



## تکنولوژی ساخت پیچ و مهره های صنعت هوایی



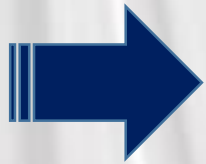
# فهرست

## تنوع متریالی Fasteners موتور GT21

- Ti64
- A286
- Waspaloy
- Alloy 718
- Alloy 600
- Alloy 625
- Greek Asc (SS418)
- SS321
- MP35N
- Aerex 350

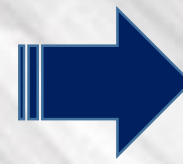
| No. | H             | Tests                                                        | Material |      |          |           |           |           |                   |       |       |           |
|-----|---------------|--------------------------------------------------------------|----------|------|----------|-----------|-----------|-----------|-------------------|-------|-------|-----------|
|     | R&A           |                                                              | A286     | Ti64 | Waspaloy | Alloy 718 | Alloy 600 | Alloy 625 | Greek Asc (SS418) | SS321 | MP35N | Aerex 350 |
| 1   | Raw Material  | VT                                                           | •        | •    | •        | •         |           |           |                   |       |       |           |
| 2   |               | UT                                                           | •        | •    | •        | •         |           |           |                   |       |       |           |
| 3   |               | DT                                                           | •        | •    | •        | •         |           |           |                   |       |       |           |
| 4   |               | Chemical Composition                                         | •        | •    | •        | •         |           |           |                   |       |       |           |
| 5   |               | Tensile Test(before precipitation/stabilization)             | •        |      | •        |           |           |           |                   |       |       |           |
| 6   |               | Hardness Test(before precipitation/stabilization)            | •        |      | •        |           |           |           |                   |       |       |           |
| 7   |               | Tensile Test at room(after precipitation/stabilization)      | •        | •    | •        | •         |           |           |                   |       |       |           |
| 8   |               | Tensile Test at high temp(after precipitation/stabilization) |          |      |          | •         |           |           |                   |       |       |           |
| 9   |               | Hardness Test(after precipitation/stabilization)             | •        |      | •        | •         |           |           |                   |       |       |           |
| 10  |               | Stress Rupture Test                                          | •        |      | •        | •         |           |           |                   |       |       |           |
| 11  |               | Surface Contamination Check                                  |          | •    |          |           |           |           |                   |       |       |           |
| 12  |               | Microscopic Examination                                      |          | •    |          | •         |           |           |                   |       |       |           |
| 13  |               | Average Grain Size                                           |          |      | •        | •         |           |           |                   |       |       |           |
| 14  | Forged Part   | Macroscopic Examination                                      | •        | •    | •        | •         |           |           |                   |       |       |           |
| 15  |               | Oxide Removal                                                | •        |      | •        | •         |           |           |                   |       |       |           |
| 16  |               | Contamination Removal Check                                  |          | •    |          |           |           |           |                   |       |       |           |
| 17  | Finished Part | VT                                                           | •        | •    | •        | •         |           |           |                   |       |       |           |
| 18  |               | DT                                                           | •        | •    | •        | •         |           |           |                   |       |       |           |
| 19  |               | MT                                                           |          |      |          |           |           |           | •                 |       |       |           |
| 20  |               | FPI                                                          | •        | •    | •        | •         |           |           |                   |       |       |           |
| 21  |               | Hardness Test                                                | •        |      | •        | •         |           |           |                   |       |       |           |
| 22  |               | Double Shear/Tensile Test                                    | •        | •    | •        | •         |           |           |                   |       |       |           |
| 23  |               | Macroscopic Examination                                      | •        | •    | •        | •         |           |           |                   |       |       |           |
| 24  |               | Microscopic Examination                                      | •        | •    | •        | •         |           |           |                   |       |       |           |
| 25  |               | Hydrogen Content                                             |          | •    |          |           |           |           |                   |       |       |           |
| 26  |               | Average Grain Size                                           | •        |      | •        | •         |           |           |                   |       |       |           |

