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NONFERROUS ALLOYS

1. GENERAL
- Ti-17 may be classified as a "beta-rich" alpha-beta alloy since its beta stabilizer content (Mo + Cr) is slightly higher than that of present commercial alloys. The alloy was developed by the General Electric Company for use in jet engines as a fan and compressor disk material. It can be processed in either the beta or alpha plus beta region and the subsequent heat treatment depends on process history.
- The alloy is new and has yet to be adopted on a large scale commercial basis, however, it does appear to have an improved combination of properties relative to other heat-treatable titanium alloys. For example, it can be heat treated to a yield strength level of 150-170 ksi which is similar to that of Ti-6Al-6V-2Sn and 20-30 ksi higher than Ti-6Al-4V. Toughness and ductility properties are higher than for Ti-6Al-6V-2Sn and creep behavior is superior to Ti-6Al-4V. The alloy has hardenability characteristics comparable to some of the beta type alloys, however, it has lower density plus higher modulus and creep strength than the beta alloys.
- To date approximately 15 production size ingots (7,000 to 14,000 lbs in weight) have been melted and then converted to billet sizes of 8-12 inch diameter using normal conversion practices. No formability problems have been encountered. Data presented on the alloy are for disk or spool forgings and were generated by the General Electric Company.
- 1.01 Commercial Designation
Ti-17
- 1.02 Alternate Designation
- 1.03 Specifications
- 1.04 Composition
Table 1.04
- 1.05 Heat Treatment
The recommended heat treatment for this alloy depends on process history. For alpha-beta processed material the heat treatment consists of a double solution treatment followed by aging. The first solution treatment should be done in the range from 1500 to 1575F for four hours followed by rapid air cooling. The higher temperature, 1575F, produces higher toughness as a result of an increased amount of acicular alpha which precipitates both during cooling and subsequent heat treatment. The second solution treatment is done at 1475F and nucleates additional acicular alpha and produces a beta matrix responsive to subsequent aging. For air cooling may be used from the second solution treatment for sections up to 3 in thick, although more consistent and slightly higher strength properties are achieved with a water quench. Heat treatment of beta processed material includes only a single 1475F four-hour solution treatment since acicular alpha is already nucleated or precipitated during cooling from the forging temperature. An aging treatment of 1150-1200F for eight hours is recommended for both the alpha-beta and beta processed material. See Figures 3.0212 and 3.0214 for the effect of solution temperature and aging temperature on the strength properties for both types of processed material.
- 1.06 Hardness
- 1.061 Through thickness hardenability of fan air cooled 16 inch diameter x 7 inch thick disk forging, Figure 1.061.
- 1.062 Through thickness hardenability of water quenched 18 inch diameter x 8 inch thick disk forging, Figure 1.062.
- 1.063 Through thickness hardenability as a function of cooling rate, Figure 1.063.
- 1.07 Forms and Conditions Available
- 1.071 To date alloy has been produced in forging form and can be obtained in alpha-beta or beta processed condition.
- 1.08 Melting and Casting Practice
Alloy is triple vacuum melted using standard sponge master alloys and melting procedures.
- 1.09 Special Considerations
- 1.091 High hardenability is one of the alloy's major attributes. (See Figures 1.061, 1.062 and 1.063).
- 1.092 Alpha-beta processed material, given conventional solution treatment, usually results in slightly higher yield strength and ductility than beta processing for a given aging treatment. (See Table 3.0218). Beta processing results in higher fracture toughness (see Table 3.02722) Creep resistance and fatigue behavior are unchanged by beta processing (4).
- 1.093 This alloy has excellent low cycle fatigue behavior and is superior to that of the Ti-6Al-4V alloy (see Figure 3.051).
2. PHYSICAL AND ENVIRONMENTAL EFFECTS
- 2.01 Thermal Properties
- 2.011 Melting range.
- 2.012 Phase changes. Alloy transforms on cooling from beta to alpha + beta at 1600 + 25F.
- 2.0121 Time-temperature-transformation diagram, Figure 2.0121.
- 2.013 Thermal conductivity.
- 2.014 Thermal expansion, Figure 2.014.
- 2.015 Specific heat.
- 2.016 Thermal diffusivity.
- 2.02 Other Physical Properties
- 2.021 Density. 0.168 lb per cu in, 4.658 gr per cu cm (1).
- 2.022 Electrical properties.
- 2.023 Magnetic properties. Alloy is nonmagnetic.
- 2.024 Emissance.
- 2.025 Damping capacity.
- 2.03 Chemical Environment
- 2.031 Corrosion resistance. There are no corrosion resistance data yet available on this alloy. However, as is common with all other titanium alloys, it would be expected that this alloy would be susceptible to solid salt stress corrosion at elevated temperatures and exhibit delayed failure of cracked specimens at room temperature in aqueous salt environments.
- 2.04 Nuclear Environment
3. MECHANICAL PROPERTIES
- 3.01 Specified Mechanical Properties
None
- 3.02 Mechanical Properties at Room Temperature
- 3.021 Tension.
- 3.0211 Stress-strain diagrams.
- 3.0212 Effect of solution temperature on aged yield strength of beta and alpha-beta processed material, Figure 3.0212.
- 3.0213 Effect of solution temperature on aged yield and tensile strength of alpha-beta processed material, Figure 3.0213.
- 3.0214 Effect of aging temperature on the yield strength of beta and alpha-beta processed material, Figure 3.0214.
- 3.0215 Effect of aging temperature on yield and tensile strength of alpha-beta processed material, Figure 3.0215.
- 3.0216 Effect of aging temperature on yield strength as a function of quench rate and section thickness in alpha-beta processed condition, Figure 3.0216.
- 3.0217 Effect of cooling rate from solution treatment on tensile properties of alpha-beta forged material, Table 3.0217.
- 3.0218 Effect of reduction ratio on the mechanical properties of alpha-beta and beta forged material, Table 3.0218.
- 3.0219 Tensile properties of beta forged disk, Table 3.0219.
- 3.022 Compression.
- 3.0221 Stress-strain diagrams.

