- 2nd grade sponge titanium
- Substitute Cr, Fe for V as beta stabilizing element
- Al addition for alpha stabilizing element
Hot workability

Test condition

Cross head speed : 50.8mm/s

Test temp. 60sec

Flow Stress (MPa)

Reduction in Area (%)

CATi(Ti-13Cr-1Fe-3Al)
DAT51(Ti-22V-4Al)
DAT55G(Ti-15V-6Cr-4Al)

Test condition

Temperature (℃)

Cross head speed : 50.8mm/s

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Hot workability

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Flow Stress (MPa)

Reduction in Area (%)

CATi(Ti-13Cr-1Fe-3Al)
DAT51(Ti-22V-4Al)
DAT55G(Ti-15V-6Cr-4Al)

Temperature (℃)
Tensile properties at room temperature

- Solution Treatment Condition

<table>
<thead>
<tr>
<th>Material</th>
<th>Strength (MPa)</th>
<th>Elongation (%)</th>
<th>Reduction in Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAT51 (Ti-22V-4Al)</td>
<td>700</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>DAT55G (Ti-15V-6Cr-4Al)</td>
<td>800</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>CATi (Ti-13Cr-1Fe-3Al)</td>
<td>900</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

- 0.2% Proof Stress
- Tensile Strength

rod
Young's modulus

Solution Treatment Condition

Young's Modulus (GPa)

DAT51 (Ti-22V-4Al)  DAT55G (Ti-15V-6Cr-4Al)  CATi (Ti-13Cr-1Fe-3Al)

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Cold workability

Flow Stress (MPa) vs. True Strain (ln(h₀/h))

- DAT55G (Ti-15V-6Cr-4Al)
- CATi (Ti-13Cr-1Fe-3Al)
- DAT51 (Ti-22V-4Al)

Solution Treatment Condition: 6x11.5mm
Characteristics of CATi (Ti-13Cr-1Fe-3Al)

Tensile Strength (MPa) vs. Elongation (%)

- DAT5(A)
- DAT55G(ST)
- DAT51(ST)
- CATi(ST)

ST: Solution Treatment Condition
A: Anneling

Elongation (%):
- 10
- 15
- 20
- 25
- 30

Tensile Strength (MPa):
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100

Examples of conditions:
- rod
- CATi(ST)
Manufacturing process

◆ Daido's original method

Sponge titanium
Ti scrap
Alloying element

Plasma melting

Plasma progressive casting furnace (PPC)

Remelting

Forging
Rolling etc.

◆ Conventional melting method

Sponge titanium
Alloying element

Vacuum melting

Compressing
Welding

VAR furnace
Manufacturing process of sheet

- **Ingot**
- **Forging**
- **Hot rolling**
- **Cold rolling**
- **Sheet**

**Dimensions:**
- Ingot: 1.7ton
- Sheet: W:400mm, T:150mm
Manufacturing process of sheet

1. Ingot
2. Forging
3. Hot rolling
4. Cold rolling
5. Sheet

Dimensions:
- W: 400mm
- T: 4mm
- W: 400mm
- T: 2mm
Influence of cold reduction on tensile properties

![Graph showing the relationship between cold reduction and tensile strength/elongation](image)

- **Tensile Strength (MPa)**
  - Sheet:
    - 0%: 1400 MPa
    - 10%: 1200 MPa
    - 20%: 1000 MPa
    - 30%: 800 MPa
    - 40%: 600 MPa
    - 50%: 400 MPa

- **Elongation (%)**
  - Sheet:
    - 0%: 12%
    - 10%: 10%
    - 20%: 8%
    - 30%: 6%
    - 40%: 4%
    - 50%: 2%

The graph illustrates the decrease in elongation and increase in tensile strength as the cold reduction percentage increases from 0% to 50% for sheet material.
Summary

◆ We have developed a Vanadium Free Beta-Titanium Alloy, CATi(Ti-13Cr-1Fe-3Al).

◆ In the solution treatment condition, CATi has the comparable tensile properties to the conventional beta titanium alloys.

◆ CATi is applicable to consumer products such as bicycle parts, eyeglass frame, etc.
Thank you for your kind attention