

Representative Title

RPD® By The Numbers

Contributors

Karl Fossum, Norsk Titanium
Asya Lou, The Boeing Company

Problem Definition

Sustainability in terms of minimizing waste of scarce strategic materials isn't just mandated in EU and CFR directives, but it also makes fiscal sense. A solution that provides titanium parts of equal or better form fit and function is needed to avoid the problem of managing a supply chain whose lead times and costs have increased exponentially since 2020. Shorter lead times enable holding less safety stock, i.e. cash on the floor. Shorter manufacturing times decrease risk of nonperformance. In short, using less material enable more savings.

Background Perspective

Norsk Titanium's approach to manufacturing existing structural titanium with a wire in arc process vice a traditional hogout from block avoids the long and growing lead times of procuring block material and machining 90% of it into chips, or waste. Norsk's preforms create the same part with a 60-70% reduction in waste, machining time and material use at equal to or better material characteristics than traditional block or bar hogouts. The only differing step in the process are the machining and build inspection steps, in that machining time is much less and inspection of the finished part via RT or UT is needed.

Technical Overview

A distinct and independent approach was adopted by Norsk Titanium and The Boeing Company to reach their conclusions centered on aerospace titanium parts applications. Over the past seven years, Norsk Preforms have successfully prevented metric tons of valuable Ti64 from becoming waste within the Boeing supply chain. This analysis was conducted by Norsk, tracking parts delivered over time and comparing them to the material

usage and resources consumed in traditional block hogging of the same part numbers. By substituting block hogouts with wire arc preforms, significant secondary benefits were realized in manufacturing, primarily by minimizing time lost in machining, as well as reducing the consumption of water (cooling fluid) and tools, ultimately leading to cost savings.

Furthermore, the implementation of wire feed applications to replace block hogouts has yielded advantageous tertiary environmental impacts, decreasing waste and emissions by up to 80% in environmental lifecycle metrics when compared to subtractive manufacturing, as illustrated by the Boeing Life Cycle Analysis spider diagram. These findings were derived from the quantities delivered by Norsk and analyzed using proprietary software against traditional block hogouts of identical part number and show that wire feed processes are capable of reducing certain wastes and emissions by 70-80% as compared to block hogouts.

All 2,200+ parts included in the study were produced on Norsk Titanium Merke IV RPD(R) Machines located in Norway and its two facilities in Plattsburgh, NY, during the period from 2017 to 2024, and have been in operation on Boeing 787s. Norsk's patented RPD(R) Process employs two direct materials: Ti64 plate as a substrate and Ti64 wire melted in an arc to create walls or shapes on that substrate. The combination of the RPD shape and substrate forms the preform, from which a fully inspected part that is equal in form, fit, and function is machined. These 2200+ parts have been absorbed by Boeing and its Tier 1 suppliers with zero quality defects, returns or escapes in accordance with BMS7-361 over this period.

Norsk will further submit that in a separate but related study, Norsk was able to avoid another 19 metric tons of titanium waste to another one of its customers, a European semiconductor tooling manufacturer. Using the same method described above, the comparison of using Norsk preforms to create the same tool that previously came from a block, it was able to save that customer from having to expand their facility footprint and machine park to meet market demand. Our preform eliminated one setup operation, and hundreds of finish machining hours, with second and third order effects in line with the aerospace parts study above. Over 160 tool preforms have been delivered with no quality defects, escapes or returns according to AMS7004 during 2023-2025.

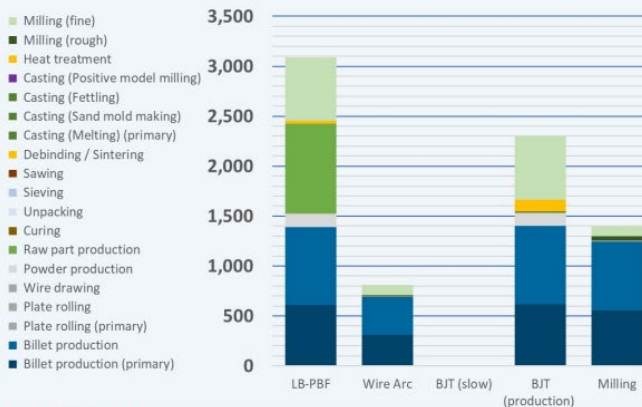
Reflections

In light of trade restrictions impacting the world's two primary titanium supply sources, it is imperative that we optimize the resources available to us domestically and through allied nations. Given the lack of a fully developed industrial base, additive manufacturing technologies serve as a crucial solution. Among these, wire feed technology stands out as one of the few that consistently delivers material characteristics that are equal to or superior to traditional methods, all while maintaining a production rate that meets demand effectively and repeatedly.