Ti64  
AMS 4967  
Annealed  
hardenable

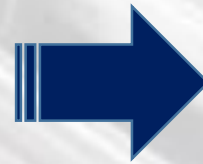


### Heat Treatment

**Solution**  
1650-1750 °F  
hold  $\pm 25$  °F  
30-60 min  
Quenched in  
water



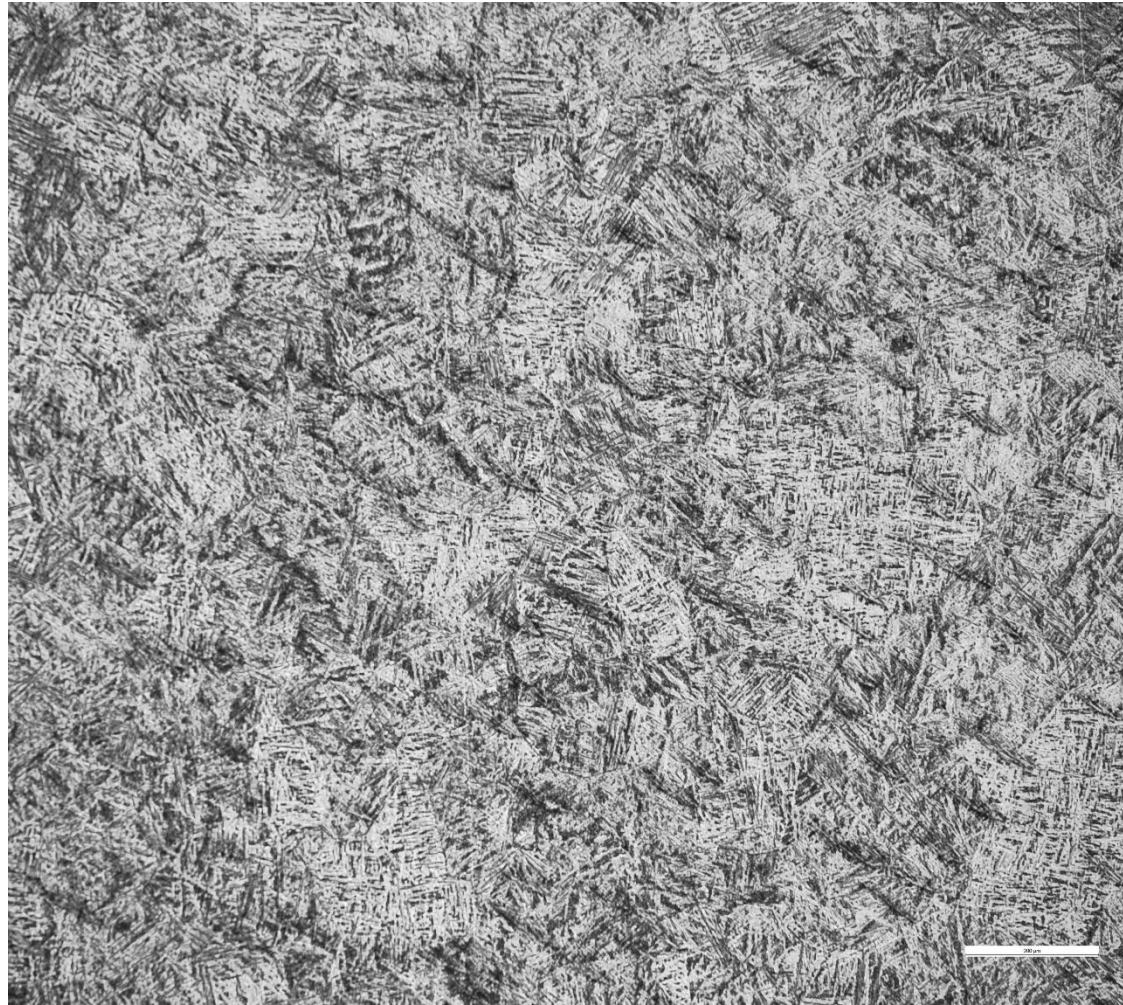
**Age**  
900-1100 °F  
hold  $\pm 10$  °F  
30-60 min  
Cooled in air



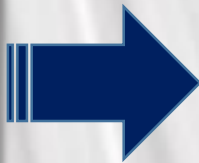
Hot Vertical Upsetting (Heading)

$\alpha$ - $\beta$  Forging( Below Beta transus Temperature)

## $\alpha$ - $\beta$ Forging( Below Beta transus Temperature)



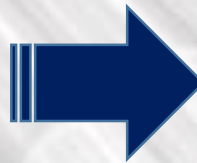
A286  
AMS 5731  
Solutioned



Hot Vertical Upsetting (Heading)



**Solution**  
 $982 \pm 25^\circ\text{C}$   
60 min  
Quench in  
water or oil



**Heat Treatment**

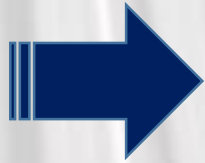
**Age**  
 $718 \pm 8^\circ\text{C}$   
16 hours  
Cooling in Air



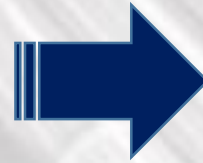
Waspaloy  
AMS 5708  
Solutioned



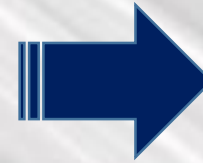
Hot Vertical Upsetting (Heading)



**Solution**  
1900-1975 °F  
hold  $\pm 25$  °F  
1-4 hours  
cooling in air or  
faster



**Stabilization**  
1550  $\pm$  15 °F  
4  $\pm$  0.5 hour  
cooling in air



**Age**  
After cold thread  
rolling(finished part)  
1400  $\pm$  15 °F  
in controlled atmosphere  
( Argon, Helium, Hydrogen)  
16 hours  
cooling equivalent to air



