# Gamma Titanium Aluminides for Aerospace Applications-Processing, Properties and Anodic Dissolution

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**Abstract –** *Titanium aluminide investigated using anodic dissolution behavior in NaCL and NaNo3 and in aqueous potassium bromide electrolytes with their various ph values. Characteristics of low density, creep resistance and high strength make TiAl make important material in respect of weight saving with high performance and this paper contains study of titanium aluminide hardness using wicker hardness tester study of anodic dissolution by using linear sweep voltametry and its machining process.*

***Key Words***: **Linear sweep voltametry , Vickers hardness tester Electro discharge machining (EDM), Titanium Aluminide.**

## 1. INTRODUCTION

Aircraft industries facing problems of passenger and goods transportation development which have to solved within few years and also turbomachinery systems demand are rapidly increasing steam turbines stationary gas, and also turbochargers [1].comparison with this conventional sources are shrinking and along with environmental pollution is rising. Besides this growth in a market considering future aircrafts engine must be fuel efficient ,clean and well maintained due to regulations .For efficient engine development gamma

Titanium Aluminides (TiAl) used in aircraft engines because of their high strength to density ratio and it has excellent temperature sustainability. TiAL replaces nickel-based super alloys because of their property of low density therefore this comes to weight savings possibility and better operation efficiency. The gamma titanium aluminide intermetallic ($\gamma$-TiAl) alloy which is capable to work at temperature up to 800ºC. This high temperature capacity of this alloy is consider for alternate of nickel based alloys, ($\gamma$-TiAl ) titanium aluminides have a density of 3.76 g/cm3 which is half of nickel alloys [2] In 2014, approximately 21,600 airplanes in service, over the next 20 years a number of aeroplane is expected to double is 43,560 airplanes. And 38,050 new airplanes and 26,730 of them, or 70 percent will be needed to achieve that number of aeroplanes.[3]

