Experimental Characterization Of Grid Loss Event On Nacelle Test-rig Using Advanced Operational Modal Analysis

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Presentation Overview

• Introduction
• Goal
• Dynamic event description
• Test Object
• Resonance estimation
• HSS Toot Contact
• HSS Bending
• HSS Bearing Slip
• Conclusions
• Next steps
Introduction

- **Main design load cases:**
  - Quasi static
  - Dynamic
  - IEC 61400-1

- **Electric excitation during grid events results in mechanical response:**
  - Grid loss
  - Low voltage ride through
Introduction

- **Bearing slip:**
  - Roller slip
  - Cage slip
- **Widely believed to be playing important role in bearing failure**

Source: Timken
Introduction

- First drivetrain torsional resonance:
  - Counter clock wise motion of rotor and generator inertia
  - About drivetrain stiffness
Research Goals

• Experimentally **perform** grid loss event on full-scale system

• **Identify** the first drivetrain torsional resonance

• Show leading role of this **resonance** in the event

• Show **gear backlashing** during event

• Experimentally show **bearing roller slip** during event
Load Case

- **Worst case grid loss event**

- **25% of nominal load**
- **Nominal RPM**
Nacelle Dynamometer
Instrumentation

• Shaft torque and bending measurements

Main Shaft Torque

HSS Torque & Bending
Instrumentation

- Tooth strain measurements
Instrumentation

• Internal bearing strain
Resonance Identification

- p-LSCE OMA estimator:
HSS gear mesh

- Teeth through backlash and re-engage at other flank
HSS gear mesh

- Teeth through backlash and re-engage at other flank
HSS bending

- Significant bending during negative torque periods
HSS Bearing Slip

- **TRB roller slip:**
  - Preload needs to be overcome

Source: Timken

Within preload

Exceeding Preload

Source: Timken
HSS Bearing Slip

- Bearing load distribution during event → Positive torque
HSS Bearing Slip

- Bearing load distribution during event → Negative torque
HSS Bearing Slip

- Bearing load distribution during event

Positive torque
Negative torque

Clear unloading on upwind side A position
HSS Bearing Slip

• Frequency domain analysis

Influence of speed fluctuation?
HSS Bearing Slip

- Frequency domain analysis combined with ordertracking
HSS Bearing Slip

- Frequency domain analysis combined with order tracking

Bearing roller slip induced by grid induced event
Conclusions

• A worst case grid loss was investigated experimentally
• The driving resonance identified at 0.64 Hz
• HSS mesh disengaging and re-engaging due to torque changes
• Dynamically changing HSS Bending
• HSS TRB roller slip due to changed loading due to grid loss experimentally shown
Next steps

- Linking these events to failure:
  - Monitoring on wind farm level:
    - SCADA data
    - CMS data
    - Additional measurements
  - Structured storage in Big-Data database
  - Event detection + link to maintenance records
  ➔ Statistically show influence of these events on failure