Acoustic Sand Monitoring

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Introduction

• Sand monitors are required to determine the effectiveness of sand control procedures
• Acoustic monitoring technique is based on passive acoustics; monitor picks up energy from particles that collide with the inside of the pipe wall
• Flow also generates noise that is detected by monitor
• Background noise level depends on fluid flow rates and many other variables
Objectives (Background Noise)

- Determine background noise levels for a range of conditions
- Examine if a model can be developed to predict the changes in background noise for changes in flow conditions
- Model could be used to determine if change in monitor output is a result of change in flow condition or the presence of sand to help set alarm levels
Approach (Background Noise)

- Background noise for each flow condition is determined by averaging raw monitor output when there is no sand present.
- Obtain background noise information from previous data.
- Run experiments to obtain additional data for background noise for various conditions.
Experiments for 4" Vertical Pipe

- Background Noise
- Tulsa University Sand Management Projects

Graph showing the relationship between \( V_{sg} \) (ft/s) and \( V_{sl} \) (ft/s) for current and previous experiments.
Background Noise

Experiments for 2" Vertical Pipe

- Current Exp.
- Previous Exp.

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Background Noise
Background Noise

Background Noise In 2" Vertical Pipe

Average Raw Data

$V_{sg}$ (ft/s)  $V_{sl}$ (ft/s)

$10^{-2}$  $10^{0}$  $10^{-1}$  $10^{0}$  $10^{1}$
Background Noise

Average Background Noise in Vertical Pipe

- 4", V_{sg} = 44 \text{ ft/s}
- 2", V_{sg} = 44 \text{ ft/s}
- 4", V_{sg} = 88 \text{ ft/s}
- 2", V_{sg} = 88 \text{ ft/s}

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Background Noise

Experiments for 2" Horizontal Pipe

Vsg (ft/s)

Vsl (ft/s)

Current Exp.

Previous Exp.

Acoustic Monitor

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Background Noise

Experiments for 4" Horizontal Pipe

Vsg (ft/s)

Vsl (ft/s)

Current Exp.

Previous Exp.

Acoustic Monitor

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Background Noise
Background Noise in 2" Horizontal Pipe

Average Raw Data

$V_{sg}$ (ft/s) $V_{sl}$ (ft/s)

$10^0$ $10^{-2}$ $10^{-1}$ $10^0$ $10^1$

$10^2$ $10^4$
Background Noise

Average Background Noise in Horizontal Pipe

- 4, Vsg = 44 ft/s''
- 2, Vsg = 44 ft/s''
- 4'', Vsg = 88 ft/s
- 2'', Vsg = 88 ft/s
Conclusion (Background Noise)

• It is not possible to determine a general model or correlation to predict change in background noise as flow conditions change based on experimental data obtained at TUSMP
Objectives (TUSMP Model)

• Previously a model was developed at TUSMP to relate acoustic monitor output to sand rate
• Additional data in larger diameter pipes has been obtained since the development of the model
• Comparison of model results with new data will be performed to determine if the model needs to be revised/updated
TUSMP Model

- Model developed to relate sand rate to acoustic monitor output

\[
(V_{rm}^2 - V_{L}^2) = \text{Sand Rate} \left( C m_p V_L \right) \left( C m_p V_L + 2V_L \right)
\]

- \( V_{rms} \) = acoustic monitor output
- \( V_b \) = acoustic monitor background noise
- \( V_L \) = representative particle impact velocity
- \( m_p \) = mass of particle
- \( C \) = coefficient
TUSMP Model

- A fit to C values was previously determined for each flow regime using a combination of superficial gas and liquid Reynolds numbers (data from 1 and 2-inch diameters only)

- Liquid
  \[ C = 1.23 \times 10^6 \left( \text{Re}_{\text{SL}} \right)^{1.27} \]

- Bubble
  \[ C = 2.32 \times 10^6 \left( \text{Re}_{\text{SG}} \right)^{0.895} \left( \text{Re}_{\text{SL}} \right)^{0.179} \]

- Dispersed Bubble
  \[ C = 1 \times 10^9 \left( \text{Re}_{\text{SG}} \right)^{-0.374} \left( \text{Re}_{\text{SL}} \right)^{-0.269} \]

- Slug/Churn
  \[ C = 2.01 \times 10^3 \left( \text{Re}_{\text{SG}} \right)^{1.20} \left( \text{Re}_{\text{SL}} \right)^{0.931} \]

- Annular
  \[ C = 3.8 \times 10^8 \left( \text{Re}_{\text{SG}} \right)^{-0.972} \]

- Gas/Mist
  \[ C = 4.95 \times 10^7 \left( \text{Re}_{\text{SG}} \right)^{0.664} \]

\[
\text{Re}_{\text{SL}} = \frac{d \rho \text{V}_{\text{SL}}}{\mu_{\text{L}}} \quad \text{Re}_{\text{SG}} = \frac{d \rho \text{V}_{\text{SG}}}{\mu_{\text{G}}}
\]
Future Work (TUSMP Model)

- Model will be compared with new experimental data for larger pipe
- If necessary, model will be revised based on new data
  
  New fits for coefficient C will be developed