Plant Simulation in Design and Optimization of Manufacturing Processes of Gas Turbine Burners

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Simulation of the burner manufacturing at Siemens Gas Turbine Plant Berlin
Simulation of the burner manufacturing
Parts

Parts of turbine classes SGT-8000H series and SGT6-5000F
Simulation of the burner manufacturing
Value stream

Value Stream Cluster
VSC 1: Final Assembly
VSC 2: Rockets
VSC 3: Manifold
VSC 4: Swirler Mach.
VSC 3a: Small Parts Mach.
VSC 6: Pilot Nozzle

Turning
Milling
Welding
Assembly & Cleaning
Testing
Supermarket
Simulation of the burner manufacturing
Customer requirements and level of details

Vision - Use of simulation systems for design and optimization of manufacturing processes
- Flow of parts
- Routings
- Human resources
- Workstations
- Loadplan

Customer requirements:
- Detection of problems in the connected domains above
- Finding of quantitative solution proposals
- Transparency
- Continuous improvement of manufacturing processes (CIP)
Simulation of the burner manufacturing
Added values and challenges

Added value for the Gas Turbine Plant:
• Simultaneous process oriented optimization of
  – Inventory
  – Lead times
  – Workers management
  – Workstations

Challenges:
• The simulation model itself, its granularity and functions
  – Model based on Plant Simulation, incl. added functions, embedded in Microsoft ACCESS for data creation and analysis
• Model parameters
  – The data must fetched in the shop floor item by item (SAP-data inappropriate)
• Acceptance of new methods (Change Management)
  – SCRUM project established with shop floor colleagues
Simulation of the burner manufacturing
Functionalities of the simulation model

<table>
<thead>
<tr>
<th>Human resources</th>
<th>Workstations</th>
<th>Load plan</th>
<th>Parts</th>
<th>Routing, flow of parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Cycle times</td>
<td>Lots</td>
<td>Machine times</td>
<td></td>
</tr>
<tr>
<td>Allocation to workstations</td>
<td>Setup times</td>
<td>Variants</td>
<td>Personal times</td>
<td></td>
</tr>
<tr>
<td>Multiple workstation operation</td>
<td>Delay times</td>
<td>Delivery dates</td>
<td>Set up times</td>
<td></td>
</tr>
<tr>
<td>Shift plan</td>
<td>Down times</td>
<td>Unexpected changes</td>
<td>Waiting times</td>
<td></td>
</tr>
<tr>
<td>Presence</td>
<td>Maintenance</td>
<td></td>
<td>Scrap</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disturbances</td>
<td></td>
<td>Rework</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qualification of other parts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Overall completion 80%
  - Software finalized
  - Data in acquisition

- Human resources:
  - Number
  - Allocation to workstations
  - Multiple workstation operation
  - Shift plan
  - Presence

- Workstations:
  - Cycle times
  - Setup times
  - Delay times
  - Down times
  - Maintenance
  - Disturbances
  - Qualification of other parts

- Load plan:
  - Lots
  - Variants
  - Delivery dates
  - Unexpected changes

- Parts:
  - Machine times
  - Personal times
  - Set up times
  - Waiting times
  - Scrap
  - Rework

- Routing, flow of parts:
  - Instructions
  - Sequence of instructions
  - Lot sizes
  - Quality breaks
  - Parallel workstations
  - Assembly/join of parts
  - Different parts on the same work station
  - Parts several on the same work station
  - Stocks
  - Kanban, cycling
  - Jams
  - Idle times
Simulation of the burner manufacturing
Added values and challenges

Manufacturing of the swirler component:
• Mechanical steps (milling, drilling, eroding)
• Welding
• 3D Coordinate-measuring – CMM
• Surface crack testing
• Mass throughput testing

Starting point:
• Completely de-coupled value stream
• All lot sizes are of value 1, in simulation workstations are added to avoid crossing value streams
• Processing times taken from shop floor
• All workers can do all work
• Simulation goal:
  – Optimization of output per day by given number of workers and their allocation to workstations
Swirler 2.0 GO: coupled vs. de-coupled value streams time on and before workstations

<table>
<thead>
<tr>
<th>Value stream</th>
<th>Queuing time in front of the workstations / days</th>
<th>Working time of the workstations / days</th>
<th>Output rate / parts per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>coupled</td>
<td>1.452</td>
<td>656</td>
<td>29.4</td>
</tr>
<tr>
<td>De-coupled</td>
<td>209</td>
<td>920</td>
<td>28</td>
</tr>
</tbody>
</table>

De-coupling of value streams does not necessarily increase the performance of the production.

Picture 1: Sum of working times, waiting times and queuing times of parts on and before workstations
Utilization of manned and non-manned workstations with a demand for a worker

Periodic repeating

Detail analysis $\Delta t = 44$ min

Long phases in which no workers are required

Long phases in which workstations can’t be put into operation because no free worker is available

$\Delta t = 45$ min

Sum of workstations working with worker

Sum of workstations waiting for a worker

Poor average
Detailed analysis of the utilization of workstations and workers
t = 11 06:28, time A

- 8 workstations waiting for a worker
- 2 workstations working without worker
- 13 workstations without part
- 8 workstations working with worker
- 0 worker without part
Detailed analysis of the utilization of workstations and workers

t = 11:07:12, time B
The periodic oscillation between too less workers and too less parts

Marching lock-step can force the bridge to resonance vibrations

Relating attributes in production:

- **Personnel:**
  - Number
  - Allocation of workers to workstations
  - Shift plan

- **Parts**
  - Packet size when charging
  - Cycling of packets
  - Sequence of packets when mixed

- **Routing:**
  - Number of working instructions
  - Sequence of instructions
  - Cycling time per instruction
  - Lot sizes
  - Cycling of workstations

An inappropriate combination of one or more of those attributes can force the production to unexpected behavior
## Investigated measures

<table>
<thead>
<tr>
<th>Number</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coupling of the value stream by appropriate lot sizes in surface crack testing and washing</td>
</tr>
<tr>
<td>2</td>
<td>Adding a milling workstation because of a bottle neck</td>
</tr>
<tr>
<td>3</td>
<td>Determination of the optimized workers allocation to workstations</td>
</tr>
<tr>
<td>4</td>
<td>Determination of appropriate shift plans (combination and number of workers)</td>
</tr>
<tr>
<td>5</td>
<td>Interruption of the routing in two phases, hereby introduction of a new material in the bill of materials</td>
</tr>
<tr>
<td>6</td>
<td>De-coupling of the two new routing by a KANBAN controlled stock</td>
</tr>
</tbody>
</table>
Simulated output rate (I)

Value streams coupled, all can all

ID shift plan

Value streams coupled, workers allocated to work stations

ID shift plan
Simulated output rate (II)

interrupted routing, all can do all

interrupted routing, worker allocated to workstations
Summary

• Plant Simulation together with extended data analysis gives strong hints to improve the output of Berlin’s swirler production 48%

Next steps:

• Installing a continuous improvement process - CIP - of production and simulation
• Extending the CIP to all other production clusters of the Berlin plant
Thank You

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