| | |
|---|----|
| | Ti |
| 5 | Al |
| 2 | Sn |
| 2 | Zr |
| 4 | Mo |
| 4 | Cr |

Ti-17

| | | | |
|---------|----|---------|--|
| | Ti | 3.023 | Impact. |
| | | 3.024 | Bending. |
| 5 | Al | 3.025 | Torsion and shear. |
| | | 3.026 | Bearing. |
| 2 | Sn | 3.027 | Stress concentration. |
| | | 3.0271 | Notch properties. (See Table 3.03711). |
| 2 | Zr | 3.02711 | Notch tensile strength of beta processed material as a function of orientation, Table 3.02711. |
| | | 3.0272 | Fracture toughness. |
| 4 | Mo | 3.02721 | Effect of solution temperature on the fracture toughness of alpha-beta processed material, Table 3.02721. |
| 4 | Cr | 3.02722 | Effect of reduction ratio on the fracture toughness of alpha-beta and beta forged material, Table 3.02722. |
| | | 3.02723 | Fracture toughness of beta forged disk, Table 3.02723. |
| Ti - 17 | | 3.028 | Combined properties. |
| | | 3.03 | <u>Mechanical Properties at Various Temperatures</u> |
| | | 3.031 | Tension. |
| | | 3.0311 | Stress-strain diagrams. |
| | | 3.0312 | Tensile properties of beta processed material as a function of test temperature, Table 3.0312. |
| | | 3.0313 | Tensile properties of alpha-beta processed material as a function of test temperature, Table 3.0313. |
| | | 3.032 | Compression. |
| | | 3.0321 | Stress-strain diagrams. |
| | | 3.033 | Impact. |
| | | 3.034 | Bending. |
| | | 3.035 | Torsion and shear. |
| | | 3.036 | Bearing. |
| | | 3.037 | Stress concentration. |
| | | 3.0371 | Notch properties. |
| | | 3.03711 | Notch tensile strength of alpha-beta processed material as a function of test temperature, Table 3.03711. |
| | | 3.0372 | Fracture toughness. |
| | | 3.038 | Combined properties. |
| | | 3.04 | <u>Creep and Creep Rupture Properties</u> |
| | | 3.041 | Creep rupture of alpha-beta processed material, Table 3.041. |
| | | 3.05 | <u>Fatigue Properties</u> |
| | | 3.051 | S-N curve for disk forging in alpha-beta processed condition, Figure 3.051. |
| | | 3.052 | Fatigue crack growth rate at RT for specimens from alpha-beta processed forging, Figure 3.052. |
| | | 3.053 | Fatigue crack growth rate at +600F for specimens from alpha-beta processed forging, Figure 3.053. |
| | | 3.06 | <u>Elastic Properties</u> |
| | | 3.061 | Poisson's ratio. |
| | | 3.062 | Modulus of elasticity. |
| | | 3.0621 | Dynamic modulus of elasticity at room and elevated temperatures, Figure 3.0621. |
| | | 3.063 | Modulus of rigidity. |
| | | 3.064 | Tangent modulus. |
| | | 3.065 | Secant modulus. |

4. FABRICATION

4.01 Forming

4.011 The alloy has demonstrated superior workability in both open and closed die forging and no cracking has been evidenced during forging operations. Both alpha-beta (1500-1575F) and beta (1650-1700F) forging practice can be used. Press forging appears to be most desirable, since the comparatively low strain rate is more compatible with the lower than usual forging temperature range required for alpha-beta processing than is hammer forging (4).

