Future Net Shape Manufacture Technology For Subsea Applications

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HVM Catapult

- Advanced Forming Research Centre
- Centre for Process Innovation
- Nuclear Advanced Manufacturing Research Centre
- Advanced Manufacturing Research Centre
- National Composites Centre
- WMG
- MTC
Taking Research into Production

Universities

1. Basic Idea
2. Concept Developed
3. Proof of Concept

MTC

4. Process Validation In Lab
5. Process Validation Production Scale
6. Process Capability Validated

Industry

7. Capability Validated Economic Run
8. Capability Validated Range Of Parts
9. Capability Validated Over Long Period

*TTI HIP Vessel is currently broken.*
Game Changing Technologies

...completely changing the way that something is done, thought about or made.

Hot Isostatic Pressing

An alternative to large castings and forgings.
Traditional Manufacturing Methods

Main methods of manufacturing components:

- Casting
- Welding
- Forging
- Extruding

Potential for defect development or non-uniformity

Inter-stage Heat treatments and post-processing → Extra time/cost
Subsequent defect development

Main defects produced by these methods:

- Porosity
- Internal shrinkages
- Interdendritic cracks
- Heat Affected Zone segregates
- Inclusions
- Hydrogen embrittlement in SS

- Distortion due to residual stresses
- Anisotropic mechanical behaviour
- Chemical segregation
- Microstructural variation

- Extruding
- Casting
- Forging
- Welding
Porosity
Grain structure

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Stress Corrosion Cracking
Repair Technologies & High Integrity Manufacture Methods

All manufacture methods may cause defects to a greater or lesser extent...

<table>
<thead>
<tr>
<th>Tolerate if...</th>
<th>Repair If...</th>
<th>Alternative Manufacture Method If...</th>
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| • Defects do not significantly impact component function or life  
  • Defects are well understood (NDE)  
  • Defects remain stable over component life | • Cost of repair is low vs replacement  
  • High lead time for replacement  
  • Repair does not reduce part performance | • Component performance can be increased  
  • Cost can be reduced (at manufacture or in life)  
  • Greater or new functionality can be attained |
Hot Isostatic Pressing
Properties produced via HIP

- Isotropic grains structure
- Refined grain size
- No chemical composition variation
- 100% densification
HIP component properties

- Isotropic mechanical behaviour
- Greater corrosion resistance/life
- High Ultrasonic inspectability
- Welds can be eliminated
- Near Net/Net shape – less machining
Component Life…

Aging equipment is one of the biggest challenges facing the industry.

- The UK Health and Safety Executive's plant-aging initiative is centred on an inspection programme
- HSE's plant-aging guide (RR509) states:

  “Aging is not about how old the equipment is. It's about what is known about its condition, and how that's changing over time.”

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Products produced via HIP

- Manifolds
- X-trees
- Well-heads
- Swivels
- Barrel Casings and hubs
- Wye Pieces

Manifolds

- First PHIP manifold in North Sea’s Jade Field 2000
- Water injection manifold installed in Heidrun field, decreasing the number of welds by 85%, manufactured in just 4 HIPed parts

[6] Sandvik Powdermet
Products produced via HIP

- Manifolds
- X-trees
- Well-heads
- Swivels
- Barrel Casings and hubs
- Wye Pieces

Swivels (5-16 tons)

- Multi-phase swivel containing complex internal flow channels, used for Floating Production Storage Offloading (FPSO)
- Claimed 10 week lead time & UT inspectable
- Just under 240 tons of HIP material for swivels can be found around the world

As forged piece

As HIPed piece

Sandvik Powdermet
Products produced via HIP

• Manifolds
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Wye Pieces

• Produced for the East Spar Project (Australia)
• Due to a design stress of 25 MPa, conventional methods of production would require a part of 3.5 tonnes, HIP only 2 tonnes\(^9\)

\(^9\) Sandvik Powdermet
Timeline of HIP product manufacture

1987  Powdermet process introduced in 1987 - solid and hollow bars, ring and preforms with the size required by the market\textsuperscript{10}

Mid 1990s  Production of Swivels by HIP processes starts\textsuperscript{10}

1998  >4000 ton of HIPed pieces for offshore industry were produced by Sandvik Powdermet –

2001  Six seabed manifold sections for BP’s Norge’s Valhall Field installed\textsuperscript{11}

2003  70 tons of HIPed pieces sent to Shah Deniz Field in Azerbaijan\textsuperscript{13}
Timeline of HIP product manufacture

2004  China National Offshore Oil Corp. (CNOOC) ordered two barrel casings for Sulzer pumps from Metso Powdermet

2006  Framo Engineering provide a swivel in duplex stainless steel for BHP Billiton’s Stybarrow FPSO

2007  Aker Kvaerner Subsea for subsea hubs for the Dalia, Gimboa, Tyrihans, Visund, Hild, and Kristin projects

2015  Impregnated drill bit series from Varel international includes cylindrical HIPed segments
The Future of Powder HIP

Advances in HIP compaction modelling:

- More complex components possible
- Improved material efficiency
- Greater design functionality

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Bodycote
New Materials & Multi Materials

- Advanced PM alloys and metal matrix composite materials
- Multi Material components

Kennametal

Sandvik Powdermet
Powder HIP Development in The UK
References


References


References


Thank you for listening

Any Questions?