

Processed Text

progress in aerospace sciences 97 2018 22 34 contents lists available at science direct progress aerospace science journal homepage www elsevier com locate paerosci recent advance development aerospace material xuesong zhanga yongjun chenb junling hua a department of mechanical engineering university of bridgeport bridgeport ct 06604 usa b materials process engineering sikorsky aircraft corporation a lockheed martin company 6900 main st stratford ct 06614 usa r c l e n f b r c keywords recent year much progress made development aerospace material structural aerospace materials engine applications alloy such as al based alloys mg based alloys ti based alloys and ni based alloys design criteria developed for aerospace industry with outstanding advantages composite materials the innovative materials mechanical properties taking more and more important roles in aircrafts however recent aerospace materials still face some major fretting wear challenge insufficient mechanical property fretting wear stress corrosion cracking corrosion corrosion consequently extensive studies have been conducted to develop the next generation aerospace materials with superior mechanical performance and corrosion resistance to achieve improvements in both performance and life cycle cost this review focuses on the following topics 1 materials requirements in design of aircraft structures engine 2 recent advance development aerospace material 3 challenge faced recent aerospace materials 4 future trends in aerospace materials 1 introduction property density damage tolerance corrosion resistance high temperature resistance typical yield strength elongation the rapid growth in the aerospace industry gives an impetus for the some metal alloys are summarized in fig 2 the density of aluminum is fast development of new aircraft materials the main driving force is cost one third that of steel 4 while the yield strength σ_y of al based alloy 7075 t6 reach 520 mpa 1 density part structure light weight design aircraft frame engine magnesium is only two thirds that of aluminum and a quarter of steel design material improved mechanical property improve while the tensile strength of mg based alloy mg97zn1y2 can reach up to fuel efficiency increase payload increase flight range 610 mpa 5 in addition mg based alloys possess exceptional stiffness directly reduce aircraft operating cost 1 therefore many and damping capability such high specific properties of mg based alloys search devoted developing material optimized enable aircraft reduce weight increase payload 5 6 property reduce weight improve damage tolerance fatigue ti based alloy ti 6al 4v alloy b120vca alloy corrosion resistance 1 ti 10v 2fe 3al posse lower density higher strength high the development of aircraft materials can be traced back to the first strength steels at high temperature the f22 fighter aircraft employed day flight year 1903 airframe wooden ti 10v 2fe 3al alloy 1240 mpa tensile strength arrestor hook structure after the year of 1927 al based alloys achieved the dominant structure 7 the increasing use of composite materials in the aerospace position aircraft material development cladding industry mainly due higher specific strength better anodizing technologies 2 al based alloys are dominant in aerospace corrosion and fatigue resistance than most metals 1 for example material over 80 years 1 however this situation has been changed in minimum yield strength carbon fiber reinforced polymer cfrp recent few years fig 1 shows the total materials used in boeing series 550 mpa density cfrp one fifth steel aircraft al based alloy tend to decrease and composites have experienced three fifths of al based alloys 8 moreover composite materials encased a rapid increase in the total materials in the latest boeing models ceramic matrix composite proven withstand high the attractiveness of light weight alloys in the manufacturing of high operating temperature of 1400 °c 1 c 9 which can satisfy the increasing performance aircraft part relies high specific property demand aircraft speed ni based superalloys excellent corresponding author department of mechanical engineering university of bridgeport bridgeport ct 06604 usa corresponding author material process engineering sikorsky aircraft corporation a lockheed martin company 6900 main st stratford ct 06614 usa e mail address xue zhang bridgeport edu x zhang http doi org 10 1016 j paerosci 2018 01 001 received 21 august 2017 received in revised form 16 january 2018 accepted 17 january 2018 0376 0421 2018 elsevier ltd all rights reserved x zhan et al progress in aerospace sciences 97 2018 22 34 2 the design criteria of the aerospace materials

the material property requirements for aerospace materials vary with the particular component under consideration. Material selection for an aircraft design depends on the design requirements of each component, including loading conditions, manufacturability, geometric limits, environmental aspects, and maintainability [21, 22]. The design criteria of the airframe materials: airframe materials are designed to provide long-term 60,000 flight hour support for both the static weight of the aircraft and additional load subjected from service [1]. This concept requires airframe materials to possess acceptable density, weight reduction, appropriate mechanical properties for the intended use. It also requires materials to provide suitable damage tolerance for the purpose of long-term use in extreme temperature condition [30, 37].

Fig. 1. Total materials used in Boeing series aircraft [1, 3]. Humidity, desert environment, ultra-violet radiation [22]. Different applications have their specific design and selection criteria of airframe materials. For example, the wing is subjected to bending during flight to support the static weight of the aircraft and dynamic loads due to maneuvering or turbulence. It is also subjected to additional loads from the landing gear, the leading edges, slats, and the trailing edge flaps during taxiing, take-offs, landing. Therefore, the wing upper surface is under compression during the flight and tension during the taxiing. The lower surface is under the opposite loads. This requires the materials for the wing to provide both high tensile strength and high compressive strength [1].

The fuselage is exposed to high cabin pressure, shear load, requires material possess high tensile shear strength. Al-based alloy is one widely used airframe material. Example: 2024 Al-based alloy has been widely used in fuselages because of its moderate yield strength (324 MPa), good fracture toughness (37 MPa·m^{1/2}), high elongation rate [21]. Moreover, the use of polymer matrix composites (PMC) such as CFRP for aircraft structures has significantly increased in recent years because of their high strength (3450–4830 MPa for standard modulus CFRP), elastic modulus (224–241 GPa), high temperature capability, and withstand temperatures between 290 and 345 °C [22]. Fig. 2. Typical yield strength and elongation of some metal alloys. Al alloys [2, 2].

The design criteria of the aircraft engine materials include 2024 T351, 2324 T39, 7050 T73651, 7075 T651, 7475 T7351, 2099, and 2199 [1]. Mg alloys include Mg97Zn1Y2, AZ91, ZK60, and WE43 [5]. Ti thrust improvement and weight reduction for aircraft engines have alloy include Ti 5Al5V5Mo3Cr, Ti 6Al4V, Ti 10V2Fe3Al, Ti 600, Ti 14Ni alloy, include Ni 15Cr10Co5, 5W, 15 alloy, 625, 16.

The driving forces in development of engine materials: the engine compressor normally range 500–600 °C [1]. High enough to meet increasing demand. Moreover, frequently used material for this part is Ti-based alloys, Ti 6Al2Sn4Zr. Fretting wear accelerates the fatigue failure of components to cause crack growth. Because of their high strength (YS 1/4 640 MPa) at high temperature, initiation sites on the material surface. However, the general theory that 450 °C and excellent corrosion resistance. The hot sections of aircraft identifies fretting behavior and the prevention of fretting is still unclear.

Engines require materials with high specific strength, creep resistance, yet [20]. Furthermore, corrosion problems also inhibit the use of aero hot corrosion resistance and high temperature resistance [21, 22]. Space materials and have caused a loss of 276 billion per year in the operating temperatures of the turbine section are usually in the range of which is much greater than the loss caused by natural disasters [21]. 1400–1500 °C [1]. Which greatly exceeds the limit of Ti-based alloys around

paper aims to review the recent advances of major aircraft materials. 600 cid 1 c 22 23 consequently the widely used materials for this application well as to provide a picture of current challenges and future trends. cation ni based superalloys ni 14 5zr 3 2mo excellent heat resistance strength 780mpa at 950 cid 1 c 24 23x zhan et al. progress in aerospace sciences 97 2018 22 34 3 recent advances in aircraft materials alloy zinc has the largest solubility 31 6wt in aluminum than any other element and the increase of zn content can improve the strength 3 1 al based alloys 27 mg and cu often used in combination with zn to form mg₂zn phase al₂cu/mg phase alcu/mgzn phase aluminum resulting al based alloy primary material aircraft remarkable solid solution strengthening the maximum tensile strength of structure increased use composite al based alloy still al zn based alloy is achieved at 2 9wt mg content 27 some al zn remains an important airframe structure material because of their several based alloy also contain copper 2wt improve tensile strength advantages such as low cost easy to manufacture and lightweight al 1 al zn based alloy exhibit the highest strength of any al based alloys based alloy heated treated loaded relatively high level 7075 alloy σ_y 510mpa therefore 7075 alloy used stress recent research development 2000 7000 building upper wing skin stringers and stabilizers where strength is the series al based alloy al li alloy aircraft application top consideration 1 28 however low fracture toughness reviewed damage tolerance and poor corrosion resistance limit the use of 7075 alloy in aerospace industry recent works focus on the development of 3 1 1 2000 series al cu based alloys al zn based alloys with balanced properties dursun et al. reported the 2000 series al based alloys are mainly alloyed with copper and they modification zn mg cu ratio improve damage tolerance of are heat treated to strength comparable to steel copper has a solubility high strength al zn based alloys 1 research has shown that the optimal amount 5 65wt cu dissolved in al matrix form mized properties of 7000 series al based alloys can be obtained when the al₂cu phase and magnesium is often used in combination with copper to zn mg ratio is around three and zn curatio is around four 29 form al₂cu/mg phase precipitation two phase result example the recent developed 7085 al based alloy is an alternative for higher strength 1 in addition 2000 series al based alloys possess σ_y 7075 al based alloy in aerospace applications due to the high properties period damage tolerance and better fatigue resistance than other series σ_y 4504mpa elongation 14 14 better damage tolerance al based alloys the properties of some 2000 series alloys 7000 series 44mpa m1 2 30 31 zr mn reported to improve alloy and al li based alloys are shown in table 1 one of the typical mechanical properties of al zn based alloys 32 33 the addition of zr example 2000 series alloy 2024 alloy widely decrease average grain size approximately 20 form rosette like studied as aircraft fuselage material where the damage tolerance is first microstructure and introduces proper distribution of these second phases consideration however the relatively low yield strength limit the use of 32 mn can combine with fe to form secondary phase in al zn based 2024 alloy high stress region addition intermetallic phase alloy increase fracture toughness al zn based alloy resulted by cu and mg can act as anodic site to reduce corrosion resistance decreasing the adverse effect of fracture toughness the optimum tance of 2024 alloy 1 too overcome these shortcomings some elements mn content at 1 0wt can increase the fracture toughness of 7000 series such as sn cd and ag have been studied to improve the mechanical alloy to 47mpa m1 2 33 impurities such as iron and silicon control properties of al cu based alloys by refining microstructure and grain size can also improve mechanical properties of al zn based alloys the typical for example they yield strength σ_y ultimate tensile strength σ_t example 7475 alloy higher fracture toughness hardness value of al cu mg based alloy increase with the content of sn 52mpa m1 2 and finer grain size than conventional 7075 alloy because up to 0 06wt but then decrease with the further increase of sn content of the lower content of iron and silicon total 0 22wt of 7475 alloy 25 further improvement of mechanical properties of al cu based alloy than 7075 alloy total 0 9wt loys can be achieved by controlling the impurities such as iron and silicon example 2224 t39 al cu based alloy higher tensile 3 1 3 al li based alloys strength σ_t 4476mpa conventional 2024 al cu based alloy the maximum solubility of li in al reaches up to 14 at a temperature σ_t 4428mpa because of the lower content of iron 0 12wt ure of 600 cid 1 c 34 the major effect of li in al is to reduce the density of silicon 0 10wt than 2024 alloy 0 5wt for both impurities 1 al based alloys when 1wt li is added the density of al based alloy is reduced by 3

while young's modulus increases by 6–35, therefore 3–1–2–7000 series Al–Zn based alloys. Al–Li based alloy is the lightest Al based alloy. 36 addition 7000 series Al based alloys are mainly alloyed with zinc and they are addition of Cu is often used in combination with Li to form a δ phase. Heat treatable highest strength series Al based to improve the mechanical properties of Al alloys. 37 consequently Al–Li based alloy possesses low density, high specific mechanical property. 2000–7000 series alloy example use table 1. 2060–T8 Al–Li based alloy for fuselage skin and upper wing skin application.

mechanical properties of some representative aluminum alloys. 1–26 cation save 7 weight, 14 weight respectively compared alloy. U.T. yield strength, fracture toughness, K_{IC}, elongation with that of conventional 2524 alloy and 2014 alloy respectively. 1 MPa, MPa, MPa, 0.5. However, high content 1–8 wt% Li in Al has been proved to 2025–428–324–37–21 cause an anisotropy problem in Al based alloys. 1–38 for example, T351 yield strength of AA2198 Al–Li based alloy in the longitudinal direction is 2026–496–365–NA–11–90 MPa, higher than that in the transverse direction. 39 the anisotropy, T351–1–2224–T39–476–345–53–10 of mechanical properties results from the crystallographic texture. Grain, 2324–T39–475–370–38–5–44–0–8 shape size precipitate aging process addition 2524–T3–434–306–40–TL–24 earlier Al–Li based alloy possesses low toughness, poor corrosion. 7150–X–808–9–776–5–12–7–14–1 resistance. Recent study focus composition optimization. T6–7075–T6–656–590–25–5–CID–3–4–6–11. Come these shortcomings, the anisotropy problem of Al–Li based alloys. 7475–552–496–42–9–12 can be reduced by introducing recrystallization through optimization of T651 composite thermal mechanical processing. 40 example 2050–T84–540–500–43–NA–2198 Al–Li based alloy containing 40 wt% Mn can be recrystallized by 2090–T83–531–483–43–9–3–40 in 3 min under the condition of 535–CID–1–C–41. In addition, they yield 2098–T82–503–476–NA–6–2099–T83–543–520–30–LT–7–6 strength of an Al–Li–Cu–Mg alloy at the rolling direction is 80 MPa, higher 2199–T8–400–345–53–10 than it is at 60–CID–1 from the rolling direction in the condition of under aged 8090–500–455–33–LT–12. However, yield strength alloy isotropy aged T851 condition 42 addition low fracture toughness. Al–Li based 24–X–Zhan et al. progress in aerospace sciences 97–2018–22–34.

alloys can be improved by reducing the insoluble second phase particles. 3–3 Ti based alloy such as Al–7Cu–2Fe–4 for example, there is a recent advanced 2199 Al–Li based alloy has 20 MPa, 1–2 higher fracture toughness than earlier 8090 Al–Li. Use Ti based alloy increased recent year based alloy obtained optimization composition shown in fig. 3. The operating empty weight (OEW) which is the weight thermal mechanical processing precipitate microstructure control of all operator items equipment required for flight and all fluid needs. 1–sary operation witnessed increasing use Ti based alloy from 1 to 19 Ti based alloys have been used for both structure and 3–2 Mg based alloys engine applications such as aircrafts, spring, helicopter rotors, systems and engine compressor parts. See fig. 4. The attractiveness of Ti based alloys. Mg is considered the lightest structural metal. 43 and can decrease mainly due high specific strength, excellent corrosion resistance, weight structure approximately 33 compared to steel. Well high temperature performance generally Ti based Al same volume of Al used and by 77.

when compared to the same alloys divided three category based type crystal volume. Steel used 44 addition low density abundance structure. Alpha titanium alloy, beta titanium alloy, alpha–beta castability, recyclability also contribute attractiveness alloy. There are recent researches on the development of Ti based alloys for Mg based alloys. 45 commercial Mg based alloys can be divided into aircraft applications are reviewed two category wrought Mg based alloys, casting Mg based alloys. Generally wrought Mg based alloys have better tensile properties than 3–3–1 Al–Ti–Zr alloys. Casting Mg based alloys but have a higher asymmetry of yield behavior.

Al–Ti–Zr alloys can be divided into alpha and near alpha. 46 admittedly the use of Mg based alloys by the top aircraft manufacturers which entirely or mostly consist of α phase with neutral alloy elements. Airbus, Boeing, Lockheed Martin limited, etc. stabilizers. 23 in general Al–Ti–Zr alloy has a lower Mg based alloy. AZ91, ZE41, WE43, ZE41 used heli density higher creep resistance and better corrosion resistance than beta.

Copter industry to make cast gearbox transmission such as for Sikorsky titanium alloy. 23 because of these properties. Alpha titanium alloy helicopter 92–UH60 helicopter 6–43–47 drawback. Cp–Ti–Ti–3Al–2.5V–Ti–5–2–5–Ti–8–1–1–Ti–6–2–4–2. IMI 829 Mg based alloy aerospace industry insufficient. IMI 834 Ti–6Al–4V used manufacture compressor. Mechanical property poor corrosion resistance stress corrosion disc blades in aircraft engines. 23–56 despite the attractiveness of Al–Cracking issue. Phas titanium alloy some research 14–57 has shown that Al–Phase.

to improve the poor corrosion resistance and insufficient mechanical properties greatly limit high temperature capability of titanium alloy. Property element Al, Zn, Zr, rare earth elements fortunately the α phase stabilizing additions enable these alloys to serve in environments such as they are being employed to improve the properties of Mg aircraft jet engines in which the temperature can reach up to 600 °C. Al based alloy refining modifying microstructure Sn, Zr and Si have been investigated to improve the heat resistance of widely studied β phase element. The low density element has a maximum α phase or near α phase titanium alloys. Al is the most widely used to improve solubility. 12 wt% in Mg and can merge into Mg to form the phases of strength α phase titanium alloy. High temperature 58 °C γ phase 17Al, 12wt% and α phase Mg which is beneficial to solid solution strengthening. Experiment conducted Jiang et al. [59] showed tensile strength of Mg-Al based alloy moderate mechanical property. Strength of Ti-25Zr titanium alloy increased from 931 MPa to 1319 MPa corrosion resistance which can be significantly improved by increasing Al content. With the increasing of Al content from 0 to 15 wt% the yield strength was 48% in addition to Al. Zr element can improve the strength increased 47% raising addition Al 15% however ductility of Mg-Al based alloys at room temperature the solution elongation decreased 14.79% to 5.55% increase Al solubility of Zn into Mg is 6.2wt% and can form α phase Mg and γ phase Zn phases content the strength efficiency of Al in Ti-Zr based alloys is mainly due to which are beneficial to improve the strengths of Mg based alloy with the total size and modulus mismatch between Al and Zr. Increase of the Zr element from 1wt% to 5wt% the yield strength of Mg-Zn based alloys rises more over the tensile strength increases to 216.8 MPa and 33.2% β phase titanium alloys elongation increases to 15.8% when the content of Zn reached up to 4wt% β phase titanium alloys are entirely or mostly consist of β phase with β and then decreases with additional Zn content. Added 5.49% stabilizer β phase near β phase alloy higher tensile fatigue even the corrosion resistance of Mg-Zn based alloy decreases with the strength α phase titanium alloy easier fabrication rising Zn content mainly increasing volume fraction of β phase products. 60% the high strength of β phase titanium alloys is resulted from the fraction of the second phase β phase Mg-Zn. 50% in Mg-Zn based alloys Zr and Y are often used in combination with Zn to improve mechanical properties. Zr is considered the best refiner for Mg based alloys without Al element due to the reaction of Zr and Al. 51% the benefit of Zr in Mg-Zn based alloy is to refine the grain size and disperse the Mg-Zn β phase. 52% Homma et al. [52] reported that the tensile strength of an Al-Zn based alloy increased 275 MPa, 148 MPa, 357 MPa, 310 MPa respectively when the content of Zr increased from 0wt% to 0.84wt%. Addition Zr rare earth element also improve mechanical properties of Mg-Zn based alloys. The Mg-97Zn-1Y alloy has the highest strength 610 MPa among Mg based alloy caused adding rapid powder metallurgy processing. However strength of Mg-Zn based alloys can be reduced when Y element exceeds the critical amount. For example Xu et al. reported that the tensile strength of Mg-Zr alloy was increased to 230 MPa by adding 1.08wt% amount of Y and then decreased to 180 MPa when the amount of Y was increased to 3.08wt%. Similar situations occurred on Y in addition. Xu et al. studied effect elongation rate of Mg-Zn based alloy result showed elongation decreased to 3.6% when the content of Y increased to 1.08wt% and then increased slightly with additional Y content. Added 5.3% Ti titanium usage in some aircrafts. 54.25% Zhang et al. progress in aerospace sciences [97]. 2018. 22. 34. Fig. 4 component made Ti based alloy landing gear beam for Boeing 747, bulkhead for a fighter aircraft, C wing box B1, B bomber aircraft springs used in Boeing aircraft, casting used in a military transport aircraft. 55% from the β phase stabilizer such as V, Mo, Nb and Cr these alloying atoms. 70% some element such as Zr has been reported to improve hardness can reduce the binding energy of the β phase atomic cluster resulting in strength Ti-6Al-4V alloy due to effect solid solution stronger bonds between alloying atoms and titanium atoms than those of strengthening in which the α phase platelets are replaced by fine acicular α phase Ti atoms and the binding energy decreases with the increasing α phase resulting in close lamellar spacing to hinder dislocation movement. Ti alloying element. 61% addition occurrence ω phase. 71% the microhardness of Ti-6Al-4V alloy can be increased to 420 Hv during cold rolling also has a significant effect on mechanical properties by adding 20wt% Zr. In addition the tensile strength can be increased β phase titanium alloy. 62% example Ti-3Al-8V-6Cr-4Mo-4Zr from 996 MPa to 1317 MPa by increasing Zr content from 0wt% to 20wt%. Alloy has a minimum UTS at 1240 MPa and Ti-15V-3Cr-3Al-3Sn has a however the elongation ratio dropped to 8.08% minimum UTS at 1034 MPa consequently these two alloys are widely used in high stress regions such as aircraft landing gear and aircraft spring. 3.4

composite materials application 60 addition Ti 3Al 8V 6Cr 4Mo 4Zr Ti 15V 3Cr 3Al 3Sn alloys
 four beta titanium alloys are instead proposed the use of composite materials has significantly increased and com-
 position Ti 10V 2Fe 3Al Ti 15Mo 2Nb 3Al 0.2Si posites now constitute more than 25% of the Airbus A380 and 50
 of the Ti 5Al 5V 5Mo 3Cr 0.5Fe and Ti 35V 35Cr 63 however beta titanium Boeing 787 aircrafts see Fig. 5
 composite materials show a great potential alloys are reported to possess low tensile ductility 55 fortunately
 potential is not only structural applications but also some engine parts shortcoming overcome optimization
 composition rising use of composite materials in the aerospace industry is mainly due to thermal mechanical
 processing example recent developed Ti 5Al 3Zr 4Mo 4V 4Cr UTS $\frac{1}{4}$ 1370 MPa elongation $\frac{1}{4}$ 17 containing trace metal recent research development
 3 wt% Zr under aging condition has a high value in both elongation ceramic metal
 and polymer matrix composite materials are reviewed UTS $\frac{1}{4}$ 1200 MPa elongation $\frac{1}{4}$ 10 64
 the increased ductility is mainly due to the growth of spherulites 3 4 1 ceramic matrix composite material
 primary α phase ceramic matrix composites CMC such as silicon carbide SiC SiC 3 3 3 α phase
 beta titanium alloys TiN TiN Si₃N₄ alumina Al₂O₃ zirconia aluminum titanate
 because of the excellent combination of strength fracture toughness Al₂TiO₅ aluminum nitride AlN matrix
 composite widely studied in recent years because of their attractive properties and ductility the α phase
 beta alloy is the most widely used Ti based alloy high temperature stability withstand operating temperature
 Wusheng et al. 2018 22 34 Fig. 5 percentage total structural weight attributed
 composite use composite Airbus A380 the percentage of total structural weight attributed composite B use
 composite Airbus A380 72 73 believe that graphene nanosheets are an efficient alternative based
 MMC reinforced 30 SiC similar density 60 higher
 for CNTs in ceramic composite because of the similar mechanical properties elastic modulus 15 higher tensile
 strength 70 higher specific properties and better dispersibility to CNTs an experiment by Walker et al.
 modulus than 2219 Al based alloys 79 recently some metals and Al 76 demonstrated an increase of 235
 in fracture toughness of Si₃N₄ alloys were studied as matrix such as aluminum magnesium titanium
 ceramic composite by adding 1.5 vol% of graphene however the concentration copper nickel 80 property matrix
 tent of graphene nanosheets should be limited at critical value for example shown in Table 2
 some fibers such as ceramic reinforcement and CNTs Liu et al. 77
 reported the fracture toughness of Al₂O₃/SiC ceramic com-
 positional carbon fiber were investigated for their potential to improve composite increased to 449 MPa m^{1/2}
 2 when graphene content rose from 0 to property MMC however fiber content 0.38 vol% dropped 353 MPa m^{1/2}
 content requirements for further improvement of mechanical properties of MMC graphene reached up to 1.33 vol%
 carbon nanotube CNTs graphene nanosheets recently shown attractiveness demand fiber higher 3 4 2
 metal matrix composite materials strength lower coefficient thermal expansion better self lubricant
 metal matrix composites MMCs hold promise for the aerospace industry ability and higher damping capacity 81
 the effect of carbon nanotubes because of their reinforced high yield strength fracture toughness
 tubes on MMC have been studied by Liao et al. 81 82 they reported low thermal expansion
 and suitable wear resistance 78 the fact that different amount of multi walled nanotube MWNT have different

