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Combustion Turbines: Critical Losses and Trends
(WGP 64(09))

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Combustion Turbines: Critical Losses and Trends

- Combined cycle cogeneration use
- The criticality of combustion turbines
- The types of machines
- Risk management means
  - on-line monitoring
  - planned overhauls
  - NDT-testing
  - metallography
- Parts and Service Agreements
- Loss Analysis
  - Technology and Machine Type
  - Loss Initiating Components
  - Causative process
- Root cause analysis
- Typical Damage
  - Technical and Design
  - Duty cycle, airflow, gas flow and fuel
  - Quality Assurance
  - Operations and Maintenance
Combined Cycle Cogeneration

1. Compressor
2. Turbine
3. Generator
4. HRSG
5. Steam turbine

Steam to process
Process return
Exhaust
Bypass stack
Air intake
Most critical: The cooling
Critically of Combustion Turbines
Types of machines
On-line monitoring
Planned overhauls
Non-Destructive Testing
Non-Destructive Testing
Non-Destructive Testing
Turbine inspection

- Looking for defects with a 3-D scan pattern
- Multiple beam angles from single probe
- Optimized focus
- Much simpler probe pan assembly – replaces multiple probes with one array
- Faster: single-pass inspection of complex geometries
Non-Destructive Testing
Non-Destructive Testing
Metallography
Parts and Service Agreements

Why?

• Reduced cash flow uncertainty
• Benefits of the latest technological innovations
• Risk sharing
• Assurance of continuing support by the OEM and availability of spare parts
• Raised re-sale value of the plant
Parts and Service Agreements

What should they include?

• a complete list of component parts which are subject to the OEM’s scheduled maintenance obligations,
• definition of the OEM’s scheduled maintenance obligations with respect to each part (inspect, repair, refurbish, replace, etc.),
• description of activities for each scheduled outage,
• definition of OEM’s unscheduled maintenance obligations,
• definition of OEM’s extra works.
Parts and Service Agreements

Other checklist items

- Which equipment components and activities are excluded from the service agreement?
- Extent of warranty obligations and definition of consequent damage excluded from warranty.
- Service Agreement for provision of spare parts and availability of OEM’s personnel only?
- Waiver of Subrogation included?
- In case of replacement of a damaged part: who owns the damaged part? (salvage value)
- Is the OEM to be included as Named Insured?
Loss Analysis: Technology and Machine Type

### OEM Products Insurance Market Consensus

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*Source – Market Placement process 2004*

- **Technology**
  - Prototype
  - Unproven
  - Proven
  - Proven but problematic
Loss Analysis: Loss Initiating Components

Electricity Producers Research Institute (EPRI) combustion turbine experience and Intelligence report 2003

- Rotating Blades & Parts of Turbine: 42.0%
- Stationary Buckets & Parts of Turbine: 21.0%
- Stationary Buckets & Parts of Compressor: 12.0%
- Bearings: 14.0%
- Recuperators and Exhaust Pipes: 5.8%
-Rotating Blades & Parts of Compressor: 5.3%
- Fittings Other than Piping: 3.4%
- Other: 4.8%
- Fire Chambers and Hot Gas Areas: 1.1%
Loss Analysis: Causative Processes

- Technical and Design issues
- Duty cycle, airflow, gas flow and fuel
- Quality assurance problems
- Operations and maintenance

A crack developed at a corrosion pit on a vane in the 4th stage and progressed by high cycle fatigue until the airfoil failed leading to further loss of blades and vanes.
Root cause analysis

• Categorising cause problematic - insurers' representatives, manufacturers and operators have different views

• Root Cause Analysis team important – representative of owner/operator, OEM engineers, the EPC and its subcontractors if still in warranty, insurance adjuster, repair vendor

• Parts and service agreements can restrict access to hardware and limit usefulness of analysis

• Will RCA arrive at a single cause?

Loss of a single Inlet Guide Vane that fractured at the guide shaft passed through the compressor generating debris as blades and vanes broke off downstream
Technical & design

• Technology in almost continuous development
• Extrapolated operating parameters – unintended consequences
• Solution to a fault can create another fault

Combustion dynamics led to the release of a fuel nozzle tip which passed into the turbine section and started the cascading damage.
Duty cycle, airflow, gas flow and fuel

- Frequent start ups and shutdowns from daily peak load operations
- Different operating characteristics of combined cycle and simple cycle machines

Blockage in some fuel nozzles due to poor quality fuel resulted in a pulse on each blade as it passed from hot to cool areas resulting in airfoil high cycle fatigue
Quality Assurance

- High precision machines, high temperatures, high pressures, high speeds
- Component failure can have disastrous consequences

Some shims between selected vanes and vane carriers migrated out, entered the air stream and caused impact damage to blades and vanes
Operations and maintenance

• Repeated incorrect procedures can build up problems
• Operators need to take the right decision when a problem occurs
• Maintenance mistakes can cause failures immediately or months later.

Contamination from a nearby cement plant entered turbine when filters were changed at load and debris was allowed to enter the unit.