Improvement of Steering Feel
Virtual Approach with HiL

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HYUNDAI-KIA GLOBAL R&D

Global research and development infrastructure

MICHIGAN: Hyundai America Technical Centre Inc.
CALIFORNIA: Hyundai California Design & Technical Centre Inc
RÜSSELSHEIM: Hyundai Motor Europe Technical Centre
NÜRBURG: Hyundai Motor Europe Test Center. Nürburgring
HYDERABAD: Hyundai Motor India Engineering Pvt.
BEIJING: Beijing Hyundai Technical Centre
YOKOHOMA: Hyundai Motor Japan R&D Centre
NAMYANG: Hyundai-Kia R&D centre
HMETC’S ROLE IN HYUNDAI MOTOR GROUP

- Adaption of Hyundai and KIA cars to European market demands
- Research & development for new technologies
- Located in Rüsselsheim since 2003
- 250+ employees
- 7 departments + administration

HMETC

1. Vehicle Test & Development
2. Steering & Suspension
3. Hyundai Design
4. Powertrain
5. Product Planning
6. Engineering Design
7. Regulation, Vehicle Safety & Environment
8. Electronics System Development
9. Administration

⇒ Vehicle test & development
⇒ Steering & Suspension
CURRENT SITUATION

- Steering tuning is performed mainly in full vehicle on proving grounds and public roads
- Majority of Hyundai / KIA cars is equipped with MDPS (Motor-Driven-Power-Steering)
- Column-MDPS for C-Hatchback
- Full electronic tuning by software of steering ECU (electronical control unit)
MOTIVATION

• Competitive with market leader
• Efficient and robust tuning process
• Shift from proving ground to laboratory and simulation » safe time & resources
WHY STEERING HARDWARE-IN-THE-LOOP?

- Independency of real-vehicle, proving ground, expert driver, weather condition
- Perfect reproduceability due to laboratory conditions and simulation (full vehicle model)
- Quicker performance of test maneuvers in all possible conditions
- Quick adaption of vehicle setup
- Real steering on bench → no need for sub-system modelization
EXPERT EVALUATION

- Confirmation of press and customer voices / market feedback
- Separation of steering feel for different areas
- Detection of performance gaps to market leader

\[
\text{Subjective Steering Feel} \rightarrow \text{Objective Steering & Handling Parameters} \rightarrow \text{Simulation of Steering & Handling} \rightarrow \text{Virtual Optimization} \rightarrow \text{Objective Confirmation}
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Targets based on feedback from press and customers (internal + external)

- "the best steering feel"
- "easy to handle"
- "precise and exact steering"
- "natural steering"
- "agile reaction"
- "good feedback"
OBJECTIFICATION OF STEERING FEEL

- Analysis of dynamic tests on proving ground
- Focus on characteristic data
- Definition of reproduceable target values
DEVELOPMENT OF SIMULATION MODEL

- **Kinematic & compliance (K&C) data** from in-house suspension parameter measurement device (SPMD)
- **Tire data** from Korean research center / tire supplier
- **Validation** against in-house dynamic tests performed on proving ground

Subjective Steering Feel

Objective Steering & Handling Parameters

Virtual Optimization

Simulation of Steering & Handling

Objective Confirmation
APPLICATION ON STEERING TEST BENCH (HIL)

- Full MDPS system installed on bench
- Simulated CANBUS data from real-time machine
- Force input on tierods from linear actuators
- IPG CarMaker real-time model calculating vehicle reaction → tierod forces
TUNING OF MDPS PARAMETERS IN LAB

- Connection to MDPS ECU via PC
- Application of same software as in real vehicle
- Real-time analysis of results
- Target-based parameter tuning
VALIDATION OF RESULTS

- Installation of MDPS system in real-vehicle
- Objective tests on proving ground
- Subjective evaluation by experts from different departments & customer group

Objective Confirmation

Virtual Optimization

Simulation of Steering & Handling

Subjective Steering Feel

Objective Steering & Handling Parameters

Dynamic tests:
- Simulation on HiL
- Real test on proving ground

Good effort level, smooth start
Similar to target

Harmonic effort build-up
Good feedback, natural feel

Subjective Steering Feel
• Expansion of maneuvers and target parameters
• Application for mass-production vehicles
• Automation of tuning process by design of experiments (DoE)
• Development of unique steering feel for Hyundai and KIA cars
Thank you for your attention