27x zhangetal progressinaerospace sciences97 2018 22 34 table2
properties of some metal matrices of composites 87 88 matrix density g cm^3 cte thermal conductivity
yield strength ut young modulus elongation 10 cid 4 6k cid 4 2 w mk mpa mpa gpa al2024 2 78 22 7
120 345 425 70 5 al6061 t6 2 71 23 2 160 193 227 69 10 al b70 2 1 13 9 240 282 338 199 10 ti6al4v
2 43 8 8 7 2 827 896 110 10 mg al6mn 1 78 26 62 130 220 45 8 mg 1 74 26 1 159 30 115 44 6 mg bni5
58 146 3 effects on matrix composites and the optimal content occurs at 0.5 wt in the range of 34–38
furthermore the mechanical properties of CNT in addition
carbon nanotubes influence the properties of matrix reinforced copper matrix nanocomposite studied
daoshu composite as well for example zhengetal 83 reported that the tensile coworkers 85
the results showed that CNT can greatly improve the property of AZ31 Mg matrix composite greatly improved
yield strength with the highest yield strength achieved at the point when introducing 1 wt % MWNT moreover
the effects of CNT on mechanical properties of 15 vol % CNT was added into copper matrix daoshu also found that the
properties of Ti matrix composite also have been studied by kondoh 84 young modulus Cu matrix composite
gradually increased for instance as shown in fig 6 the addition of MWNT from 0.18 wt % increasing CNT content
in addition to the matrices of Al–Mg–Ti and Cu–0.35 wt % can continuously increase the tensile strength yield strength
hwangetal studied the effects of MWNT on the properties of Ti matrix hardness Ti nanocomposites moreover
addition composite 86 specifically the young modulus and yield strength of
MWNT does not reduce the elongation of Ti and its composites which is
nanocomposites were increased by 21 GPa and 521 MPa with the increase of fig 6
the mechanical properties of the extruded Ti and its nanocomposites yield strength ultimate tensile strength
and elongation b vickers hardness 81 28x zhangetal progressinaerospace sciences97 2018 22 34
MWNT from 0 to 6 vol % respectively of additional alloy elements although steel still plays an important role
in the aerospace industry especially for gears bearing carriage 3 4 3 polymer matrix composites fastener
steel conventional aerospace industry alloy polymer matrix composite PMCs grouped two categories
experienced a rapid decrease in recent years due to lower specific properties thermoplastic and thermoset
based on the differences in matrix strength and corrosion resistance than new materials such as light alloys
characteristic the prominent advantages of polymer matrix composites and composites 106 well known high
specific strength specific modulus to overcome these shortcomings recent studies focus on the development
example the density of carbon fiber CF reinforced epoxy composite is
one of the new low alloy steels and nano steels when compared to conventional only half that of Al based alloys while
the tensile strength and elastic modulus are three times and two times higher respectively than those of conventional carbon steel low alloy steel show better performance
modulus are three times and two times higher respectively than those of conventional carbon steel low alloy steel show better performance
capacity wear corrosion Al based alloy 89 the excellent properties of fibers contribute to load resistance
in recent studies the most attractive type of low alloy steel advances in PMCs
and the properties of some fibers are shown in table 3 shown ultrahigh strength steel UHSS UHSS yield
both thermoset and thermoplastic PMCs have been used for aerospace strength 1380 MPa due to finer grain
size precipitation structure application such as ailerons flap landing gear doors Boeing strengthening 107
some typical UHSS are 4130 4140 4340 6150 777 787 airplane 50 weight CFRP 90 9260 300M and D6ac 106
108 the compositions yield strengths although the conventional CF can improve the strength of PMCs the CF
application typical ultra high strength low alloy steel reinforced composite likely suffer stress
concentration demonstrated in table 4 however UHSS are prone to degradation by
because of the brittleness of CF 91 therefore recent investigations of hydrogen H because hydrogen atoms at
crack tip weaken inter fibers for PMCs have focused on the natural fibers 92 carbon nanotubes
atomic bonds and facilitate crack growth by slip and microvoid and the 93 graphene 94 and basalt 95
natural fibers such as flax hemp distribution of hydrogen is highly nonuniform under an applied stress banana
bamboo and recycled cellulose fiber RCF are being used in the cause localized deformation localized failure
109 polymer system to improve the mechanical properties of PMC 96 Li addition UHSS recent developed
nanostructure steel nano and coworkers 97 reported the tensile strength of high density poly steels with ultra
fine grains nanosize particles and nanosize phases have ethylene HDPE with 20
flax fiber is twice that of HDPE without any been studied
then nano steels have a higher strength and better corrosion flax content however
the main disadvantage of natural fibers polymer resistance due to prevention dislocation movement nano
composites is the incompatibility between the hydrophilic natural fibers particle fewer defect surface steel

110 typical and the hydrophobic thermoplastic matrix 98 in addition to natural example nanostructure steel
 9Cr oxide dispersion strengthened fiber reinforced pmcs carbon nanotube reinforced pmcs od steel
 strength 9Cr od steel σ_s 845 mpa widely used military aircraft structure component σ_{ts} 915 mpa higher
 conventional sae 2330 steel conductive coatings for fighter jets 99 according to earlier works by σ_s 689 mpa
 σ_{ts} 841 mpa 111 qian et al 100 and biercuk et al 101 carbon nanotubes can significantly improve elastic
 modulus break strength hardness 3.6 ni based superalloy polymer composites however
 according to the review paper by mittal and co-workers 93 various investigations 102 reported that when the
 recent advanced ni based superalloys containing γ ni3 al ti content cnt exceeded critical point
 mechanical property phase with high volume fractions resulting the high strength of ni based
 decreased with increasing the content of cnt compared to cnt reinforced superalloys at high temperature 113
 for example the tensile strength of pmcs graphene based polymer composite much better
 of wrought ni cr w superalloy can reach up to 550 mpa at 800 °C 1.11 mechanical properties 103
 for example wan et al 104 reported that due to their high strength at high temperature superalloys are widely
 tensile strength epoxy composite increased 52.98 mpa
 used in some aero engine parts such as the combustor and turbine section 71.54 mpa by adding only 0.1 wt
 graphene oxide go furthermore where operating temperatures range between 1100 and 1250 °C 1.14
 basalt another effective reinforcement pmcs recent test on the application of ni
 based superalloy in the pw4000 engine are shown ducted zhang et al 105 showed tensile strength tensile
 in fig 7 ni based superalloys have shown little inherent resistance to modulus flexural strength
 and flexural modulus of polybutylene succinate high temperature oxidation 113 chiu and co-workers 115
 reported rate continuously increased basalt fiber content increased
 that the addition of al improved the oxidation resistance the oxide layer from 0 to 15 vol thickness of cm 247 lcn
 based superalloy at oxidation time of 100 h reduced 20 μ m 6 μ m adding 1 wt al 3.5 steel
 formation of al₂O₃ can prevent the outward diffusion of cation and inward diffusion oxygen ion addition
 researcher steel used aerospace industry ever since first reported that the addition of chromium in ni
 based superalloy improves aircraft was built by the Wright brothers with the development of new
 the hot corrosion and oxidation resistance however the high content of technology
 the composition of steel has changed from carbon and iron cr reported detrimental microstructural stability
 116 into a complex alloy combined with the element of Fe and an abundance example chen et al 116 reported
 stress rupture life table 3 properties of some reinforcement of composites 87 fiber density g cm³
 thermal conductivity young tensile strain to fracture hardness maximum service w °C 1.1 c modulus
 strength failure toughness vickers temperature gpa mpa mpa m0 5 hv oc al fiber 3.5 22.5 305 2200 0.9
 1.75 650 1000 al whisker 3.96 22.5 455 1550 0.225 4.5 2350 1000 boric 2.75 38 400 3000 0.75 3 900
 550 gr 1.95 140 700 2200 0.75 1.5 700 600 sic whisker 3.17 80 460 7000 0.225 2.75 950 1150 sic 3.18
 80 465 2750 0.225 2.75 3250 1050 boron carbide 2.5 19 400 2400 0.75 3 900 550 1.86 185 307 965 3.5
 13 260 300 tidiboride 4.6 73 525 320 0.15 5.5 2750 1450 29x zhan et al
 progress in aerospace sciences 97 2018 22 34 table 4 the compositions yield strength
 and applications of the ultra high strength low alloy steels 106 108 112 c mn si ni cr mo v co maximum
 application yield strength mpa aermet 100 0.23 0.01 0.01 11 14 3 00 1 18 13 44 1700 shaft fittings
 landing gears axles turbine components airframe 4130 0.31 0.50 0.28 0.95 0.20 1110 axle rotor gear
 fuselage snapsprings crankshaft 4140 0.41 0.88 0.28 0.95 0.20 1110 4340 0.41 0.70 0.28 1.83 0.80 0
 25 2020 6150 0.51 0.80 0.28 0.95 0.20 1225 snapsprings propeller cones gear shaft pins and bolts 9260
 0.60 0.88 2.00 1149 spring 300m 0.83 0.77 1.63 1.83 0.83 0.40 0.05 1689 landing gears airframe
 fastener d6ac 0.45 0.75 0.28 0.55 1.05 1.00 0.08 1379 landing gears spring shaft fig 7 the use of ni
 based superalloy in pw4000 engine 117 ni based superalloy with 5 wt of cr was 3.7 times longer than that of
 interface by the effect of residual amine intrinsic self healing is mostly ni based alloy without cr content
 however high ratio cr under the condition of manual intervention kausch et al 123 inves
 content results in the formation of the topologically close packed phase
 triggered the crack healing behavior of some thermoplastic materials and brittle depleted potent solid solution
 strengthening element found that the strength can be restored by heating these materials over 100 °C from the
 matrix the glass transition temperature because of the interdiffusion of molecular entanglement glassy
 polymer wu et al 124 reviewed 4 new materials potential for aircraft self
 healing behavior for both thermoset and thermoplastic materials and reported intrinsic self healing achieved

self-reliant material self-cleaning polymeric self-method photo-induced healing reversible bond formation repairing material potential high use flight vehicle healing chain-end recombination self-healing material self-cleaning material found natural environment one potentially used aerospace industry self-healing material example is lotus leaves when water is poured over these leaves it rolls containing boron b can be used for aircraft engine parts through the off-as beads and takes away dirt on the leaves 118 the mechanisms of formation B_2O_3 seal matrix crack high temperature self-cleaning material divided two categories first 121 in addition some self-healing materials such as self-healing hole based on the wettability of the surface and the second one is the photo-low glass fiber epoxy composites with excellent fatigue resistance can be used as a catalytic feature 119 120 hydrophobic surface potentially used in aircraft structural applications because of the ability self-cleaning material material interface protected polar to heal microcracks before crack growth to failure 121 furthermore molecules absorb water rolls off the surface with the dirt 5 light self-healing materials such as self-healing epoxy composite can protect captured photoactive surface process produce aircraft structures from corrosion by coating because they can recover oxidative radical mineralize absorb organic molecules their protectability after damages 121 119 based on these properties the material can be applied to the fabric of seats and carpets in future aircraft 5 challenges faced in the development of recently advanced addition self-cleaning material self-repairing self-healing material material widely studied researched last several decades the self-healing materials can be polymer ceramic or metal matrix 5 1 fretting wear composite 121 self-repairing material protect integrity structure maintain function material mechanical fretting wear is caused by small amplitude less than about $100\mu\text{m}$ damage and corrosion the self-healing materials can be divided into two oscillatory movement two contact body 20 125 fretting category which are extrinsic self-healing and intrinsic self-healing wear can create initiate cracks on the damaged surface and reduce extrinsic self-healing relies on the healing agent which is stored in matrix life component 126 fretting wear occurs aircraft materials advance two types of containers pipelines and microcaps structural components and engine parts such as the bearings shaft bolted sleeves the cracks can be bound by the releasing of healing agent to connection and blade disc assemblies 127 titanium based alloys mostly are crack planes because of the capillary effect Zhan et al 122 noted that used connect component often fretting the crack healing process is more efficient by mixing epoxy monomer load which easily suffer fretting damage consequently recent studies and solvent it is because the epoxy monomer can be cured on the matrix off fretting behaviors focus on titanium based alloys 128 a few researchers 30x Zhan et al progress in aerospace sciences 97 2018 22 34 have conducted tests seeking to eliminate the fretting wear behavior of 5 3 stress corrosion cracking SCC and hydrogen embrittlement aerospace materials and coworkers 129 investigated three methods used for fretting damage prevention new design surface modification stress corrosion cracking is considered as one of the most dangerous use lubricant widely studied method surface failure mechanisms because SCC can cause slow crack growth under a modification modification surface hardness adhesion safe loading condition when the crack size reached the critical value 126 the difference in hardness between two mating pairs can greatly crack by SCC with the safe loading can cause the sudden failure of material influence fretting wear Lemm et al 130 reported total net material SCC is resulted from three-way interaction which are mechanical wear volumes of a range of equal hardness steel pairs hardness from 250 stress susceptible alloy and corrosive environment 142 the mechanical kgf/mm² CID 4 2 to 850 kgf/mm² CID 4 2 are similar around 0.45 mm³ however the hardness difference is relevant because hydrogen initially occurs at the total net wear volume experienced small reduction 0.35 mm³ tip of cracks in an aqueous environment 143 SCC and the behaviors in increasing hardness difference 600 kgf/mm² CID 4 2 Lemm some susceptible metallic materials such as steels 144 aluminum based alloys coworkers 130 also reported that the wear volume of the harder part 145 and magnesium based alloys 146 have been widely investigated magnesium can reach up to 95% of total wear volume because of the protection of the high intrinsic dissolution tendency and the impurities and the second softer part oxide based fretting wear debris Sarhan et al 131 phase act local cathode accelerate corrosion local studied relation hardness fatigue life hard anodized galvanic which contributes to the magnesium based alloys susceptibility to SCC aluminum 7075 T6 aerospace alloy the results showed that fatigue life of this addition magnesium based alloy aluminum based alloy 3 5 wt

alloy optimized improving surface hardness 393 hv higher content of mg are also susceptible to SCC it is known that the low stress regions however the hard anodized coating has no or negative segregation of mg along grain boundary facilitate hydrogen diffusion effect on fatigue life in high stress regions over 200 MPa. Zhang et al. entry accelerates the transport of hydrogen and provides sites for grain coarsening. 132 reported improvement surface boundary embrittlement by hydrogen chemisorption. 147 mg dissolves hardness can greatly improve the fatigue life of Al-coated Al7075-T6. In general, the high anodic β phase of Al₃Mg₂ which can increase alloy low cyclic fatigue improvement adhesion the susceptibility of Al-based alloys to SCC. 142, 148 in order to prevent significantly improve the fatigue life in high cyclic fatigue other properties SCC and the some elements have been studied in recent years to improve properties such as toughness, friction factor and bonding strength also have cracking resistance. 144, 149 studied some alloying elements in been investigated to prevent fretting damage. Du et al. 133 reported mg based alloys and reported the element has a positive effect on the that bonding strength and toughness have a greater effect than the friction improvement SCC resistance. Peng et al. 150 reported SCC factor on fretting wear resistance of diamond like and graphite like resistance was increased with the increase of size and spacing of grain. Carbon coated Ti based alloys although researchers have studied fretting boundary precipitates. Gupta by reducing the propagation rate and the behavior. Material general theory describing fretting concentration of atomic hydrogen relatedly. Methods such as theoretical behavior and prevention is still not mature. 20 further works should include quantum mechanical models. Recent nano research and atomic concentration mechanism fretting develop effective investigation have been developed to study the mechanism of the methods to improve fretting resistance and SCC however the applicable prediction approach remains nonexistent because the mechanisms of the SCC are not affected by one or two corrosion parameter but by multiple factors including ambient medium mechanical properties and manufacturing processes. 151, 152 corrosion involves the chemical degradation of materials when the materials react to their environment. 134 corrosion such as uniform corrosion conclusion and future trends corrosion pitting corrosion crevice corrosion organic galvanic corrosion cause failure of components when the remaining materials after cannot the present review shows that significant progress has been made in support applied load moreover corrosion compromise with the development of both aircraft structural materials and engine components that are prone to fail by other modes. 135 metal corrosion can reduce the design criteria for the aircraft structural materials require the cause a loss of 276 billion per year in the US much greater than the loss material possess appropriate mechanical property suitable caused by natural disasters. 21 based on the prediction only up to 30 damage tolerance different conditions Al based alloy corrosion loss avoided corrosion prevention method primary material in this field for many years because of their well known. 21 various studies have investigated corrosion behaviors in different mechanical behavior use polymer matrix composite material therefore enabling the straightforward selection of materials increased in recent years due to superior mechanical properties such as for use in different environments however some suitable materials for higher specific strength and stiffness when compared to Al based alloys corrosion resistance may not support other requirements for example however conventional carbon fiber reinforced polymer matrix high corrosion resistance material always used aircraft composites are more likely to suffer from stress concentration in addition structures because of the strength weight ratio therefore methods have been used mg based alloy steel Ti based alloy been developed to prevent corrosion of structure materials and the most aerospace applications is restricted by some challenges the criteria for widely investigated disbonding. 21 the functions of the coating are 1 aircraft engine require material provide suitable mechanical provide local corrosion barrier 2 act as a sacrificial anode 3 property density corrosion resistance high temperature supply solute ions. 136 however conventional corrosion coating has compressor section temperature range difficulty providing active corrosion inhibitor therefore defect 500, 600 °C. 1, 2, 3 Ti based alloys are the primary materials Ni based super protected transport inhibitor liquid alloy primary material high temperature corrosive phase. 136 chromium 137 has been studied as providing 1400, 1500 °C. 1, 2 c turbine section efficient corrosion inhibitors however chromium has been reported to in the future

specific mechanical properties and challenges such as cause health problems and environment disasters in its hexavalent form fretting wear corrosion and SCC will be the main drivers in the development 138 although some other elements such as graphene 139 cerium element selection next generation structure material sulphate 140 oxide rare earth element 141 airframe material dominated various material all studied improve protective performance mechanism based alloy Ti based alloy steel composite work corrosion behavior and prevention need to be further study airframe materials should focus on the following three topics develop new metal alloys with higher specific mechanical properties by various strategy including microstructure refinement impurities control thermal mechanical processing ii develop new method 31 x zhan et al progress in aerospace sciences 97 2018 22 34 composition modification coating and microstructure control too 29 x li j starink analysis of precipitation and dissolution in overaged 7xxx composites the challenges of metal alloys including more efficient prevention aluminium alloys using DSC 2000 30 v antipov et al high strength Al-Zn-Mg alloys and light Al alloys method for fretting wear of Ti based alloys more efficient prediction and simulation heat treat 53 9 10 2012 428 433 prevention methods for corrosion SCC and the Al based alloys Mg 31 karabin f barlat r shuey finite element modeling of plane strain toughness based alloy steel iii develop new composite material for 7085 aluminum alloy metall mater trans 40 2 2009 354 364 MMC/PMC balanced property fiber selection 32 ebrahimi et al the microstructure hardness and tensile properties of a new super high strength aluminum alloy with Zr addition mater de 31 9 2010 future trends of aircraft engine materials focus on how to withstand the 4450 4456 rising engine temperature and maintain the proper mechanical properties 33 w nam h lee the effect of Mn on the mechanical behavior of Al alloys metall mater int 6 1 2000 13 16 tie future work focus following topic 34 uddin et al effect of Li addition on microstructure and mechanical properties improve the high temperature resistance of Ti based alloys by controlling of Al-Mg-Si alloy int j mater re 105 8 2014 770 777 phases through alloying and thermal mechanical processing ii develop 35 uddin et al the synergistic effect of Li addition on microstructure texture and mechanical properties of extruded Al-Mg-Si alloys mater chem phys 174 advanced Ni based superalloys alloying element prevent 2016 11 22 high temperature oxidation such as Al and Zr iii develop the advanced 36 r wanhill aerospace applications of aluminum lithium alloys aluminum MMC with higher fracture toughness by revealing the optimized content lithium alloys elsevier 2014 pp 503 535 offibers such as graphene platelet 37 h garmestani et al modeling the evolution of anisotropy in Al alloys application to Al-Li 2090 t8e41 int j plast 18 10 2002 1373 1393 38 kalyanam et al delamination cracking in advanced aluminum lithium reference alloy experimental and computational studies eng fract mech 76 14 2009 2174 2191 39 p cavaliere et al 2198 Al plates joined by friction stir welding mechanical 1 dursun c souts recent developments in advanced aircraft aluminum alloys mater de 56 2014 862 871 and microstructural behavior mater de 30 9 2009 3622 3631 40 singh et al texture evolution and anisotropy in Al-Cu-Mg alloys texture 2 e starke j staley application of modern aluminum alloys to aircraft prog aero sci 32 2 3 1996 131 172 mater re 1999 219 234 3 warren developments and challenges for aluminum from Boeing perspective 41 tsivoulas p prangnell the effect of Mn and Zr dispersoid forming additions on recrystallization resistance in Al-Cu-Li 2198 sheet Al mater 77 2014 materials forum citeseer 2004 1 16 4 r ap j p lir ci ao tija nj mli eu llh e av erlu tio ran f 4a 3l l 9i ba 2se 01p 2r od 3u 3c 2t 5 f 3o 3r 3a 7e aerospace and space 42 p gregson et al role of vacancies in co-precipitation of δ and δ' phases in Al-Li-Cu-Mg alloys mater sci technol 2 4 1986 349 353 5 chen et al recent advances on the development of magnesium alloys for biodegradable implants acta biomater 10 11 2014 4561 4573 43 ostrovsky andy henn present state and future of magnesium application in 6 f czerwinski controlling the ignition and flammability of magnesium for aerospace industry aerospace applications corrosion sci 86 2014 1 16 44 chandrasekaran john effect of materials and temperature on the 7 r boyer r briggs the use of β titanium alloys in the aerospace industry forward extrusion of magnesium alloys mater sci eng a 381 1 2004 j mater eng perform 14 6 2005 681 685 308 319 45 w jian et al ultra strong Mg alloy via nano spaced stacking faults mater rese 8 cesedupack database lett 1 2 2013 61 66 9 sommers et al ceramics and ceramic matrix composites for heat exchangers in advanced thermal systems a review appl therm eng 30 11 2010 46 c bettles gibson current wrought magnesium alloys strengths and

