

# 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 NaNO<sub>3</sub> and in aqueous potassium bromide electrolytes with their various pH values. Characteristics of low density, creep resistance and high strength make TiAl an 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 be solved within few years and also turbomachinery systems demand are rapidly increasing steam turbines stationary gas, and also turbochargers [1]. Comparison with these 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 800°C. This high temperature capacity of this alloy is considered for alternate of nickel based alloys, ( $\gamma$ -TiAl) titanium aluminides have a density of 3.76 g/cm<sup>3</sup> which is half of nickel alloys [2] In 2014, approximately 21,600 airplanes in service, over the next 20 years a number of aeroplanes is expected to double to 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]

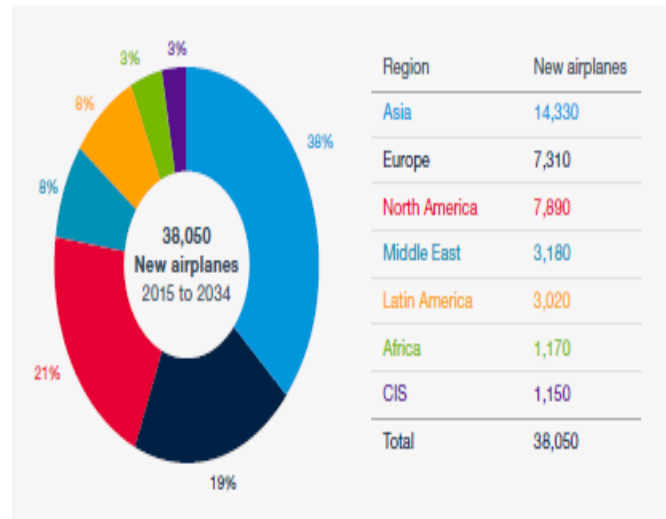


Fig -1: Demand for Aero crafts in future [3]

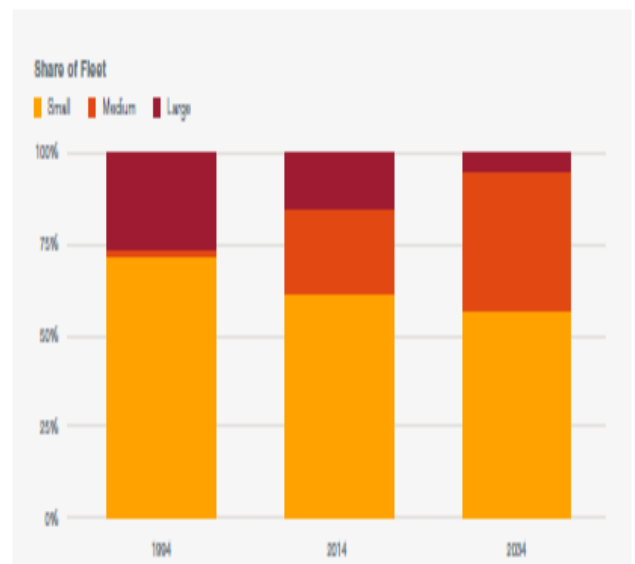


Fig -2: Airlines focus on efficiency along with flexibility [3]

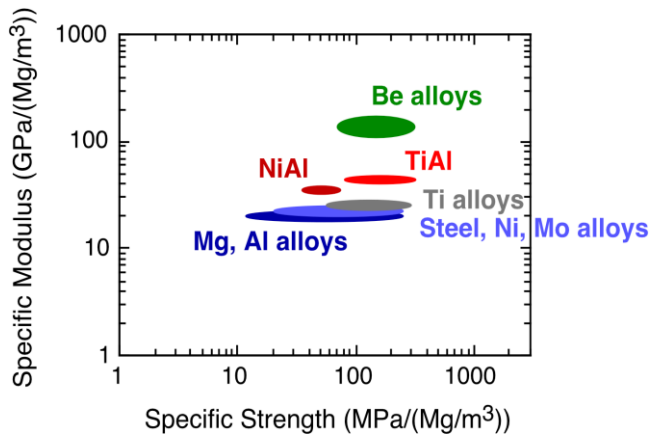


Fig -3: General Properties Of TiAl[4]

