University of Huddersfield Repository

Abobghala, Abdelmenem, Pislaru, Crinela and Iwnicki, S.

Optimising the energy efficiency of rail vehicles by a novel application of integrated active control method for vehicle traction and steering systems

Original Citation


This version is available at http://eprints.hud.ac.uk/19006/

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

• The authors, title and full bibliographic details is credited in any copy;
• A hyperlink and/or URL is included for the original metadata page; and
• The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.

http://eprints.hud.ac.uk/
Active wheelsets steering control for railway vehicles travelling around curves

Market requirements

- Facilitate highly efficient movement of passenger and freight.
- Continuous improvement of rolling stock energy and carbon efficiency.
- Reliable, energy efficient, low whole life cost rolling stock.
- Energy efficient drive systems which produce less pollution.
- Reduction of tractive energy, peak power demand and the unit costs.

Proposed adaptive integrated control for traction and active wheelset systems

Controller

\[
 u(t) = u_n(t) + u_f(t),
\]

\[ u(t) \in \mathbb{R}^m \] is the control input.

\[ u_n(t) \in \mathbb{R}^m \] is the nominal feedback control.

\[ u_n(t) = K_1 x(t) + K_2 c(t) \]

\[ K_1 \in \mathbb{R}^{m \times n} ; \text{ feedback gain, } K_2 \in \mathbb{R}^{m \times m} ; \text{ feedforward gain} \]

\[ u_f(t) \in \mathbb{R}^m \] is the adaptive feedback control.

Adaptive mechanism

\[
 u_a(t) = -\tilde{W}_a \sigma(x(t)) - W_{ua} u_a(x(t))
\]

\[ \tilde{W}_a(t) \in \mathbb{R}^{m \times m} & W_{ua}(t) \in \mathbb{R}^{m \times m} \text{ are the estimates weight matrix} \]

\[ \sigma : \mathbb{R}^n \rightarrow \mathbb{R} \] is a known basis function of the form \( \sigma(x) = [\sigma_1(x), \sigma_2(x), \ldots, \sigma_l(x)]^T \)

\[ x(t) \in \mathbb{R}^n \] is the state vector available for feedback.

Adaptive control method – uses a controller which must adapt the commands depending on variable parameters or uncertainties.

Novelty: advantages of the proposed method

- Novel controller which enables significant reduction of creep forces within wheel-rail interface and reduction of motor current.
- Energy efficient integrated adaptive control method for vehicle traction and active steering systems.
- Significant improvements to vehicle dynamic performance.
- Easy integration with intelligent condition monitoring systems.

Traction control systems in railway vehicles

Controller: generates control signals based on command signals, feedback and signals generated by adaptive mechanism.

Adaptive mechanism: applies the proposed control method in order to optimise the operation of controller.

System identification: performs the processing of signals (such as \( v, B, \omega, T, \ldots \)) which are directly measured form the rail vehicle.