4.02 Machining and Grinding

Contact Air Force Machinability Data Center,
3980 Rosslyn Drive
Cincinnati, Ohio 45209

4.03 Joining4.04 Surface Treatment

| Source | (1) | |
|------------|------------------|---------|
| | Weight (percent) | |
| | Minimum | Maximum |
| Aluminum | 4.5 | 5.5 |
| Tin | 1.5 | 2.5 |
| Zirconium | 1.5 | 2.5 |
| Molybdenum | 3.5 | 4.5 |
| Chromium | 3.5 | 4.5 |
| Oxygen | 0.08 | 0.13 |
| Nitrogen | - | 0.04 |
| Hydrogen | - | 0.0125 |
| Iron | - | 0.30 |

TABLE 1.04 COMPOSITION

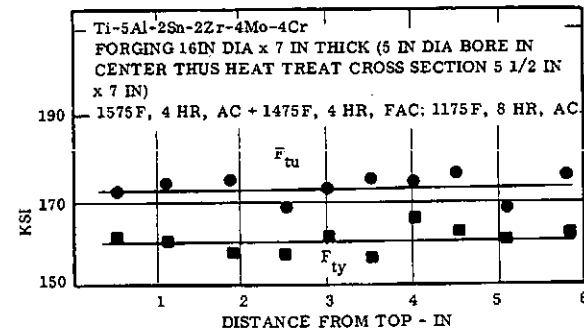


FIG. 1.061 THROUGH THICKNESS HARDENABILITY OF FAN COOLED 16 IN DIAMETER x 7 INCH THICK DISK FORGING. (1)

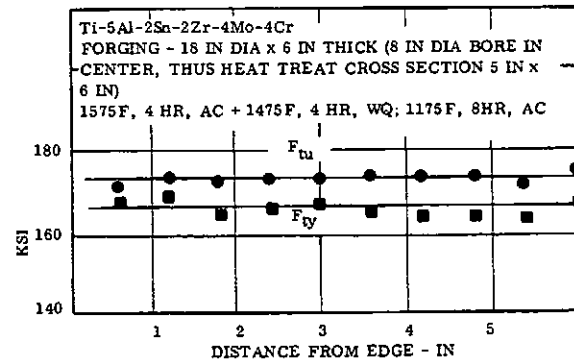


FIG. 1.062 THROUGH THICKNESS HARDENABILITY OF WATER QUENCHED 18 INCH DIAMETER x 6 INCH THICK DISK FORGING. (4)

NONFERROUS ALLOYS

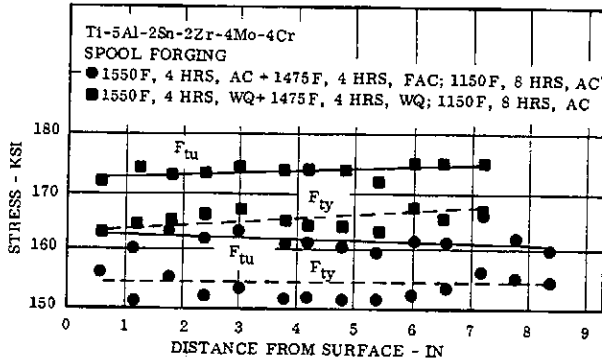


FIG. 1.063 THROUGH THICKNESS HARDENABILITY AS A FUNCTION OF COOLING RATE. (3)

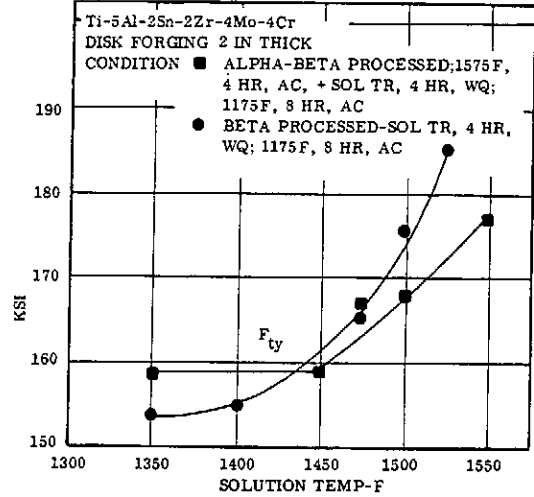


FIG. 3.0212 EFFECT OF SOLUTION TEMPERATURE ON AGED YIELD STRENGTH OF BETA AND ALPHA-BETA PROCESSED MATERIAL. (2)

| |
|------|
| Ti |
| 5 Al |
| 2 Sn |
| 2 Zr |
| 4 Mo |
| 4 Cr |

Ti - 17

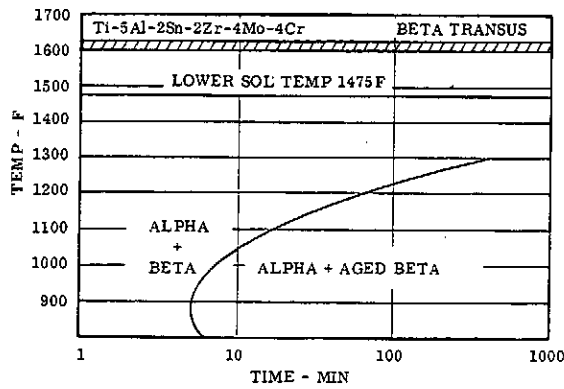


FIG. 2.0121 ISOTHERMAL TRANSFORMATION DIAGRAM. (11)

