The Development of MAGSPLIT® Magnetic Powersplit Technology into Vehicle Powertrain Applications

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Agenda

• MAGSPLIT Compared to the State of the Art Hybrids
• The Magnetic Gear and Evolution of MAGSPLIT
• Torsional Vibration Filtering
• Transmission Configurations, Optimisation & Scalability
• Development into Vehicle Applications with Romax
• Summary
Px v DHT

Px is cost Add to Existing Powertrain

DHT Substitutes Existing Powertrain

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Evolution of the typewriter

Evolution of the power train?

Basic 4x2 Plug-In Hybrid Transmission
Hybrid Topology & Complexity

VW DQ400e P2

Toyota DHT

Magnetic Powersplit DHT

HIGH COMPLEXITY

LOW COMPLEXITY
Mechanical vs Magnetic Planetary Gears

- High speed magnet rotor (Sun Gear)
- Steel pole piece rotor (Planet carrier)
- Outer Magnet Array (Ring gear)
Magnetic Planetary Gear

3 Pole Pair Inner
5 Pole Pair Outer

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5 Pole Pair Inner
3 Pole Pair Outer
Magnetic Planetary Gear and MAGSPLIT®
Magnetic Planetary Gear and MAGSPLIT®
Torsional Vibration Filtering

...on test rig

...on 2 cyl TDI engine
MAGSPLIT Transmission Configurations

FWD / AWD

RWD / AWD
Opportunities for TM Cost Saving

Motor torque vs. Motor rotation speed diagram with annotations:
- TM in Parallel Axis Position
- Gearing to Final Drive

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Powertrain System Sizing

Fuel Consumption Map [g/kW-Hr]

EFFECT OF VARYING INTRINSIC RATIO

Normalized Output Speed for Magnetic Powersplit Device

Normalized Engine Speed
Importance of Scalability

US Hybrid Sales in 2015

Propulsion Proportion by Region (2015)
Ongoing collaboration with Romax

- Romax and Magnomatics undertake ongoing collaborative research on MAGSPLIT technology
- This collaboration is carried out under several UK Government funded projects
- This collaboration is of mutual benefit to both companies
- Magsplit provides a challenging case study for the development of Romax advanced system simulation tools and capabilities
- Magnomatics gain insight in the design optimisation of the Magsplit topology and its system integration challenges
Collaboration with mutual benefits

Romax implements:
- Advanced system integration processes
- Simulation toolchain for electro-mechanical design
- Concept design tools
- Analysis of system dynamics and system interactions

Romax gains:
- Real life application of new tools
- 1st hand experience of requirements of active design project

Magnomatics gains:
- Insight in system interactions and design trade-offs
- Right First Time concept design
- Insight in system dynamics
- Reduced development time and cost
MAGSPLIT:
Magnetic Power Split Technology for Parallel Hybrid Electric Vehicles

Aims:

• Optimise Magnomatics’ Magsplit transmission for use in the Ford C-Max Hybrid
• Design, manufacture and test a prototype Magsplit device

Results:

• Development of rapid concept design optimisation tools
• 2000 ratio variants, each with their own shift strategy, were created and analysed in 1 week
• Sensitivity to various drive cycles was completed for all designs, allowing the best (least sensitive) design to be selected
IMPACT:
Integrated Magnetic Powersplit
Advanced Control and Testing

Project Aim:
Develop, simulate, build, and test a magsplit drivetrain demonstrator with engine, magsplit, transmission, electric machine, power electronics, and battery

Romax Develops:
• Complete electromechanical powertrain design process and system integration
• Dynamic analysis of the whole system to capture system effects and interactions between electrical and mechanical components
• Appropriate level of detail at each stage to balance simulation speed with required accuracy
• Correlation of full system simulation models with test results for efficiency and dynamic behaviour
MAGSPLIT Development

2014

Hybrid Hardware and Control System Development on Engine

2015/6

Transmission Manufacture and Engine Testing

2017/8

Vehicle Trials

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MAGSPLIT Summary

• Class Leading Fuel Efficiency and Cost
• Upgrade Px using Existing Architecture
• TV Filtering Enables 3 & 2 Cyl Gasoline and Diesel Hybrids
• Enabling Engine Efficiency Increase by Maximising BSFC
• Transmission uses Common E.machine Manufacturing Techniques
• Scalable With Single Tooling Across Multiple Vehicle Platforms
Thank You