



# NEAR-NET SHAPE TITANIUM FOR PRECISE MANUFACTURING

Stress-relieved feedstock drives quality while reducing scrap and improving production efficiency



## SUMMARY

### Advanced materials for advanced manufacturing

In medical part manufacturing, precision is everything. Implants, hardware, and instrumentation must be produced to increasingly tighter specifications, and the production process itself must be fine-tuned for efficiency in order for companies to meet demand and remain profitable.

#### **Using conventionally ground bar and material saw-cut from plate creates manufacturing challenges:**

- Processing steps are required before component manufacturing can begin that add cost and logistical planning, including rough machining and stress relieving.
- Materials produced have two grain structures, longitudinal and transverse, which react differently and cause extensive movement of the part during machining.
- Residual stresses result in increased scrap rates, as components warp and move during machining when these stresses are released.

Replacing conventionally produced feedstock with near-net shape titanium bars optimizes material usage, while streamlining and stabilizing medical part production. High-value downstream benefits—including high yield and low scrap rate, minimized inspection, and the possibility to integrate automation—can only be realized with a stable production process.

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Carpenter Technology's state-of-the-art titanium processing creates stress-relieved, near-net shape feedstock for precision machining.

## MATERIAL SOLUTIONS

### Novel processes and geometries

Carpenter Technology has developed a proprietary process to create tight-tolerance shaped titanium bars, including:

- Rolled rectangular flat bar that guarantees longitudinal grain flow and reduces residual stress through a unique straightening process.
- Dimensionally true hexagonal bar with surfaces precisely 60 degrees apart.
- ULTRABAR® with exceptional diameter uniformity, straightness, and finish for Swiss-style machine applications.

With end-to-end control of the process, every titanium product is manufactured to precise specifications. Carpenter Technology can adjust the process in-house to make profiles with very specific mechanical properties. It can, for example, provide several different strength levels in the same profile while holding required profile geometry and tolerances.

High-quality titanium stock at a near-net shape allows medical device manufacturers to stabilize their process, eliminate machining steps, reduce scrap rates, and increase manufacturing capacity because of the machinability of the stress-free product.



# Lean, efficient production

Manufacturing with conventionally produced materials includes:

- Initial rough machining to remove material from feedstock and convert it to the specified shape and size.
- A stress relieving heat treatment process to ensure dimensional stability and mechanical integrity.
- Finish machining, including trimming to exact specifications and surface finish grinding.

Switching to the tighter dimensional tolerances of near-net titanium shapes allows manufacturers to eliminate one or more of these steps. Minimizing the material removed by selecting the right material shape means the stress relieve operation after roughing is no longer necessary. Near-net shapes are produced as stress relieved product, which reduces movement, warping, and bending during machining. The decreased machining vibration also maintains surface finish, virtually eliminating the need for finish grinding.

With fewer operations, manufacturers need less cycle time during machining and have a more streamlined, automated manufacturing process — minimizing personnel count on the production floor and optimizing unattended run time.



## Material quality for process stability

Grain structure affects the mechanical properties of material, and grain direction must be considered in production to predict and adjust for a material's behavior during processing.

Starting with a near-net titanium shape allows grain orientation issues to be circumvented. For example, the metallurgical properties of Carpenter Technology's flat rectangular rolled bar exhibit only one grain structure for the full length of the bar. Material saw-cut from plate contains two grain structures and requires the longitudinal grain direction to be marked because it is cross-rolled.

Consistency is also an issue. Conventionally ground bar and saw-cut plate grain structures are not uniform across batches or, often, within a single run. Samples are taken from the edges for testing, but this does not guarantee that the properties in the center or down the length of the material will match the values from the edges.

The manufacturing process for Carpenter Technology's near-net titanium shapes ensures consistent mechanical properties and thicknesses from end to end, bar to bar, and lot to lot.



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Selecting the proper material shape impacts the machined quality. Titanium bars with superior parallel and perpendicular true dimensions are better suited for joint and spinal implants, bone plates and screws, and other critical medical applications.

## Optimized machining

Machining conventionally ground bar and saw-cut plate titanium can create expensive extra steps and scrap during medical device production. Parts lacking precise dimensional accuracy will physically move during machining as stresses release. This vibration can cause warping, surface defects, misaligned components, and compromised structural integrity. Off-tolerance parts that need to be reworked or scrapped are costly from both a materials and production standpoint, particularly during the final stages of production when complex geometrical features have already been machined.

Using stress-relieved, near-net shape titanium virtually eliminates machining vibration. It works extremely well with auto-loaders and moves efficiently through guide bushings, allowing for higher speeds and feed rates while maintaining part integrity and quality. In addition to greater yields, improved machinability results in fewer production interruptions for machine adjustments, less overall machine downtime, and increased tool and machine life.

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The further scrap gets down the pipeline, the more expensive it is. Starting with a stress-free product reduces movement during machining operations, preserving the value of the part itself, as well as the machine and staff time invested.



## CONCLUSION

### Precise, at-scale manufacturing

Medical part manufacturers are driven by increasing market pressure for the highest quality products at the lowest cost. Carpenter Technology's near-net shape titanium feedstock is a mill-supplied solution for precise, cost-effective machining.

- Tighter dimensional tolerance with a stress-relieved grain structure drives quality, machinability, and part performance.
- Superior machinability facilitates streamlined production with measurably less material and part scrap.
- An expanding portfolio of high-quality shaped titanium provides manufacturers with the essential materials to create the medical parts of the future.

Manufacturers of industry-best medical devices and instrumentation have realized efficiency improvements of 25% or more with Carpenter Technology's tight-tolerance, near-net shape feedstock.



**For additional information, please  
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