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Titanium Milling
Optimization

Xiquan Wang, Ph.D.
Outline

- Introduction of TechSolve
- Introduction of Titanium Milling
- Technical Difficulties in Titanium Milling
- Titanium Milling Optimization
- Case Studies
TechSolve Overview

- TechSolve is
  - A Manufacturing Improvement organization focused on solving cost, productivity, and quality issues in
    - Design Engineering
    - Manufacturing Engineering
    - Supply Chain
    - Shop Floor
  for both New Product Introductions and Legacy Programs
TechSolve Background

Formerly The Institute of Advanced Manufacturing Sciences, Inc. (IAMS)

1982: IAMS Founded

1984: Joined Ohio’s Edison Center Network

1994: Joined National Institute of Standards & Technologies (NIST) network of 60 Manufacturing Centers

2000: IAMS name changed to TechSolve

2007: Launched Edison Center for Smart Manufacturing Technology
Broad Customer Base Serving Many Verticals
TechSolve Strengths

- Manufacturing Process Development
  - Aerospace Machining
    - Hard Metals
    - Composites
  - From Design to Shop Floor

- Application of Advanced Manufacturing Technology
  - Smart Machine Platform Initiative (SMPI)
  - Advanced application and testing laboratory in house
    - Machinability testing (new materials, cutting tools etc.)

- Implementation of Lean Principles
  - Lean in the Machine™

- Supplier Development
Titanium Metallurgy

- \(\alpha\) (alpha) and near-\(\alpha\)
  - Low to medium strength
  - Example: Ti-6-2-4-2

- \(\alpha-\beta\) (alpha-beta)
  - Medium to high strength
  - Example: Ti-6-4

- \(\beta\) (beta) and near \(\beta\)
  - High strength up to intermediate temperature levels
  - Example: Ti-17, Ti-5-5-5-3
Titanium Milling

Face Milling

End Milling
The overall machining performance is a function of multiple interrelated criteria:

- Tool-wear / Tool-life
- Chip-form / Chip Breakability
- Machining Performance
- System Dynamics
- Cutting Force / Power
- Surface Roughness
Difficulties in Titanium Milling

- Titanium is a poor conductor of heat
- Titanium has a high tendency for chemical reactions
- The modulus of elasticity of titanium is low compared to steel and aluminum
- Work hardening characteristics
Guidelines for Titanium Milling

- Sharp tools
Guidelines for Titanium Milling

- Large volume of cutting fluid
Guidelines for Titanium Milling

- Climb milling
- Rigid tools and fixture
- Etc.
Tool Path Improvement in Titanium Milling

- Traditional
- Trochoidal
- Curvilinear
Optimization of Ti Milling

Understanding the process leads to 3X productivity improvement without any capital expenditure.
## Case Study #1: Merritt Tool Co.

<table>
<thead>
<tr>
<th><strong>Objectives:</strong></th>
<th><strong>Measures:</strong></th>
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</thead>
<tbody>
<tr>
<td>Needed Assistance on Cost Reduction for Ti Part</td>
<td>Reduce material cost by more than 25%</td>
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<tr>
<td>Wanted to take cost out of machining processes</td>
<td>Reduce machining time by more than 25%</td>
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<tr>
<td>Elimination of Waste in Machining</td>
<td>Improve quality in process to &gt;90% acceptable</td>
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<tr>
<td>Needed to Improve Quality Yield</td>
<td>Expected Benefits:</td>
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<table>
<thead>
<tr>
<th><strong>Accomplishments:</strong></th>
<th><strong>Next Steps:</strong></th>
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<tbody>
<tr>
<td>33% Material Cost Reduction</td>
<td>Implementing recommendations</td>
</tr>
<tr>
<td>50% Machining Time Reduction</td>
<td></td>
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<tr>
<td>Quality improvement</td>
<td>Issues:</td>
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<tr>
<td></td>
<td>Time – these type of changes are medium to long term</td>
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<tr>
<td></td>
<td>Manpower to implement.</td>
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<tr>
<td>New process is 97% acceptable</td>
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<tr>
<td>35% improvement in yield</td>
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Issues:
- Time – these type of changes are medium to long term
- Manpower to implement.
# Case Study #2: RMI Titanium

## Objectives:
- Address $3 MM customer’s complaint regarding poor machinability of RMI Titanium plate products

## Measures:
- Compare machinability characteristics of RMI Titanium products with those of the competition
  - Tool Wear
  - Machining Forces
  - Surface Finish

## Accomplishments:
- Demonstrated no difference in machinability characteristics between RMI Titanium plate products and those of competitors
- Results indicate RMI Titanium plate products actually machined better than competitors

## Next Steps:
- Machinability data presented to $3 MM customer and customer relationship preserved
Thank You!