## Heat Treatment

| No. | material             | Base Metal                   | Application Temp                                                                            | Purchased raw material                  | 1st Cycle                                                                                | 2nd Cycle                                                                                                                                                                                                                  | 3rd Cycle                                                                                                                                                                           | Description                                                                                                                                                        |  |  |  | Picture                                                                             |
|-----|----------------------|------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|-------------------------------------------------------------------------------------|
| 1   | Ti64                 | Titanium                     | 315.5 °C                                                                                    | Ti64<br>AMS 4967<br>Annealed hardenable | <b>Solution</b><br>1650-1750 °F<br>hold ±25 °F<br>30-60 min<br>Quenched in water         | <b>Aging</b><br>900-1100 °F<br>hold ±10 °F<br>30-60 min<br>Cooled in air                                                                                                                                                   | -                                                                                                                                                                                   | عملیات حرارتی بعد از فورج انجام می شود.<br>چون بعد از فورج عمق براده برداری حداقل<br>0.5 میلی متر است در نتیجه نگرانی بابت<br>باقی مانده لایه آلفا کیس وجود ندارد. |  |  |  |   |
|     |                      |                              |                                                                                             |                                         | <b>Solution</b><br>982 ±25 °C<br>60 min<br>Quench in water or oil                        | <b>Aging</b><br>718 ±8 °C<br>16 hours<br>Cooling in Air                                                                                                                                                                    |                                                                                                                                                                                     |                                                                                                                                                                    |  |  |  |                                                                                     |
| 2   | A286                 | Iron<br>(Stainless<br>steel) | strength up to 704°C<br>oxidation resistance up to 816 °C                                   | A286<br>AMS 5731<br>Solutioned          | <b>Solution</b><br>982 ±25 °C<br>60 min<br>Quench in water or oil                        | <b>Aging</b><br>718 ±8 °C<br>16 hours<br>Cooling in Air                                                                                                                                                                    | -                                                                                                                                                                                   |                                                                                                                                                                    |  |  |  |  |
| 3   | Waspaloy             | Nickel                       | strength up to 816°C<br>oxidation resistance up to 954 °C                                   | Waspaloy<br>AMS 5708<br>Solutioned      | <b>solution</b><br>1900-1975 °F<br>hold ±25 °F<br>1-4 hours<br>cooling in air or faster  | <b>Stabilization</b><br>1550 ± 15 °F<br>4 ± 0.5 hour<br>cooling in air                                                                                                                                                     | <b>Aging</b><br>after cold rolling thread<br>rolling(finished part)<br>1400 ± 15 °F<br>in cotrolled atmosphere<br>(Argon,Helium, Hydrogen)<br>16 hours<br>cooling equivalent to air |                                                                                                                                                                    |  |  |  |                                                                                     |
|     |                      |                              |                                                                                             |                                         | <b>solution</b><br>1725-1850 °F<br>hold ±25 °F<br>1±0.1 hour<br>cooling in air or faster | <b>Aging</b><br>1325 ± 15 °F<br>8±0.25 hour<br>in cotrolled atmosphere<br>(Argon,Helium, Hydrogen)<br>furnace cooling with cooling rate<br>100 ± 15 °F/hour<br>to 1150 ± 15 °F<br>8±0.25 hour<br>cooling equivalent to air | -                                                                                                                                                                                   | چون قطعات بعد از Aging ماشینکاری می<br>شوند و اکسید سطحی در اثر ماشینکاری از<br>بین می رود<br>بنابراین نیازی به عملیات حرارتی در<br>اتمسفر کنترل شده نیست.         |  |  |  |  |
| 4   | Alloy 718            | Nickel                       | resistance to creep and<br>stress-rupture up to 704 °C<br>oxidation resistance up to 982 °C | Alloy 718<br>AMS 5662<br>Solutioned     | <b>solution</b><br>1725-1850 °F<br>hold ±25 °F<br>1±0.1 hour<br>cooling in air or faster | <b>Aging</b><br>1325 ± 15 °F<br>8±0.25 hour<br>in cotrolled atmosphere<br>(Argon,Helium, Hydrogen)<br>furnace cooling with cooling rate<br>100 ± 15 °F/hour<br>to 1150 ± 15 °F<br>8±0.25 hour<br>cooling equivalent to air | -                                                                                                                                                                                   |                                                                                                                                                                    |  |  |  |                                                                                     |
| 5   | Greek Asc<br>(SS418) | Iron<br>(Stainless<br>steel) | oxidation resistance up to 538 °C                                                           | SS 418 (martesitic)                     | <b>Quench</b><br>954 ±6 °C<br>15-20 min<br>cooling in paraffin oil                       | <b>Temper</b><br><700 °C<br>>1 hour<br>Cooling                                                                                                                                                                             | -                                                                                                                                                                                   |                                                                                                                                                                    |  |  |  |                                                                                     |
| 6   | Alloy 600            | Nickel                       | oxidation resistance up to 1093 °C                                                          | Alloy 600<br>AMS 5665                   | -                                                                                        | -                                                                                                                                                                                                                          | -                                                                                                                                                                                   |                                                                                                                                                                    |  |  |  |                                                                                     |
| 7   | Alloy 625            | Nickel                       | Corrosion and oxidation<br>resistance up to 1093 °C                                         | Alloy 625<br>AMS 5666<br>Annealed       | -                                                                                        | -                                                                                                                                                                                                                          | -                                                                                                                                                                                   |                                                                                                                                                                    |  |  |  |                                                                                     |
| 8   | MP35N                | Cobalt                       | strength, fatigue, and<br>corrosion resistance up to 371 °C                                 | MP35N<br>AMS 7468                       | Aging<br>after forging<br>1000-1200 °F<br>hold ±25 °F<br>4-4.5 hours<br>cooling in air   |                                                                                                                                                                                                                            |                                                                                                                                                                                     |                                                                                                                                                                    |  |  |  |                                                                                     |
|     |                      |                              |                                                                                             |                                         |                                                                                          |                                                                                                                                                                                                                            |                                                                                                                                                                                     |                                                                                                                                                                    |  |  |  |                                                                                     |
| 9   | SS321                | Iron<br>(Stainless<br>steel) | oxidation resistance up to 816 °C                                                           | SS 321<br>AMS 5645<br>Solutioned        | -                                                                                        | -                                                                                                                                                                                                                          |                                                                                                                                                                                     |                                                                                                                                                                    |  |  |  |                                                                                     |
| 10  | Aerex 350            | Nickel                       |                                                                                             |                                         |                                                                                          |                                                                                                                                                                                                                            |                                                                                                                                                                                     |                                                                                                                                                                    |  |  |  |                                                                                     |