1277 1291 weakness jom57 5 2005 46 49 47 luo magnesium casting technology for structural applications
j magnesium 10 g sim et al effect of nb precipitate coarsening on the high temperature alloys 1 1 2013 2 22
strength in nb containing ferritic stainless steels mater sci eng a396 1 2005 159 165 48 z wen et al
corrosion behavior of mg and its alloys with differential contents 11 g bai et al
effect of temperature on tensile behavior of ni cr w based in a modified simulated body fluid j alloy comp 488 1
2009 392 399 superalloy materials science and engineering a528 4 2011 1974 1978 49 b zhang l geng
wang research on mg zn ca alloy as degradable biomaterial intech open access publisher 2011 12 p j
arrazola et al machinability of titanium alloys ti6al4v and ti555 3 j mater process technol 209 5 2009 2223
2230 50 song et al the effect of zn concentration on the corrosion behavior of mg xzn 13 g srinivasu et al
tensile and fracture toughness of high strength β titanium alloy corrosion sci 65 2012 322 330 alloy ti 10v 2fe
3al as a function of rolling and solution treatment 51 liu et al refinement effect of cerium
calcium and strontium in az91 temperature mater de 47 2013 323 330 magnesium alloy j mater process
technol 209 8 2009 3999 4004 52 homma et al effect of zr addition on the mechanical properties of as
extruded 14 z te ml piy ei rn ag ure et jl ah lli og yh c cy oc mle pf 5ti 0g 9ue 5p ro 2p 0er 1t 1y 2f 0t 8i 1
6 0 20 08a 6ll oyat ambient mg zn ca z alloys mater sci eng a527 9 2010 2356 2362 53 xu et al
effect of y concentration on the microstructure and mechanical 15 j wang et al
the microstructure evolution and its effect on the mechanical properties of as cast mg zn z alloys j alloy comp
432 1 2007 129 134 properties of a hot corrosion resistant ni based superalloy during long term
thermal exposure mater de 39 2012 55 62 54 j krane et al ed
proceedings of the 2013 international symposium on 16 zgün et al
injection molding of nickel based 625 superalloy sintering heat liquid metal processing casting springer 2016
55 j c williams e starke progress in structural materials for aerospace systems treatment
microstructure and mechanical properties j alloy comp 546 2013 192 207 acta mater 51 19 2003 5775
5799 56 l jing properties and application of titanium alloys nonferrous metals 17 z alam et al
effect of cyclic oxidation on the tensile behavior of directionally solidified cm 247 l cni based superalloy at 870 °c
1 c mater sci eng a527 23 process 4 2002 002 2010 6211 6218 57 w jia et al
on the influence of processing parameters on microstructural evolution of an earl phase titanium alloy mater sci
eng a530 2011 135 143 18 z wang et al the microstructure and mechanical properties of deposited in 718
by selective laser melting j alloy comp 513 2012 518 523 58 atapour et al
corrosion behavior of β titanium alloys for biomedical application mater sci eng c31 5 2011 885 891 19 n
arivazhagan et al investigation on aisi 304 austenitic stainless steel to aisi 59 x jiang et al
structure and mechanical properties of ti z binary alloy after a
4140 low alloy steel dissimilar joints by gas tungsten arc electron beam and friction welding mater de 32 5
2011 3036 3050 addition mater sci eng a586 2013 301 305 20 k sikdar shekhar k balani
fretting wear of mg li al based alloys wear 318 60 r boyer r briggs
the use of β titanium alloys in the aerospace industry 1 2014 177 187 j mater eng perform 22 10 2013
2916 2920 61 song et al theoretical study of the effects of alloying elements on the strength 21 kesavan
gopiraman n sulochana green inhibitors for corrosion of metals a review chem sci rev lett 1 1 2012 1 8
and modulus of β type bio titanium alloys mater sci eng a260 1 1999 269 274 22 z huda p edi
materials selection in design of structures and engines of supersonic aircrafts a review mater de 46 2013 552
560 62 x zhao et al β type titanium alloys with changeable young's modulus for spinal fixation applications
acta biomater 8 5 2012 1990 1997 23 c veiga j davim loureiro properties and application of titanium alloys
brief review rev adv mater sci 32 2 2012 133 148 63 j cotton et al
state of the art in β titanium alloys for airframe applications jom 67 6 2015 1281 1303 24 p zhang et al
plastic deformation behavior and processing map of ni based superalloy mater de 2015 65 1980 2015
575 584 64 j lu et al precipitation behavior and tensile properties of new high strength β titanium alloy ti
1300 j alloy comp 637 2015 1 4 25 banerjee et al
effect of trace addition of sn on microstructure and mechanical properties of al cu mg alloys mater de 31 8
2010 4007 4015 65 j wood et al thermomechanical processing and heat treatment of ti 6al 2sn 2zr 2cr 2mo
for structural applications mater sci eng a243 26 e salamci
mechanical properties of spray cast 7xxx series aluminum alloys turk j eng environ sci 26 4 2002 345 352
66 1 q u1 9 e9 t8 l1 0 b9 e h1 a1 v8 io rand modeling of high temperature deformation of an $\alpha\beta$ 27 j yu x li
modelling of the precipitated phases and properties of al zn mg cu titanium alloy mater sci eng a555 2012 99

105 alloy j phase equilibrium diffusion 32 4 2011 350 67 zhu et al
characterization of hot deformation behavior of fcs cast tc 21 28 eling aluminium alloys available from <http://www.eling.com> titanium alloy using processing map mater sci eng a 528 3 2011 aluminium alloys html 1757 1763 32x zhan et al progress in aerospace sciences 97 2018 22 34 68 c cui et al
titanium alloy production technology market prospects and 106 prasad n e and r wanhill
aerospace materials and material technologies industry development mater de 32 3 2011 1684 1691 107 j
r davis alloying understanding the basics as in international 2001 69 zherebtsov et al
mechanical properties of ti 6al 4vtitanium alloy with 108 g murray
handbook of materials selection for engineering applications crc
submicrocrystalline structure produced by severe plastic deformation 2005 press 1997 70 r h hu j k lim
hardness and wear resistance improvement of surface 109 j c cid 2 wiek
prevention methods against hydrogen degradation of steel j achiev compos ite layer on ti 6al
4v substrate fabricated by powder sintering mater mater manuf eng 43 1 2010 214 221 design 1980 2015
31 5 2010 2670 2675 110 f buazar cheshmehkani kassae nanosteel synthesis via arc discharge 71 r jing
et al structure and mechanical properties of ti 6al 4v alloy after media and current effects j iran chem soc 9 2
2012 151 156 zirconium addition mater sci eng a 552 2012 295 300 111 k mo et al
synchrotron study on load partitioning between ferrite martensite 72 l pilato j michno
advanced composite materials springer science and nanoparticles of a9crdss steel j nucl mater 455 1 2014
376 381 business media 1994 112 uluc et al the role of heat treatment and alloying elements on hydrogen 73 j
pora composite materials in the airbus a380 from history to future uptake in aermet 100 ultrahigh strength steel
j electroanal chem 739 2015 proceedings of iccm 13 plenary lecture cd rom 2001 130 136 74 ahmad b
yazdani zhu recent advances on carbon nanotubes and graphene 113 e ezugwu z wang machado
the machinability of nickel based alloys reinforced ceramics nanocomposites nanomaterials 5 1 2015 90
114 review j mater process technol 86 1 1999 1 16 75 fan et al
progress of ceramic matrix composites brake materials for aircraft 114 soo et al
machinability and surface integrity of fr1000 nickel based application rev adv mater sci 44 2016 313 325
superalloy cirpan manuf technol 60 1 2011 89 92 76 l walker et al
toughening in graphene ceramic composites acs nano 5 4 115 chiou et al
effects of aluminum addition on the high temperature 2011 3182 3190 oxidation behavior of cm 247 l cni
based superalloy int j electrochem sci 10 77 j liu h yan k jiang mechanical properties of graphene platelet
reinforced 2015 5981 5993 aluminac ceramic composites ceram int 39 6 2013 6215 6221 116 j chen et al
improvement of stress rupture property by cr addition in ni based 78 j liu j li c xu
interaction of the cutting tools and the ceramic reinforced metal single crystal superalloys mater sci eng a 528
10 2011 3791 3798 matrix composites during micro machining a review cirpj manuf sci technol 117 locq p
caron on some advanced nickel based superalloys for disk 7 2 2014 55 70 application aerospace lab 3
2011 1 9 79 prater friction stir welding of metal matrix composites for use in aerospace 118 com pony
future technologies available from <http://www.airbus.com> structure acta astronaut 93 2014 366 373
innovation future airbus concept plane airbus concept cabin future 80 moghadam et al
mechanical and tribological properties of self lubricating technology
metal matrix nanocomposites reinforced by carbon nanotubes cnts 119 g soliveri et al double sided self
cleaning polymeric materials the hydrophobic graphene a review compos part b eng 77 2015 402 420
and photoactive approach colloid surface physicochem eng aspect 483 81 c tjong
recent progress in the development and properties of novel metal 2015 285 291
matrix nanocomposites reinforced with carbon nanotubes and graphene 120 p parkin r g palgrave self
cleaning coatings j mater chem 15 17 2005 nanosheets mater sci eng rrep 74 10 2013 281 350 1689
1695 82 j z liao j tan sridhar spark plasmas interred multi wall carbon nanotube 121 r da c melchior k
karumbaiah self healing composites for aerospace reinforced aluminum matrix composites mater de 31
2010 s96 s100 application advanced composite materials for aerospace engineering 83 x zeng et al
a new technique for dispersion of carbon nanotube in a metal melt processing properties and applications 2016
p 333 mater sci eng a 527 20 2010 5335 5340 122 zhang rong design and synthesis of self
healing polymers sci china 84 k kondoh et al characteristics of powder metallurgy pure titanium matrix chem
55 5 2012 648 676 composite reinforced with multi wall carbon nanotubes compos sci technol 69 123 h
kausch k jud molecular aspects of crack formation and healing in glassy 7 2009 1077 1081 polymer plast

rubberprocess appl 2 3 1982 265 268 85 w daoush etal
 electricalandmechanicalpropertiesofcarbonnanotube 124 wu meure solomon self
 healingpolymericmaterials areviewof
 reinforcedcoppernanocompositesfabricatedbyelectrolessdepositionprocess recentdevelopments prog
 polym sci 33 5 2008 479 522 mater sci eng a513 2009 247 253 125 shen etal dual
 rotaryfrettingwearof7075alloyinmediaofoilandwater 86 j hwang etal interfaceanalysisofultra
 highstrengthcarbonnanotube nickel wear301 1 2013 540 550
 compositesprocessedbymolecularlevelmixing carbon57 2013 282 287 126 amanov etal
 frettingwearandfrictionreductionofcptitaniumand 87 du
 advancedcompositematerialsandaerospaceengineering fuhecailliao ti 6al
 4valloybyultrasonicanocrystallinesurfacemodification surf coating xuebaoactamater compos sin
 china24 1 2007 1 12 technol 207 2012 135 142 88 matweb materialpropertydata 127 g majzoobi r
 hojjati soori frettingfatiguebehaviorofal7075 t6atsub 89 r wang r zheng g zheng
 polymermatrixcompositesand zerotemperature tribol int 44 11 2011 1443 1451 technology elsevier
 2011 128 g wu etal effectoffrettingonfatigueperformanceofti 1023titaniumalloy 90 pimenta pinho
 recyclingcarbonfibrereinforcedpolymersforstructural wear309 1 2014 74 81 application
 technologyreviewandmarketoutlook wastemanag 31 2 2011 129 fu j wei w batchelor
 someconsiderationsonthemitigationoffretting 378 392 damagebytheapplicationofsurface
 modificationtechnologies j mater process 91 j f paiva n santos c rezende mechanicalandmorphological
 technol 99 1 2000 231 245 characterizationofcarbonfiberfabricreinforcedepoxycompositesusedin 130 j
 lemm etal theinfluenceofsurfacehardnessontheftrettingwearofsteel aeronauticalfield mater re 12 3 2009
 367 374 pair itsroleindebrisretentioninthecontact tribol int 81 2015 258 266 92 k l pickering efendy le
 areviewofrecentdevelopmentsinnatural 131 sarhan e zalnezhad hamdi
 theinfluenceofhighersurfacehardnesson fibrecompositesandtheirmechanicalperformance compos
 partaappl sci frettingfatiguelifeofhardanodizedaerospaceal7075 t6alloy mater sci eng manuf 83 2016 98
 112 a560 2013 377 387 93 g mittal etal areviewoncarbonnanotubesandgrapheneasfillersin 132 e
 zalnezhad sarhan hamdi investigatingthefrettingfatiguelifeofthin reinforcedpolymernanocomposites j ind
 eng chem 21 2015 11 25 filmtitaniumnitridecoatedaerospaceal7075 t6alloy mater sci eng a559 94 k da
 prusty graphene basedpolymercompositesandtheirapplications 2013 436 446 polym plast technol eng
 52 4 2013 319 331 133 du etal frettingwearandfrettingfatiguebehaviorsofdiamond likecarbon 95 v
 dhand etal ashortreviewonbasaltfiberreinforcedpolymercomposites andgraphite
 likecarbonfilmsdepositedonti 6al 4valloy appl surf sci 313 compos partbeng 73 2015 166 180 2014 462
 469 96 n saba etal areviewondynamicmechanicalpropertiesofnaturalfibre 134 b shaw r g kelly
 whatiscorrosion 2006 reinforcedpolymercomposites construct build mater 106 2016 149 159 135
 findlay n harrison whyaircraftfail mater today5 11 2002 18 25 97 li x etal
 theinfluenceoffibercontentonpropertiesofinjectionmoldedflax 136 f presuel moreno etal corrosion
 resistantmetalliccoatings mater today11 fiber hdpebiocomposites 10 2008 14 23 98 h ku etal
 areviewonhetensilepropertiesofnaturalfiberreinforcedpolymer 137 v moutarlier b neveu gigandet
 evolutionofcorrosionprotectionforsol gel composite compos partbeng 42 4 2011 856 873
 coatingsdopedwithinorganicinhibitors surf coating technol 202 10 2008 99 c kingston etal
 releasecharacteristicsofselectedcarbonnanotubepolymer 2052 2058 composite carbon68 2014 33 57
 138 nematollahzadeh seraj b mirzayi catecholaminecoatedmaghemite 100 qian etal
 loadtransferanddeformationmechanismsincarbonnanotube
 nanoparticlesfortheenvironmentalremediation hexavalentchromiumions polystyrenecomposites appl
 phys lett 76 20 2000 2868 2870 removal chem eng j 277 2015 21 29 101 biercuk etal
 carbonnanotubecompositesforthermalmanagement appl 139 j hu etal
 areviewontheuseofgrapheneasaprotectivecoatingagainst phys lett 80 15 2002 2767 2769 corrosion
 annjmater sci eng 1 3 2014 16 102 l chen x j pang z l yu studyonpolycarbonate multi walledcarbon 140
 kozhukharov etal protectiveabilityofhybridnano compositecoatingswith
 nanotubescompositelproducedbymeltprocessing mater sci eng a457 1
 ceriumsulphateasinhibitoragainstcorrosionofaa2024aluminiumalloy prog 2007 287 291 org coating73 1
 2012 95 103 103 kuilla etal recentadvancesingraphenebasedpolymercomposites prog 141 l
 zheludkevich etal oxidenanoparticlereservoirsforstorageandprolonged polym sci 35 11 2010 1350 1375

release of the corrosion inhibitors electrochem commun 7 8 2005 836 840 104 j wan et al
mechanical properties of epoxy composites filled with silane 142 n winzer et al
a critical review of the stress corrosion cracking scc functionalized graphene oxide compos parta appl sci
manuf 64 2014 magnesium alloys adv eng mater 7 8 2005 659 693 79 89 143 v raja shoji
stress corrosion cracking theory and practice elsevier 2011 105 zhang et al
mechanical and thermal properties of basalt fiber reinforced poly butylenesuccinate composite mater chem
phys 133 2 2012 845 849 33x zhan et al progress in aerospace sciences 97 2018 22 34 144 j shu et al
the effect of copper and molybdenum on pitting corrosion and stress 148 antuono et al
grain boundary misorientation dependence of β phase corrosion cracking behavior of ultra
pure ferritic stainless steels corrosion sci 57 precipitation in an al mg alloy scripta mater 76 2014 81 84 2012
89 98 149 k w guo a review of magnesium magnesium alloys corrosion and its protection 145 r goswami et al
microstructural evolution and stress corrosion cracking recent pat corros sci 2 2010 13 21 behavior of al
5083 metall mater trans 42 2 2011 348 355 150 g peng et al influence of repetitive
r treatment on the strength and scc 146 uematsu kakiuchi nakajima
stress corrosion cracking behavior of the resistance of al zn mg alloy mater sci eng a 528 12 2011 4014
4018 wrought magnesium alloy az31 under controlled cathodic potentials mater sci 151 j woodtli r
kieselbach damaged due to hydrogen embrittlement and stress eng a 531 2012 171 177 corrosion cracking
eng fail anal 7 6 2000 427 450 147 k vasudevan r doherty aluminum alloys contemporary research and
152 djukic et al hydrogen embrittlement of low carbon structural steel procedia application
contemporary research and applications vol 31 elsevier 2012 mater sci 3 2014 1167 1172 34

Top Keywords

alloy: 0.3471344755957891
etal: 0.3471344755957891
mater: 0.25601167575189443
al: 0.2256374091372629
ti: 0.2126198663024208
based: 0.20828068535747343
sci: 0.17356723779789454
eng: 0.14753215212821036
material: 0.14753215212821036
based alloys: 0.13451460929336825
high: 0.13451460929336825
cid: 0.1301754283484209
mg: 0.12149706645852618
however: 0.11715788551357881
strength: 0.11715788551357881
22: 0.10847952362368408
composite: 0.095461980788842
corrosion: 0.095461980788842
2011: 0.0824444379539999
self: 0.0824444379539999
10: 0.07810525700905255
steel: 0.07810525700905255
2012: 0.07376607606410518
2014: 0.07376607606410518
property: 0.07376607606410518
temperature: 0.07376607606410518
34: 0.06942689511915781
addition: 0.06942689511915781
aircraft: 0.06942689511915781
li: 0.06508771417421046

mechanical: 0.06508771417421046
zn: 0.06508771417421046
2013: 0.06074853322926309
2015: 0.06074853322926309
2018: 0.06074853322926309
6al: 0.06074853322926309
11: 0.05640935228431573
matrix: 0.05640935228431573
ni: 0.05640935228431573
progressinaerospace: 0.05640935228431573
recent: 0.05640935228431573
zhangetal: 0.05640935228431573
21: 0.05207017133936836
cu: 0.05207017133936836
de: 0.05207017133936836
example: 0.05207017133936836
14: 0.047730990394421
20: 0.047730990394421
2010: 0.047730990394421
forexample: 0.047730990394421
structure: 0.047730990394421
technol: 0.047730990394421
tensile: 0.047730990394421
used: 0.047730990394421
23: 0.043391809449473635
31: 0.043391809449473635
3al: 0.043391809449473635
75: 0.043391809449473635
application: 0.043391809449473635
density: 0.043391809449473635
higher: 0.043391809449473635
low: 0.043391809449473635
use: 0.043391809449473635
2009: 0.039052628504526274
chem: 0.039052628504526274
et: 0.039052628504526274
fiber: 0.039052628504526274
reported: 0.039052628504526274
resistance: 0.039052628504526274
surface: 0.039052628504526274
weight: 0.039052628504526274
12: 0.034713447559578905
15: 0.034713447559578905
2000: 0.034713447559578905
28: 0.034713447559578905
30: 0.034713447559578905
55: 0.034713447559578905
aerospace: 0.034713447559578905
fig: 0.034713447559578905
fretting: 0.034713447559578905
hardness: 0.034713447559578905
improve: 0.034713447559578905
increased: 0.034713447559578905

phase: 0.034713447559578905
polymer: 0.034713447559578905
reinforced: 0.034713447559578905
specific: 0.034713447559578905
titanium: 0.034713447559578905
toughness: 0.034713447559578905
13: 0.030374266614631544
16: 0.030374266614631544
2005: 0.030374266614631544
32: 0.030374266614631544
33: 0.030374266614631544
43: 0.030374266614631544
44: 0.030374266614631544
74: 0.030374266614631544
80: 0.030374266614631544
81: 0.030374266614631544
83: 0.030374266614631544
95: 0.030374266614631544
compos: 0.030374266614631544
cr: 0.030374266614631544
elongation: 0.030374266614631544
fracture: 0.030374266614631544
healing: 0.030374266614631544
int: 0.030374266614631544
modulus: 0.030374266614631544
moreover: 0.030374266614631544
mpa: 0.030374266614631544
process: 0.030374266614631544
stress: 0.030374266614631544
therefore: 0.030374266614631544
yieldstrength: 0.030374266614631544
18: 0.02603508566968418
2016: 0.02603508566968418
25: 0.02603508566968418
40: 0.02603508566968418
60: 0.02603508566968418
600: 0.02603508566968418
70: 0.02603508566968418
76: 0.02603508566968418
77: 0.02603508566968418
airbus: 0.02603508566968418
alpha: 0.02603508566968418
basedalloy: 0.02603508566968418
carbon: 0.02603508566968418
content: 0.02603508566968418
development: 0.02603508566968418
engine: 0.02603508566968418
inaddition: 0.02603508566968418
posse: 0.02603508566968418
processing: 0.02603508566968418
respectively: 0.02603508566968418
scc: 0.02603508566968418
studied: 0.02603508566968418

two: 0.02603508566968418
wear: 0.02603508566968418
widely: 0.02603508566968418
zhang: 0.02603508566968418
znbasedalloys: 0.02603508566968418
106: 0.021695904724736818
121: 0.021695904724736818
130: 0.021695904724736818
2002: 0.021695904724736818
26: 0.021695904724736818
38: 0.021695904724736818
42: 0.021695904724736818
4v: 0.021695904724736818
52: 0.021695904724736818
53: 0.021695904724736818
7075: 0.021695904724736818
86: 0.021695904724736818
89: 0.021695904724736818
airframe: 0.021695904724736818
appl: 0.021695904724736818
areview: 0.021695904724736818
beta: 0.021695904724736818
better: 0.021695904724736818
cleaning: 0.021695904724736818
comp: 0.021695904724736818
condition: 0.021695904724736818
consequently: 0.021695904724736818
damage: 0.021695904724736818
develop: 0.021695904724736818
due: 0.021695904724736818
element: 0.021695904724736818
elsevier: 0.021695904724736818
graphene: 0.021695904724736818
increase: 0.021695904724736818
industry: 0.021695904724736818
manuf: 0.021695904724736818
pmcs: 0.021695904724736818
t6: 0.021695904724736818
thermal: 0.021695904724736818
wang: 0.021695904724736818
zr: 0.021695904724736818
105: 0.017356723779789453
10v: 0.017356723779789453
133: 0.017356723779789453
135: 0.017356723779789453
136: 0.017356723779789453
142: 0.017356723779789453
17: 0.017356723779789453
19: 0.017356723779789453
2024: 0.017356723779789453
2fe: 0.017356723779789453
2sn: 0.017356723779789453
345: 0.017356723779789453

39: 0.017356723779789453
41: 0.017356723779789453
45: 0.017356723779789453
46: 0.017356723779789453
47: 0.017356723779789453
50: 0.017356723779789453
500: 0.017356723779789453
51: 0.017356723779789453
57: 0.017356723779789453
62: 0.017356723779789453
65: 0.017356723779789453
69: 0.017356723779789453
71: 0.017356723779789453
73: 0.017356723779789453
78: 0.017356723779789453
79: 0.017356723779789453
88: 0.017356723779789453
92: 0.017356723779789453
93: 0.017356723779789453
98: 0.017356723779789453
99: 0.017356723779789453
a528: 0.017356723779789453
aluminum: 0.017356723779789453
category: 0.017356723779789453
chen: 0.017356723779789453
component: 0.017356723779789453
compressor: 0.017356723779789453
conventional: 0.017356723779789453
fatigue: 0.017356723779789453
furthermore: 0.017356723779789453
grain: 0.017356723779789453
increasing: 0.017356723779789453
lett: 0.017356723779789453
loys: 0.017356723779789453
method: 0.017356723779789453
one: 0.017356723779789453
part: 0.017356723779789453
performance: 0.017356723779789453
phys: 0.017356723779789453
prog: 0.017356723779789453
section: 0.017356723779789453
series: 0.017356723779789453
superalloys: 0.017356723779789453
t39: 0.017356723779789453
tolerance: 0.017356723779789453
usa: 0.017356723779789453
ut: 0.017356723779789453
year: 0.017356723779789453
yield: 0.017356723779789453
00: 0.01301754283484209
01: 0.01301754283484209
08wt: 0.01301754283484209
103: 0.01301754283484209