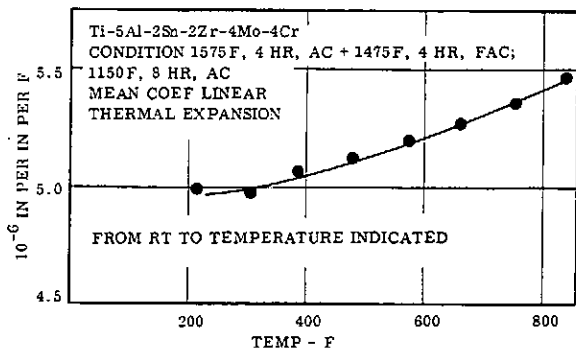


FIG. 2.014 THERMAL EXPANSION. (3)

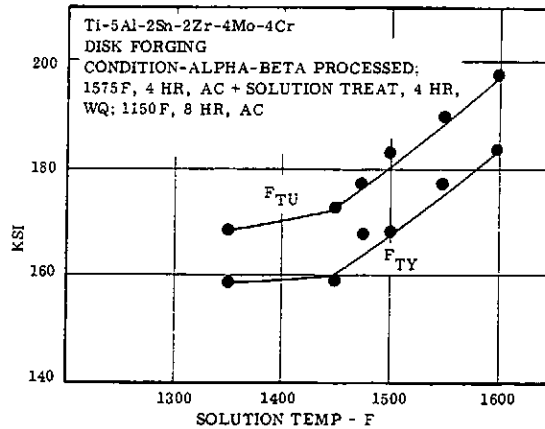


FIG. 3.0213 EFFECT OF SOLUTION TEMPERATURE ON AGED YIELD AND TENSILE STRENGTH OF ALPHA-BETA PROCESSED MATERIAL. (4)

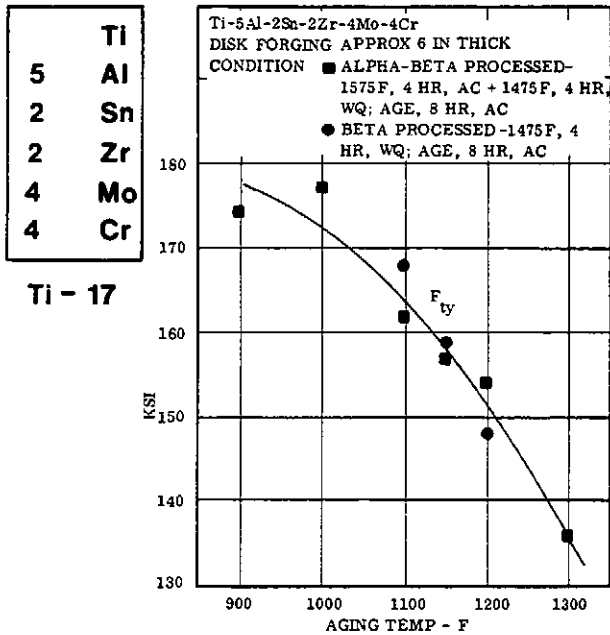


FIG. 3.0214 EFFECT OF AGING TEMPERATURE ON THE YIELD STRENGTH OF BETA AND ALPHA-BETA PROCESSED MATERIAL. (2)

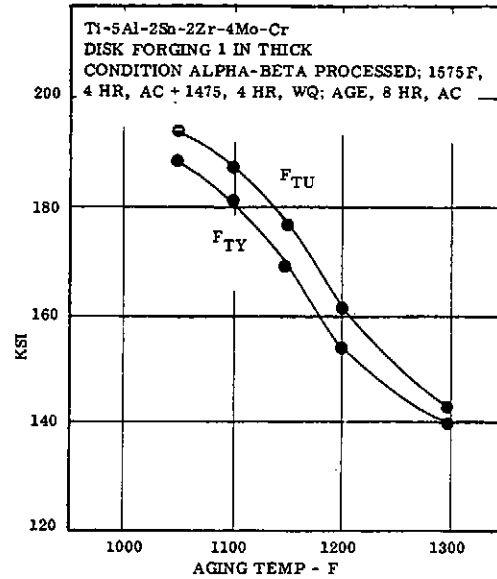


FIG. 3.0215 EFFECT OF AGING TEMPERATURE ON YIELD AND TENSILE STRENGTH OF ALPHA-BETA PROCESSED MATERIAL. (4)

