ODIN Optimised Electric Drivetrains

Powering the electric car market through innovative integrated powertrains

The four-year ODIN project aimed to develop a compact and cost effective powertrain for electric vehicles (EVs). Co-funded by the Seventh Framework Programme for Research and Technological Development (FP7), which brings all research-related EU initiatives together under a single umbrella, the consortium partners included Bosch, GKN, Renault and Romax in working to integrate mechanical and electrical components within an optimised drivetrain.

The project emerged because the EU wanted to stimulate growth in the EV market by reducing overall vehicle costs, achieved via the smarter integration of gearbox, motor and electronics, and avoiding permanent magnets. Through its innovative software and consulting expertise, Romax accelerated development, pushing designs in the right direction and helping towards the goal of creating a compact, durable, quiet but energy- and cost-efficient powertrain to enable the mass production of fully electric cars in the EU.

Feedback from the FP7/EU was highly positive: “Deliverables for the period under analysis were received on time and they are all at a high level of quality and clarity. The expected outcomes will provide significant innovation in the domain of EVs and related fully-integrated complex systems... and more generally to the automotive community.”

Client

European collaborative project ODIN (Optimised electric Drivetrain by INtegration) was co-funded by the European Union (FP7), consortium partners include Bosch, GKN, Renault, Fuchs, Romax, CIE Automotive, ISEA (RWTH Aachen University).

Challenge

Reduce cost of electric vehicles (EVs) and enable sustainable manufacturing while ensuring high performance and meeting automotive quality standards.

Solution

Detailed system level engineering of the electro-mechanical package to control key attributes of cost, efficiency, durability and NVH by using Romax technical consulting services, Concept and RomaxDESIGNER software tools throughout the design cycle.

Benefits

Speeding development towards an optimal solution - a 30-40% overall cost reduction and a 1-2% improvement in gearbox efficiency was achieved, when compared to reference powertrains. The goal is to stimulate the EV marketplace and enable mass production in the EU of cheap, durable, power-dense electric vehicles.

Ensuring innovative concepts and faster design

The EU went on to focus on the simulation aspects, describing the ODIN project as "addressing multiple disciplines in a very structured manner" and, crucially, it requires solving "fundamental engineering problems at the earliest stage" through a "well-structured design process and innovative design techniques." Romax played a key role, including RomaxDESIGNER – the industry-leading gear, driveline and bearing system design software, currently licensed by 14 of the world's top 15 automakers.

"Properly integrated powertrains have a high potential to reduce costs, using high-speed electric motors to reduce space requirements and weight," says Barry James, Chief Technical Officer, Romax. "The objective is to create a compact drive without compromising on torque capability. To achieve this, as things become smaller and more power dense, it's essential you can address component integration issues from the very first stages, and validate your high-speed concepts."

He says the key is bringing powerful simulation early in the design process, backed by industry and engineering expertise, to avoid problems and so optimise designs.

With ODIN achieving a 30-40% cost reduction compared to reference powertains, the resulting technology should enable an EV mass market to develop and help expand that market. The development strategy, founded on concept iteration with early stage simulations and analysis to arrive at optimal designs faster, covered:

- Reduced parts count - highly integrated, high speed motor and quiet, efficient gearbox
- Dry sump gearbox with innovative oil chemistry
- Power electronics - high switching frequency, innovative topology
- Cooling and lubrication - one combined circuit (oil) for all components
- System simulations - a "whole system approach" for all components, and combinations

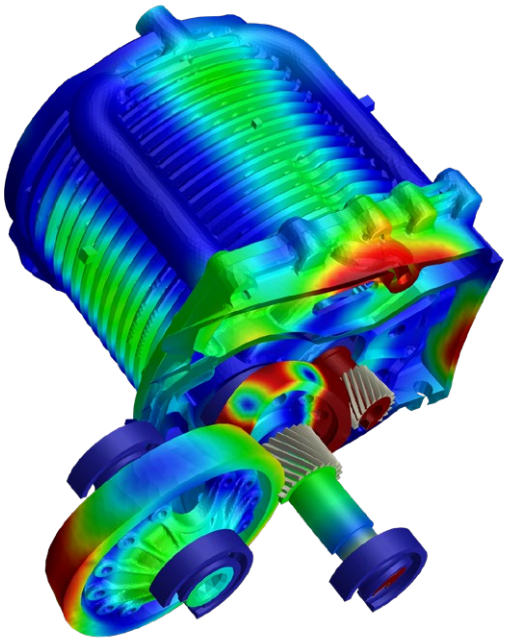
Integrating all sub-components while recognising practical requirements for industrialisation is critical, and the target was a genuinely cost-efficient mass-production compatible design. However, the consortium was initially baffled by the range of options.

"Identifying the right calculations and including appropriate simulations in the initial stages mean you can see what works and highlight potential problems earlier," James says. Romax has supported gearbox design by simulating various configurations and multi-speed gearboxes, different types of gear sets and different ratios, helping whittle possible designs down to the three most promising designs.

The team also simulated different phases, pole pairs and speed/torque ratings for the motor, enabling designers to focus on the four most promising designs.

Dealing with noise and vibration

Regarding noise, vibration and harshness (NVH), concerns included whether torque ripple would cause noise and drive-ability issues, problems due to high speeds, identifying if gear noise or motor noise was the greater problem, finding the quietest design, and more. Simulations looked at the entire e-powertrain, not only the individual sub-systems of the gearbox and motor, and excited the complete system from various sources including gear transmission error, and torque ripple,



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>
> **Barry James,**
> Chief Technology Officer, Romax Technology

Since the time of writing this case study, the Romax product offering has evolved. Romax Concept retains its name, but the features and benefits described as part of RomaxDesigner are now available within products on the Romax platform: Spectrum, Energy, Enduro, and Evolve.

electro-magnetic forces and unbalance from the motor. "Our simulation has been correlated against test data from GKN Driveline and we also drew on our field experience," James adds.

"You can't predict everything early in the design process when the design is changing, and trying to include every last detail can simply lead to 'paralysis by analysis'. So we were very careful to avoid that, and instead do the right simulation to get the best design guidance at each point." This concept of parsimony means you work as efficiently as possible, only doing what you actually need to do – and no more. "Working this way brings noise simulation early in the design process so you can actually make an informed design change at a point where it makes a difference and before the cost of rework becomes prohibitive."

With ODIN, noise minimisation simulations informed design actions such as changing a mount position, and introducing ribs on specific gearbox panel locations to reduce radiated noise. Other issues examined in the project included the impact of using a single cooling circuit with the same fluid, oil, for cooling and lubrication, and high switching frequencies in power electronics. These results assisted the design of this new e-powertrain for the Renault Zoe, the first car designed for mass production solely as an EV. As the EU's FP7 recently reported, the project's progress has already convinced reviewers that "the main objective of a compact, cost effective e-powertrain for EVs is indeed achievable."

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