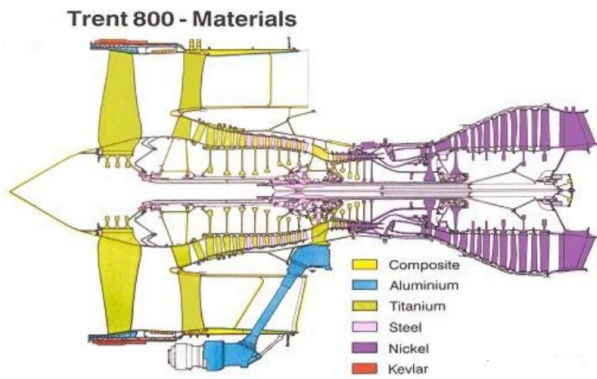


Fig -4: Areas of application prefer Titanium and Nickel-based alloys in aero engines [4]

1.2. 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

1.1 Properties

Table -1: Properties of Gamma Titanium Aluminide

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

1.3 Cutting



Fig -6: Sample cutting for hardness testing

### 1.4 Micro hardness Testing procedure

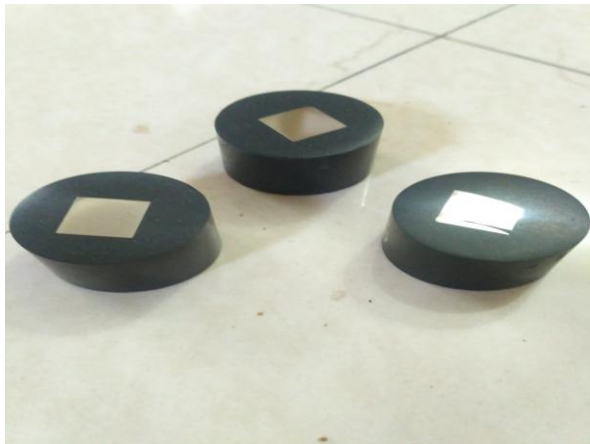


Fig -7: Prepared mold for testing



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 material start dissolve and maximum current density  $J_{max}$  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  $\text{NaNO}_3$ ,  $\text{NaCl}$  and  $\text{KBr}$  as electrolyte

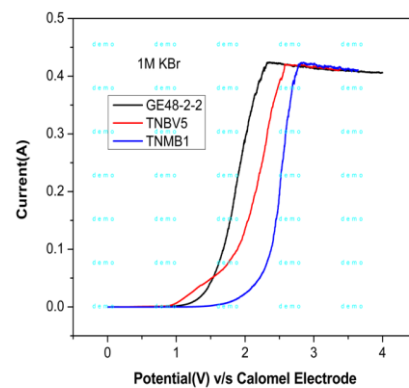


Chart -1: Result of dissolution rate of titanium aluminide in 1M KBr solution

Linear Sweep Voltammetry: At different Speed

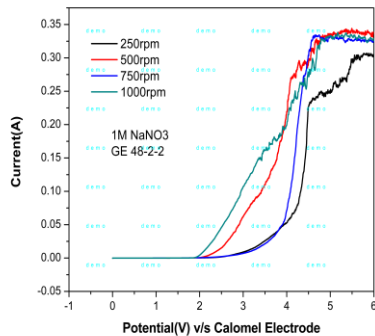


Chart -2: Dissolution rate at different speed for Ge-48-2-2

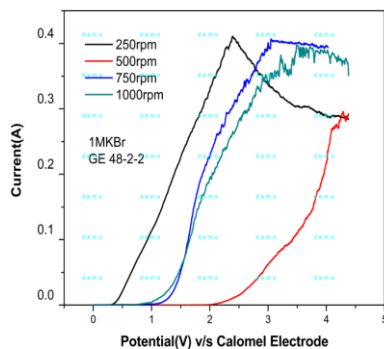


Chart -3: Dissolution rate at 1M KBr different speed for Ge-48-2-2

### 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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