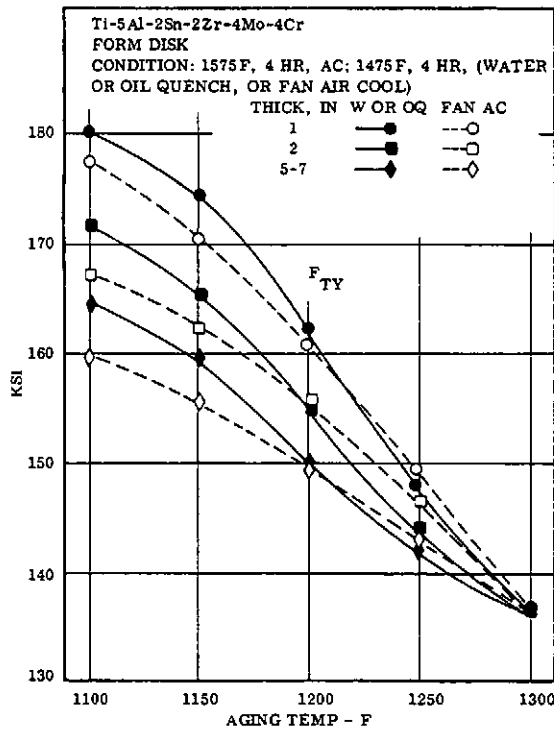


FIG. 3.0216 EFFECT OF AGING TEMPERATURE ON YIELD STRENGTH AS A FUNCTION OF QUENCH RATE AND SECTION THICKNESS IN ALPHA-BETA PROCESSED CONDITION. (3)

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NONFERROUS ALLOYS

| Source | | (3) | | | | | | | |
|----------------------------|-----------------------|--|--------------------|--------------|-----------------------|-----------------------|--------------------|--------------|--|
| Alloy | | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | | | | |
| Form | | Spool Forging | | | | | | | |
| Condition | | 1550 F, 4 hrs, AC + 1475 F, 4 hrs, AC; 1150 F, 8 hrs, AC | | | | | | | |
| Cooling Media | | AC | | | | WQ | | | |
| Distance from Surface (in) | F _{ty} (ksi) | F _{tu} (ksi) | e (2 in) (percent) | RA (percent) | F _{ty} (ksi) | F _{tu} (ksi) | e (2 in) (percent) | RA (percent) | |
| 0.6 | 156 | 163 | 10 | 33 | 168 | 172 | 5 | 9 | |
| 1.2 | 151 | 160 | 12 | 33 | 169 | 174 | 12 | 36 | |
| 1.8 | 155 | 163 | 11 | 30 | 165 | 173 | 9 | 27 | |
| 2.4 | 152 | 162 | 10 | 27 | 166 | 173 | 10 | 28 | |
| 3.0 | 153 | 163 | 10 | 19 | 167 | 174 | 10 | 35 | |
| 3.6 | 151 | 161 | 10 | 28 | 165 | 174 | 9 | 32 | |
| 4.2 | 152 | 161 | 11 | 26 | 164 | 174 | 9 | 31 | |
| 4.8 | 151 | 160 | 9 | 30 | 164 | 174 | 10 | 24 | |
| 5.4 | 151 | 159 | 13 | 32 | 163 | 172 | 6 | 24 | |
| 6.0 | 152 | 161 | 12 | 28 | 167 | 175 | 8 | 25 | |
| 6.6 | 153 | 161 | 11 | 27 | 165 | 175 | 8 | 23 | |
| 7.2 | 156 | 166 | 10 | 19 | 167 | 175 | 10 | 28 | |
| 7.8 | 155 | 162 | 11 | 30 | | | | | |
| 8.4 | 154 | 160 | 10 | 26 | | | | | |

TABLE 3.0217 EFFECT OF COOLING RATE FROM SOLUTION TREATMENT ON TENSILE PROPERTIES OF ALPHA-BETA FORGED MATERIAL

| | |
|---|----|
| 5 | Ti |
| 2 | Al |
| 2 | Sn |
| 4 | Zr |
| 4 | Mo |
| | Cr |

Ti - 17

| Source | | (2) | | | | |
|-------------------|-----------------|--|-----------------------|--------------------|--------------|--|
| Alloy | | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | |
| Form | | Disk Forgings | | | | |
| Condition | | 1550F, 4 hr, AC + 1475F, 4 hr, FAC; 1150F, 8 hr, AC (a) 1475F, 4 hr, FAC; 1150F, 8 hr, AC (b) | | | | |
| Forging Condition | Reduction Ratio | F _{tu} (ksi) | F _{ty} (ksi) | e (2 in) (percent) | RA (percent) | |
| Alpha-beta (a) | 2:1 | 174 | 167 | 8.8 | 24.1 | |
| Forged | 3:1 | 171 | 166 | 11.1 | 33.4 | |
| | 4:1 | 175 | 169 | 9.4 | 28.8 | |
| Beta forged (b) | 2:1 | 175 | 162 | 8.1 | 18.9 | |
| | 3:1 | 173 | 160 | 10.0 | 22.6 | |
| | 4:1 | 172 | 161 | 8.3 | 19.1 | |

TABLE 3.0218 EFFECT OF REDUCTION RATIO ON THE MECHANICAL PROPERTIES OF ALPHA-BETA AND BETA FORGED MATERIAL

| Source | | (3) | | |
|-------------|-----------------------|-------------------------------------|---------------------------|--|
| Alloy | | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | |
| Form | | Disk Forging | | |
| Condition | | 1450F, 4 hrs, FAC; 1150F, 8 hrs, AC | | |
| Orientation | F _{tu} (ksi) | NTS-ksi (K _t = 3.5) | NTS/F _{tu} Ratio | |
| Tang. | 171 | 244 | 1.43 | |
| Radial | 172 | 235 | 1.37 | |
| Axial | 169 | 203 | 1.20 | |