108: 0.01301754283484209
110: 0.01301754283484209
112: 0.01301754283484209
113: 0.01301754283484209
114: 0.01301754283484209
115: 0.01301754283484209
116: 0.01301754283484209
119: 0.01301754283484209
120: 0.01301754283484209
126: 0.01301754283484209
129: 0.01301754283484209
131: 0.01301754283484209
134: 0.01301754283484209
140: 0.01301754283484209
1400: 0.01301754283484209
143: 0.01301754283484209
144: 0.01301754283484209
146: 0.01301754283484209
148: 0.01301754283484209
149: 0.01301754283484209
151: 0.01301754283484209
159: 0.01301754283484209
1999: 0.01301754283484209
2000seriesal: 0.01301754283484209
2007: 0.01301754283484209
2008: 0.01301754283484209
225: 0.01301754283484209
24: 0.01301754283484209
247lcni: 0.01301754283484209
27: 0.01301754283484209
29: 0.01301754283484209
2mo: 0.01301754283484209
2zr: 0.01301754283484209
35: 0.01301754283484209
37: 0.01301754283484209
400: 0.01301754283484209
455: 0.01301754283484209
49: 0.01301754283484209
4zr: 0.01301754283484209
550: 0.01301754283484209
56: 0.01301754283484209
58: 0.01301754283484209
5wt: 0.01301754283484209
61: 0.01301754283484209
63: 0.01301754283484209
64: 0.01301754283484209
66: 0.01301754283484209
7000: 0.01301754283484209
7475: 0.01301754283484209
84: 0.01301754283484209
87: 0.01301754283484209
90: 0.01301754283484209
96: 0.01301754283484209

a527: 0.01301754283484209
adv: 0.01301754283484209
advance: 0.01301754283484209
aerospacematerials: 0.01301754283484209
alloying: 0.01301754283484209
also: 0.01301754283484209
bridgeport: 0.01301754283484209
cfrp: 0.01301754283484209
cnts: 0.01301754283484209
co: 0.01301754283484209
coating: 0.01301754283484209
com: 0.01301754283484209
compositematerials: 0.01301754283484209
composition: 0.01301754283484209
copper: 0.01301754283484209
corrosionresistance: 0.01301754283484209
corrosionsci: 0.01301754283484209
demand: 0.01301754283484209
design: 0.01301754283484209
different: 0.01301754283484209
earth: 0.01301754283484209
elastic: 0.01301754283484209
flight: 0.01301754283484209
form: 0.01301754283484209
frettingwear: 0.01301754283484209
fuselage: 0.01301754283484209
future: 0.01301754283484209
http: 0.01301754283484209
improvement: 0.01301754283484209
jiang: 0.01301754283484209
lemm: 0.01301754283484209
life: 0.01301754283484209
liu: 0.01301754283484209
load: 0.01301754283484209
lower: 0.01301754283484209
mainly: 0.01301754283484209
mgalloys: 0.01301754283484209
mmc: 0.01301754283484209
mo: 0.01301754283484209
modification: 0.01301754283484209
na: 0.01301754283484209
nanotube: 0.01301754283484209
od: 0.01301754283484209
optimization: 0.01301754283484209
oxide: 0.01301754283484209
partbeng: 0.01301754283484209
plast: 0.01301754283484209
polym: 0.01301754283484209
poor: 0.01301754283484209
range: 0.01301754283484209
rare: 0.01301754283484209
re: 0.01301754283484209
reduce: 0.01301754283484209

repairing: 0.01301754283484209
research: 0.01301754283484209
rev: 0.01301754283484209
sarhan: 0.01301754283484209
showed: 0.01301754283484209
sic: 0.01301754283484209
size: 0.01301754283484209
strengthening: 0.01301754283484209
superalloy: 0.01301754283484209
surf: 0.01301754283484209
technology: 0.01301754283484209
total: 0.01301754283484209
typical: 0.01301754283484209
uhss: 0.01301754283484209
volume: 0.01301754283484209
wu: 0.01301754283484209
www: 0.01301754283484209
xu: 0.01301754283484209
young: 0.01301754283484209
yu: 0.01301754283484209
05: 0.008678361889894726
08: 0.008678361889894726
100: 0.008678361889894726
1000: 0.008678361889894726
101: 0.008678361889894726
102: 0.008678361889894726
104: 0.008678361889894726
107: 0.008678361889894726
109: 0.008678361889894726
111: 0.008678361889894726
1110: 0.008678361889894726
117: 0.008678361889894726
118: 0.008678361889894726
122: 0.008678361889894726
123: 0.008678361889894726
124: 0.008678361889894726
125: 0.008678361889894726
127: 0.008678361889894726
128: 0.008678361889894726
132: 0.008678361889894726
137: 0.008678361889894726
138: 0.008678361889894726
139: 0.008678361889894726
141: 0.008678361889894726
145: 0.008678361889894726
147: 0.008678361889894726
150: 0.008678361889894726
1500: 0.008678361889894726
152: 0.008678361889894726
15v: 0.008678361889894726
1689: 0.008678361889894726
177: 0.008678361889894726
1980: 0.008678361889894726

1997: 0.008678361889894726
1wt: 0.008678361889894726
2001: 0.008678361889894726
2004: 0.008678361889894726
207: 0.008678361889894726
209: 0.008678361889894726
2099: 0.008678361889894726
2198al: 0.008678361889894726
2200: 0.008678361889894726
2224: 0.008678361889894726
2324: 0.008678361889894726
2750: 0.008678361889894726
276billionperyearintheus: 0.008678361889894726
282: 0.008678361889894726
287: 0.008678361889894726
291: 0.008678361889894726
2cr: 0.008678361889894726
2wt: 0.008678361889894726
300: 0.008678361889894726
305: 0.008678361889894726
313: 0.008678361889894726
319: 0.008678361889894726
330: 0.008678361889894726
350: 0.008678361889894726
36: 0.008678361889894726
370: 0.008678361889894726
392: 0.008678361889894726
3cr: 0.008678361889894726
4130: 0.008678361889894726
4140: 0.008678361889894726
425: 0.008678361889894726
428: 0.008678361889894726
4340: 0.008678361889894726
450: 0.008678361889894726
476: 0.008678361889894726
48: 0.008678361889894726
483: 0.008678361889894726
496: 0.008678361889894726
4mo: 0.008678361889894726
503: 0.008678361889894726
54: 0.008678361889894726
540: 0.008678361889894726
552: 0.008678361889894726
59: 0.008678361889894726
5al5v5mo3cr: 0.008678361889894726
5fe: 0.008678361889894726
5v: 0.008678361889894726
6150: 0.008678361889894726
67: 0.008678361889894726
68: 0.008678361889894726
6900mainst: 0.008678361889894726
6cr: 0.008678361889894726
700: 0.008678361889894726

7000seriesal: 0.008678361889894726
72: 0.008678361889894726
777: 0.008678361889894726
7wt: 0.008678361889894726
82: 0.008678361889894726
85: 0.008678361889894726
8v: 0.008678361889894726
900: 0.008678361889894726
91: 0.008678361889894726
9260: 0.008678361889894726
94: 0.008678361889894726
97: 0.008678361889894726
9cr: 0.008678361889894726
9wt: 0.008678361889894726
a380: 0.008678361889894726
actabiometer: 0.008678361889894726
actamater: 0.008678361889894726
adding: 0.008678361889894726
adhesion: 0.008678361889894726
advanced: 0.008678361889894726
aged: 0.008678361889894726
al2cumg: 0.008678361889894726
alockheedmartincompany: 0.008678361889894726
aluminiumalloys: 0.008678361889894726
among: 0.008678361889894726
andcoworkers: 0.008678361889894726
andti: 0.008678361889894726
appropriate: 0.008678361889894726
approximately: 0.008678361889894726
attractiveness: 0.008678361889894726
availablefrom: 0.008678361889894726
az91: 0.008678361889894726
ba: 0.008678361889894726
basalt: 0.008678361889894726
basedsuperalloy: 0.008678361889894726
behavior: 0.008678361889894726
betatitaniumalloys: 0.008678361889894726
boeing: 0.008678361889894726
boyer: 0.008678361889894726
briggs: 0.008678361889894726
cabin: 0.008678361889894726
capability: 0.008678361889894726
casting: 0.008678361889894726
cation: 0.008678361889894726
cd: 0.008678361889894726
ceramic: 0.008678361889894726
challenge: 0.008678361889894726
cm3: 0.008678361889894726
cold: 0.008678361889894726
compared: 0.008678361889894726
concept: 0.008678361889894726
consideration: 0.008678361889894726
containing: 0.008678361889894726

correspondingauthor: 0.008678361889894726
coworkers: 0.008678361889894726
crack: 0.008678361889894726
ct06604: 0.008678361889894726
ct06614: 0.008678361889894726
da: 0.008678361889894726
daoush: 0.008678361889894726
defect: 0.008678361889894726
densityg: 0.008678361889894726
developed: 0.008678361889894726
divided: 0.008678361889894726
du: 0.008678361889894726
effect: 0.008678361889894726
effective: 0.008678361889894726
ei: 0.008678361889894726
ele: 0.008678361889894726
electrochem: 0.008678361889894726
eling: 0.008678361889894726
engineapplications: 0.008678361889894726
envi: 0.008678361889894726
environment: 0.008678361889894726
er: 0.008678361889894726
ever: 0.008678361889894726
excellent: 0.008678361889894726
extreme: 0.008678361889894726
failure: 0.008678361889894726
fan: 0.008678361889894726
fastener: 0.008678361889894726
first: 0.008678361889894726
focus: 0.008678361889894726
forinstance: 0.008678361889894726
formation: 0.008678361889894726
fortunately: 0.008678361889894726
fracturetoughness: 0.008678361889894726
gear: 0.008678361889894726
generally: 0.008678361889894726
good: 0.008678361889894726
gpa: 0.008678361889894726
greatly: 0.008678361889894726
guo: 0.008678361889894726
hamdi: 0.008678361889894726
healingmaterialssuchasself: 0.008678361889894726
heat: 0.008678361889894726
helicopter: 0.008678361889894726
highest: 0.008678361889894726
hu: 0.008678361889894726
hv: 0.008678361889894726
hydrogen: 0.008678361889894726
icon: 0.008678361889894726
ii: 0.008678361889894726
iii: 0.008678361889894726
improved: 0.008678361889894726
inaddi: 0.008678361889894726

include: 0.008678361889894726
inhibitor: 0.008678361889894726
insufficient: 0.008678361889894726
io: 0.008678361889894726
jing: 0.008678361889894726
known: 0.008678361889894726
landing: 0.008678361889894726
landinggears: 0.008678361889894726
lialloys: 0.008678361889894726
libasedalloys: 0.008678361889894726
light: 0.008678361889894726
like: 0.008678361889894726
lithiumalloys: 0.008678361889894726
local: 0.008678361889894726
localized: 0.008678361889894726
lt: 0.008678361889894726
lubricant: 0.008678361889894726
made: 0.008678361889894726
magnesium: 0.008678361889894726
mechanicalproperties: 0.008678361889894726
mechanism: 0.008678361889894726
meet: 0.008678361889894726
met: 0.008678361889894726
metal: 0.008678361889894726
metall: 0.008678361889894726
microstructure: 0.008678361889894726
mmcs: 0.008678361889894726
mn: 0.008678361889894726
movement: 0.008678361889894726
much: 0.008678361889894726
mwnt: 0.008678361889894726
nano: 0.008678361889894726
nanocomposites: 0.008678361889894726
nanosheets: 0.008678361889894726
nanostructure: 0.008678361889894726
net: 0.008678361889894726
new: 0.008678361889894726
nickel: 0.008678361889894726
nitride: 0.008678361889894726
oc: 0.008678361889894726
ofal: 0.008678361889894726
operating: 0.008678361889894726
optimized: 0.008678361889894726
org: 0.008678361889894726
paerosci: 0.008678361889894726
partaappl: 0.008678361889894726
payload: 0.008678361889894726
peng: 0.008678361889894726
perform: 0.008678361889894726
pmc: 0.008678361889894726
precipitate: 0.008678361889894726
precipitation: 0.008678361889894726
prevention: 0.008678361889894726

primary: 0.008678361889894726
processengineering: 0.008678361889894726
progress: 0.008678361889894726
propertiesandapplicationsoftitaniumalloys: 0.008678361889894726
propertiesofal: 0.008678361889894726
protected: 0.008678361889894726
rate: 0.008678361889894726
ratio: 0.008678361889894726
recently: 0.008678361889894726
reduction: 0.008678361889894726
reportedthat: 0.008678361889894726
reportedthe: 0.008678361889894726
result: 0.008678361889894726
reviewed: 0.008678361889894726
seefig: 0.008678361889894726
selection: 0.008678361889894726
shaft: 0.008678361889894726
shear: 0.008678361889894726
shown: 0.008678361889894726
si: 0.008678361889894726
sikorskyaircraftcorporation: 0.008678361889894726
snapsprings: 0.008678361889894726
solid: 0.008678361889894726
solution: 0.008678361889894726
song: 0.008678361889894726
spring: 0.008678361889894726
stability: 0.008678361889894726
stabilizer: 0.008678361889894726
starke: 0.008678361889894726
stratford: 0.008678361889894726
strengthal: 0.008678361889894726
stresscorrosioncracking: 0.008678361889894726
stressregions: 0.008678361889894726
structural: 0.008678361889894726
suffer: 0.008678361889894726
suitable: 0.008678361889894726
t351: 0.008678361889894726
t651: 0.008678361889894726
t6alloy: 0.008678361889894726
t8: 0.008678361889894726
t83: 0.008678361889894726
tance: 0.008678361889894726
te: 0.008678361889894726
temperatureoxidation: 0.008678361889894726
terials: 0.008678361889894726
term: 0.008678361889894726
thecompositions: 0.008678361889894726
thermalconductivity: 0.008678361889894726
theself: 0.008678361889894726
three: 0.008678361889894726
tion: 0.008678361889894726
titaniumalloy: 0.008678361889894726
toovercometheseshortcomings: 0.008678361889894726

total0: 0.008678361889894726
trans: 0.008678361889894726
tribol: 0.008678361889894726
turbine: 0.008678361889894726
type: 0.008678361889894726
uddin: 0.008678361889894726
ultra: 0.008678361889894726
universityofbridgeport: 0.008678361889894726
uted: 0.008678361889894726
wanhill: 0.008678361889894726
well: 0.008678361889894726
wing: 0.008678361889894726
withstand: 0.008678361889894726
work: 0.008678361889894726
worker: 0.008678361889894726
zalnezhad: 0.008678361889894726
ze41: 0.008678361889894726
zheng: 0.008678361889894726
zhu: 0.008678361889894726
zralloys: 0.008678361889894726
001: 0.004339180944947363
002: 0.004339180944947363
01p: 0.004339180944947363
0376: 0.004339180944947363
0421: 0.004339180944947363
06wt: 0.004339180944947363
08a: 0.004339180944947363
0er: 0.004339180944947363
0g: 0.004339180944947363
0t: 0.004339180944947363
0wt: 0.004339180944947363
1016: 0.004339180944947363
1023titaniumalloy: 0.004339180944947363
1050: 0.004339180944947363
1077: 0.004339180944947363
1081: 0.004339180944947363
10v2fe3al: 0.004339180944947363
10wt: 0.004339180944947363
1149: 0.004339180944947363
1150: 0.004339180944947363
1167: 0.004339180944947363
1172: 0.004339180944947363
1225: 0.004339180944947363
1240mpa: 0.004339180944947363
1277: 0.004339180944947363
1281: 0.004339180944947363
1291: 0.004339180944947363
12wt: 0.004339180944947363
1300: 0.004339180944947363
1303: 0.004339180944947363
1350: 0.004339180944947363
1373: 0.004339180944947363
1375: 0.004339180944947363

1379: 0.004339180944947363
1380mpa: 0.004339180944947363
1393: 0.004339180944947363
1443: 0.004339180944947363
1450: 0.004339180944947363
1451: 0.004339180944947363
148mpa: 0.004339180944947363
1550: 0.004339180944947363
156: 0.004339180944947363
15mo: 0.004339180944947363
15vol: 0.004339180944947363
160: 0.004339180944947363
165: 0.004339180944947363
166: 0.004339180944947363
1684: 0.004339180944947363
1691: 0.004339180944947363
1695: 0.004339180944947363
1700: 0.004339180944947363
171: 0.004339180944947363
172: 0.004339180944947363
174: 0.004339180944947363
1757: 0.004339180944947363
1763: 0.004339180944947363
180: 0.004339180944947363
185: 0.004339180944947363
187: 0.004339180944947363
18wt: 0.004339180944947363
1903: 0.004339180944947363
192: 0.004339180944947363
193: 0.004339180944947363
1974: 0.004339180944947363
1978: 0.004339180944947363
1982: 0.004339180944947363
1986: 0.004339180944947363
199: 0.004339180944947363
1990: 0.004339180944947363
1994: 0.004339180944947363
1996: 0.004339180944947363
1cr: 0.004339180944947363
1showsthetotalmaterialsusedinboeingseries: 0.004339180944947363
1t: 0.004339180944947363
1y: 0.004339180944947363
2003: 0.004339180944947363
2006: 0.004339180944947363
2018elsevierltd: 0.004339180944947363
202: 0.004339180944947363
2020: 0.004339180944947363
2025: 0.004339180944947363
2026: 0.004339180944947363
2050: 0.004339180944947363
2052: 0.004339180944947363
2058: 0.004339180944947363
2060: 0.004339180944947363

2090: 0.004339180944947363
2098: 0.004339180944947363
20 μ m: 0.004339180944947363
214: 0.004339180944947363
2174: 0.004339180944947363
219: 0.004339180944947363
2191: 0.004339180944947363
2199: 0.004339180944947363
220: 0.004339180944947363
221: 0.004339180944947363
2223: 0.004339180944947363
2230: 0.004339180944947363
224: 0.004339180944947363
227: 0.004339180944947363
22fighteraircraftemployed: 0.004339180944947363
22wt: 0.004339180944947363
231: 0.004339180944947363
2330: 0.004339180944947363
234: 0.004339180944947363
2350: 0.004339180944947363
2356: 0.004339180944947363
2362: 0.004339180944947363
23x: 0.004339180944947363
240: 0.004339180944947363
2400: 0.004339180944947363
241gpa: 0.004339180944947363
245: 0.004339180944947363
247: 0.004339180944947363
247lc: 0.004339180944947363
24x: 0.004339180944947363
2524: 0.004339180944947363
253: 0.004339180944947363
258: 0.004339180944947363
25o: 0.004339180944947363
25x: 0.004339180944947363
25zrtitaniumalloyincreasedfrom931mpato1319mpa: 0.004339180944947363
260: 0.004339180944947363
265: 0.004339180944947363
266: 0.004339180944947363
2670: 0.004339180944947363
2675: 0.004339180944947363
268: 0.004339180944947363
269: 0.004339180944947363
26x: 0.004339180944947363
274: 0.004339180944947363
275mpa: 0.004339180944947363
2767: 0.004339180944947363
2769: 0.004339180944947363
277: 0.004339180944947363
27x: 0.004339180944947363
281: 0.004339180944947363
285: 0.004339180944947363
2868: 0.004339180944947363

2870: 0.004339180944947363
28x: 0.004339180944947363
2916: 0.004339180944947363
2920: 0.004339180944947363
295: 0.004339180944947363
29x: 0.004339180944947363
2e: 0.004339180944947363
2f: 0.004339180944947363
2higherfracture toughness than earlier 8090al: 0.004339180944947363
2i: 0.004339180944947363
2l: 0.004339180944947363
2nb: 0.004339180944947363
2p: 0.004339180944947363
2r: 0.004339180944947363
2se: 0.004339180944947363
2si: 0.004339180944947363
2t: 0.004339180944947363
2to850kgfmm: 0.004339180944947363
2w: 0.004339180944947363
2when graphene content rose from 0 to: 0.004339180944947363
3000: 0.004339180944947363
300m: 0.004339180944947363
300mandd6ac: 0.004339180944947363
301: 0.004339180944947363
3036: 0.004339180944947363
3050: 0.004339180944947363
306: 0.004339180944947363
307: 0.004339180944947363
308: 0.004339180944947363
30x: 0.004339180944947363
310mpa: 0.004339180944947363
3182: 0.004339180944947363
3190: 0.004339180944947363
31x: 0.004339180944947363
320: 0.004339180944947363
322: 0.004339180944947363
323: 0.004339180944947363
324: 0.004339180944947363
324mpa: 0.004339180944947363
325: 0.004339180944947363
3250: 0.004339180944947363
32x: 0.004339180944947363
331: 0.004339180944947363
333: 0.004339180944947363
338: 0.004339180944947363
33vol: 0.004339180944947363
33x: 0.004339180944947363
3450: 0.004339180944947363
348: 0.004339180944947363
349: 0.004339180944947363
352: 0.004339180944947363
353: 0.004339180944947363
354: 0.004339180944947363

355: 0.004339180944947363
357mpa: 0.004339180944947363
35cr: 0.004339180944947363
35mm3: 0.004339180944947363
35v: 0.004339180944947363
35wt: 0.004339180944947363
3622: 0.004339180944947363
3631: 0.004339180944947363
364: 0.004339180944947363
365: 0.004339180944947363
366: 0.004339180944947363
367: 0.004339180944947363
373: 0.004339180944947363
374: 0.004339180944947363
376: 0.004339180944947363
377: 0.004339180944947363
378: 0.004339180944947363
3791: 0.004339180944947363
3798: 0.004339180944947363
37mpam1: 0.004339180944947363
381: 0.004339180944947363
387: 0.004339180944947363
38vol: 0.004339180944947363
393: 0.004339180944947363
399: 0.004339180944947363
3999: 0.004339180944947363
3a: 0.004339180944947363
3c: 0.004339180944947363
3l: 0.004339180944947363
3mo: 0.004339180944947363
3o: 0.004339180944947363
3r: 0.004339180944947363
3snalloys: 0.004339180944947363
3snhasa: 0.004339180944947363
3timesmore: 0.004339180944947363
3u: 0.004339180944947363
3wt: 0.004339180944947363
4004: 0.004339180944947363
4007: 0.004339180944947363
4014: 0.004339180944947363
4015: 0.004339180944947363
4018: 0.004339180944947363
402: 0.004339180944947363
4140lowalloysteeldissimilarjointsbygastungstenarc: 0.004339180944947363
420: 0.004339180944947363
427: 0.004339180944947363
432: 0.004339180944947363
433: 0.004339180944947363
434: 0.004339180944947363
436: 0.004339180944947363
4450: 0.004339180944947363
4456: 0.004339180944947363
446: 0.004339180944947363

44mpam1: 0.004339180944947363
4561: 0.004339180944947363
4573: 0.004339180944947363
45mm3: 0.004339180944947363
460: 0.004339180944947363
462: 0.004339180944947363
465: 0.004339180944947363
469: 0.004339180944947363
475: 0.004339180944947363
479: 0.004339180944947363
4830mpaforstandardmoduluscrp: 0.004339180944947363
488: 0.004339180944947363
49mpam1: 0.004339180944947363
4a: 0.004339180944947363
4al: 0.004339180944947363
4r: 0.004339180944947363
4valloy: 0.004339180944947363
4valloyafter: 0.004339180944947363
4valloybyultrasonicnanocrystallinesurfacemodification: 0.004339180944947363
4valloycanbeincreasedto420hv: 0.004339180944947363
4vsubstratefabricatedbypowdersintering: 0.004339180944947363
4vtitaniumalloywith: 0.004339180944947363
5083: 0.004339180944947363
513: 0.004339180944947363
518: 0.004339180944947363
520: 0.004339180944947363
520mpa: 0.004339180944947363
522: 0.004339180944947363
523: 0.004339180944947363
525: 0.004339180944947363
52mpam1: 0.004339180944947363
531: 0.004339180944947363
5335: 0.004339180944947363
5340: 0.004339180944947363
535: 0.004339180944947363
53mpam1: 0.004339180944947363
543: 0.004339180944947363
546: 0.004339180944947363
54mpabyaddingonly0: 0.004339180944947363
550mpa: 0.004339180944947363
560: 0.004339180944947363
575: 0.004339180944947363
5775: 0.004339180944947363
5799: 0.004339180944947363
584: 0.004339180944947363
590: 0.004339180944947363
5981: 0.004339180944947363
5993: 0.004339180944947363
5al3zr4mo4v4cr: 0.004339180944947363
5al5v5mo3cr0: 0.004339180944947363
5p: 0.004339180944947363
5ti: 0.004339180944947363
5vol: 0.004339180944947363

