Titanium Surface Inspection Of Bar Stock

Detect Defects Before They Impact Your Products

Albert R. Fletcher
What Do These 3 Industries Have in Common?
They have chosen to “raise the bar” for their titanium testing.
18-month independent test findings

More than one-half of the time, visual inspection is inaccurate.
Test Results:

- Over 260,000 lbs. of titanium
- 18-month
- independent testing
- 120 orders
- Approximately 200 samples
Test Results:

<table>
<thead>
<tr>
<th></th>
<th>UT</th>
<th>PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>38%</td>
<td>53%</td>
</tr>
<tr>
<td>Void</td>
<td>38%</td>
<td>67%</td>
</tr>
<tr>
<td>Chevron</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Transverse</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td>Total Indications</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

To be the standard by which all other testing laboratories are measured.
Case Study
Following are illustrated results of Visual, Ultrasonic Shear Wave, and Fluorescent Penetrant Inspections on a recently processed 90-bar order of titanium.

<table>
<thead>
<tr>
<th>Bar Number</th>
<th>UT Reject</th>
<th>PT Reject</th>
<th>Visual</th>
<th>Type of Defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td></td>
<td>X</td>
<td>X</td>
<td>Linear</td>
</tr>
<tr>
<td>85</td>
<td>X</td>
<td>X</td>
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<td>Linear</td>
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<tr>
<td>75</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Linear</td>
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<td>34</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Linear</td>
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<tr>
<td>30</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Linear/Internal</td>
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<tr>
<td>67</td>
<td></td>
<td></td>
<td>X</td>
<td>Linear</td>
</tr>
<tr>
<td>92</td>
<td>X</td>
<td></td>
<td></td>
<td>Internal</td>
</tr>
<tr>
<td>71</td>
<td></td>
<td></td>
<td>X</td>
<td>N/R Pit</td>
</tr>
<tr>
<td>15</td>
<td>X</td>
<td></td>
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<tr>
<td>43</td>
<td></td>
<td></td>
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</table>
Finding The Defects That Make A Difference

- Internal and external defects are common in titanium bar
- Defects can compromise end-use finished goods
- Defective product must be segregated
The Effective Approach To Discovering Defects

- Identify the types of defects to be detected and eliminated
- Define the inspection processes used to find them
Defects Defined
Surface defects on titanium bar typically include one or more of the following:

- Laps, Seams
- Cracks
- Pits

Any of these defects can impact the integrity and performance of components made from titanium.
Defect Detection Techniques

Surface defects on titanium bar are commonly detected with:

- Ultrasonic Inspection
- Fluorescent Liquid Penetrant Inspection
- Eddy Current Inspection
- Visual Inspection
Ultrasonic Inspection... Understanding The Differences

There are two types of ultrasonic inspection techniques:

• Longitudinal Wave Inspection
• Ultrasonic Shear Wave Inspection
Ultrasonic Longitudinal Wave Inspection

- Pinpoints internal defects in bar products
- Passes a compressional wave through a water couplant into the titanium bar
- Reflections from internal defects change the wave pattern
- This technique is similar to sonar
Ultrasonic Longitudinal Wave Inspection

The ideal conditions for detection:

- Energy from the sound beam has a good reflecting surface
- There is ideally a perpendicular surface
Ultrasonic Shear Wave Inspection

- Used to inspect bar stock for surface defects
- Relies on reflection of the sound beam from surface discontinuities
- Can produce inaccurate results if the orientation of defects scatters or deflects the sound beam
Ultrasonic Shear Wave Inspection relies on reflection of the sound beam from surface discontinuities back to the transmitter.
Ultrasonic Shear Wave Inspection

At times, the orientation of defects scatters or deflects the sound beam, resulting in a diminished signal or no detection.

Or the geometry of surface laps can reflect the sound beam away without any sound reflected back to the receiver.
Bar Cross-Section And Sound Reflection

The ideal condition for detection is where the energy from the sound beam has a good reflecting surface—ideally a perpendicular surface.
Bar Cross-Section And Sound Reflection

The probability of effective detection decreases with:

- Reduction of the reflecting angle
- Varied geometry of surface laps that can reflect the sound beam away from the receiver
Fluorescent Liquid Penetrant Inspection

This type of evaluation involves:

- Applying fluorescent dye with low surface tension to the bar surface
- Letting the dye dwell for a specified amount of time and absorb into surface defects through capillary action
- Rinsing the bar after the dwell time is complete to remove dye from the outside surface
- Allowing the bar to dry
- Applying a developer solution that draws penetrant trapped in defects to the surface Evaluating defects under an ultraviolet light
Fluorescent Liquid Penetrant Inspection

This method of evaluation is effective because:

• Surface defects are easily detected
• It is less susceptible to handling marks (scratches and dings) than other methods
Fluorescent Liquid Penetrant Inspection

This method of evaluation has the following limitations:

• Labor intensiveness
• Cost
Eddy Current Inspection

Eddy Current Inspection is a method of non-destructive testing that is performed by:

- Passing a tightly wound coil of wire in the form of a probe along the surface of a test sample
- Creating an electrical circuit comprised of the coil and the sample
- Detecting changes in electrical currents within the coil when defects are found

An oscillator inside the test instrument drives the electrical circuit. When defects are found and current changes occur, an alarm is produced.
Eddy Current Inspection

Limitations of Eddy Current Inspection:

- Handling marks can produce false calls during the inspection process
- Cost can be considerable
- Individual fixtures and probes are required for a wide range of bar diameters
Visual Inspection

Visual inspection can be effective in detecting many types of surface-related defects.

The following defects, however, may not be found visually:

- Fine, tight, or linear indications
- Laps, chevrons, etc.
## Conclusion

### 90 piece 1.250" Diameter Ti. Bar Case Study

**Defect Record**

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Questions And Comments