Notch radius = 0.006 inch

TABLE 3.02711 NOTCH TENSILE STRENGTH OF BETA PROCESSED MATERIAL AS A FUNCTION OF ORIENTATION

| Source | | (2) | | | | |
|------------------|----------------|---|-----------------------|--------------------|--------------|--|
| Alloy | | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | |
| Form | | Forged disk (21 in dia. x 2-1/4 in. thick) | | | | |
| Condition | | Beta forged + 1475F 4 hr, WQ; 1175F, 8 hr, AC | | | | |
| Location in Disk | Test Direction | F _{tu} (ksi) | F _{ty} (ksi) | e (2 in) (percent) | RA (percent) | |
| Rim | Tang. | 172 | 162 | 11 | 23 | |
| Web | Tang. | 169 | 158 | 10 | 23 | |
| Bore | Radial | 172 | 162 | 9 | 22 | |

Data average of two tests.

TABLE 3.0219 TENSILE PROPERTIES OF BETA FORGED DISK

| Source | | (2) | |
|------------|---------------------------|---|--|
| Alloy | | Ti-5Al-2Sn-2Zr-4Mo-4Cr | |
| Form | | Disk forging, 18 in dia. x 2 in thick | |
| Condition | | Sol. temp., 4 hr, AC + 1475F, 4 hr, WQ; 1150F, 8 hr, AC | |
| Sol. Temp. | F _{ty} (a) (ksi) | K _{IC} (b) (ksi√in) | |
| 1500 | 165 | 25 | |
| 1550 | 163 | 28 | |
| 1575 | 162 | 46 | |

(a) Average of two tests.
(b) 1 inch thick compact tension specimen.
Plane strain fracture toughness by ASTM E399-74

TABLE 3.02721 EFFECT OF SOLUTION TEMPERATURE ON THE FRACTURE TOUGHNESS OF ALPHA-BETA PROCESSED MATERIAL

CODE 3724

PAGE 5

NONFERROUS ALLOYS

RELEASED: SEPTEMBER 1976

| | | | | | | | |
|-----------------------|----------------------------------|--|--|---------------------------------|---|---------------------------------|--|
| 5 2 2 4 4 | Ti Al Sn Zr Mo Cr | Source | (2) | | | | |
| | | Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | |
| | | Form | Disk Forging | | | | |
| | | Condition | Alpha-beta forged 1550F, 4 hr, FAC + 1475F, 4 hr. FAC: 1150F, 8 hr, AC | | Beta forged 1475F, 4 hr, FAC; 1150F, 8 hr, AC | | |
| | | Reduction Ratio | F _{ty} (a) (ksi) | K _{Ic} (b) (ksi√in) | F _{ty} (a) (ksi) | K _{Ic} (b) (ksi√in) | |
| | | 2:1 | 167 | 37.8 | 162 | 62.6 | |
| | | 3:1 | 166 | 32.9 | 160 | 55.5 | |
| | | 4:1 | 169 | 33.9 | 161 | 50.2 | |
| | | (a) Average of two tests (see Table 3.0218 for balance of smooth tensile properties). | | | | | |
| | | (b) 1 inch thick compact tension specimen. TL specimen orientation. Plane strain fracture toughness by ASTM E399-74. | | | | | |

TABLE 3.02722 EFFECT OF REDUCTION RATIO ON THE FRACTURE TOUGHNESS OF ALPHA-BETA AND BETA FORGED MATERIAL

| | | | | | |
|-----------------------|----------------------------------|--|---|-----------------------------|--|
| 5 2 2 4 4 | Ti Al Sn Zr Mo Cr | Source | (2) | | |
| | | Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | |
| | | Form | Forged disk (21 in diameter x 2-1/4 in thick) | | |
| | | Condition | Beta forged + 1475F, 4 hr, WQ; 1175F 8 hr, AC | | |
| | | Location | F _{ty} (a) (ksi) | K _{Ic} (ksi√in) | |
| | | in Disk | | | |
| | | Rim | 162 | 62 (b)(c) | |
| | | Bore | 162 | 71 (d) | |
| | | (a)(b) Average of two tests. | | | |
| | | (c) TL specimen orientation. (d) LT specimen orientation. 1 inch thick compact tension specimen. Plane strain fracture toughness by ASTM E399-74. | | | |