5w: 0.004339180944947363
5zr: 0.004339180944947363
60000flight: 0.004339180944947363
610mpa: 0.004339180944947363
6211: 0.004339180944947363
6215: 0.004339180944947363
6218: 0.004339180944947363
6221: 0.004339180944947363
625: 0.004339180944947363
637: 0.004339180944947363
648: 0.004339180944947363
650: 0.004339180944947363
656: 0.004339180944947363
659: 0.004339180944947363
65wt: 0.004339180944947363
676: 0.004339180944947363
681: 0.004339180944947363
685: 0.004339180944947363
693: 0.004339180944947363
6a1: 0.004339180944947363
6am: 0.004339180944947363
6co5: 0.004339180944947363
6cr10: 0.004339180944947363
6e: 0.004339180944947363
6k: 0.004339180944947363
6ll: 0.004339180944947363
6mo: 0.004339180944947363
6wt: 0.004339180944947363
6µm: 0.004339180944947363
7000series: 0.004339180944947363
7050: 0.004339180944947363
7075al: 0.004339180944947363
7150x: 0.004339180944947363
739: 0.004339180944947363
770: 0.004339180944947363
776: 0.004339180944947363
780mpaat950: 0.004339180944947363
787: 0.004339180944947363
7e: 0.004339180944947363
7nb: 0.004339180944947363
7timeslongerthanthatof: 0.004339180944947363
808: 0.004339180944947363
8090: 0.004339180944947363
827: 0.004339180944947363
836: 0.004339180944947363
840: 0.004339180944947363
845: 0.004339180944947363
849: 0.004339180944947363
84wt: 0.004339180944947363
856: 0.004339180944947363
862: 0.004339180944947363
871: 0.004339180944947363
873: 0.004339180944947363

885: 0.004339180944947363
891: 0.004339180944947363
896: 0.004339180944947363
8i: 0.004339180944947363
8mpaand: 0.004339180944947363
8wt: 0.004339180944947363
90mpahigherthanthatinthetransversedirection: 0.004339180944947363
950: 0.004339180944947363
965: 0.004339180944947363
98mpa: 0.004339180944947363
9gpaforanal2o3basedcomposite: 0.004339180944947363
9i: 0.004339180944947363
9ue: 0.004339180944947363
a0: 0.004339180944947363
a1: 0.004339180944947363
a243: 0.004339180944947363
a260: 0.004339180944947363
a381: 0.004339180944947363
a396: 0.004339180944947363
a457: 0.004339180944947363
a513: 0.004339180944947363
a530: 0.004339180944947363
a531: 0.004339180944947363
a552: 0.004339180944947363
a555: 0.004339180944947363
a559: 0.004339180944947363
a560: 0.004339180944947363
a586: 0.004339180944947363
aa: 0.004339180944947363
ability: 0.004339180944947363
aboeingperspective: 0.004339180944947363
absorb: 0.004339180944947363
abundance: 0.004339180944947363
acasting: 0.004339180944947363
accelerate: 0.004339180944947363
acceleratethetransportofhydrogen: 0.004339180944947363
acceptable: 0.004339180944947363
accepted17january2018: 0.004339180944947363
accordingtoearlierworksby: 0.004339180944947363
accordingtothereviewpaperbymittal: 0.004339180944947363
accounted: 0.004339180944947363
achiev: 0.004339180944947363
achieved: 0.004339180944947363
acriticalreviewofthestresscorrosioncracking: 0.004339180944947363
acsnano5: 0.004339180944947363
act: 0.004339180944947363
actaastronaut: 0.004339180944947363
actasasacrificialanode: 0.004339180944947363
active: 0.004339180944947363
additionofcuisoftenusedincombinationwithlitoformal2culiphase: 0.004339180944947363
adepartmentofmechanicalengineering: 0.004339180944947363
admittedly: 0.004339180944947363
advancedcompositematerials: 0.004339180944947363

advancedcompositematerialsandaerospaceengineering: 0.004339180944947363
advancedcompositematerialsforaerospaceengineering: 0.004339180944947363
advantageessuchaslowcost: 0.004339180944947363
aermet100: 0.004339180944947363
aero: 0.004339180944947363
aeronauticalfield: 0.004339180944947363
aerospaceapplications: 0.004339180944947363
aerospaceapplicationsisrestrictedbysomechallenges: 0.004339180944947363
aerospaceapplicationsofaluminum: 0.004339180944947363
aerospaceindustry: 0.004339180944947363
aerospacelab: 0.004339180944947363
aerospacematerialsandmaterialtechnologies: 0.004339180944947363
afewresearchers: 0.004339180944947363
aftertheyearof1927: 0.004339180944947363
ag: 0.004339180944947363
aging: 0.004339180944947363
ah: 0.004339180944947363
ahighintrinsicdissolutiontendency: 0.004339180944947363
ahmad: 0.004339180944947363
ahmadet: 0.004339180944947363
ahmadetal: 0.004339180944947363
aircraftapplicationsarereviewed: 0.004339180944947363
aircraftdesigndependonthedesignrequirementsofeachcomponent: 0.004339180944947363
aircraftjetenginesinwhichthetemperaturecanreachupto600: 0.004339180944947363
aircraftstructuresfromcorrosionbycoating: 0.004339180944947363
aircraftwasbuiltbythewrightbrothers: 0.004339180944947363
airframematerials: 0.004339180944947363
airframematerialsaredesignedtoprovidelong: 0.004339180944947363
airframematerialsshouldfocusonthefollowingthreetopics: 0.004339180944947363
airplane: 0.004339180944947363
aisi304: 0.004339180944947363
aisi321: 0.004339180944947363
al2024: 0.004339180944947363
al2cuphase: 0.004339180944947363
al2o3: 0.004339180944947363
al2tio5: 0.004339180944947363
al6061: 0.004339180944947363
al7075: 0.004339180944947363
alalloys: 0.004339180944947363
alam: 0.004339180944947363
albasedalloys: 0.004339180944947363
albasedalloysatroomtemperature: 0.004339180944947363
albemet: 0.004339180944947363
alcontent: 0.004339180944947363
alcumgzn: 0.004339180944947363
alfiber: 0.004339180944947363
alisthemostwidelyusedtoimprove: 0.004339180944947363
alloyhas20mpam1: 0.004339180944947363
alloyhasaminimumutsat1240mpa: 0.004339180944947363
alloyhasayieldstrengthandanultimatetensilestrengthof1180mpa: 0.004339180944947363
alloyinaerospaceindustry: 0.004339180944947363
alloys1: 0.004339180944947363
alloysarereportedtopossesslowtensileductility: 0.004339180944947363

alloyscanbeimprovedbyreducingtheinsolublesecond: 0.004339180944947363
alloystendtoincrease: 0.004339180944947363
alloysto47mpam1: 0.004339180944947363
allrightsreserved: 0.004339180944947363
aln: 0.004339180944947363
along: 0.004339180944947363
alphaal: 0.004339180944947363
alphaornearalphatitaniumalloys: 0.004339180944947363
alphatitaniumalloyhasalower: 0.004339180944947363
alphatitaniumalloys: 0.004339180944947363
alphatitaniumalloyscanbedividedintoalphaandnear: 0.004339180944947363
also reported that the wear volume of the harder part: 0.004339180944947363
although: 0.004339180944947363
although aerospace materials have made great advancements: 0.004339180944947363
although researchers have studied fretting: 0.004339180944947363
although some other elements: 0.004339180944947363
although the conventional cfc can improve the strength of pmcs: 0.004339180944947363
alumina: 0.004339180944947363
aluminac ceramic composites: 0.004339180944947363
aluminium alloys using dsc: 0.004339180944947363
aluminum alloys: 0.004339180944947363
always: 0.004339180944947363
alwhisker: 0.004339180944947363
amanov: 0.004339180944947363
amount: 0.004339180944947363
amount of y: 0.004339180944947363
amplitude: 0.004339180944947363
anal: 0.004339180944947363
analysis of precipitation and dissolution in overaged 7xxx: 0.004339180944947363
and 1300 mpa under submicrocrystalline: 0.004339180944947363
and 2199: 0.004339180944947363
and a g have been studied to improve the mechanical: 0.004339180944947363
and aisi 347: 0.004339180944947363
andal: 0.004339180944947363
and all fluid nesses: 0.004339180944947363
and applications of the ultra: 0.004339180944947363
and atom: 0.004339180944947363
and basalt: 0.004339180944947363
and better fatigue resistance than other series: 0.004339180944947363
and biercuketal: 0.004339180944947363
and blade: 0.004339180944947363
and bonding strength also have: 0.004339180944947363
and can decrease: 0.004339180944947363
and can form α : 0.004339180944947363
and composites: 0.004339180944947363
and composites have experi: 0.004339180944947363
and compressor discs: 0.004339180944947363
and corrosive environment: 0.004339180944947363
and cr: 0.004339180944947363
and cu: 0.004339180944947363
and damping capability: 0.004339180944947363
and ductility: 0.004339180944947363
and ductility of mg: 0.004339180944947363

andelongation: 0.004339180944947363
andexcellentcorrosionresistance: 0.004339180944947363
andfinergrainsizethanconventional7075alloybecause: 0.004339180944947363
andflexuralmodulusofpolybutylenesucci: 0.004339180944947363
andgoodversatility: 0.004339180944947363
andgraphite: 0.004339180944947363
andheofal: 0.004339180944947363
andhigherdampingcapacity: 0.004339180944947363
andhightemperatureresistance: 0.004339180944947363
andhydrogenembrittlement: 0.004339180944947363
andlightweight: 0.004339180944947363
andmagnesiumisoftenusedincombinationwithcopperto: 0.004339180944947363
andmaintainability: 0.004339180944947363
andmanufacturingprocesses: 0.004339180944947363
andmg: 0.004339180944947363
andmicrostructuralbehavior: 0.004339180944947363
andmicrostructurecontroltoover: 0.004339180944947363
andmodulusof β : 0.004339180944947363
andnanoparticlesofa9crodssteel: 0.004339180944947363
andnanosizephaseshave: 0.004339180944947363
andni: 0.004339180944947363
andphotoactiveapproach: 0.004339180944947363
andpolymercompositesare: 0.004339180944947363
andpolymermatrixcompositematerialsarereviewed: 0.004339180944947363
andpoorcorrosionresistancelimittheuseof7075: 0.004339180944947363
andprovidesitesforgrain: 0.004339180944947363
andr: 0.004339180944947363
andrecycledcellulosefiber: 0.004339180944947363
ands: 0.004339180944947363
andsc: 0.004339180944947363
andscwillbethemaindriversinthedevel: 0.004339180944947363
andsihavebeeninvestigatedtoimprovetheheat: 0.004339180944947363
andsolvent: 0.004339180944947363
andsuitablewearresistance: 0.004339180944947363
andthe: 0.004339180944947363
andthebindingenergydecreaseswiththeincreasingcon: 0.004339180944947363
andthehydrophobicthermoplasticmatrix: 0.004339180944947363
andtheimpuritiesandthesecond: 0.004339180944947363
andtheincreaseofzncontentcanimprovethestrength: 0.004339180944947363
andthemost: 0.004339180944947363
andthen: 0.004339180944947363
andthendecreasedto180mpawhentheamountofy: 0.004339180944947363
andthendecreaseswithadditionalzncontentadded: 0.004339180944947363
andtheoptimalcontentoccursat0: 0.004339180944947363
andthepropertiesofsomefibersareshownintable: 0.004339180944947363
andthesecondoneisthepho: 0.004339180944947363
andthetrailingedgeflapsduring: 0.004339180944947363
andwe43: 0.004339180944947363
andwroughtin718: 0.004339180944947363
andy: 0.004339180944947363
andzn: 0.004339180944947363
anewtechniquefordispersionofcarbonnanotubeinametal melt: 0.004339180944947363
anexperimentbywalkeret: 0.004339180944947363

annjmater: 0.004339180944947363
anodized: 0.004339180944947363
anodizingtechnologies: 0.004339180944947363
another: 0.004339180944947363
antipov: 0.004339180944947363
antuono: 0.004339180944947363
ao: 0.004339180944947363
aof: 0.004339180944947363
ap: 0.004339180944947363
applicationofmodernaluminumalloystoaircraft: 0.004339180944947363
applicationtoal: 0.004339180944947363
applied: 0.004339180944947363
areanefficientalternative: 0.004339180944947363
arebeingusedinthe: 0.004339180944947363
aredominantinaerospace: 0.004339180944947363
areheattreatabletostrengthcomparabletosteel: 0.004339180944947363
aresimilar: 0.004339180944947363
areviewof: 0.004339180944947363
areviewofmagnesium: 0.004339180944947363
areviewofrecentdevelopmentsinnatural: 0.004339180944947363
areviewoncarbonnanotubesandgrapheneasfillersin: 0.004339180944947363
areviewondynamicmechanicalpropertiesofnaturalfibre: 0.004339180944947363
areviewonthetensilepropertiesofnaturalfiberreinforcedpolymer: 0.004339180944947363
areviewontheuseofgrapheneasaprotectivecoatingagainst: 0.004339180944947363
arivazhagan: 0.004339180944947363
around: 0.004339180944947363
around0: 0.004339180944947363
arrazola: 0.004339180944947363
arrestor: 0.004339180944947363
asafunctionofrollingandsolutiontreatment: 0.004339180944947363
ashortreviewonbasaltfiberreinforcedpolymercomposites: 0.004339180944947363
asminternational: 0.004339180944947363
aspect: 0.004339180944947363
asshowninfig: 0.004339180944947363
atapour: 0.004339180944947363
atatempa: 0.004339180944947363
athightemperature: 0.004339180944947363
ati: 0.004339180944947363
atomicbondsandfacilitatecrackgrowthbyslipandmicrovoid: 0.004339180944947363
atomsat: 0.004339180944947363
attrib: 0.004339180944947363
aturessuchas700: 0.004339180944947363
av: 0.004339180944947363
average: 0.004339180944947363
avoided: 0.004339180944947363
axle: 0.004339180944947363
az31: 0.004339180944947363
b1: 0.004339180944947363
b120vca: 0.004339180944947363
b2o3: 0.004339180944947363
b9: 0.004339180944947363
bai: 0.004339180944947363
balanced: 0.004339180944947363

balani: 0.004339180944947363
bamboo: 0.004339180944947363
banana: 0.004339180944947363
banerjee: 0.004339180944947363
barlat: 0.004339180944947363
basedal: 0.004339180944947363
basedalloyinaerospaceapplicationsduetothehighproperties: 0.004339180944947363
basedalloyis: 0.004339180944947363
basedalloyisanalternativefor: 0.004339180944947363
basedalloyistorefinethegrainsizeanddispersethemgzn2phase: 0.004339180944947363
basedalloysachievedthedominant: 0.004339180944947363
basedalloysandreportedthemnelementhasapositiveeffectonthe: 0.004339180944947363
basedalloysaremainlyalloyedwithcopperandthey: 0.004339180944947363
basedalloysaremainlyalloyedwithzincandtheyare: 0.004339180944947363
basedalloysaretheprimarymaterials: 0.004339180944947363
basedalloysbuthaveahigherasymmetryofyieldbehavior: 0.004339180944947363
basedalloysbycontrolling: 0.004339180944947363
basedalloysbythetopaircraftmanu: 0.004339180944947363
basedalloyscanbedividedinto: 0.004339180944947363
basedalloyscanbeobtainedwhenthe: 0.004339180944947363
basedalloysfor: 0.004339180944947363
basedalloyshavebeenusedforbothstructureand: 0.004339180944947363
basedalloyshavebettertensilepropertiesthan: 0.004339180944947363
basedalloysmostlyare: 0.004339180944947363
basedalloyspossesseexceptionalstiffness: 0.004339180944947363
basedalloyspossesssu: 0.004339180944947363
basedalloystoscc: 0.004339180944947363
basedalloyswhile: 0.004339180944947363
basedalloyswithoutal: 0.004339180944947363
basedonthedifferencesinmatrix: 0.004339180944947363
basedontheprediction: 0.004339180944947363
basedontheseproperties: 0.004339180944947363
basedonthewettabilityofthesurface: 0.004339180944947363
basedpolymercompositesandtheirapplications: 0.004339180944947363
basedsuper: 0.004339180944947363
basedsuperalloyat870: 0.004339180944947363
basedsuperalloyatoxidationtimeof100h: 0.004339180944947363
basedsuperalloyduringlong: 0.004339180944947363
basedsuperalloyimproves: 0.004339180944947363
basedsuperalloyinthePW4000engineareshown: 0.004339180944947363
basedsuperalloysfordisk: 0.004339180944947363
basedsuperalloyshaveshownlittleinherentresistanceto: 0.004339180944947363
basedsuperalloywith5: 0.004339180944947363
basesuperalloyinPW4000engine: 0.004339180944947363
batchelor: 0.004339180944947363
bearing: 0.004339180944947363
becausehydrogen: 0.004339180944947363
becauseof: 0.004339180944947363
becauseofthebrittlenessofcf: 0.004339180944947363
becauseoftheexcellentcombinationsofstrength: 0.004339180944947363
becauseoftheirhighstrength: 0.004339180944947363
becauseofthelowercontentsofiron: 0.004339180944947363
becausetheycanrecover: 0.004339180944947363

beendevelopedtopreventcorrosionofstructurematerials: 0.004339180944947363
beeninvestigatedtopreventfrettingdamage: 0.004339180944947363
beenstudied: 0.004339180944947363
beenthe driving forces in development of engine materials: 0.004339180944947363
beenwidely: 0.004339180944947363
behaviorandpreventionisstillnotmature: 0.004339180944947363
behaviorofal: 0.004339180944947363
believethatgraphenenanoplatelets: 0.004339180944947363
betaalloyisthemostwidelyusedti: 0.004339180944947363
betatitanium: 0.004339180944947363
betatitaniumalloysareentirelyormostlyconsistof β phasewith β : 0.004339180944947363
betatitaniumalloyti: 0.004339180944947363
betatypeti: 0.004339180944947363
bettles: 0.004339180944947363
biereuk: 0.004339180944947363
bilityofznintomgis6: 0.004339180944947363
biodegradableimplants: 0.004339180944947363
biomaterial: 0.004339180944947363
bmaterials: 0.004339180944947363
body: 0.004339180944947363
boeing787aircrafts: 0.004339180944947363
bolted: 0.004339180944947363
bomber: 0.004339180944947363
bond: 0.004339180944947363
boroncarbide: 0.004339180944947363
borsic: 0.004339180944947363
boththermosetandthermoplasticpmcshavebeenusedforaerospace: 0.004339180944947363
boundary: 0.004339180944947363
boundaryembrittlementbyhydrogenchemisorption: 0.004339180944947363
boundaryprecipitates: 0.004339180944947363
boundbythereleasingofhealingagentto: 0.004339180944947363
box: 0.004339180944947363
break: 0.004339180944947363
briefreview: 0.004339180944947363
brittle: 0.004339180944947363
buazar: 0.004339180944947363
build: 0.004339180944947363
buildingupperwingskin: 0.004339180944947363
bulkheadforafighteraircraft: 0.004339180944947363
businessmedia: 0.004339180944947363
butthendecreasewiththefurtherincreaseofsncontent: 0.004339180944947363
butylenesuccinate: 0.004339180944947363
byadding20wt: 0.004339180944947363
byreducingthepropagationrateandthe: 0.004339180944947363
byselectivelasermelting: 0.004339180944947363
c31: 0.004339180944947363
ca: 0.004339180944947363
caalloyasdegradable: 0.004339180944947363
cades: 0.004339180944947363
calciumandstrontiuminaz91: 0.004339180944947363
canalsoimprovemechanicalpropertiesofal: 0.004339180944947363
canbereducedbyintroducingrecrystallizationthroughoptimizationof: 0.004339180944947363
canbeusedforaircraftenginepartsthroughthe: 0.004339180944947363

can continuously increase the tensile strength: 0.004339180944947363
can increase the fracture toughness of 7000 series: 0.004339180944947363
can reach upto: 0.004339180944947363
can reach upto 95: 0.004339180944947363
can reduce the binding energy of the beta: 0.004339180944947363
capacity: 0.004339180944947363
captured: 0.004339180944947363
carbon 57: 0.004339180944947363
carbon 68: 0.004339180944947363
carbon coated ti: 0.004339180944947363
carbon fiber reinforced silicon carbide has been in ves: 0.004339180944947363
carbon nanotube composites for thermal management: 0.004339180944947363
carbon nanotubes: 0.004339180944947363
carbon nanotubes can signify: 0.004339180944947363
carbon nanotubes influence the properties of mg matrix: 0.004339180944947363
caron: 0.004339180944947363
carriage: 0.004339180944947363
casing: 0.004339180944947363
castability: 0.004339180944947363
casting mg: 0.004339180944947363
cast mg: 0.004339180944947363
cast tc 21: 0.004339180944947363
cate: 0.004339180944947363
catecholamine coated maghemite: 0.004339180944947363
cathode: 0.004339180944947363
cause: 0.004339180944947363
cause a loss of: 0.004339180944947363
cause an anisotropy problem in al: 0.004339180944947363
caused: 0.004339180944947363
caused by natural disasters: 0.004339180944947363
cause failure of components when the remaining materials after cannot: 0.004339180944947363
cause health problems and environment disasters in its hexavalent form: 0.004339180944947363
cavaliere: 0.004339180944947363
ceram: 0.004339180944947363
ceramic composite by adding 1: 0.004339180944947363
ceramic matrix com: 0.004339180944947363
ceramic matrix composite material: 0.004339180944947363
ceramic matrix composites: 0.004339180944947363
ceramic or metal matrix: 0.004339180944947363
ceramics and ceramic matrix composites for heat exchangers: 0.004339180944947363
cerium: 0.004339180944947363
cerium sulphate as inhibitor against corrosion of aa 2024 aluminium alloy: 0.004339180944947363
cesed upack database: 0.004339180944947363
cf: 0.004339180944947363
chain: 0.004339180944947363
challenges faced in the development of recently advanced: 0.004339180944947363
chamber: 0.004339180944947363
chandrasekaran: 0.004339180944947363
chanical: 0.004339180944947363
chanical properties of mg: 0.004339180944947363
characteristic: 0.004339180944947363
characteristics of powder metallurgy pure titanium matrix: 0.004339180944947363
characterization of hot deformation behavior of as: 0.004339180944947363

characterizationsofcarbonfiberfabricreinforcedepoxycompositesusedin: 0.004339180944947363
chenb: 0.004339180944947363
cheshmehkani: 0.004339180944947363
china: 0.004339180944947363
china24: 0.004339180944947363
chiou: 0.004339180944947363
chiouandcoworkers: 0.004339180944947363
chromium: 0.004339180944947363
chromiumhasbeenreportedto: 0.004339180944947363
ci: 0.004339180944947363
cirpann: 0.004339180944947363
cirpj: 0.004339180944947363
citeseer: 0.004339180944947363
cladding: 0.004339180944947363
cleaningcoatings: 0.004339180944947363
cleaningpolymericmaterials: 0.004339180944947363
cm: 0.004339180944947363
cmc: 0.004339180944947363
cmcwithhigherfracturetoughnessbyrevealingtheoptimizedcontent: 0.004339180944947363
cnt: 0.004339180944947363
cntwasaddedintocoppermatrix: 0.004339180944947363
coating73: 0.004339180944947363
coatingsdopedwithinorganicinhibitors: 0.004339180944947363
coefficient: 0.004339180944947363
colloid: 0.004339180944947363
combustion: 0.004339180944947363
comethechallengesofmetalalloys: 0.004339180944947363
cometheseshortcomings: 0.004339180944947363
commercialmg: 0.004339180944947363
commun: 0.004339180944947363
comparedtocntrein: 0.004339180944947363
compony: 0.004339180944947363
compositeaswell: 0.004339180944947363
compositecoatingswith: 0.004339180944947363
compositelayeronti: 0.004339180944947363
compositematerialsintheairbusa380: 0.004339180944947363
compositematerialsshowagreatpo: 0.004339180944947363
compositereinforcedwithmulti: 0.004339180944947363
compositesaremorelikelytosufferfromstressconcentration: 0.004339180944947363
compositesistheincompatibilitybetweenthehydrophilicnaturalfibers: 0.004339180944947363
compositesprocessedbymolecularlevelmixing: 0.004339180944947363
compositionmodification: 0.004339180944947363
compromise: 0.004339180944947363
con: 0.004339180944947363
concentrate: 0.004339180944947363
concentration: 0.004339180944947363
concentrationofatomichydrogen: 0.004339180944947363
conclusionandfuturetrends: 0.004339180944947363
conducted: 0.004339180944947363
conductivecoatingsforfighterjets: 0.004339180944947363
connect: 0.004339180944947363
connection: 0.004339180944947363
consist: 0.004339180944947363