# لیست تجهیزات مورد نیاز:

| ردیف | نام تجهیزات                  |
|------|------------------------------|
| 1    | تجهیزات برش مواد اولیه (اره) |
| 2    | کوره عملیات حرارتی خلا       |
| 3    | کوره عملیات حرارتی معمولی    |
| 4    | دستگاه پرس ۱۶۰ تن            |
| 5    | دستگاه پیش گرم القایی        |
| 7    | دستگاه وایرکات               |
| 8    | اسپارک                       |
| 9    | دستگاه رولینگ رزوه           |
| 10   | دستگاه سوپر دریل             |
| 11   | دستگاه تراش منوال            |
| 12   | دستگاه فرز منوال             |
| 13   | فرز CNC سه محور              |
| 14   | دستگاه تراش CNC سه محور      |
| 15   | دستگاه سنگ محور              |
| 16   | دستگاه سنگ سنترلس            |
| 17   | دستگاه دریل رادیال           |
| 18   | تجهیزات بازرسی و اندازه گیری |

## ترتیب مصور فرآیند های ساخت پیچ و مهره



تامین مواد خام



برشکاری



گرم کردن به روش القایی



انتقال مواد خام  
گداخته به قالب



فورج داغ کلگی



فورج داغ کلگی



فورج داغ کلگی



فورج داغ کلگی



خارج شدن از قالب و سرد شدن قطعه



عملیات حرارتی بعد از فورج



آماده جهت ماشینکاری



ماشینکاری



فرزکاری شده



بیلر برش خورده



قطعه فورج شده (کله زنی)



عملیات حرارتی شده



تراشکاری اولیه



تراشکاری CNC



سنگ زنی شده



رولینگ سرد (هد تو شنک)