TABLE 3.02723 FRACTURE TOUGHNESS OF BETA FORGED DISK

| | | | | | | | |
|-----------------------|----------------------------------|----------------|-------------------------------------|-----------------------|-----------------------|--------------------|--------------|
| 5 2 2 4 4 | Ti Al Sn Zr Mo Cr | Source | (3) | | | | |
| | | Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | |
| | | Form | Disk Forging | | | | |
| | | Condition | 1450F, 4 hrs, FAC; 1150F, 8 hrs, AC | | | | |
| | | Test Temp. (F) | Orientation | F _{tu} (ksi) | F _{ty} (ksi) | e (2 in) (percent) | RA (percent) |
| | | 75 | Radial | 170 | 160 | 9 | 22 |
| | | 75 | Radial | 172 | 162 | 12 | 23 |
| | | 75 | Axial | 168 | 154 | 12 | 23 |
| | | 75 | Axial | 168 | 155 | 13 | 28 |
| | | 400 | Radial | 153 | 132 | 13 | 36 |
| 400 | | 151 | 132 | 13 | 42 | | |
| 600 | | 143 | 119 | 14 | 41 | | |
| 600 | | 142 | 118 | 11 | 37 | | |
| 800 | | 139 | 116 | 17 | 52 | | |
| 800 | | 139 | 116 | 14 | 51 | | |

TABLE 3.0312 TENSILE PROPERTIES OF BETA PROCESSED MATERIAL AS A FUNCTION OF TEST TEMPERATURE

| | | | | | | | |
|-----------------------|----------------------------------|----------------|--|-----------------------|-----------------------|--------------------|--------------|
| 5 2 2 4 4 | Ti Al Sn Zr Mo Cr | Source | (3) | | | | |
| | | Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | | | |
| | | Form | Spool Forging | | | | |
| | | Condition | 1550F, 4 hrs, AC + 1475F, 4 hrs, FAC; 1150, 8 hr, AC | | | | |
| | | Test Temp. (F) | Orientation | F _{tu} (ksi) | F _{ty} (ksi) | e (2 in) (percent) | RA (percent) |
| | | 75 | Radial | 172 | 166 | 8 | 26 |
| | | 75 | | 171 | 162 | 12 | 32 |
| | | 75 | | 163 | 155 | 11 | 39 |
| | | 200 | | 156 | 127 | 12 | 36 |
| | | 400 | | 144 | 122 | 14 | 46 |
| 600 | | 143 | 118 | 12 | 46 | | |
| 600 | | 137 | 115 | 11 | 49 | | |
| 700 | | 133 | 108 | 13 | 47 | | |

TABLE 3.0313 TENSILE PROPERTIES OF ALPHA-BETA PROCESSED MATERIAL AS A FUNCTION OF TEST TEMPERATURE

NONFERROUS ALLOYS

| | | | |
|--|--|--------------------------------|---------------------------|
| Source | (3) | | |
| Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | | |
| Form | Spool Forging | | |
| Condition | 1550F, 4 hr, AC + 1475F, 4 hr, FAC; 1150F, 8 hrs, AC | | |
| Test Temp. (F) | F _{tu} (ksi) | NTS - ksi (K _t = 4) | NTS/F _{tu} Ratio |
| 75 | 166 | 213 | 1.28 |
| 200 | 156 | 215 | 1.38 |
| 400 | 141 | 205 | 1.45 |
| 600 | 139 | 190 | 1.36 |
| 700 | 132 | 189 | 1.44 |
| Data average of 3 tests. Notch specimen (see Table 3.02711). Notch radius = 0.0047 inch. | | | |

| | |
|---|----|
| | Ti |
| 5 | Al |
| 2 | Sn |
| 2 | Zr |
| 4 | Mo |
| 4 | Cr |

Ti - 17

TABLE 3.03711 NOTCH TENSILE STRENGTH OF ALPHA-BETA PROCESSED MATERIAL AS A FUNCTION OF TEST TEMPERATURE

| | | |
|-----------------|--|--------------|
| Source | (3) | |
| Alloy | Ti-5Al-2Sn-2Zr-4Mo-4Cr | |
| Form | Spool Forging | |
| Condition | 1550F, 4 hr., AC + 1475F, 4 hr, FAC; 1150F, 8 hr, AC | |
| Temperature (F) | Stress (ksi) | Time (hours) |
| 400 | 145 | 0.01 |
| 400 | 142.5 | > 671.9 |
| 400 | 142 | > 793.6 |
| 600 | 140 | 0.1 |
| 600 | 137.5 | > 670.5 |
| 600 | 130 | > 721.5 |
| 800 | 115 | 8 |
| 900 | 70 | > 140 |
| 950 | 70 | ≈ 16 |

TABLE 3.041 CREEP RUPTURE OF ALPHA-BETA PROCESSED MATERIAL

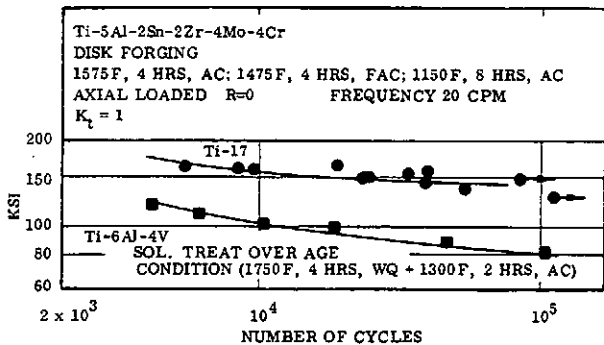


FIG. 3.051 S-N CURVE FOR DISK FORGING IN ALPHA-BETA PROCESSED CONDITION. (2)

