Optimalization of control algorithm of MR damper

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Theory is when one knows everything but nothing works. Practice is when everything works but nobody knows why. In our lab, theory and practice go hand in hand: nothing works and nobody knows why.

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BUT

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- MR damper
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MR damper

- slit
- cylinder
- floating piston
- coil winding
- MR fluid

Graph showing force (F) versus current (I) with various currents indicated:
- 0A (deminimization)
- 0.05A
- 0.25A
- 0.5A
- 0.75A
- 1A
- 1.5A
- 2A

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Control Algorithms

\[ v_1 v_{12} \geq 0 \quad F_{sa} = c_{sky} v_1 \]
\[ v_1 v_{12} < 0 \quad F_{sa} = 0 \]
Current state of art

- A comprehensive analysis of the response time of MR dampers (Apr 2006) Jeong-Hoi Koo, Fernando D Goncalves, Mehdi Ahmadian,

- Dynamic modeling of large-scale magnetorheological damper systems for civil engineering applications (October 2003) Guangqiang Yang, Billie F. Spencer, Jr, Hyung-Jo Jung, and J. David Carlson

\[
\begin{align*}
i &= \frac{1}{L} \int u(t) \, dt, \\
u(t) &= i \cdot R_L \implies i &= \frac{U}{R_L}(1 - e^{-\frac{R_i t}{L}})
\end{align*}
\]
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**AIMS**
- To measure time response dependances
- To find sources of the long time response
- To design optimized controller
- To use and compare suspension quality with advanced control algorithms
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Measuring stand

![Diagram of measuring stand with circuit and force and voltage vs. time graph]
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Results – time response of the coil’s current

\[ i = \frac{1}{L} \int u(t) \, dt, \quad u(t) = i \cdot R_L \Rightarrow i = \frac{U}{R_L} \left( 1 - e^{-\frac{R_L t}{L}} \right) \]
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Results – time response of the coil’s current

- The response time of the controller + damper with oil with smaller ratio of Fe particles to base oil is shorter

- PWM mode significantly reduces time response

[Graphs showing time constants for different fluids and current values]
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Results – time response of force

- The higher the current is, the faster response

Possible diagnostics of cavitations

Voltage and current during cavitation

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Results – time response of force

- PWM controller significantly reduces overall time response of the MR damper
- The time response of the MR damper is much longer than time response of MR fluid

MR damper force time response

![Graph showing time response of MR damper force](chart.png)

- MR 140 - voltage controller
- MR140 - PWM controller
- OL-J3 Voltage controller
- OL-J3 PWM controller

<table>
<thead>
<tr>
<th>Current [A]</th>
<th>Time [ms]</th>
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<tbody>
<tr>
<td>0</td>
<td>30</td>
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<tr>
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<td>25</td>
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<td>20</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
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Plans for future

- Finding of the cause of the long time response
  - Measurement of the magnetization of the coil's core
- The possibility of using current overdrive
- Design of the controller with recuperation (improving efficiency)
- Measurements of the suspension quality of the advanced control algorithms with voltage and PWM controller