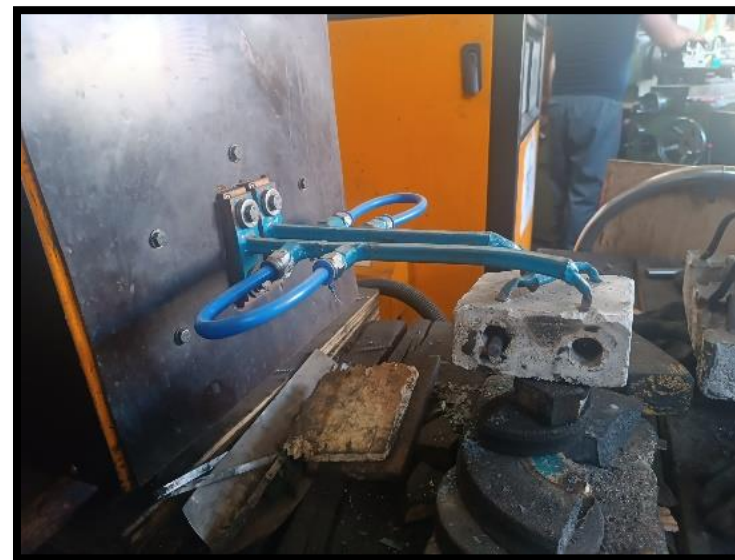
فرزکاری شده



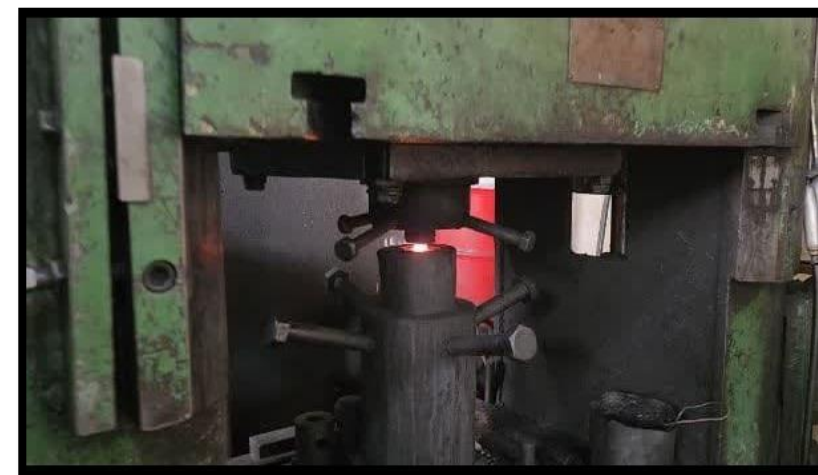
پوشش آنادایز شده



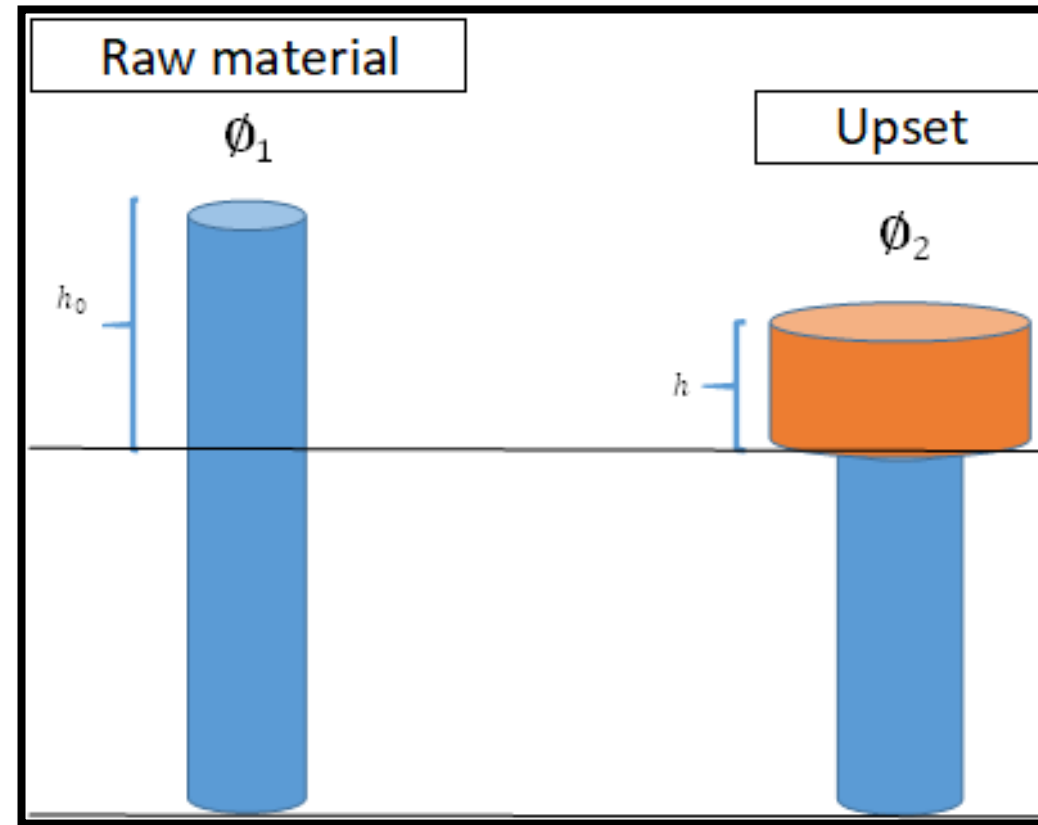
اره



پیش گرم فورج به روش القایی



مراحل فورج داغ (کله زنی)



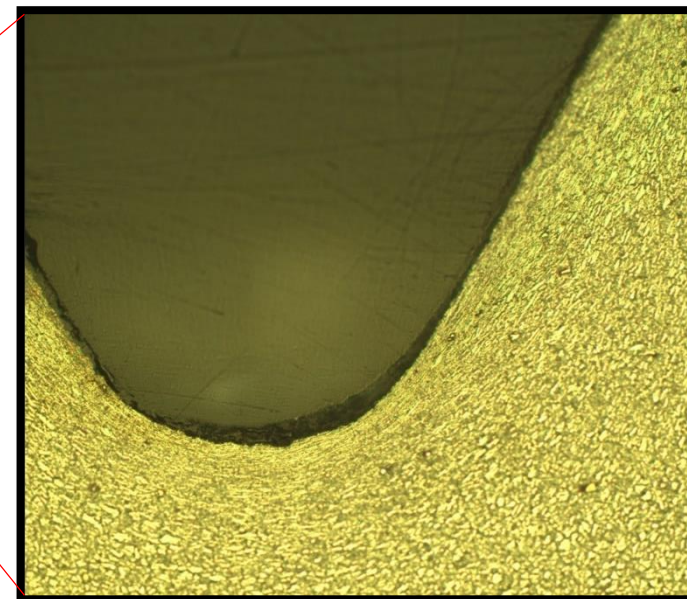
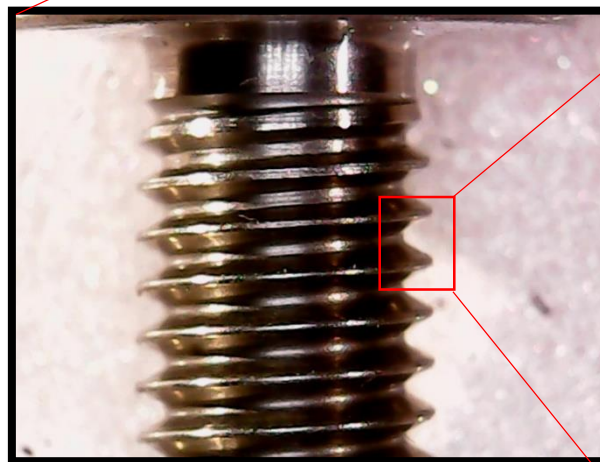
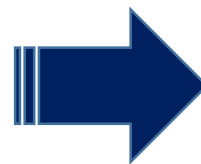
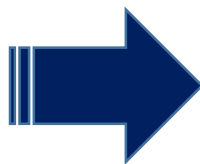
$$h_0 - h < 2.5 * \phi_1 \quad \text{avoid buckling}$$

|       |       |          |    |
|-------|-------|----------|----|
| $h_0$ | 23.52 | $\phi_1$ | 10 |
| $h$   | 12    | $\phi_2$ | 14 |

