Near-Net-Shape manufacturing by Linear Friction Welding

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Near Net Shape Manufacturing by LFW

- What Linear Friction Welding (LFW) is?
  - How fast, reproducible
  - Why it keeps a forged microstructure

- What manufacturing with LFW means?
  - How can it help stabilising a production
  - How it can help reducing component “time to market”

- Applications of LFW for Aerospace
  - What is the typical LFW manufacturing route
  - Is it cost efficient
  - How can it stimulate new designs
TWI: The Welding Institute

- £75M/year of R&D in
  - Materials Joining
  - Structural Integrity and
  - NDT undertaken each year

- 850 employees

- Five UK technical centres and 11 international offices and training centres

- More than 700 Industrial Members in 3500 locations in 79 countries

- Non-governmental and not for profit distributing organisation
Friction and Forge Processes Team

- Based in Cambridge
- 15 Engineers and Technicians
- 53 years of R&D in Friction Processes
  - Started Rotary Friction Welding in 1961
  - Pioneered Linear Friction Welding in 1984
  - Invented Friction Stir Welding in 1991
- Capability at all TRLs / MRLs
  - Concept
  - Feasibility
  - Development
  - Demonstration
  - Application
  - Procurement
  - Support
Linear Friction Welding

High quality, automated, quick, self regulated, self cleaning, repeatable welding process

Linear Friction *Stir* Welding
LFW current products: Blisks

- Critical aero engine component: compressor rotor
- Mature production: fighters engines
  - Power to Weight ratio
  - Performance

- Uptake: large civil engines
- Fuel saving
- Environmental regulations
- In-house knowledge and qualification
LFW: High Quality Weld in Ti Alloys

- Fine grained hot forged microstructure
- Thin heat affected zone
- Recrystallised to fine grained equiaxed microstructure at weld centre
LFW of Titanium alloys

- Dependable
  - Fast: typical cycle time under 5min
  - Accurate: typical positioning under 0.10mm
  - Reproducible: typical positioning under 0.25mm

- Performant
  - Preserves a forged microstructure
  - Can be post weld heat treated for performance
  - Near-parent tensile and fatigue properties can be achieved

- Currently applied to critical AeroEngine components
Airframe bracket by LFW route

- Case study: Bracket
  - Standard manufacturing route: machined from solid
    - Buy to fly: 12.5 : 1
    - 2000 parts/year over 10 years
    - Would require 27 milling CNCs
Typical LFW production route

Workpiece A

Linear Friction Welding → PWHT → NDI → Final Machining

Workpiece B
LFW production route: Bracket

Foot from plate

Upstand from plate

Linear Friction Welding (1 machine)

PWHT

NDI

Final Machining (7 CNCs)

Buy to Fly 1.6 : 1

81% potential costs savings
NNS by LFW: Notable Potential Savings

- 81% potential overall costs savings
  - 87% on materials
  - 61% in production
  - £9.8m or $15m/year potential savings

- Buy to Fly
  - 12.5 : 1 originally
  - 1.6 : 1 for LFW route

- Viable route
  - Bracket: 400 parts/year
  - Large influence of material costs

Benefits of LFW production route

- Control input material = stabilise production costs
  - Near net shape of simple components
  - Can make use of common Ti stock plates
  - Helps reducing component “time to market”

- Produce faster
  - LFW’s fast cycle time means less machines
  - One LFW machine can serve several CNCs

- Start producing quicker
  - Production changeover under 30min possible
  - Typical new tooling manufacture: Start an entire new production under 15 days
Material tailoring
- Dissimilar grades of Ti alloy can be welded together for performance (strain, temperature, weight, costs)

New Design Freedoms
- Adding large components together
- Small protruding features
- Strengthening element
- Reducing part count
- LFW can open design beyond traditional considerations

Example:
- Ti6246
- Ti64

Courtesy of Airbus
Half Machined wing rib Segment

- Potential for other aerospace materials
  - Nickel superalloy
  - Aluminium Copper Lithium

- Ex: Al-Cu-Li wing rib segment
  - 95+ % Yield and UTS
Near Net Shape Manufacturing by LFW

- **Disruptive production method**
  - Fast and reproducible addition of components
  - Keeps forged microstructure
  - Keeps forged parts characteristics

- **Agility in manufacturing**
  - Stabilises production costs by controlling Ti input
  - Can make use of common stock plates for a range of parts
  - Helps reducing component “time to market”

- **Application in Aerospace**
  - Alternative, cost efficient production path
  - Allows material tailoring
  - Opens to new designs freedoms
TWI’s 3rd Biennial International Linear Friction Welding Symposium

19th March 2015 in Cambridge

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