Minerals solutions for various modes of noise reduction in Polyolefins

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North America
Outline

- IMERYS
- Background
- Objectives/Approach
- Noise Reduction Modes & Test Results
  - DMA
  - CenterPoint
  - STL
- Mechanicals
- Conclusions
IMERYS - Leading Global Supplier of Performance Minerals

- €4.6 billion Revenue
- +50 Countries
- 18,300 Employees
- + 90 New products in 2016
- 270 Operating sites
- #1 or #2 On most of our markets

Imerys Technology Centers / Functional Additives

Over +30 Functional Minerals
Background

Vehicle Interior Noise

- Noise: Environment pollution
- Car noise: Caused by powertrain, wind/air and tire/road
- Electric/hybrid vehicles: Induction machines whines, higher vibration level, wind/air and tire/road. Zero BSR (buzz, squeak and rattle)¹

Current strategies (noise, vibration and shock control)

- Absorptive: Foams, coatings, perforated sheet metal
- Barrier: Mass-Loaded Plastics, Sealants and Sealing Tapes
- Vibration: Isolators, dampers, constraint layers
- Barrier/Foam composites
- Silencers

References

1) Sound & Vibration/April 2011, The Future of Electric Vehicle Noise Control
2) Images: https://earglobal.com/media/5748/floortreatment.jpg (accessed on 07.22.2018)
Screening Objectives

Objectives

- Evaluate performance of various minerals/grades for noise reduction
- Capture performance space in various noise treatments
  - Barrier
  - Damper
  - Absorber
- Understand relative mechanical performance of various mineral grades
- Identify difference in noise and mechanical performance as a function of particle size
Approach

Experimental
- Melt compound via 25mm co-rotating/intermeshing TSE (46:1, L/D)
- ASTM test specimen prepared via 66T Arburg injection molding unit

Sound Testing
- Dynamic mechanical analysis
- CenterPoint
- Sound transmission loss

Mechanical
- Test specimen conditioned 1 week at 23 °C/50% Rh prior to testing
- Testing conducted via ASTM standards/guidelines (D792, D1238, D256, D790, D638 and D648), and other internal methods
Materials

• PP Homopolymer - Ineos PP- H13M00
  o MFI = 13.5 g/10 min (@230 °C, 2.16 kg)
  o Flex Modulus = 1655 MPa

• Addivant Polybond 3000
  o Maleated PP
  o MFI = 405 g/ 10 min (@190 °C, 2.16 kg)

• Strucktol RP 11
  o Processing Aid (viscosity modifier)

• Minerals
  • Talc
    o Coarse (4.5 µm), fine (1.2 µm) and HAR (2.3 µm)
  • Mica
    o Coarse (150 µm) and fine (30 µm)
  • Wollastonite
    o HAR Coarse (18 µm, laser) and HAR medium (12 µm, laser)
  • CaCO₃
    • Fine (3 µm) and Ultra-fine (1.1 µm)
  • Graphite
    • Coarse (<150 µm) and fine (39 µm, d90)
  • BaSO₄ (3 µm, laser)
  • Chopped GF (10 µm x 4mm)
Noise Reduction Process

• **Type of sound**
  • Airborne noise (sound)
  • Structure-borne noise (vibration)

• **Type of treatments to reduce the noise**

  • Barrier treatment
    • Airborne Noise

  • Absorption treatment
    • Airborne Noise

  • Damping treatment
    • Structure-borne noise

• All treatments are frequency dependent
• Performance of damper is also temperature dependent
Noise reduction testing

1) Dynamic Mechanical Analysis (Damping)
2) CenterPoint (Damping)
3) Sound Transmission Loss (Barrier)
Dynamic Mechanical Analysis

Damping

- Reduction of kinetic energy present in a system, through transformation into another form of energy
- Damping performance is commonly expressed in terms of loss factor

Viscoelastic material

\[
\tan \delta = \frac{E''}{E'}
\]

- \(E''\): Loss modulus (viscous factor, dissipates energy)
- \(E'\): Storage modulus (elastic factor, stores energy)

Initial Position

Final Position

Loss tangent, \(\tan \delta\)

DMA
Three point bending mode
Test Results - Dynamic Mechanical Analysis

DMA performed in three point bending mode at 10 Hz frequency from -3 °C to 80 °C
30% Mineral filled PP

- Wide range of performances with mineral filled compounds
- Glass fiber filled compounds have lowest viscoelastic loss
Mica, wollastonite and CaCO₃ grades show superior damping behavior as compared to the neat resin.
CenterPoint Test (ISO16940)

