NVH Optimisation of an Electric Parking Brake

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EPB Noise Optimisation Process

- Use of NVH development tools
EPB Noise Optimisation Process

- Use of NVH development tools
- Efficient development process
EPB Noise Optimisation Process

- Use of NVH development tools
- Efficient development process
- Effective noise reduction
Electric Parking Brake (EPB)

- parking the vehicle at 30% hill
Electric Parking Brake
EPB Noise

... is not a vehicle interior noise issue

... is an exterior noise concern
Noise Characteristic
Noise Characteristic

Wavelet analysis

apply

Speed reduction

Howling noise

3000 Hz
2000 Hz
1000 Hz

40  60
Noise Characteristic

Wavelet analysis

• Apply noise comparable to release noise, but mirrored

• Noise annoying mainly during apply „howling sound“

• Structural resonance at 1400 Hz in combination with speed reduction
Noise Radiation

- Impact hammer test at the rotor shows no significant resonance at 1400 Hz
- The cause of the structural resonance is not the rotor
Impact hammer test at the rotor shows no significant resonance at 1400 Hz.

The cause of the structural resonance is not the rotor.

Laser holography

• Cause of the noise is not the caliper.

• Cause seems to be the actuator.
Laser Holography of Housing

=> housing cover shows big amplitudes
Modal Analysis at 1457 Hz
Modal Analysis at 1529 Hz

=>
Calculated Noise Radiation

- Deformed plot
- Pressure
- Displ, X comp
Housing Modification

Baseline shell mesh
Baseline solid mesh
Modification solid mesh

Improvement not sufficient

Baseline Modification

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Actuator Design

- motor; 5 poles
- drive gear; 15 teeth
- toothed belt
- gear
- swash plate
- sliding block
- cover
Detailed Noise Analysis

- clearance compensation
- apply

- speed characteristic
- harmonic of gear meshing noise
- structural resonance
- gear meshing noise
- rattle noise
- 5th motor order

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High-Speed Camera Analysis

=> Belt touches housing
=> Discontinuity of rotation = cause of rattle noise
Solution Strategy

EXCITATION IS:

a) Motor and gear order related

b) Rattle noise is non-stationary

SOLUTION STRATEGY CONSEQUENTLY:

1: Optimize belt drive

2: Decoupling of motor and gear against housing

3: Increase of housing stiffness
EPB Noise Reduction

1. Increase of housing stiffness
2+3. Decoupling from housing
   Increase of stiffness
1+2+3. Helical gearing decoupling from housing
   Increase of stiffness
Solution Strategy

EXCITATION IS:

✓ Motor and gear order related

SOLUTION STRATEGY CONSEQUENTLY:

1: Optimize belt drive
2: Decoupling of motor and gear against housing
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b) Rattle noise is non-stationary
Solution Strategy

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1: Optimize belt drive
2: Decoupling of motor and gear against housing
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b) Rattle noise is non-stationary

“DoE”
# Rattle Noise Investigation Using DoE

## Testplan

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DoE Result
DoE Result

Main factors:
- torque
- speed
- gear guiding

Main influences
Rattle Noise Reduction

standard motor

stronger motor
Comparison Before / After

- Reduced motor and gear order related noise
- Reduced rattle noise
Summary

EPB noise reduction by combining

- Multi channel sound quality system
- Laser holography
- Noise simulation
- High speed camera
- DoE philosophy and software