**Upset forging** is sometimes the sole method used for forging a specific shape, such as turbine engine disks, from titanium alloys. More often, however, upsetting is used as a method of preforming to reduce the number of forging operations or to save material input, as is true for other materials (see the article "Hot Upset Forging" in this Volume). Upsetting in titanium alloys is often preferred to extrusion for creating large-headed sections adjacent to smaller cross sections. In the upset forging of titanium alloys, the unsupported length of a round section to be upset should not exceed 2.5 times the diameter; for a rectangular or square cross section, 2.5 times the diagonal. The maximum amount of upset achievable in titanium alloys without reheating depends on the alloy, but for the more readily deformable alloys, it is usually 2.5 times the diameter (or diagonal). Without several heating and upsetting operations, it is impossible to produce an upset in titanium alloys as thin or having as sharp corners as are typically produced in alloy steels.



# رولینگ رزوه





حجم: 300 litter

حداکثر دمای کاری : 1200°C

توان الکتریکی: 30 Kw

## عملیات حرارتی تحت گاز آرگون، هیدروژن، نیتروژن تا دمای ۱۶۰۰ درجه

کوره تیوبی عملیات حرارتی دمای ۱۶۰۰ درجه قابلیت عملیات حرارتی و پخت قطعات سرامیکی که تحت اتمسفر خاصی می بایست حرارت دهی شوند، مناسب می باشد.

- اسم کامل دستگاه به فارسی: کوره تیوبی اتمسفر کنترل/خلأ دمای ۱۶۰۰ درجه
- اسم دستگاه به لاتین: Atmosphere Control/Vacuum Tube Furnace
- مدل دستگاه: TEF۱۶۰۰-۲۰۰۹
- کمپانی سازنده: آرژینه صنعت پرتو
- طول منطقه گرم: ۱۵ سانتی متر
- قطر دهانه راکتور: ۷.۵ سانتی متر
- قابلیت رسم گراف عملیات حرارتی
- میزان خلأ در حالت سرد:  $10^{-9} \times 10^{-6}$  mbar
- میزان خلأ در حالت گرم:  $1.4 \times 10^{-6}$  mbar
- قابلیت عملیات حرارتی تحت گازهای خنثی، هیدروژن و ترکیبی
- دقت دمایی: ۲۴ °C