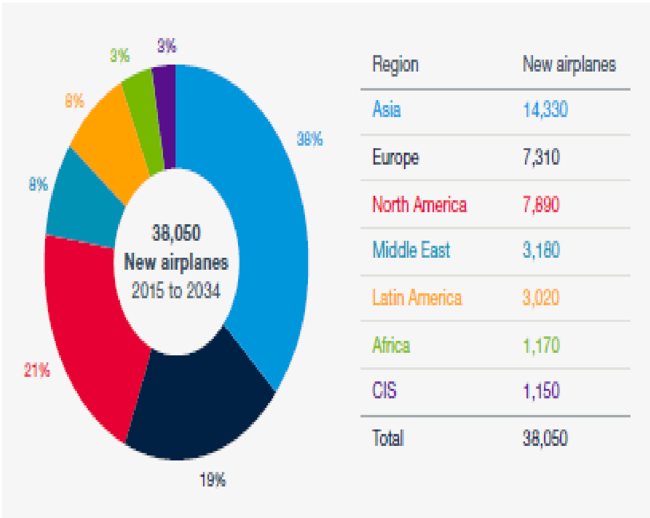


**Fig -1:** Demand for Aero crafts in future[3]

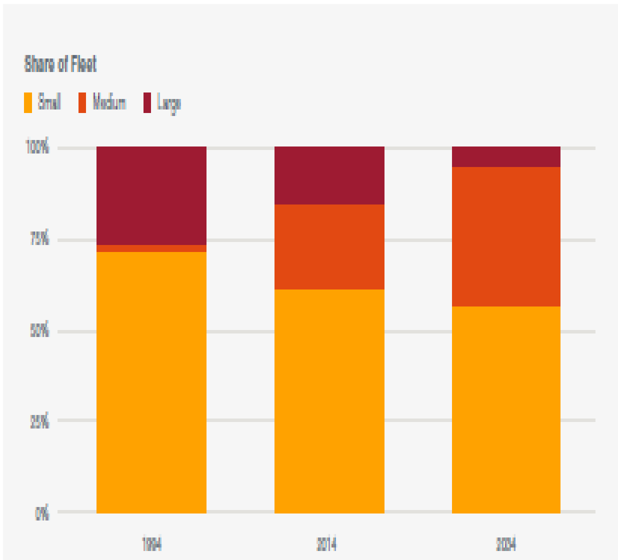


**Fig -2:** Airlines focus on efficiency along with flexibility [3]

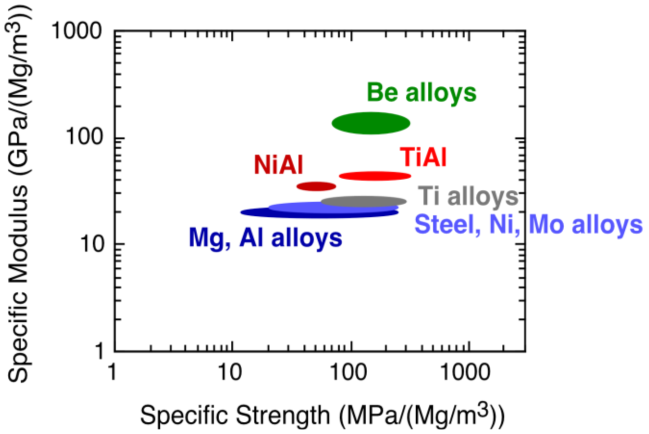


**Fig -3**: General Properties Of TiAl[4]

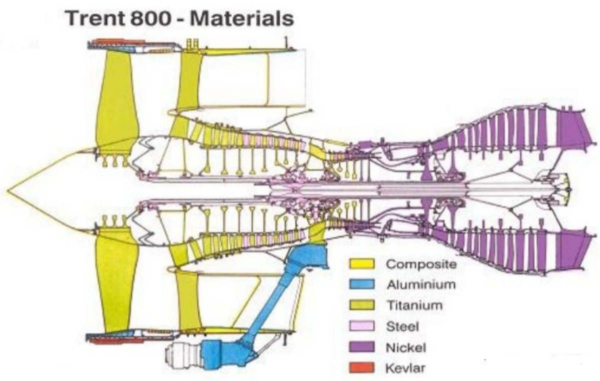


**Fig -4:** Areas of application prefer Titanium and Nickel-based alloys in aero engines [4]

### 1.1Properties

**Table -1:** Properties of Gamma Titanium Aluminide

| | Unit | Aluminum | Nikel Alloys | ᵞ-TiAl |
|---|---|---|---|---|
| Density | g/cm³ | 2.70 | 8.30 | 3.80 |
| Room Temp. Ductility | % | 45 | 3-10 | 2 |
| Operation Temp. Ductility | % | -- | 10-20 | 5-12 |
| Tensile Strength | N/mm³ | 90-600 | 345-1450 | 450-800 |
| Yield Strength | N/mm³ | 35-500 | 105-1200 | 400-650 |
| Melting Point | °C | 660 | 1455 | 1460 |
| Thermal Conductivity | W/mK | 230 | 11.3 | 22 |

### 1.2. Material & Experimentation

The three basic alloy types in gamma phase have the following composition:

a)TNM B1 type [Ti (43),5Al-(4)Nb-1Mo-0,1B(at.-%)] this material used as feed stock materials for thermochemical processing to semi-finished products maintaining high values of resistance and oxidation.

b) TiAl 48-2-2 (TNbi-33Al-2.6Cr-4.8) application: feed stock materials for further VAR based casting processes to g-TiAl components.

c) TNBv5 [Ti(57.9)Al-(31)Nb10.9-B0.1-C0.1] Therefore electrochemical dissolution behavior of titanium plus titanium alloys be investigated via different electrolytes with changeable pH-values. In addition toward aqueous NaNO3 as well as NaCl solutions, electrolytes which be mainly often use in the industrial application, a KBr base electrolyte was preferred. Solutions contain bromide ions well-known to be appropriate for the anodic dissolution of titanium and its alloys.