construct: 0.004339180944947363
consumption: 0.004339180944947363
contact: 0.004339180944947363
contain: 0.004339180944947363
containingboron: 0.004339180944947363
contemporaryresearchand: 0.004339180944947363
contemporaryresearchandapplications: 0.004339180944947363
contentresultsintheformationofthetopologicallyclose: 0.004339180944947363
contentslistsavailableatsciencedirect: 0.004339180944947363
continuously: 0.004339180944947363
contribute: 0.004339180944947363
control: 0.004339180944947363
controllingtheignitionandflammabilityofmagnesiumfor: 0.004339180944947363
conventionalcorrosioncoatinghas: 0.004339180944947363
copperhasasolubility: 0.004339180944947363
copterindustrytomakecastgearboxtransmissionssuchasforsikorsky: 0.004339180944947363
corros: 0.004339180944947363
corrosionandfatigueresistancethanmostmetals: 0.004339180944947363
corrosionbehaviorandpreventionneedtobefurtherstudy: 0.004339180944947363
corrosionbehaviorof β titaniumalloysforbiomedical: 0.004339180944947363
corrosionbehaviorsofmganditsalloyswithdifferentialcontents: 0.004339180944947363
corrosioncracking: 0.004339180944947363
corrosioncrackingbehaviorofultra: 0.004339180944947363
corrosioninvolvesthechemicaldegradationofmaterialswhenthe: 0.004339180944947363
corrosionproblemsalsoinhibittheuseofaero: 0.004339180944947363
corrosionresistancemaynotsupporttotherrequirements: 0.004339180944947363
corrosionresistantni: 0.004339180944947363
corrosive: 0.004339180944947363
corrosivephase: 0.004339180944947363
cost: 0.004339180944947363
cotton: 0.004339180944947363
cp: 0.004339180944947363
crackbysscwiththesafeloadingcancausethe sudden failure ofma: 0.004339180944947363
cracking: 0.004339180944947363
crackingissue: 0.004339180944947363
crackingresistance: 0.004339180944947363
crackplanesbecauseofthecapillaryeffect: 0.004339180944947363
crankshaft: 0.004339180944947363
crc: 0.004339180944947363
creepresistance: 0.004339180944947363
crevicecorrosion: 0.004339180944947363
critical: 0.004339180944947363
crystal: 0.004339180944947363
cte: 0.004339180944947363
cualloy: 0.004339180944947363
cualloysandlightal: 0.004339180944947363
cubasedal: 0.004339180944947363
cubasedalloys: 0.004339180944947363
cubasedalloysbyrefiningmicrostructureandgrainsize: 0.004339180944947363
cui: 0.004339180944947363
cunderemergencybrakeconditions: 0.004339180944947363
curatioisaroundfour: 0.004339180944947363
currentwroughtmagnesiumalloys: 0.004339180944947363

cy: 0.004339180944947363
cyclecost: 0.004339180944947363
cyclic: 0.004339180944947363
cyclicfatigue: 0.004339180944947363
czerwinski: 0.004339180944947363
d6ac: 0.004339180944947363
da7: 0.004339180944947363
damageandcorrosion: 0.004339180944947363
damagebytheapplicationofsurface: 0.004339180944947363
damageduetohydrogenembrittlementandstress: 0.004339180944947363
damagetolerance: 0.004339180944947363
daoushalsofoundthatthe: 0.004339180944947363
davim: 0.004339180944947363
davis: 0.004339180944947363
day: 0.004339180944947363
dch: 0.004339180944947363
debris: 0.004339180944947363
decrease: 0.004339180944947363
decreased: 0.004339180944947363
decreasedto3: 0.004339180944947363
decreasedwithincreasingthecontentofcnt: 0.004339180944947363
decreasingtheadverseeffectoffeonfracturetoughness: 0.004339180944947363
deformation: 0.004339180944947363
delaminationcrackinginadvancedaluminum: 0.004339180944947363
demonstratedanincreaseof235: 0.004339180944947363
demonstratedintable4: 0.004339180944947363
densityalelementhasamaximum: 0.004339180944947363
densitypoly: 0.004339180944947363
departmentofmechanicalengineering: 0.004339180944947363
depleted: 0.004339180944947363
describing: 0.004339180944947363
desert: 0.004339180944947363
designandsynthesisofself: 0.004339180944947363
designcriteria: 0.004339180944947363
despitethe: 0.004339180944947363
despitetheattractivenessofal: 0.004339180944947363
detrimental: 0.004339180944947363
developedforaerospaceindustrywithoutstandingadvantages: 0.004339180944947363
developing: 0.004339180944947363
developmentsandchallengesforaluminum: 0.004339180944947363
developtheadvanced: 0.004339180944947363
devoted: 0.004339180944947363
df: 0.004339180944947363
dhand: 0.004339180944947363
difference: 0.004339180944947363
differentapplicationshavetheirspecificdesignandselectioncriteriaof: 0.004339180944947363
difficulty: 0.004339180944947363
diffusion: 0.004339180944947363
directly: 0.004339180944947363
discassemblies: 0.004339180944947363
discbladesinaircraftengines: 0.004339180944947363
dislocation: 0.004339180944947363
dispersion: 0.004339180944947363

dissolved: 0.004339180944947363
distributionofhydrogenishighlynonuniformunderanappliedstress: 0.004339180944947363
djukic: 0.004339180944947363
doherty: 0.004339180944947363
doi: 0.004339180944947363
dominated: 0.004339180944947363
doublesideself: 0.004339180944947363
doun: 0.004339180944947363
drawback: 0.004339180944947363
dropped: 0.004339180944947363
dual: 0.004339180944947363
ducted: 0.004339180944947363
duction: 0.004339180944947363
duetal: 0.004339180944947363
dueto: 0.004339180944947363
duetotheirhighstrengthathightemperature: 0.004339180944947363
duringcoldrollingalsohasasignificanteffectonmechanicalproperties: 0.004339180944947363
dursun: 0.004339180944947363
dursunetal: 0.004339180944947363
dustrybecauseoftheirreinforcedhigheryieldstrength: 0.004339180944947363
e9: 0.004339180944947363
earlier: 0.004339180944947363
easier: 0.004339180944947363
easytomanufacture: 0.004339180944947363
ebrahimi: 0.004339180944947363
ed: 0.004339180944947363
edi: 0.004339180944947363
edu: 0.004339180944947363
efendy: 0.004339180944947363
effectofcyclicoxidationonthetensilebehaviorofdirectionally: 0.004339180944947363
effectoffrettingonfatigueperformanceofti: 0.004339180944947363
effectofliadditiononmicrostructureandmechanicalproperties: 0.004339180944947363
effectofmaterialsandtemperatureonthe: 0.004339180944947363
effectofnbprecipitatecoarseningonthehightemperature: 0.004339180944947363
effectotemperatureontensilebehaviorofni: 0.004339180944947363
effectoftraceadditionsofsnonmicrostructureandmechanical: 0.004339180944947363
effectofyconcentrationonthemicrostructureandmechanical: 0.004339180944947363
effectofzradditiononthemechanicalpropertiesofas: 0.004339180944947363
effectsofaluminumadditiononthehightemperature: 0.004339180944947363
effectsonalmatrixcomposites: 0.004339180944947363
efficiency: 0.004339180944947363
efficientcorrosioninhibitors: 0.004339180944947363
electricalandmechanicalpropertiesofcarbonnanotube: 0.004339180944947363
electroanal: 0.004339180944947363
electronbeamand: 0.004339180944947363
elementduetothereactionofzrandal: 0.004339180944947363
elementexceedsthecriticalamount: 0.004339180944947363
elongationincreasesto15: 0.004339180944947363
elongation $\frac{1}{4}$ 10: 0.004339180944947363
elongation $\frac{1}{4}$ 14: 0.004339180944947363
elongation $\frac{1}{4}$ 17: 0.004339180944947363
enable: 0.004339180944947363
encedarapidincreaseinthetotalmaterialsinthelatestboeingmodels: 0.004339180944947363

end: 0.004339180944947363
enginecompressorparts: 0.004339180944947363
enginesrequirematerialswithhighspecificstrength: 0.004339180944947363
enough: 0.004339180944947363
entanglement: 0.004339180944947363
entry: 0.004339180944947363
environ: 0.004339180944947363
epoxy: 0.004339180944947363
epoxycompositewithexcellentfatigueresistancecanbe: 0.004339180944947363
equipmentrequiredforflight: 0.004339180944947363
erlu: 0.004339180944947363
erties: 0.004339180944947363
ertiesandbetterdispersibilitytocnts: 0.004339180944947363
ertiessuchastoughness: 0.004339180944947363
especiallyforgears: 0.004339180944947363
etan: 0.004339180944947363
ethylene: 0.004339180944947363
eu: 0.004339180944947363
evolutionofanearalphatitaniumalloy: 0.004339180944947363
evolutionofcorrosionprotectionforsol: 0.004339180944947363
exampleislotusleaves: 0.004339180944947363
exceeded: 0.004339180944947363
excellentheat: 0.004339180944947363
exhaustnozzle: 0.004339180944947363
expansion: 0.004339180944947363
experienced: 0.004339180944947363
experienceda: 0.004339180944947363
experiment: 0.004339180944947363
experimentalandcomputationalstudies: 0.004339180944947363
exposed: 0.004339180944947363
extensivestudieshavebeenconductedtodevelopthenextgenerationaerospacematerialswith:
0.004339180944947363
extrinsicself: 0.004339180944947363
extruded: 0.004339180944947363
ezugwu: 0.004339180944947363
fabrication: 0.004339180944947363
faced: 0.004339180944947363
facilitate: 0.004339180944947363
facturers: 0.004339180944947363
fail: 0.004339180944947363
failuremechanismsbecausestccancausesthegrowthofcracksundera: 0.004339180944947363
fastdevelopmentofnewaircraftmaterials: 0.004339180944947363
feature: 0.004339180944947363
fewer: 0.004339180944947363
fibersforpmchhavefocusedonthenaturalfibers: 0.004339180944947363
fibrecompositesandtheirmechanicalperformance: 0.004339180944947363
fifth: 0.004339180944947363
fifthsofal: 0.004339180944947363
filmtitaniumnitridecoatedaerospaceal7075: 0.004339180944947363
findlay: 0.004339180944947363
finegrains: 0.004339180944947363
finer: 0.004339180944947363
finiteelementmodelingofplanestrain Toughness: 0.004339180944947363

fixationapplications: 0.004339180944947363
flap: 0.004339180944947363
flaxcontent: 0.004339180944947363
flaxfiberistwicethatofhdpewithoutany: 0.004339180944947363
flexuralstrength: 0.004339180944947363
flighttosupportthestaticweightoftheaircraftanddynamicloadsdueto: 0.004339180944947363
floorsupportstructure: 0.004339180944947363
following: 0.004339180944947363
for7085aluminumalloy: 0.004339180944947363
foraircraftstructureshassignificantlyincreasedinrecentyearsbecause: 0.004339180944947363
forbothimpurities: 0.004339180944947363
forced: 0.004339180944947363
forcntsinceramiccompositebecauseofthesimilarmechanicalprop: 0.004339180944947363
formationofal2o3canpreventtheoutwarddiffusionofcationandin: 0.004339180944947363
formingadditionson: 0.004339180944947363
forthewingtoprovidebothhightensilestrengthandhighcompressive: 0.004339180944947363
foruseindifferentenvironments: 0.004339180944947363
forwardextrusionofmagnesiumalloys: 0.004339180944947363
found: 0.004339180944947363
foundthatthestrengthcanberestoredbyheatingthesematerialsover: 0.004339180944947363
fourbetatitaniumalloysareinsteadypro: 0.004339180944947363
fract: 0.004339180944947363
fractionsofthesecondphasemgxzny: 0.004339180944947363
fracturetough: 0.004339180944947363
frame: 0.004339180944947363
frequentlyusedmaterialforthispartisti: 0.004339180944947363
frettingfatiguebehaviorofal7075: 0.004339180944947363
frettingfatiguelifeofhardanodizedaerospaceal7075: 0.004339180944947363
frettingwearacceleratesthefatiguefailureofcomponentstocausecrack: 0.004339180944947363
frettingwearandfrettingfatiguebehaviorsofdiamond: 0.004339180944947363
frettingwearandfrictionreductionofcptitaniumand: 0.004339180944947363
frettingweariscausedbysmall: 0.004339180944947363
frettingwearofmg: 0.004339180944947363
frictionfactor: 0.004339180944947363
frictionstirweldingofmetalmatrixcompositesforuseinaerospace: 0.004339180944947363
frictionwelding: 0.004339180944947363
from0to15vol: 0.004339180944947363
from1: 0.004339180944947363
from996mpato1317mpabyincreasingzrcontentfrom0wt: 0.004339180944947363
fromhistorytofuture: 0.004339180944947363
fromthebeta: 0.004339180944947363
fromtherollingdirectionintheconditionofunder: 0.004339180944947363
fu: 0.004339180944947363
fuandcoworkers: 0.004339180944947363
fuel: 0.004339180944947363
fuhecaillao: 0.004339180944947363
function: 0.004339180944947363
functionalizedgrapheneoxide: 0.004339180944947363
furtherimprovementofmechanicalpropertiesofal: 0.004339180944947363
furtherworksshould: 0.004339180944947363
futuretechnologies: 0.004339180944947363
futuretrendsinaerospacematerials: 0.004339180944947363
futuretrendssofaircraftengine: 0.004339180944947363

galvanic: 0.004339180944947363
garmestani: 0.004339180944947363
gbp: 0.004339180944947363
gearddoors: 0.004339180944947363
gel: 0.004339180944947363
general: 0.004339180944947363
generation: 0.004339180944947363
geng: 0.004339180944947363
geometriclimits: 0.004339180944947363
gibson: 0.004339180944947363
gigandet: 0.004339180944947363
glassy: 0.004339180944947363
gnp: 0.004339180944947363
go: 0.004339180944947363
gopiraman: 0.004339180944947363
gories: 0.004339180944947363
goswami: 0.004339180944947363
gr: 0.004339180944947363
gradually: 0.004339180944947363
grainboundarymisorientationdependenceof β phase: 0.004339180944947363
grapheneoxide: 0.004339180944947363
graphenereachedupto1: 0.004339180944947363
graphenetoimprovethefracturetoughnessofceramicmatrixcompos: 0.004339180944947363
greeninhibitorsforcorrosionofmetals: 0.004339180944947363
gregson: 0.004339180944947363
grouped: 0.004339180944947363
h1: 0.004339180944947363
half: 0.004339180944947363
handbookofmaterialsselectionforengineeringapplications: 0.004339180944947363
hard: 0.004339180944947363
hardenability: 0.004339180944947363
hardnessandtensilepropertiesofanew: 0.004339180944947363
hardnessandwearresistanceimprovementofsurface: 0.004339180944947363
hardnesscangreatlyimprovethefatiguelifeofatincoatedal7075: 0.004339180944947363
hardnessfrom250: 0.004339180944947363
hardnesssteelpairs: 0.004339180944947363
hardnessvalueofal: 0.004339180944947363
harrison: 0.004339180944947363
hasbeenstudiedasproviding: 0.004339180944947363
hash: 0.004339180944947363
hasshownthatalphaphase: 0.004339180944947363
havebeenwidelyinvestigated: 0.004339180944947363
haveconductedtestsseekingtoeliminatethefrettingwearbehaviorof: 0.004339180944947363
havedifferent: 0.004339180944947363
havefocused: 0.004339180944947363
hdpe: 0.004339180944947363
hdpebiocomposites: 0.004339180944947363
healingandintrinsicself: 0.004339180944947363
healingbehaviorforboththermosetandthermoplasticmaterialsand: 0.004339180944947363
healingcompositesforaerospace: 0.004339180944947363
healingepoxycompositcanprotect: 0.004339180944947363
healinghol: 0.004339180944947363
healingismostly: 0.004339180944947363

healingmaterials can be divided into two: 0.004339180944947363
healingmaterials can be polymer: 0.004339180944947363
healingpolymeric materials: 0.004339180944947363
healingpolymers: 0.004339180944947363
healingrelies on the healing agent: 0.004339180944947363
heated: 0.004339180944947363
heat treat: 0.004339180944947363
heli: 0.004339180944947363
helicopter rotor systems and: 0.004339180944947363
hemp: 0.004339180944947363
henn: 0.004339180944947363
hexavalent chromium ions: 0.004339180944947363
high content: 0.004339180944947363
higher content of mg are also susceptible to: 0.004339180944947363
higher creep resistance and better corrosion resistance than beta: 0.004339180944947363
higher specific strength and stiffness when compared to al: 0.004339180944947363
higher strength: 0.004339180944947363
high hardness: 0.004339180944947363
high strength carbon nanotube: 0.004339180944947363
high strength low alloy steels: 0.004339180944947363
hojjati: 0.004339180944947363
hold promise for the aerospace in: 0.004339180944947363
homma: 0.004339180944947363
homma et al: 0.004339180944947363
hook: 0.004339180944947363
hot: 0.004339180944947363
hot corrosion resistance: 0.004339180944947363
hour: 0.004339180944947363
hrc: 0.004339180944947363
html: 0.004339180944947363
hua: 0.004339180944947363
huda: 0.004339180944947363
humidity: 0.004339180944947363
hwang: 0.004339180944947363
hwanget al: 0.004339180944947363
hydrogen embrittlement of low carbon structural steel: 0.004339180944947363
hydrophobic: 0.004339180944947363
ical and quantum mechanical models: 0.004339180944947363
ical properties: 0.004339180944947363
icantly: 0.004339180944947363
identifies fretting behavior and the prevention of fretting is still unclear: 0.004339180944947363
ih: 0.004339180944947363
ii00: 0.004339180944947363
imi829: 0.004339180944947363
imi834: 0.004339180944947363
improvement of stress: 0.004339180944947363
improve the high: 0.004339180944947363
improving: 0.004339180944947363
impurities control: 0.004339180944947363
impurities such as iron and silicon control: 0.004339180944947363
in 3 min under the condition of 535: 0.004339180944947363
in 718: 0.004339180944947363
in addition to al: 0.004339180944947363

in addition to natural: 0.004339180944947363
in addition to the matrices of: 0.004339180944947363
in advanced thermal systems: 0.004339180944947363
in aluminum than any: 0.004339180944947363
in a modified simulated body fluid: 0.004339180944947363
include 2024: 0.004339180944947363
including: 0.004339180944947363
including loading conditions: 0.004339180944947363
including microstructure refinement: 0.004339180944947363
including more efficient prevention: 0.004339180944947363
increased in recent years due to superior mechanical properties such as: 0.004339180944947363
increased slightly with additional content added: 0.004339180944947363
increase of the zirconium element from 1 wt: 0.004339180944947363
increasing content: 0.004339180944947363
ind: 0.004339180944947363
induced: 0.004339180944947363
industry development: 0.004339180944947363
in fig: 0.004339180944947363
influence: 0.004339180944947363
influence of repetitive: 0.004339180944947363
in fracture toughness of Ti-3Al : 0.004339180944947363
ing 747: 0.004339180944947363
in general: 0.004339180944947363
in Ti-6Al-4V form the high anodic β phase of Al-3Mg-2 : 0.004339180944947363
initiation sites on the material surface: 0.004339180944947363
injection molding of nickel based 625 superalloy: 0.004339180944947363
in mg: 0.004339180944947363
in mg and can merge into mg to form the phases of: 0.004339180944947363
innovation: 0.004339180944947363
in order to prevent: 0.004339180944947363
in recent studies: 0.004339180944947363
in tech open access publisher: 0.004339180944947363
integrity: 0.004339180944947363
interaction of the cutting tools and the ceramic: 0.004339180944947363
interface: 0.004339180944947363
interface analysis of ultra: 0.004339180944947363
interface by the effect of residual amine: 0.004339180944947363
intermetallic: 0.004339180944947363
in the aerospace industry: 0.004339180944947363
in the future: 0.004339180944947363
in the range of 34: 0.004339180944947363
into a complex alloy combined with the element of Fe and an abundance: 0.004339180944947363
intrinsic: 0.004339180944947363
intrinsic self: 0.004339180944947363
introducing 1 wt: 0.004339180944947363
introduction: 0.004339180944947363
in ves: 0.004339180944947363
investigated three methods: 0.004339180944947363
investigating the fretting fatigue life of thin: 0.004339180944947363
investigation on AISI 304 austenitic stainless steel to AISI: 0.004339180944947363
in which the α phase platelets are replaced by fine acicular α_0 : 0.004339180944947363
ion: 0.004339180944947363
iran: 0.004339180944947363

isotropy: 0.004339180944947363
istentbecausethemechanismsofheandscarenotaffectedbyone: 0.004339180944947363
isticinvestigationshavebeendevelopedtostudythemechanismofhe: 0.004339180944947363
italsorequiresmaterialsto: 0.004339180944947363
ites: 0.004339180944947363
itis: 0.004339180944947363
itisalsosubjectedtoadditionalloadsfrom: 0.004339180944947363
itisbecausetheepoxymonomercanbecuredonthematrix: 0.004339180944947363
itrolls: 0.004339180944947363
itsroleindebrisretentioninthecontact: 0.004339180944947363
jia: 0.004339180944947363
jian: 0.004339180944947363
jl: 0.004339180944947363
john: 0.004339180944947363
jom57: 0.004339180944947363
jom67: 0.004339180944947363
journalhomepage: 0.004339180944947363
jud: 0.004339180944947363
junling: 0.004339180944947363
kakiuchi: 0.004339180944947363
kalyanam: 0.004339180944947363
karabin: 0.004339180944947363
karumbaiah: 0.004339180944947363
kassae: 0.004339180944947363
kausch: 0.004339180944947363
kauschetal: 0.004339180944947363
kelly: 0.004339180944947363
kesavan: 0.004339180944947363
keywords: 0.004339180944947363
kgf: 0.004339180944947363
kgfmm: 0.004339180944947363
kic: 0.004339180944947363
kieselbach: 0.004339180944947363
kingston: 0.004339180944947363
knownthatthe: 0.004339180944947363
kondoh: 0.004339180944947363
kozhukharov: 0.004339180944947363
krane: 0.004339180944947363
ku: 0.004339180944947363
kuilla: 0.004339180944947363
l1: 0.004339180944947363
landinggear: 0.004339180944947363
landinggearbeamforboe: 0.004339180944947363
landinggearsaxles: 0.004339180944947363
last: 0.004339180944947363
le: 0.004339180944947363
lee: 0.004339180944947363
lessthanabout100 μ m: 0.004339180944947363
level: 0.004339180944947363
lh: 0.004339180944947363
li2090: 0.004339180944947363
liaa2198sheet: 0.004339180944947363
liao: 0.004339180944947363

libased: 0.004339180944947363
libasedalloycontaining40wt: 0.004339180944947363
libasedalloyforfuselageskinandupperwingskinappli: 0.004339180944947363
libasedalloyinthelongitudedirectionis: 0.004339180944947363
libasedalloysareshownintable1: 0.004339180944947363
lightest: 0.004339180944947363
liisadded: 0.004339180944947363
likeandgraphite: 0.004339180944947363
likecarbon: 0.004339180944947363
likecarbonfilmsdepositedonti: 0.004339180944947363
likely: 0.004339180944947363
lim: 0.004339180944947363
limit: 0.004339180944947363
limited: 0.004339180944947363
liplatesjoinedbyfrictionstirwelding: 0.004339180944947363
liquid: 0.004339180944947363
liquidmetalprocessing: 0.004339180944947363
lir: 0.004339180944947363
lithium: 0.004339180944947363
liuetal: 0.004339180944947363
llh: 0.004339180944947363
lli: 0.004339180944947363
loaded: 0.004339180944947363
loadtransferanddeformationmechanismsincarbonnanotube: 0.004339180944947363
locate: 0.004339180944947363
lockheed: 0.004339180944947363
locq: 0.004339180944947363
loe: 0.004339180944947363
loss: 0.004339180944947363
loureiro: 0.004339180944947363
lowglassfiber: 0.004339180944947363
lowthermalexpansion: 0.004339180944947363
loyscanbeachievedbycontrollingtheimpurities: 0.004339180944947363
lp: 0.004339180944947363
lu: 0.004339180944947363
lubricating: 0.004339180944947363
luo: 0.004339180944947363
m0: 0.004339180944947363
machado: 0.004339180944947363
machinabilityandsurfaceintegrityofrr1000nickelbased: 0.004339180944947363
machinabilityoftitaniumalloys: 0.004339180944947363
machining: 0.004339180944947363
magnesiumalloy: 0.004339180944947363
magnesiumalloys: 0.004339180944947363
magnesiumalloyscorrosionanditsprotection: 0.004339180944947363
magnesiumcastingtechnologyforstructuralapplications: 0.004339180944947363
magnesiumisonlytwo: 0.004339180944947363
mailaddress: 0.004339180944947363
maintain: 0.004339180944947363
majzoobi: 0.004339180944947363
maneuveringorturbulence: 0.004339180944947363
manufacturability: 0.004339180944947363
manufacture: 0.004339180944947363