| BASIC SIZE   |                    | THDS<br>PER<br>INCH | EXTERNAL THREAD - UNJF CLASS 3A |        |                   |        |                   |        |                |       | INTERNAL THREAD - UNJF CLASS 3B |        |                   |        |              |
|--------------|--------------------|---------------------|---------------------------------|--------|-------------------|--------|-------------------|--------|----------------|-------|---------------------------------|--------|-------------------|--------|--------------|
| PRI-<br>MARY | SECON-<br>DARY     |                     | MAJOR<br>DIAMETER               |        | PITCH<br>DIAMETER |        | MINOR<br>DIAMETER |        | ROOT<br>RADIUS |       | MINOR<br>DIAMETER               |        | PITCH<br>DIAMETER |        | MAJOR<br>DIA |
|              |                    |                     | MIN                             | MAX    | MIN               | MAX    | MIN               | MAX    | MIN            | MAX   | MIN                             | MAX    | MIN               | MAX    | MIN          |
| 1            | 2                  | 3                   | 4                               | 5      | 6                 | 7      | 8                 | 9      | 10             | 11    | 12                              | 13     | 14                | 15     | 16           |
| .0600        | .0730<br><br>.0990 | 80                  | .0568                           | .0600  | .0506             | .0519  | .0435             | .0456  | .0019          | .0023 | .0479                           | .0511  | .0519             | .0536  | .0600        |
|              |                    | 72                  | .0695                           | .0730  | .0626             | .0640  | .0547             | .0570  | .0021          | .0025 | .0595                           | .0631  | .0640             | .0659  | .0730        |
| .0860        |                    | 64                  | .0822                           | .0860  | .0744             | .0759  | .0656             | .0680  | .0023          | .0028 | .0708                           | .0749  | .0759             | .0779  | .0860        |
|              |                    | 56                  | .0949                           | .0990  | .0858             | .0874  | .0757             | .0784  | .0027          | .0032 | .0816                           | .0862  | .0874             | .0895  | .0990        |
| .1120        |                    | 48                  | .1075                           | .1120  | .0967             | .0985  | .0849             | .0880  | .0031          | .0038 | .0917                           | .0971  | .0985             | .1008  | .1120        |
| .1250        |                    | 44                  | .1202                           | .1250  | .1083             | .1102  | .0954             | .0987  | .0034          | .0041 | .1029                           | .1088  | .1102             | .1126  | .1250        |
| .1380        |                    | 40                  | .1329                           | .1380  | .1198             | .1218  | .1057             | .1092  | .0038          | .0045 | .1137                           | .1202  | .1218             | .1243  | .1380        |
| .1640        |                    | 36                  | .1585                           | .1640  | .1439             | .1460  | .1282             | .1320  | .0042          | .0050 | .1370                           | .1442  | .1460             | .1487  | .1640        |
| .1900        |                    | 32                  | .1840                           | .1900  | .1674             | .1697  | .1497             | .1539  | .0047          | .0056 | .1596                           | .1675  | .1697             | .1726  | .1900        |
|              |                    | .2160               | 28                              | .2095  | .2160             | .1904  | .1928             | .1702  | .1748          | .0054 | .0064                           | .1812  | .1896             | .1928  | .1959        |
| .2500        |                    | 28                  | .2435                           | .2500  | .2243             | .2268  | .2041             | .2088  | .0054          | .0064 | .2152                           | .2229  | .2268             | .2300  | .2500        |
| .3125        |                    | 24                  | .3053                           | .3125  | .2827             | .2854  | .2591             | .2644  | .0063          | .0075 | .2719                           | .2799  | .2854             | .2890  | .3125        |
| .3750        |                    | 24                  | .3678                           | .3750  | .3450             | .3479  | .3214             | .3268  | .0063          | .0075 | .3344                           | .3417  | .3479             | .3516  | .3750        |
| .4375        |                    | 20                  | .4294                           | .4375  | .4019             | .4050  | .3736             | .3797  | .0075          | .0090 | .3888                           | .3970  | .4050             | .4091  | .4375        |
| .5000        |                    | 20                  | .4919                           | .5000  | .4643             | .4675  | .4360             | .4422  | .0075          | .0090 | .4513                           | .4591  | .4675             | .4717  | .5000        |
| .5625        |                    | 18                  | .5538                           | .5625  | .5230             | .5264  | .4916             | .4983  | .0083          | .0100 | .5084                           | .5166  | .5264             | .5308  | .5625        |
| .6250        |                    | 18                  | .6163                           | .6250  | .5854             | .5889  | .5540             | .5608  | .0083          | .0100 | .5709                           | .5788  | .5889             | .5934  | .6250        |
| .7500        |                    | 16                  | .7406                           | .7500  | .7056             | .7094  | .6702             | .6778  | .0094          | .0113 | .6892                           | .6977  | .7094             | .7143  | .7500        |
| .8750        |                    | 14                  | .8647                           | .8750  | .8245             | .8286  | .7841             | .7925  | .0107          | .0129 | .8055                           | .8152  | .8286             | .8339  | .8750        |
| 1.0000       |                    | 12                  | .9886                           | 1.0000 | .9415             | .9459  | .8944             | .9038  | .0125          | .0150 | .9189                           | .9289  | .9459             | .9516  | 1.0000       |
| 1.1250       |                    | 12                  | 1.1136                          | 1.1250 | 1.0664            | 1.0709 | 1.0192            | 1.0288 | .0125          | .0150 | 1.0439                          | 1.0539 | 1.0709            | 1.0768 | 1.1250       |
| 1.2500       |                    | 12                  | 1.2386                          | 1.2500 | 1.1913            | 1.1959 | 1.1442            | 1.1538 | .0125          | .0150 | 1.1689                          | 1.1789 | 1.1959            | 1.2019 | 1.2500       |
| 1.3750       |                    | 12                  | 1.3636                          | 1.3750 | 1.3162            | 1.3209 | 1.2690            | 1.2788 | .0125          | .0150 | 1.2939                          | 1.3039 | 1.3209            | 1.3270 | 1.3750       |
| 1.5000       |                    | 12                  | 1.4886                          | 1.5000 | 1.4411            | 1.4459 | 1.3940            | 1.4038 | .0125          | .0150 | 1.4189                          | 1.4289 | 1.4459            | 1.4522 | 1.5000       |