**Fig -5**: Specimen

### 1.3 Cutting

**Fig -6:** Sample cutting for hardness testing

### 1.4 Micro hardness Testing procedure

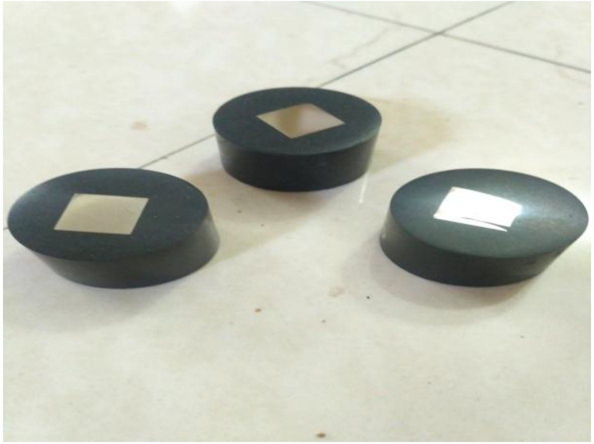

**Fig -7:** Prepared mold for testing

**Fig -8:** Vickers Microhardness Tester

**Table -2:** Results of hardness testing

| MICROHARDNESS INSPECTION REPORT | | | |
|---|---|---|---|
| M/C NAME- VICKERS MICRHARDNSS TESTER | | MAKE- SHIMADZU HMV-G21ST | |
| MASTER – 700 HV | | ACTUAL READING – 710 HV | |
| Distance in mm | TNBV5 | **TiAl 48-2-2** | **TNMB1** |
| 0.10 | 383 | 279 | 367 |
| 0.20 | 368 | 275 | 368 |
| 0.30 | 371 | 270 | 370 |
| 0.40 | 367 | 280 | 358 |
| 0.50 | 389 | 265 | 376 |

### 2. ANODIC DISSOLUTION

The anodic dissolution of every material is mostly dependent on the material composition, pretreatment of material, type of electrolyte, composition of electrolyte, electrolyte concentration, pH value, electrolyte flow rate and type of power supply. Anodic dissolution of any material is directly relative to the current efficiency and current density.[5] There are various techniques through which one can well estimate the anodic dissolution of any material such as; Current efficiency curve, polarization curve, Chronoamperometry and Linear sweep voltammetry

### 2.1 Linear sweep voltammetry

To inspect the dissolution behavior of titanium alloys in various types of electrolytes, linear sweep voltammetry (LSV) measurements be performed. This test gives the result of dissolution potential E diss, at this potential rate matrial start dissolve and maximum current density Jmax it can be get via the process of dissolution method.[6]

Application:

Study of kinetics

Study of adsorption

Characterization of new materials

1. LSV of Different Material using NaNO3, NaCl and KBr as electrolyte

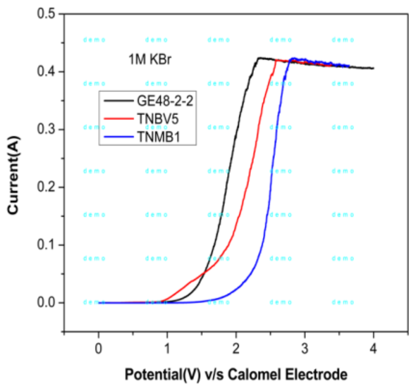


**Chart -1:** Result of dissolution rate of titanium aluminide in 1M KBr solution

Linear Sweep Voltammetry: At different Speed

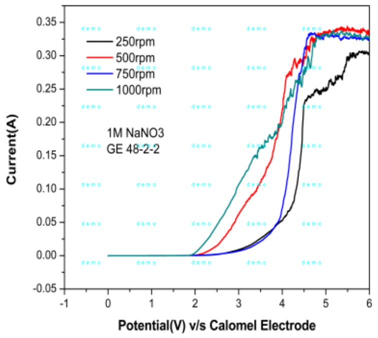


**Chart -2:** Dissolution rate at different speed for Ge-48-2-2

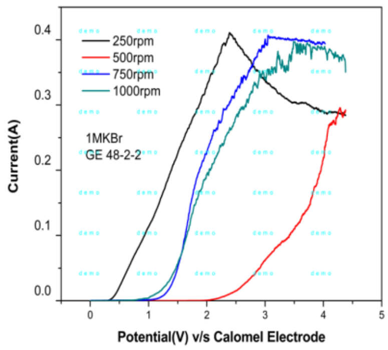


**Chart -3:** Dissolution rate at 1M KBr different speed for Ge-48-2-2

## 3. CONCLUSIONS

In this paper gives the basic research area about gamma titanium aluminide and its application and need of using this material for future use in aerospace for efficient aircraft engine. As per hardness testing results and comparing with standards we identified this material is gamma titanium aluminide .And result variation in hardness near about 5% which is acceptable as per standards. Linear sweep voltametry gives dissolution rate its start from potential rate 1.8V.

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