many: 0.004339180944947363
marketprospectsand: 0.004339180944947363
martensite: 0.004339180944947363
martin: 0.004339180944947363
materialpropertydata: 0.004339180944947363
materialsarerequiredtopossesslowdensitiesforweightreduction: 0.004339180944947363
materialsforum: 0.004339180944947363
materialsover80years: 0.004339180944947363
materialsreacttotheirenvironment: 0.004339180944947363
materialsrequirementsindesignofaircraftstructures: 0.004339180944947363
materialsscienceandengineering: 0.004339180944947363
materialsselectionforan: 0.004339180944947363
materialsselectionindesignofstructuresandenginesof: 0.004339180944947363
matricesuchasaluminum: 0.004339180944947363
matrixcompositesduringmicro: 0.004339180944947363
matrixnanocompositesreinforcedwithcarbonnanotubesandgraphene: 0.004339180944947363
matweb: 0.004339180944947363
maximum: 0.004339180944947363
maximumservice: 0.004339180944947363
mech: 0.004339180944947363
mechan: 0.004339180944947363
mechanicalandmorphological: 0.004339180944947363
mechanicalandthermalpropertiesofbasaltfiberreinforcedpoly: 0.004339180944947363
mechanicalandtribologicalpropertiesofself: 0.004339180944947363
mechanicalprocessing: 0.004339180944947363
mechanicalpropertiesfortheintendeduse: 0.004339180944947363
mechanicalpropertiesofal: 0.004339180944947363
mechanicalpropertiesofepoxycompositesfilledwithsilane: 0.004339180944947363
mechanicalpropertiesofextrudedal: 0.004339180944947363
mechanicalpropertiesofgrapheneplatelet: 0.004339180944947363
mechanicalpropertiesofsomerepresentativealuminumalloys: 0.004339180944947363
mechanicalpropertiesofspraycastxxxseriesaluminiumalloys: 0.004339180944947363
mechanicalpropertiesofti: 0.004339180944947363
mechanicalpropertiesthanconventionalstainlesssteelathightemper: 0.004339180944947363
mediaandcurrenteffects: 0.004339180944947363
melchior: 0.004339180944947363
mentsfromthey: 0.004339180944947363
mentsor α stabilizers: 0.004339180944947363
mentssuchasyarebeingemployedtoimprovethepropertiesofmg: 0.004339180944947363
merit: 0.004339180944947363
metalcorrosioncan: 0.004339180944947363
metallurgy: 0.004339180944947363
metalmatrixcompositematerials: 0.004339180944947363
metalmatrixcomposites: 0.004339180944947363
metalmatrixnanocompositesreinforcedbycarbonnanotubes: 0.004339180944947363
methodforfrettingwearofti: 0.004339180944947363
methodshave: 0.004339180944947363
methodssuchastheoret: 0.004339180944947363
methodstoimprovefrettingresistance: 0.004339180944947363
meure: 0.004339180944947363
mg17al12and α : 0.004339180944947363
mg97zn1y2: 0.004339180944947363
mgal6mn: 0.004339180944947363

mgalloy: 0.004339180944947363
mgalloyattherollingdirectionis80mpahigher: 0.004339180944947363
mgalloysincludemg97zn1y2: 0.004339180944947363
mgandcuoftenusedincombinationwithzntoformmgzn2phase: 0.004339180944947363
mgandy: 0.004339180944947363
mgbasedalloyincreasewiththecontentofsn: 0.004339180944947363
mgcontent: 0.004339180944947363
mgdissolv: 0.004339180944947363
mghas: 0.004339180944947363
mgisconsideredthelighteststructuralmetal: 0.004339180944947363
mgratioisaroundthree: 0.004339180944947363
mgznphases: 0.004339180944947363
mgbni5: 0.004339180944947363
michno: 0.004339180944947363
microstructural: 0.004339180944947363
microstructuralevolutionandstresscorrosioncracking: 0.004339180944947363
microstructureandintroducesproperdistributionofthesecondphases: 0.004339180944947363
microstructureandmechanicalproperties: 0.004339180944947363
military: 0.004339180944947363
mineralize: 0.004339180944947363
minimum: 0.004339180944947363
minimumutsat1034mpa: 0.004339180944947363
mirzayi: 0.004339180944947363
mittal: 0.004339180944947363
mizedpropertiesof7000seriesal: 0.004339180944947363
mk: 0.004339180944947363
ml: 0.004339180944947363
mle: 0.004339180944947363
mli: 0.004339180944947363
mm: 0.004339180944947363
mncanberecrystallizedby: 0.004339180944947363
mncancombinewithfetoformsecondaryphaseinal: 0.004339180944947363
mncontentat1: 0.004339180944947363
moalloyswithchangeableyoung: 0.004339180944947363
modelingtheevolutionofanisotropyinal: 0.004339180944947363
modellingoftheprecipitatedphasesandpropertiesofal: 0.004339180944947363
moderate: 0.004339180944947363
modificationtechnologies: 0.004339180944947363
modifying: 0.004339180944947363
modulusarethreetimesandtwotimeshigher: 0.004339180944947363
modulusthan2219al: 0.004339180944947363
moghadam: 0.004339180944947363
moisture: 0.004339180944947363
molecularaspectsofcrackformationandhealinginglassy: 0.004339180944947363
molecule: 0.004339180944947363
moleculesabsorptionaswaterrollsoffthesurfacewiththedirt: 0.004339180944947363
moreefficientpredictionand: 0.004339180944947363
moreno: 0.004339180944947363
moutarlier: 0.004339180944947363
mpam0: 0.004339180944947363
muchgreaterthanthe loss: 0.004339180944947363
multi: 0.004339180944947363
murray: 0.004339180944947363

mwntdoesnotreducetheelongationoftianditscomposites: 0.004339180944947363
mwntfrom0to6vol: 0.004339180944947363
nacelle: 0.004339180944947363
nakajima: 0.004339180944947363
nam: 0.004339180944947363
nanocomposite: 0.004339180944947363
nanomaterials: 0.004339180944947363
nanomaterials5: 0.004339180944947363
nanoparticlesfortheenvironmentalremediation: 0.004339180944947363
nanosizeparticles: 0.004339180944947363
nanosteelsynthesisviaarcdischarge: 0.004339180944947363
nanotubescompositепroducedbymeltprocessing: 0.004339180944947363
nate: 0.004339180944947363
natural: 0.004339180944947363
naturalfibers: 0.004339180944947363
nb: 0.004339180944947363
ncc: 0.004339180944947363
near: 0.004339180944947363
nematollahzadeh: 0.004339180944947363
ness: 0.004339180944947363
neveu: 0.004339180944947363
newdesign: 0.004339180944947363
newmaterialspotentialforaircraft: 0.004339180944947363
newmetalalloyswithhigherspecificmechanicalpropertiesbyvarious: 0.004339180944947363
next: 0.004339180944947363
ni3: 0.004339180944947363
nicompositewereincreasedby21gpaand521mpawiththeincreaseof: 0.004339180944947363
nismsofheandscarererelevantbecausehydrogeninitiallyoccursatthe: 0.004339180944947363
nium: 0.004339180944947363
nj: 0.004339180944947363
nonferrousmetals: 0.004339180944947363
normally: 0.004339180944947363
notedthat: 0.004339180944947363
nucl: 0.004339180944947363
obtained: 0.004339180944947363
occurrence: 0.004339180944947363
occurs: 0.004339180944947363
oew: 0.004339180944947363
of7475alloy: 0.004339180944947363
ofadditionalalloyelements: 0.004339180944947363
ofalloperatoritems: 0.004339180944947363
ofawroughtni: 0.004339180944947363
ofcontainers: 0.004339180944947363
ofcrwas3: 0.004339180944947363
offasbeadsandtakesawaydirtontheleaves: 0.004339180944947363
offibers: 0.004339180944947363
offrettingbehaviorsfocusonti: 0.004339180944947363
offs: 0.004339180944947363
ofgraphene: 0.004339180944947363
ofliinaluminumhasbeenprovedto: 0.004339180944947363
ofmechanicalpropertiesresultsfromthecrystallographictexture: 0.004339180944947363
ofseatsandcarpetsinfutureaircraft: 0.004339180944947363
often: 0.004339180944947363

ofthe: 0.004339180944947363
oftheairbusa380and50: 0.004339180944947363
oftheirhighstrength: 0.004339180944947363
ofthelowercontentofironandsilicon: 0.004339180944947363
oftotalwearvolumebecauseoftheprotectionofthe: 0.004339180944947363
og: 0.004339180944947363
oneofthetypical: 0.004339180944947363
onlyhalfthatofal: 0.004339180944947363
onlyupto30: 0.004339180944947363
onsomeadvancednickel: 0.004339180944947363
onthefracturetoughnessofcmcareinconsistent: 0.004339180944947363
ontheinfluenceofprocessingparametersonmicrostructural: 0.004339180944947363
operatingtemperatureof1400: 0.004339180944947363
operatingtemperaturesoftheturbinesectionareusuallyintherangeof: 0.004339180944947363
operation: 0.004339180944947363
opment: 0.004339180944947363
opmentofnewlowalloysteelsandnanosteels: 0.004339180944947363
optimummaterialschoiceforthisapplication: 0.004339180944947363
orgalvaniccorrosion: 0.004339180944947363
organic: 0.004339180944947363
oscillatory: 0.004339180944947363
ostrovsky: 0.004339180944947363
otherelement: 0.004339180944947363
otherprop: 0.004339180944947363
over200mpa: 0.004339180944947363
overcome: 0.004339180944947363
oxidationbehaviorofcm: 0.004339180944947363
oxidative: 0.004339180944947363
oxidenanoparticlereservoirsforstorageandprolonged: 0.004339180944947363
oxygen: 0.004339180944947363
oyatambient: 0.004339180944947363
packedphase: 0.004339180944947363
pair: 0.004339180944947363
paiva: 0.004339180944947363
palgrave: 0.004339180944947363
pang: 0.004339180944947363
paperaimstoreviewtherecentadvancesofmajoraircraftmaterials: 0.004339180944947363
parameterbutbymultiplefactorsincludingambientmedium: 0.004339180944947363
parkin: 0.004339180944947363
particle: 0.004339180944947363
percentage: 0.004339180944947363
periordamagetolerance: 0.004339180944947363
pf: 0.004339180944947363
phaseequilibriadiffusion32: 0.004339180944947363
phaseparticles: 0.004339180944947363
phasesin: 0.004339180944947363
phasesthroughalloyingandthermal: 0.004339180944947363
phasewithhighvolume fractions: 0.004339180944947363
phastitaniumalloy: 0.004339180944947363
photo: 0.004339180944947363
photoactive: 0.004339180944947363
physicochem: 0.004339180944947363
pickering: 0.004339180944947363

pilato: 0.004339180944947363
pimenta: 0.004339180944947363
pinho: 0.004339180944947363
pinsandbolts: 0.004339180944947363
pipelinesandmicrocap: 0.004339180944947363
pittingcorrosion: 0.004339180944947363
piy: 0.004339180944947363
plane: 0.004339180944947363
plasticdeformationbehaviorandprocessingmapsofani: 0.004339180944947363
plenarylecture: 0.004339180944947363
point: 0.004339180944947363
polar: 0.004339180944947363
polymercomposites: 0.004339180944947363
polymeric: 0.004339180944947363
polymermatrixcomposites: 0.004339180944947363
polymermatrixcompositesand: 0.004339180944947363
polymersystemtoimprovethe mechanical properties of pmc: 0.004339180944947363
polystyrene composites: 0.004339180944947363
ponents that are prone to fail by other modes: 0.004339180944947363
pora: 0.004339180944947363
ported that the addition of chromium in ni: 0.004339180944947363
posite increased to 4: 0.004339180944947363
posites are normally used in high: 0.004339180944947363
posites now constitute more than 25: 0.004339180944947363
position: 0.004339180944947363
potent: 0.004339180944947363
potential: 0.004339180944947363
potentially: 0.004339180944947363
potentially used in aircraft structural applications because of the ability: 0.004339180944947363
powder: 0.004339180944947363
pp: 0.004339180944947363
prangnell: 0.004339180944947363
prasad: 0.004339180944947363
prater: 0.004339180944947363
precipitation behavior and tensile properties of new high strength: 0.004339180944947363
precipitation in an al: 0.004339180944947363
present state and future of magnesium application in: 0.004339180944947363
press: 0.004339180944947363
pressure: 0.004339180944947363
presuel: 0.004339180944947363
prevent: 0.004339180944947363
prevention methods against hydrogen degradation of steel: 0.004339180944947363
prevention methods for corrosion: 0.004339180944947363
primary material in this field for many years because of their well: 0.004339180944947363
primary α phase: 0.004339180944947363
procedia: 0.004339180944947363
proceedings of iccm 13: 0.004339180944947363
proceedings of the 2013 international symposium on: 0.004339180944947363
produce: 0.004339180944947363
progress in structural materials for aerospace systems: 0.004339180944947363
progress of ceramic matrix composites brake materials for aircraft: 0.004339180944947363
propeller cones: 0.004339180944947363
properties and applications: 0.004339180944947363

propertiesofahot: 0.004339180944947363
propertiesofas: 0.004339180944947363
propertiesofsomemetalmatricesofcomposites: 0.004339180944947363
propertiesofsomereinforcementsofcomposites: 0.004339180944947363
propertiesoftimatrixcompositealsohavebeenstudiedbykondoh: 0.004339180944947363
protect: 0.004339180944947363
protective: 0.004339180944947363
protectiveabilityofhybridnano: 0.004339180944947363
proven: 0.004339180944947363
provide: 0.004339180944947363
providealocalcorrosionbarrier: 0.004339180944947363
providesuitabledamagetoleranceforthe: 0.004339180944947363
providing: 0.004339180944947363
prusty: 0.004339180944947363
pureferriticstainlesssteels: 0.004339180944947363
purposeoflong: 0.004339180944947363
qian: 0.004339180944947363
qianetal: 0.004339180944947363
quirementsforfurtherimprovementofmechanicalpropertiesofmmc: 0.004339180944947363
radiation: 0.004339180944947363
radical: 0.004339180944947363
raising: 0.004339180944947363
raja: 0.004339180944947363
ran: 0.004339180944947363
randmodelingofhightemperaturedeformationofan $\alpha\beta$: 0.004339180944947363
rapid: 0.004339180944947363
rapiddecreasein: 0.004339180944947363
rcf: 0.004339180944947363
reach: 0.004339180944947363
reachupto1200: 0.004339180944947363
received21august2017: 0.004339180944947363
receivedinrevisedform16january2018: 0.004339180944947363
recentadvancesinaircraftmaterials: 0.004339180944947363
recentadvancesingraphenebasedpolymercomposites: 0.004339180944947363
recentadvancesoncarbonnanotubesandgraphene: 0.004339180944947363
recentadvancesonthedevelopmentofmagnesiumalloysfor: 0.004339180944947363
recentaerospacematerialsstillfacesomemajor: 0.004339180944947363
recentdevelopments: 0.004339180944947363
recentdevelopmentsinadvancedaircraftaluminiumalloys: 0.004339180944947363
recentfewyears: 0.004339180944947363
recentinvestigationsof: 0.004339180944947363
recentnano: 0.004339180944947363
recentpat: 0.004339180944947363
recentprogressinthedevelopmentandpropertiesofnovelmetal: 0.004339180944947363
recentstudies: 0.004339180944947363
recentstudiesfocusonthedevel: 0.004339180944947363
recentworksfocusonthedevelopmentof: 0.004339180944947363
recombination: 0.004339180944947363
recrystallizationresistanceinal: 0.004339180944947363
recyclability: 0.004339180944947363
recyclingcarbonfibrereinforcedpolymersforstructural: 0.004339180944947363
reduced: 0.004339180944947363
reducedby3: 0.004339180944947363

reductionthroughweightreductionandservicelifeextensionofaircraft: 0.004339180944947363
reference: 0.004339180944947363
refinementeffectofcerium: 0.004339180944947363
refining: 0.004339180944947363
region: 0.004339180944947363
reinforcedaluminummatrixcomposites: 0.004339180944947363
reinforcedceramicsnanocomposites: 0.004339180944947363
reinforcedcoppernanocompositesfabricatedbyelectrolessdepositionprocess: 0.004339180944947363
reinforcedepoxycomposites: 0.004339180944947363
reinforcedmetal: 0.004339180944947363
reinforcedpolymercomposites: 0.004339180944947363
reinforcedpolymernanocomposites: 0.004339180944947363
reinforcement: 0.004339180944947363
relatedly: 0.004339180944947363
relation: 0.004339180944947363
relatively: 0.004339180944947363
releasecharacteristicsofselectedcarbonnanotubepolymer: 0.004339180944947363
releaseofthecorrosioninhibitors: 0.004339180944947363
reliant: 0.004339180944947363
relies: 0.004339180944947363
remainsimportantairframestructurematerialsbecauseoftheirseveral: 0.004339180944947363
remarkablesolid: 0.004339180944947363
removal: 0.004339180944947363
reportedthatthetensile: 0.004339180944947363
reportedthattheutsandysofanal: 0.004339180944947363
reportedthatwhenthe: 0.004339180944947363
reportedtheeffectsofcarbonnanotubes: 0.004339180944947363
reportedthefracturetoughnessofaluminaceramiccom: 0.004339180944947363
reportedto: 0.004339180944947363
require: 0.004339180944947363
requires: 0.004339180944947363
rese: 0.004339180944947363
researched: 0.004339180944947363
researcher: 0.004339180944947363
researchhasshownthattheopti: 0.004339180944947363
researchonmg: 0.004339180944947363
resis: 0.004339180944947363
resistanceof: 0.004339180944947363
resistanceofal: 0.004339180944947363
resistancestrength: 0.004339180944947363
resistancewasincreasedwiththeincreaseofsizeandspacingofgrain: 0.004339180944947363
resistantmetalliccoatings: 0.004339180944947363
resultedbycuandmgcanactasanodicsitetoreducecorrosionresis: 0.004339180944947363
resulting: 0.004339180944947363
resultingcloselamellarspacingstohinderdislocationmovement: 0.004339180944947363
resultingin: 0.004339180944947363
resultingindifferentselectioncriteriaforaircraftenginematerials: 0.004339180944947363
resultingthehighstrengthofni: 0.004339180944947363
reversible: 0.004339180944947363
review: 0.004339180944947363
rezende: 0.004339180944947363
ri: 0.004339180944947363
rial: 0.004339180944947363

rising: 0.004339180944947363
risingengine temperatureandmaintainthepropermechanicalproper: 0.004339180944947363
risinguseofcompositematerialsintheaerospaceindustryismainlydue: 0.004339180944947363
rn: 0.004339180944947363
ro: 0.004339180944947363
roleofvacanciesincoprecipitationof δ 0: 0.004339180944947363
rom: 0.004339180944947363
rong: 0.004339180944947363
ronment: 0.004339180944947363
ronmentaspects: 0.004339180944947363
rosette: 0.004339180944947363
ro spaceand space: 0.004339180944947363
rotaryfrettingwearof7075alloyinmediaofoilandwater: 0.004339180944947363
rotor: 0.004339180944947363
rratreatmentonthestrengthandsc: 0.004339180944947363
rrep: 0.004339180944947363
rubberprocess: 0.004339180944947363
rupture: 0.004339180944947363
rupturepropertybycradditioninni: 0.004339180944947363
s100: 0.004339180944947363
s96: 0.004339180944947363
saba: 0.004339180944947363
sae: 0.004339180944947363
safeloadingcondition: 0.004339180944947363
salamci: 0.004339180944947363
samevolumeofaluminumusedandby77: 0.004339180944947363
santos: 0.004339180944947363
sary: 0.004339180944947363
save: 0.004339180944947363
sccandhe: 0.004339180944947363
sccandhebehaviorsin: 0.004339180944947363
sccisresultedfromthree: 0.004339180944947363
science: 0.004339180944947363
scriptamater: 0.004339180944947363
seal: 0.004339180944947363
search: 0.004339180944947363
sectioncomponentsrequirehighspecificstrengthandcorrosionresistant: 0.004339180944947363
segregation: 0.004339180944947363
semiproducs: 0.004339180944947363
seraj: 0.004339180944947363
several: 0.004339180944947363
shaftfittings: 0.004339180944947363
shape: 0.004339180944947363
shaw: 0.004339180944947363
shekhar: 0.004339180944947363
shen: 0.004339180944947363
shoji: 0.004339180944947363
shortcoming: 0.004339180944947363
show: 0.004339180944947363
showninfig: 0.004339180944947363
shownintable2: 0.004339180944947363
shu: 0.004339180944947363
shuey: 0.004339180944947363

si3n4: 0.004339180944947363
sialloy: 0.004339180944947363
sialloys: 0.004339180944947363
sicwhisker: 0.004339180944947363
siforstructuralapplications: 0.004339180944947363
significantlyimprovethefatiguelifeinhigh: 0.004339180944947363
sikdar: 0.004339180944947363
sil: 0.004339180944947363
silicon: 0.004339180944947363
sim: 0.004339180944947363
similar: 0.004339180944947363
similarsituationsoccurredonys: 0.004339180944947363
sin: 0.004339180944947363
since: 0.004339180944947363
singh: 0.004339180944947363
singlecrystalsuperalloys: 0.004339180944947363
sintering: 0.004339180944947363
small: 0.004339180944947363
smaterials: 0.004339180944947363
smaterialsfocusonhowtowithstandthe: 0.004339180944947363
smc: 0.004339180944947363
smodulus: 0.004339180944947363
smodulusandyieldstrengthof: 0.004339180944947363
smodulusforspinal: 0.004339180944947363
smodulusincreasesby6: 0.004339180944947363
sn: 0.004339180944947363
soc: 0.004339180944947363
softening: 0.004339180944947363
softer: 0.004339180944947363
solidifiedcm: 0.004339180944947363
soliveri: 0.004339180944947363
solomon: 0.004339180944947363
solubility12: 0.004339180944947363
solutestrengthening: 0.004339180944947363
solutionstrengthening: 0.004339180944947363
someal: 0.004339180944947363
someconsiderationsonthemitigationoffretting: 0.004339180944947363
someelements: 0.004339180944947363
someelementshavebeenstudiedinrecentyearstoimprove: 0.004339180944947363
someelementssuchaszrhasbeenreportedtoimprovehardness: 0.004339180944947363
somefiberssuchasceramicreinforcementandcon: 0.004339180944947363
sometetalalloysaresummarizedinfig: 0.004339180944947363
sometetalsandal: 0.004339180944947363
somerresearch: 0.004339180944947363
someself: 0.004339180944947363
somesuitablematerialsfor: 0.004339180944947363
somesusceptiblemetallicmaterialssuchasteels: 0.004339180944947363
sometypicalutssare: 0.004339180944947363
sommers: 0.004339180944947363
soo: 0.004339180944947363
soori: 0.004339180944947363
soutis: 0.004339180944947363
spacedstackingfaults: 0.004339180944947363