Obtains the response (acceleration) as the bar is excited with specific force

Loss factor ($\eta$) = \frac{\text{Amount of energy lost or dissipated}}{\text{Maximum potential energy in the vibrating system}}

Test Conditions

- Temperature - 23 °C and 60 °C
- Frequency - 200, 400 and 800 Hz
Test Results - CenterPoint (ISO 16940)

- Test performed at 23 °C and 60 °C
- Loss factor at resonant frequencies are interpolated to 200, 400 and 800 Hz
Test Results - CenterPoint (ISO 16940)

- Test performed at 23 °C and 60 °C
- Loss factor at resonant frequencies are interpolated to 200, 400 and 800 Hz

- Performance is temperature dependent
- Talc, mica coarser grades to be superior to their fine counterparts
Sound transmission loss testing (per SAE J1400 (2017))

Sound transmission loss (STL)

\[ \tau = \frac{\text{sound transmitted}}{\text{sound incident}} \]

\[ STL = 10 \log \left( \frac{1}{\tau} \right) \text{ dB} \]
Test Results - Sound transmission loss testing (SAE J1400)

Controls

Sound Transmission Loss (dB)

- Neat Resin
- Glass Fiber
- Barium Sulfate

Frequency

Sound Transmission Loss (dB)

Talc

- Neat Resin
- Coarse Talc
- Fine Talc
- HAR Talc

Frequency

Mica

- Neat Resin
- Fine Mica
- Coarse Mica

Frequency

Wollastonite

- Neat Resin
- HAR Medium
- Wollastonite
- HAR Coarse

Frequency

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Test Results - Sound transmission loss testing (SAE J1400)

- All mineral filled compounds show 2-3 dB STL as compared to the neat resin
- Performance is density dependent; morphology has minimal influence
Summary: Noise reduction testing

- No universal solution for different types of noise treatments

- Dynamic mechanical analysis which imparts viscoelastic loss indicates mica, wollastonite and CaCO$_3$ are better than h-PP
  - **Recommendations:** Suzorite® Mica and Nyglos®, Aspect® Wollastonite line of products

- CenterPoint test which imparts vibrational damping shows **coarser grades** to be superior than their fine counterparts
  - **Recommendations:**
    - Room Temperature: JetFil® and Suzorite® coarser grades
    - Elevated temperature: JetFil®, Suzorite® and Nyglos® coarser grades

- STL data indicate improved barrier performance using all the mineral filled compounds (surface density effect)
  - **Potential Recommendations:** JetFil®, Suzorite® and Nyglos® line of products
Mechanical and thermal testing

Flex | Tensile | Izod Impact
# Mechanical Properties

At 30% loading, tested in ASTM

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Measured Density, g/cc</th>
<th>Flexural Modulus (Young's Automatic), MPa</th>
<th>Tensile Strength, MPa</th>
<th>Notched Izod, J/m (RT)</th>
<th>HDT (66 psi), deg C</th>
<th>Noise mode</th>
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<tr>
<td>h-PP</td>
<td>0.913</td>
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- Various possibility among different minerals
- Range of properties within various grades of mineral
Conclusion

- Noise reduction using minerals:
  - **No universal solution**
  - Selection is dependent on type of noise treatment; also needs to meet mechanical properties
    - **Visco-elastic** damping: improvement with addition of mica, wollastonite and/or ground calcium carbonate
    - **Vibration** damping: improvement with coarser mineral grades
    - **Barrier**: improvement with mineral addition; performance appears to be density dependent

- Range of mechanical properties possible among various minerals and within specific mineral type
Conclusion

Selection is dependent upon specification requirements and cost

- **Talc**
  - Good stiffness-impact balance, color, compatibility, nucleation, *vibrational and barrier*. Exact grade depending on specification
  - **Recommendations**: Macro-crystalline/*Jetfil®, Jetfine®* grades (balance of vibrational-barrier and mechanical performance), Micro-crystalline/*Nicron®, Mistrocell®* (foaming, absorption)

- **Mica**
  - Material of choice for vibrational damping; bitumen/heavy layers
  - **Recommendations**: *Suzorite®* for maximum reinforcement, dimensional stability, potentially for all noise modes

- **Wollastonite**
  - Improves *viscoelastic damping and barrier performance*
  - **Recommendations**: *Nyglos®, Aspect®* for superior mechanical properties, flow and color
Thank you for your attention!

Acknowledgment
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