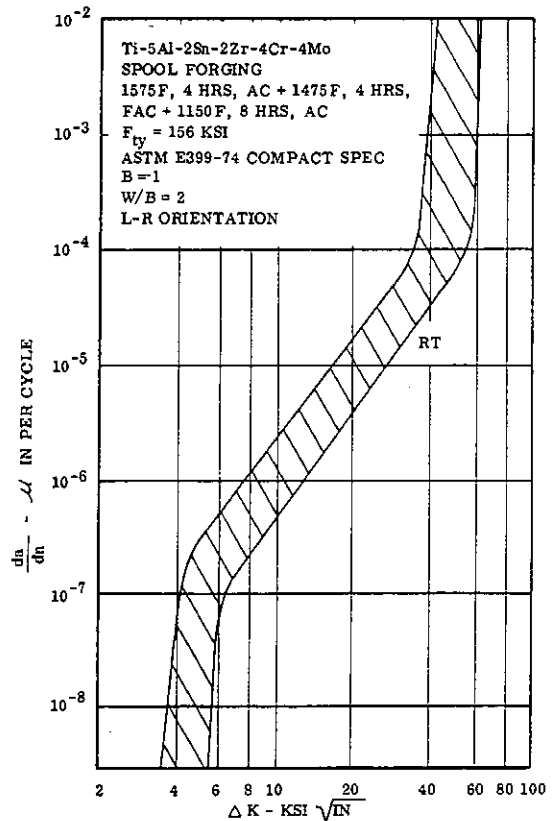


FIG. 3.052 FATIGUE CRACK GROWTH RATE AT ROOM TEMPERATURE FOR SPECIMENS FROM ALPHA-BETA PROCESSED FORGING. (3)

| | |
|---|----|
| | Ti |
| 5 | Al |
| 2 | Sn |
| 2 | Zr |
| 4 | Mo |
| 4 | Cr |

Ti - 17

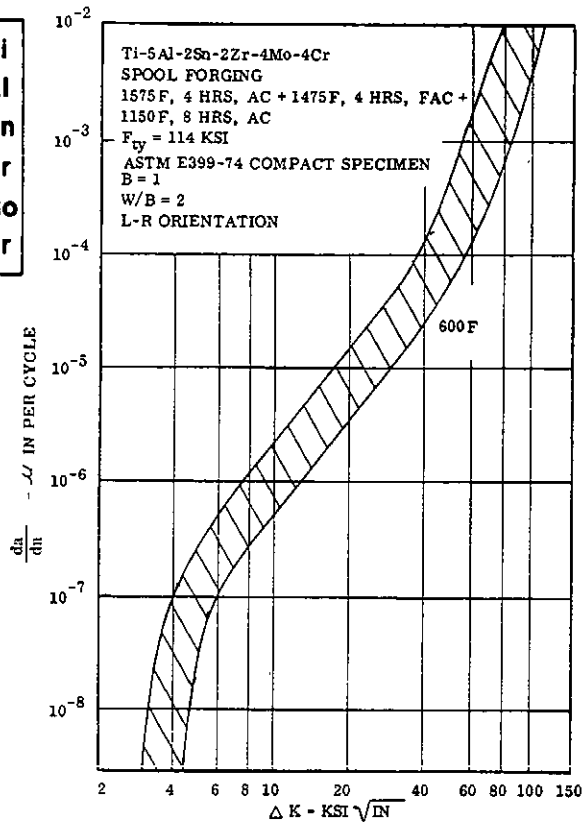


FIG. 3.053 FATIGUE CRACK GROWTH RATE AT +600F FOR SPECIMENS FROM ALPHA-BETA PROCESSED FORGING. (3)

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4. "Ti-17 A New High-Strength/Toughness, Deep-Hardenable, Titanium Alloy", Private Communication from Gene E. Best, Manager, Materials Data Unit, General Electric Co., Cincinnati, Ohio (January 16, 1975).

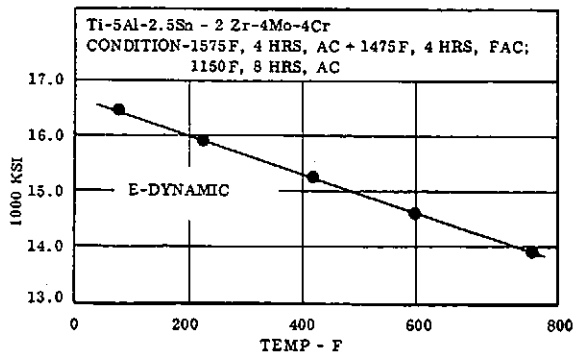


FIG. 3.0621 DYNAMIC MODULUS OF ELASTICITY AT ROOM AND ELEVATED TEMPERATURES. (3)