Gas Turbines & Advanced Manufacturing

... this isn’t a linear progression

NETL University Turbines System Research (UTSR) Workshop November 3, 2015
Bryan Dods

Imagination at work.
HEAVY METAL IS COOL AGAIN
WORLD'S LARGEST, MOST EFFICIENT GAS TURBINE FOR 60HZ APPLICATIONS
Changes and Implications

**Challenge:**
- 65% - 67% efficiency
  - Reduced assembly clearances
  - Tighter part tolerances
- 3100°F Firing Temperature
  - Harder to manufacture alloys
  - New cooling schemes
- Output
  - Larger machines, part size and number of stages
  - Higher compression
Advanced Production Systems
Concept of Operations

<table>
<thead>
<tr>
<th>People &amp; Culture</th>
<th>Enable people to pursue their interests and achieve their potential</th>
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<tbody>
<tr>
<td>Ecosystem</td>
<td>Customers, suppliers, competitors, and other industries are making moves that must be included in scenario planning</td>
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<tr>
<td>Infrastructure</td>
<td>Factories, logistics, and customers physical assets</td>
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<td>Business Process</td>
<td>Brilliant factory &amp; industrial internet; ERP, where the competitive advantage/business value is captured</td>
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<tr>
<td>Architecture</td>
<td>Service bus, industrial plug n play; hardware and IT systems interfaces; machine to machine; factory to factory or supplier to supplier networks, information transfer corridors; Cyber security; Array of wireless technologies and hardware systems</td>
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<tr>
<td>Network</td>
<td>Model Based Enterprise, physics based models, &amp; HPC</td>
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<tr>
<td>Modeling, Simulation &amp; Controls</td>
<td>speed, higher quality, higher capability, decisioning / algorithms,</td>
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<tr>
<td>Value Stream Application</td>
<td>Raw material conversion to finish product; leadtime; lean , waste, set-ups</td>
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<tr>
<td>Processes</td>
<td>Emerging &amp; existing capabilities; machine cycle, part features, consumables</td>
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<tr>
<td>Equipment / Hardware</td>
<td>Machine design, analysis &amp; characterization, performance, tools/fixtures</td>
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<tr>
<td>Data Management &amp; Analysis</td>
<td>Data structures, aggregation, signal processing, graphing, transfer</td>
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<tr>
<td>Data Input / Sensor</td>
<td>Digital capability, sensor integration, near real time</td>
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Customers, suppliers, competitors, and other industries are making moves that must be included in scenario planning. Factories, logistics, and customers physical assets are changing, and the competitive advantage/business value is captured through the Brilliant factory & industrial internet; ERP. There is a focus on Model Based Enterprise, physics based models, & HPC. Raw material conversion to finish product; leadtime; lean , waste, set-ups are important factors. Emerging & existing capabilities; machine cycle, part features, consumables are key considerations. Machine design, analysis & characterization, performance, tools/fixtures play a crucial role. Data structures, aggregation, signal processing, graphing, transfer are also important. Digital capability, sensor integration, near real time are essential aspects.
Critical Advanced Manufacturing Technologies

Model Based Enterprise
• MBd, MBm, MBs
• Modeling & Simulation
• HPC as the next controls platform

Additive Manufacturing
• Polymers
• Metals
• Ceramics

Composites
• Large scale composite structures
• High temperature fiber/resin systems (800°F – 1100°F)
• 3D Manufacturing - Pultrusion, 3D Weaving, Cont. Compression Molding
• Ceramic matrix composites

Industrial Internet….Brilliant Factories
• Robotics
• Automation
GE Greenville World’s Only FSFL Validation Facility

- Over $170MM invested
- > 7000 data streams; 1 terrabyte/hour
- > 500,000 horsepower generated
- Accelerates New Product Introduction by ≈ 1 year
- Supplied by on-site LNG facility for fuel flexibility
And What’s Next… Advanced Manufacturing Works

$73MM Investment
132K sq ft
80+ new Advanced Manufacturing jobs

Opening - November 4