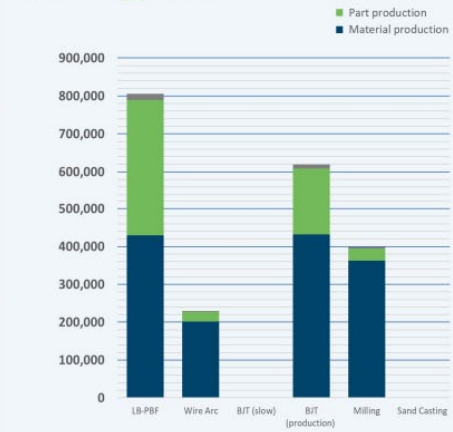
The Numbers

Program	Demand delivered	RPD™ mass printed	Legacy Bar/Block needed	Delta
Commercial Aerospace	2200+ parts	18,000 kg	32,000 kg	14,000 kg (14MT)
Industrial wafer trays	160	15,000 kg	34,000 kg	19,000 kg (19 MT)
Defense aerostructures	Undisclosed	Undisclosed	Undisclosed	1,000 kg (1 MT)

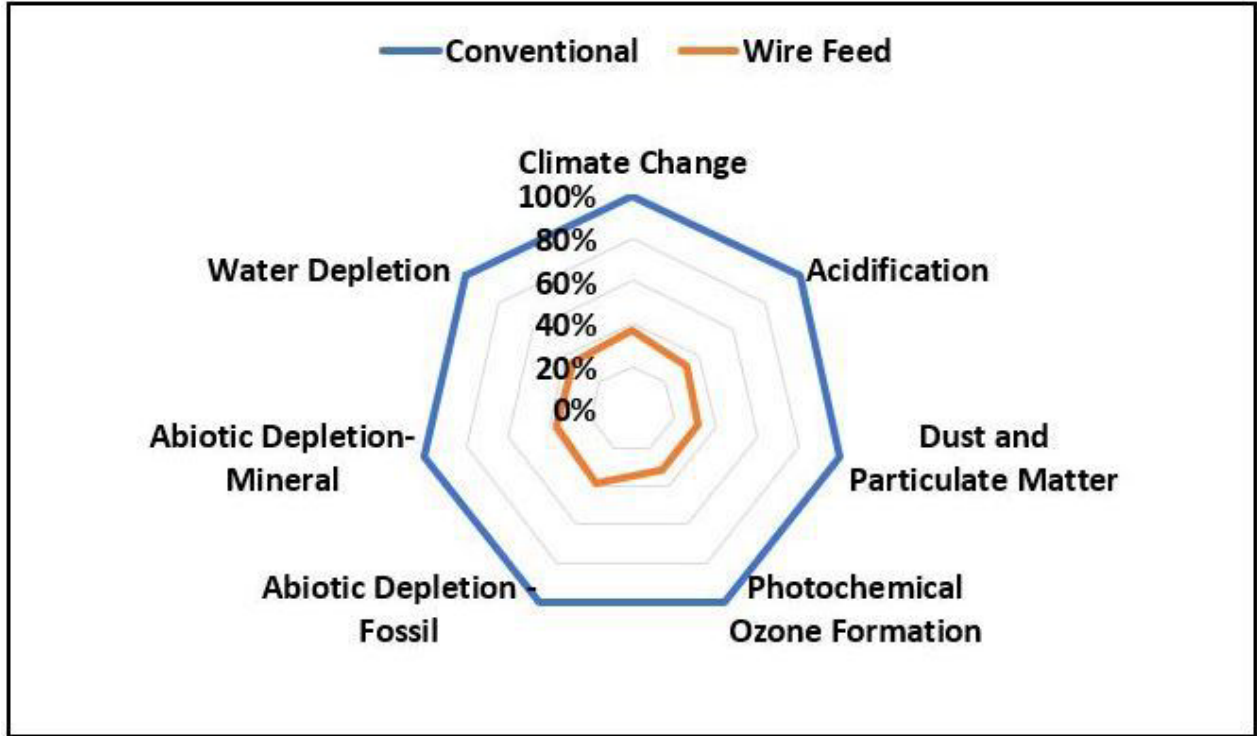
Energy Consumption (kWh/part) - without consumables



CO2 Emission (g/part) Overall



Source: AM Power



Norsk Titanium near net shape approach

<ul style="list-style-type: none"> ▪ RPD™ Form <ul style="list-style-type: none"> ▪ Deposited <ul style="list-style-type: none"> ▪ Wire on substrate ▪ Heat treated ▪ Dimensional inspection ▪ RPD™ Sonic <ul style="list-style-type: none"> - RPD™ Form + - Rough Machined - UT Inspected* ▪ Finished part <ul style="list-style-type: none"> - RPD™ Sonic + - Finish Machined - Finish Processes    <div style="background-color: #003366; color: white; padding: 5px; text-align: center;"> <p><i>RPD™ Buy to Fly ratio 9:1</i></p> </div>	<ul style="list-style-type: none"> ▪ Bar/Block  <ul style="list-style-type: none"> ▪ Finished part <ul style="list-style-type: none"> - Block + - Rough Machined - Finish Machined - Finish Processes <div style="background-color: #333333; color: white; padding: 5px; text-align: center;"> <p><i>Bar/Block Buy to Fly ratio 20:1</i></p> </div>
---	---

Our process – Rapid Plasma Deposition (RPD®)

A low capital cost, clean-cell additive manufacturing technology

Wire in Arc, inert atmosphere

~75% less energy

~75% less raw material

~90% less time



Existing titanium value chain



Ore reduced to porous sponges



Sponges melted to ingots

Ingots converted to wire



Ingots cast into titanium blocks

Wire melted into near-net-shapes



Ingots forged to gross shapes with expensive dies



Shapes machined to parts