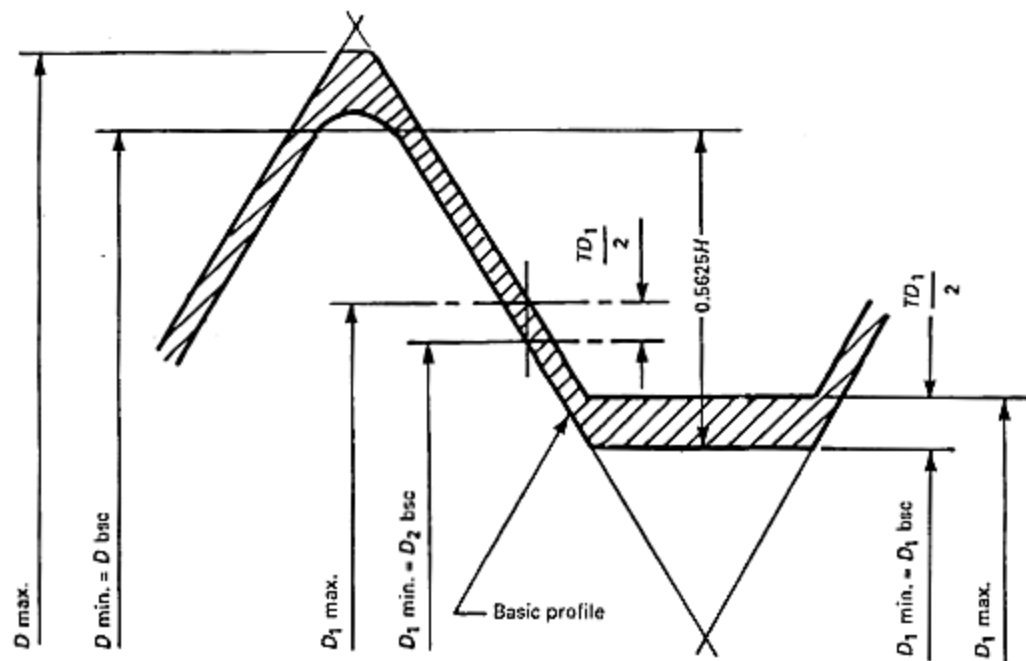
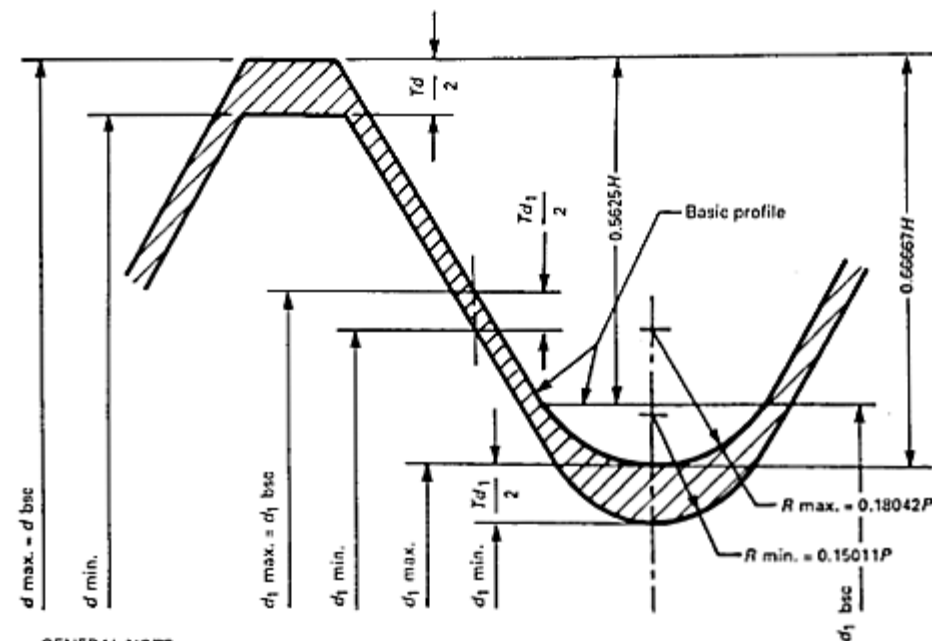


FIG. 2 INTERNAL UNJ THREAD DESIGN PROFILE AND TOLERANCES



GENERAL NOTE:  
Rounded crest is optional (See para. 5.3)

FIG. 3 EXTERNAL UNJ THREAD DESIGN PROFILE AND TOLERANCES



### 5.1.1 Type:

5.1.1.1 Type I—Fluorescent dye.

5.1.1.2 Type II—Visible dye.

### 5.1.2 Method:

5.1.2.1 Method A—Water washable.

5.1.2.2 Method A(W)—Water washable-water containing.

5.1.2.3 Method B—Post-emulsifiable, lipophilic.

5.1.2.4 Method C—Solvent-removable.

5.1.2.5 Method D—Post-emulsifiable, hydrophilic.

5.1.3 Sensitivity—(These levels apply to Type I penetrant systems only. Type II penetrant systems have only a single sensitivity and it is not represented by any of the levels listed as follows):

5.1.3.1 Sensitivity Level 1/2 —Very low.

5.1.3.2 Sensitivity Level 1—Low.

5.1.3.3 Sensitivity Level 2—Medium.

5.1.3.4 Sensitivity Level 3—High.

5.1.3.5 Sensitivity Level 4—Ultrahigh.

| Penetrant |                                                | Excess penetrant remover |                        | Developer      |                                                  |
|-----------|------------------------------------------------|--------------------------|------------------------|----------------|--------------------------------------------------|
| Type      | Denomination                                   | Method                   | Denomination           | Form           | Denomination                                     |
| I         | Fluorescent Water washable                     | A                        | Water                  | a              | Dry                                              |
| II        | Colour contrast                                | B                        | Lipophilic emulsifier  | b              | Water-soluble                                    |
| III       | Dual purpose (fluorescent and colour contrast) | C                        | Solvent                | c              | Water-suspendable                                |
|           |                                                | D                        | Hydrophilic emulsifier | d              | Solvent-based (non-aqueous for type I)           |
|           |                                                | E <sup>a</sup>           | Water and solvent      | e              | Solvent-based (non-aqueous for Types II and III) |
|           |                                                |                          |                        | f              | Special application                              |
|           |                                                |                          |                        | g <sup>b</sup> | No developer (type I only)                       |

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