space materials and have caused a loss of: 0.004339180944947363
spark plasmas intermetallic: 0.004339180944947363
specifically: 0.004339180944947363
specific mechanical properties and challenges such as: 0.004339180944947363
speed: 0.004339180944947363
springer: 0.004339180944947363
springer science: 0.004339180944947363
springs used in Boeing aircraft: 0.004339180944947363
Sridhar: 0.004339180944947363
Srinivasu: 0.004339180944947363
Staley: 0.004339180944947363
Starink: 0.004339180944947363
state of the art in beta titanium alloys for airframe applications: 0.004339180944947363
steels include AISI 316L: 0.004339180944947363
steel still plays an important role: 0.004339180944947363
steels with ultra: 0.004339180944947363
still: 0.004339180944947363
still face major challenges: 0.004339180944947363
still limited by the insufficient mechanical properties such as strength: 0.004339180944947363
strain to: 0.004339180944947363
strategy: 0.004339180944947363
strength and corrosion resistance than new materials such as light alloys: 0.004339180944947363
strengthened: 0.004339180944947363
strength in b.c. containing ferritic stainless steels: 0.004339180944947363
strength of an: 0.004339180944947363
strength of a Ti: 0.004339180944947363
strengths and: 0.004339180944947363
strengths of Mg: 0.004339180944947363
strength steel: 0.004339180944947363
strength steels at high: 0.004339180944947363
stress corrosion cracking behavior of the: 0.004339180944947363
stress corrosion cracking is considered as one of the most dangerous: 0.004339180944947363
stress regions such as aircraft landing gear and aircraft spring: 0.004339180944947363
stringers and stabilizers where strength is the: 0.004339180944947363
stronger bonds between alloying atoms and titanium atoms than those of: 0.004339180944947363
structural components and engine parts such as the bearing shaft: 0.004339180944947363
structure and mechanical properties of Ti: 0.004339180944947363
structure and mechanical properties of Ti-Zr binary alloy after Al: 0.004339180944947363
structure applications such as sailers: 0.004339180944947363
structures because of the strength: 0.004339180944947363
stt: 0.004339180944947363
studied as aircraft fuselage material where the damage tolerance is first: 0.004339180944947363
studied some alloying elements in: 0.004339180944947363
studied the effects of Mn on the properties of Ni matrix: 0.004339180944947363
study: 0.004339180944947363
study on polycarbonate: 0.004339180944947363
subjected from service: 0.004339180944947363
submicrocrystalline structure produced by severe plastic deformation: 0.004339180944947363
such as aircraft spring: 0.004339180944947363
such as Al: 0.004339180944947363
such as Al-7Cu-2Fe: 0.004339180944947363
such as Al and Zr: 0.004339180944947363
such as CFRP: 0.004339180944947363

suchasflax: 0.004339180944947363
suchasgraphene: 0.004339180944947363
suchasgrapheneplatelet: 0.004339180944947363
suchasironandsil: 0.004339180944947363
suchassiliconcarbide: 0.004339180944947363
suchassn: 0.004339180944947363
suchasuniform: 0.004339180944947363
suchasv: 0.004339180944947363
suchhighspecificpropertiesofmg: 0.004339180944947363
sules: 0.004339180944947363
sulochana: 0.004339180944947363
sulphate: 0.004339180944947363
superalloysarewidely: 0.004339180944947363
superalloysathightemperature: 0.004339180944947363
superalloyscanreachupto300mpaat700: 0.004339180944947363
superhighstrengthaluminumalloywithzraddition: 0.004339180944947363
superiormechnicalperformanceandcorrosionresistancetoachieveimprovementsinbothperformanceandlife: 0.004339180944947363
supersonicaircrafts: 0.004339180944947363
supplysoluteions: 0.004339180944947363
support: 0.004339180944947363
supportforboththestaticweightofaircraftandadditionalload: 0.004339180944947363
surfacemodification: 0.004339180944947363
susceptibilitytoscc: 0.004339180944947363
susceptiblealloy: 0.004339180944947363
sy: 0.004339180944947363
synchrotronstudyonloadpartitioningbetweenferrite: 0.004339180944947363
t3: 0.004339180944947363
t3511: 0.004339180944947363
t6aerospacealloy: 0.004339180944947363
t6atsub: 0.004339180944947363
t7351: 0.004339180944947363
t73651: 0.004339180944947363
t82: 0.004339180944947363
t84: 0.004339180944947363
t851: 0.004339180944947363
t8al: 0.004339180944947363
t8e41: 0.004339180944947363
table1: 0.004339180944947363
table2: 0.004339180944947363
table3: 0.004339180944947363
table4: 0.004339180944947363
take: 0.004339180944947363
takingmoreandmoreimportantrolesinaircrafts: 0.004339180944947363
tan: 0.004339180944947363
tanceof2024alloy: 0.004339180944947363
taxiing: 0.004339180944947363
tc21: 0.004339180944947363
technologyreviewandmarketoutlook: 0.004339180944947363
temperatureresistanceofti: 0.004339180944947363
temperaturesectionsinaircraftsuchas: 0.004339180944947363
tempering: 0.004339180944947363
tensileandfracturetoughnessofhighstrengthβtitanium: 0.004339180944947363

tensilestrengthofhigh: 0.004339180944947363
tent: 0.004339180944947363
tentinalnotonlystructuralapplicationsbutalsosomeengineparts: 0.004339180944947363
tentofgrapheneplateletshouldbelimitedatcriticalvalue: 0.004339180944947363
termusein: 0.004339180944947363
test: 0.004339180944947363
texture: 0.004339180944947363
textureand: 0.004339180944947363
textureevolutionandanisotropyinal: 0.004339180944947363
than2024alloy: 0.004339180944947363
than7075alloy: 0.004339180944947363
thanitisat60: 0.004339180944947363
thanthestrengthofstainlesssteelat700: 0.004339180944947363
thanthoseof: 0.004339180944947363
thatbondingstrengthandtoughnesshaveagreatereffectthanthe: 0.004339180944947363
thatdifferentamountsofmulti: 0.004339180944947363
thattheadditionofalimprovedtheoxidationresistance: 0.004339180944947363
theadditionofmwntfrom0: 0.004339180944947363
theadditionofzr: 0.004339180944947363
theal: 0.004339180944947363
thealpha: 0.004339180944947363
thealphastabilizingadditionsenablethesealloystoservein: 0.004339180944947363
theanisotropy: 0.004339180944947363
theanisotropyproblemofal: 0.004339180944947363
theapplicablepredictionapproachremainsnonex: 0.004339180944947363
theapplicationsofaerospace materialsare: 0.004339180944947363
theapplicationsofni: 0.004339180944947363
theattractivenessoflight: 0.004339180944947363
theattractivenessofti: 0.004339180944947363
thebenefitofzrinmg: 0.004339180944947363
thecf: 0.004339180944947363
thecompositionofsteelhaschangedfromcarbonandiron: 0.004339180944947363
thecon: 0.004339180944947363
thecorrosionresistanceofmg: 0.004339180944947363
thecrackscanbere: 0.004339180944947363
thecrackshealingprocessismoreefficientbymixingepoxymonomer: 0.004339180944947363
thecriteriafor: 0.004339180944947363
thedensityofal: 0.004339180944947363
thedensityofaluminumis: 0.004339180944947363
thedensityofcarbonfiber: 0.004339180944947363
thedesigncriteriafortheaircraftstructuralmaterialsrequirethe: 0.004339180944947363
thedesigncriteriaoftheaerospace materials: 0.004339180944947363
thedesigncriteriaoftheaircraftengine: 0.004339180944947363
thedesigncriteriaoftheairframematerials: 0.004339180944947363
thedevelopmentofaircraftmaterialscanbetracedbacktothefirst: 0.004339180944947363
thedevelopmentofbothaircraftstructuralmaterialsandenginemate: 0.004339180944947363
thedifferenceinhardnessbetweentwomatingpairscangreatly: 0.004339180944947363
theeffectofcopperandmolybdenumonpittingcorrosionandstress: 0.004339180944947363
theeffectofmnandzrdispersoid: 0.004339180944947363
theeffectofmnonthemechanicalbehaviorofalloys: 0.004339180944947363
theeffectofznconcentrationonthe corrosionbehaviorofmg: 0.004339180944947363
theeffectsofcarbonnano: 0.004339180944947363
theeffectsofcntsonmechanical: 0.004339180944947363

theelongationrationdroppedto8: 0.004339180944947363
theengine: 0.004339180944947363
theexcellentpropertiesoffiberscontributetoad: 0.004339180944947363
thef: 0.004339180944947363
thefunctionsofthecoatingare: 0.004339180944947363
thegeneraltheorythat: 0.004339180944947363
theglasstransitiontemperaturebecauseoftheinterdiffusionofmolec: 0.004339180944947363
thehardanodizedcoatinghasnoornega: 0.004339180944947363
thehighcontentof: 0.004339180944947363
thehighstrengthofbetatitaniumalloysisresulted: 0.004339180944947363
thehotcorrosionandoxidationresistance: 0.004339180944947363
thehotsectionsofaircraft: 0.004339180944947363
thehydrophobic: 0.004339180944947363
theincreasedductilityinmainlyduetothe growth of sphericity: 0.004339180944947363
theincreasinguseofcompositematerialsintheaerospace: 0.004339180944947363
theinfluenceoffibercontentonpropertiesofinjectionmoldedflax: 0.004339180944947363
theinfluenceofhighersurfacehardnesson: 0.004339180944947363
theinfluenceofsurfacehardnessonthe fretting wear of steel: 0.004339180944947363
theinnovativematerials: 0.004339180944947363
theirprotectabilityafterdamages: 0.004339180944947363
thelandinggear: 0.004339180944947363
theleadingedgeslats: 0.004339180944947363
thelow: 0.004339180944947363
thelowersurfaceisundertheoppositeloads: 0.004339180944947363
themachinabilityofnickel: 0.004339180944947363
themaindisadvantageofnaturalfibers: 0.004339180944947363
themaindrivingforceiscost: 0.004339180944947363
themajoreffectofliinalistoreducethedensityof: 0.004339180944947363
thematerialcanbeappliedtothefabric: 0.004339180944947363
thematerialpropertyrequirementsforaerospacematerialsvarywith: 0.004339180944947363
themaximumsolubilityofliinalreachesupto14: 0.004339180944947363
themaximumtensilestrengthof: 0.004339180944947363
themecha: 0.004339180944947363
themechanicalpropertiesofcnt: 0.004339180944947363
themechanicalpropertiesoftheextrudedtiandits: 0.004339180944947363
themechanisms of: 0.004339180944947363
themg97zn1y2alloyhasthe: 0.004339180944947363
themicrohardnessofti: 0.004339180944947363
themicrostructure: 0.004339180944947363
themicrostructureandmechanicalpropertiesofdeposited: 0.004339180944947363
themicrostructureevolutionanditseffectonthemechanical: 0.004339180944947363
themostattractivetypeoflowalloysteel: 0.004339180944947363
thenanosteelshaveahigherstrengthandbettercorrosion: 0.004339180944947363
theoperatingemptyweight: 0.004339180944947363
theoperatingtempera: 0.004339180944947363
theoptimum: 0.004339180944947363
theoreticalstudyoftheeffectsofalloyingelements on the strength: 0.004339180944947363
theory: 0.004339180944947363
theoryandpractice: 0.004339180944947363
theoxidelayer: 0.004339180944947363
theparticularcomponentunderconsideration: 0.004339180944947363
thepcentageoftotalstructuralweightattrib: 0.004339180944947363
thepresentreviewshowsthatsignificantprogresshasbeenmadein: 0.004339180944947363

the prominent advantages of polymer matrix composites: 0.004339180944947363
the properties of some 2000 series alloys: 0.004339180944947363
the rapid growth in the aerospace industry gives an impetus for the: 0.004339180944947363
the recent advanced 2199al: 0.004339180944947363
the recent developed 7085al: 0.004339180944947363
the recent researches on the development of Ti: 0.004339180944947363
therefore enabling the straightforward selection of materials: 0.004339180944947363
the relatively low yield strength limits the use of: 0.004339180944947363
the results showed that CNT can greatly improve the: 0.004339180944947363
the results showed that fatigue life of this: 0.004339180944947363
therm: 0.004339180944947363
thermal exposure: 0.004339180944947363
thermo mechanical processing and heat treatment of: 0.004339180944947363
thermo plastic and thermo set: 0.004339180944947363
the role of heat treatment and alloying elements on hydrogen: 0.004339180944947363
these alloying atoms: 0.004339180944947363
these alloys have been applied: 0.004339180944947363
these properties: 0.004339180944947363
these two alloys are widely: 0.004339180944947363
the solu: 0.004339180944947363
the strength efficiency of Al-Ti: 0.004339180944947363
the susceptibility of Al: 0.004339180944947363
the synergistic effect of Ti addition on microstructure: 0.004339180944947363
the tensile strength: 0.004339180944947363
the tensile strength and elastic: 0.004339180944947363
the tensile strength can be increased: 0.004339180944947363
the typical: 0.004339180944947363
the use of beta titanium alloys in the aerospace industry: 0.004339180944947363
the use of composite materials has significantly increased and com: 0.004339180944947363
the use of mg: 0.004339180944947363
the use of ni: 0.004339180944947363
the use of polymer matrix composites: 0.004339180944947363
the use of β titanium alloys in the aerospace industry: 0.004339180944947363
the α increases to 216: 0.004339180944947363
the α of mg: 0.004339180944947363
the widely used materials for this appli: 0.004339180944947363
the wing is subjected to bending during: 0.004339180944947363
the yield: 0.004339180944947363
the yield strength: 0.004339180944947363
the yield strength of: 0.004339180944947363
the yield strength of wrought ni: 0.004339180944947363
the yield strength was: 0.004339180944947363
the young: 0.004339180944947363
they reported: 0.004339180944947363
thickness of cm: 0.004339180944947363
thirds that of aluminum and a quarter of steel: 0.004339180944947363
third that of steel: 0.004339180944947363
this concept requires airframe materials to: 0.004339180944947363
this requires the materials: 0.004339180944947363
this review focuses on the following topics: 0.004339180944947363
this situation has been changed in: 0.004339180944947363
thrust improvement and weight reduction for aircraft engines have: 0.004339180944947363
Ti-6Al-4V: 0.004339180944947363

ti6al4vandti555: 0.004339180944947363
tatomiccluster: 0.004339180944947363
tatoms: 0.004339180944947363
tidiboride: 0.004339180944947363
tie: 0.004339180944947363
tigatedasacandidateforaircraftbrakeswherethetemperaturecould: 0.004339180944947363
tigatedthecrackhealingbehaviorofsomethermoplasticmaterialsand: 0.004339180944947363
tigue: 0.004339180944947363
tija: 0.004339180944947363
timetal: 0.004339180944947363
tio: 0.004339180944947363
tionfactoronfrettingwearresistanceofdiamond: 0.004339180944947363
tip: 0.004339180944947363
tipsofcracksinanaqueousenvironment: 0.004339180944947363
tita: 0.004339180944947363
titanate: 0.004339180944947363
titaniumalloyproductiontechnology: 0.004339180944947363
titaniumalloys: 0.004339180944947363
titaniumalloyusingprocessingmap: 0.004339180944947363
titaniumusageinsomeaircrafts: 0.004339180944947363
tiu: 0.004339180944947363
tiveeffectonfatiguelifeinhigh: 0.004339180944947363
tjong: 0.004339180944947363
tl: 0.004339180944947363
to0: 0.004339180944947363
to15: 0.004339180944947363
to19: 0.004339180944947363
to20wt: 0.004339180944947363
to5wt: 0.004339180944947363
tocatalytic: 0.004339180944947363
today11: 0.004339180944947363
today5: 0.004339180944947363
tohealmicrocracksbeforecrackgrowthtofailure: 0.004339180944947363
toimprovethe mechanical properties of al alloys: 0.004339180944947363
toimprovethepoorcorrosionresistanceandinsufficientmechanical: 0.004339180944947363
toleranceof: 0.004339180944947363
toovercomethisshortcoming: 0.004339180944947363
top: 0.004339180944947363
topic: 0.004339180944947363
totalmaterialsusedinboeingseriesaircraft: 0.004339180944947363
totheirhigherspecificstrengthandbettercorrosionandfatigueresis: 0.004339180944947363
tothesizeandmodulusmisfitsbetweenalandzr: 0.004339180944947363
tougheningingrapheneceramiccomposites: 0.004339180944947363
transport: 0.004339180944947363
treatable: 0.004339180944947363
treated: 0.004339180944947363
treatment: 0.004339180944947363
tsivoulas: 0.004339180944947363
tt: 0.004339180944947363
tubesonmmchavebeenstudiedbyliaoetal: 0.004339180944947363
turbinecomponents: 0.004339180944947363
turbinesection: 0.004339180944947363
tureof600: 0.004339180944947363

tures: 0.004339180944947363
turk: 0.004339180944947363
typebio: 0.004339180944947363
typicalyieldstrengthandelongationofsomeetalalloys: 0.004339180944947363
u1: 0.004339180944947363
uematsu: 0.004339180944947363
uh60: 0.004339180944947363
uhssarepronetodegradationby: 0.004339180944947363
ular: 0.004339180944947363
ultimatetensilestrength: 0.004339180944947363
ultimatetensilestrengths: 0.004339180944947363
ultrahigh: 0.004339180944947363
ultrastrongmgalloyvianano: 0.004339180944947363
uluc: 0.004339180944947363
undercompressionduringtheflightandtensionduringthetaxing: 0.004339180944947363
understandingthebasics: 0.004339180944947363
undertheconditionofmanualintervention: 0.004339180944947363
upper: 0.004339180944947363
uptakeinaermet100ultrahigh: 0.004339180944947363
upto0: 0.004339180944947363
ure: 0.004339180944947363
usedforfrettingdamageprevention: 0.004339180944947363
usedinamilitarytransportaircraft: 0.004339180944947363
usedinfuselagesbecauseofitsmoderateyieldstrength: 0.004339180944947363
usedinhigh: 0.004339180944947363
usedinsomeaeroenginepartssuchasthecombustorandturbinesection: 0.004339180944947363
ush: 0.004339180944947363
uts $\frac{1}{4}$ 1200mpa: 0.004339180944947363
uts $\frac{1}{4}$ 1370mpa: 0.004339180944947363
uts $\frac{1}{4}$ 428mpa: 0.004339180944947363
uts $\frac{1}{4}$ 476mpa: 0.004339180944947363
uts $\frac{1}{4}$ 841mpa: 0.004339180944947363
uts $\frac{1}{4}$ 915mpa: 0.004339180944947363
v8: 0.004339180944947363
value: 0.004339180944947363
vancesinpmcs: 0.004339180944947363
various: 0.004339180944947363
variousinvestigations: 0.004339180944947363
variousstudieshaveinvestigatedcorrosionbehaviorsindifferent: 0.004339180944947363
variousworks: 0.004339180944947363
vasudevan: 0.004339180944947363
vehicle: 0.004339180944947363
veiga: 0.004339180944947363
ventional: 0.004339180944947363
ventionalcarbonfiberwereinvestigatedfortheirpotentialtoimprove: 0.004339180944947363
vickers: 0.004339180944947363
vickershardness: 0.004339180944947363
violet: 0.004339180944947363
vk: 0.004339180944947363
vol: 0.004339180944947363
walker: 0.004339180944947363
wallcarbonnanotube: 0.004339180944947363
wallcarbonnanotubes: 0.004339180944947363

walledcarbon: 0.004339180944947363
wallednanotube: 0.004339180944947363
wan: 0.004339180944947363
wanetal: 0.004339180944947363
ward: 0.004339180944947363
warren: 0.004339180944947363
wasincreasedto3: 0.004339180944947363
wastemanag: 0.004339180944947363
wayinteraction: 0.004339180944947363
wbased: 0.004339180944947363
we43a: 0.004339180944947363
weakeninter: 0.004339180944947363
weakness: 0.004339180944947363
wear301: 0.004339180944947363
wear309: 0.004339180944947363
wear318: 0.004339180944947363
wearcancreateinitiatecracksonthedamagedsurfaceandreducefa: 0.004339180944947363
wearvolumesofarangeofequal: 0.004339180944947363
wei: 0.004339180944947363
weightalloysinthemanufacturingofhigh: 0.004339180944947363
weighratio: 0.004339180944947363
wellastoprovideapictureofcurrentchallengesandfuturetrends: 0.004339180944947363
wen: 0.004339180944947363
werestudiedas: 0.004339180944947363
whatiscorrosion: 0.004339180944947363
when1wt: 0.004339180944947363
whencomparedtocon: 0.004339180944947363
whencomparedtothesame: 0.004339180944947363
whenthecontentofyincreasedto1: 0.004339180944947363
whenthecontentofznreachedupto4wt: 0.004339180944947363
whenthecontentofzrincreasedfrom0wt: 0.004339180944947363
whenthecracksizereachedthecriticalvalue: 0.004339180944947363
whenwaterispouredovertheseleaves: 0.004339180944947363
whereoperatingtemperaturesrangebetween1100and1250: 0.004339180944947363
whicharebeneficialtoimprovethestrengthsofmg: 0.004339180944947363
whichareextrinsicself: 0.004339180944947363
whicharemechanical: 0.004339180944947363
whichcanbesignificantlyimprovedbyincreasing: 0.004339180944947363
whichcanincrease: 0.004339180944947363
whichcansatisfytheincreasing: 0.004339180944947363
whichcontribute to themg: 0.004339180944947363
whicheasily suffer fretting damage: 0.004339180944947363
whichentirelyormostlyconsistsof α phasewithneutralalloyele: 0.004339180944947363
whichgreatlyexceedsthelimitofti: 0.004339180944947363
whichis: 0.004339180944947363
whichis2: 0.004339180944947363
whichisbeneficialtosolid: 0.004339180944947363
whichismuchgreaterthanthe loss caused by natural disasters: 0.004339180944947363
whichisstoredinma: 0.004339180944947363
whichistheweight: 0.004339180944947363
whilethetensilestrengthofmg: 0.004339180944947363
whiletheyieldstrength: 0.004339180944947363
whileyoung: 0.004339180944947363

whyaircraftfail: 0.004339180944947363
widelyinvestigatediscoating: 0.004339180944947363
widelystudiedinrecentyearsbecauseoftheirattractiveproperties: 0.004339180944947363
widelystudiedisalelement: 0.004339180944947363
wiek: 0.004339180944947363
williams: 0.004339180944947363
winzer: 0.004339180944947363
with20: 0.004339180944947363
without: 0.004339180944947363
withstandtemperaturesbetween290and345: 0.004339180944947363
withthatofconventional2524alloyand2014alloy: 0.004339180944947363
withthe: 0.004339180944947363
withthedevelopmentofnew: 0.004339180944947363
withthehighestyieldstrengthachievedatthepointwhen: 0.004339180944947363
withtheincreasingofalcontentfrom0: 0.004339180944947363
witnessed: 0.004339180944947363
wood: 0.004339180944947363
wooden: 0.004339180944947363
woodtli: 0.004339180944947363
wrought: 0.004339180944947363
wroughtmagnesiumalloyaz31undercontrolledcathodicpotentials: 0.004339180944947363
wroughtmg: 0.004339180944947363
wsuperalloycanreachupto550mpaat800: 0.004339180944947363
xuebaoactamater: 0.004339180944947363
xuesong: 0.004339180944947363
xuetal: 0.004339180944947363
xuezhang: 0.004339180944947363
xzn: 0.004339180944947363
yan: 0.004339180944947363
yareoftenusedincombinationwithzntoimprovemechanicalprop: 0.004339180944947363
yazdani: 0.004339180944947363
yet: 0.004339180944947363
yh: 0.004339180944947363
yieldstrengthofaa2198al: 0.004339180944947363
yieldstrengths: 0.004339180944947363
yongjun: 0.004339180944947363
ys¼504mpa: 0.004339180944947363
ys¼510mpa: 0.004339180944947363
ys¼610mpa: 0.004339180944947363
ys¼640mpa: 0.004339180944947363
ys¼689mpa: 0.004339180944947363
ys¼845mpa: 0.004339180944947363
zalnez: 0.004339180944947363
zeng: 0.004339180944947363
zerotemperature: 0.004339180944947363
zgün: 0.004339180944947363
zhanga: 0.004339180944947363
zhao: 0.004339180944947363
zheludkevich: 0.004339180944947363
zhengetal: 0.004339180944947363
zherebtsov: 0.004339180944947363
zinchasthelargestsolubility: 0.004339180944947363
zirconia: 0.004339180944947363

zirconiumaddition: 0.004339180944947363
zk60: 0.004339180944947363
znbased: 0.004339180944947363
znbasedalloy: 0.004339180944947363
znbasedalloydecreaseswiththe: 0.004339180944947363
znbasedalloyisachievedat2: 0.004339180944947363
znbasedalloyscanbereducedwheny: 0.004339180944947363
znbasedalloysexhibitthehigheststrengthofanyal: 0.004339180944947363
znbasedalloysrises: 0.004339180944947363
znbasedalloyswithbalancedproperties: 0.004339180944947363
znelementcanimprovethestrength: 0.004339180944947363
zralloywasincreasedto230mpabyadding1: 0.004339180944947363
zrand: 0.004339180944947363
zrbasedalloysismainlydue: 0.004339180944947363
zrisconsideredthebestrefinerformg: 0.004339180944947363
zrunderagingconditionhasahighervaluesinbothelongation: 0.004339180944947363