Who's Afraid of Innovation?

Dr. Michael Platten, Romax Technology Ltd.

There are varying opinions as to what constitutes innovation, but in our industry and in the engineering world as a whole, we typically think of innovation as being the use of technologies different from those we use at the moment to do things better, faster and cheaper. Of course we all have design and manufacturing methods that improve with time, and we continue to make progress and do things better. But innovation is something more than that; it is out of our comfort zone. Put simply, innovation implies risk.

Why Innovate?

There are three fundamental demands from an engineering perspective that drives us to innovate:

Demand from the customer for better performance at lower cost.

"Give me more for less" has always been and will continue to be the primary requirement from the customer. Performance of a design is measured by whether it meets certain targets and avoids failure modes, which are in turn determined by customer requirements. Inevitably, design targets will sometimes conflict. In the case of an automotive transmission, we may be looking at reducing weight while improving efficiency and noise without compromising durability. These requirements are interdependent, and if we are to be radical in our designs, we need to ensure that improving one thing does not break something else.

Demand for new technology either to keep up with the competition, to meet the challenges of legislation or sometimes just technology for technology's sake.

Experience and incremental improvement play a major role in the design of "conventional" drivelines, but new driveline concepts do not have this history of successes and failures behind them. Novel drivelines can have new kinds of failure modes or vastly different performance targets from conventional ones. In addition, new concepts are often heavily patented, and designers need to find ways to avoid infringements. This means that we as engineers must rely heavily on simulations that we can trust. We must also ensure that any knowledge gained is retained for the future.

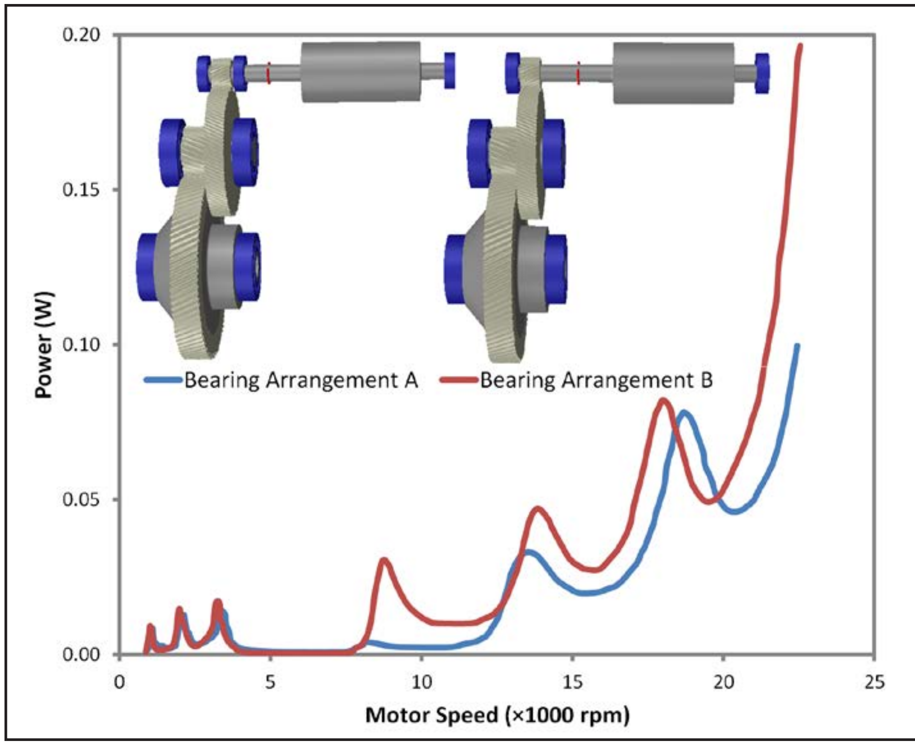

Figure 1 Two competing bearing arrangements are compared for noise performance in the early *Concept* layout stage by estimating total potential bearing vibratory power. Option A is much better at high speeds, but requires an extra bearing which increases cost.

Demand for reduced development time and cost.

These days, the mantra of the entire engineering world is cost reduction and faster time-to-market. Shorter, cheaper development means that more must be done in less time, so the design and analysis phases need to be streamlined and efficient. We must also consider that tooling lead times for items like gears and castings remain relatively long, so these designs must be finalized early.

To really make an impact on development cycle time, design problems need to be identified at the design phase rather than the prototyping phase to minimize prototype cycles. Of course, design problems are better (and more cheaply) solved in the design phase instead of taking remedial action later on — provided you have the CAE tools and associated development processes in place to do it. This "Right First Time" approach is critical to the management of innovation risk.

Mitigate the Risk

Many writers on innovation focus on the environment, freedom and organizational support needed to promote innovation. However, businesses still need to make money. This balance between the huge opportunities available to those who innovate and the risk (and it will happen sooner or later) of investing in something that never quite works is a constant worry. Even the aerospace industry — by nature one of the most conservative of development environments — is having to become considerably more adventurous in its engineering outlook for geared power systems to meet delivery targets that have been shortened literally by years and to comply with aggressive legislation on efficiency and noise.

The most fundamental way to mitigate innovation risk is to have a solid business plan against which new developments can be measured. Regular reviews of technological readiness must be performed and those that carry them out must have the power and the will to pull the plug when necessary.

In the end, though, it is people, not organizations, that innovate, and innovative people need to have a broad knowledge of the technologies around them. I defined innovation as "the use of different technologies from those that we use at the moment" not simply "the use of new technologies." Although original research is a part of the innovation package, engineers can make great leaps in development by taking successful technologies from other areas and applying them to their own problems — a much less risky approach.

My colleagues and I were recently called upon to help in the development of a locomotive electric drivetrain. The basic design had remained unchanged for more than forty years simply because it worked and there was no reason to do anything different. New legislation in environmental noise meant that major reductions in gearbox noise had to be made. We were quickly and successfully able to adapt our methods for gearbox noise simulation and experience in optimizing designs in the automotive world (where customer pressure and competition have demanded such improvements for a long time) to this new application.

Even when corporate inertia can be successfully overcome, innovators still need the right tools and methods to actually make innovation a viable business option. Development processes are defined largely by the available tools and methods. If all you have is a hammer, then everything starts to look like a nail; it is a cliché, but true nonetheless. As tools and methods develop, it is inevitable that design processes will also develop to make best use of them.

To grasp the opportunities of innovation, the engineer must first and foremost have the right tools available to quickly and confidently assess if there is any merit in a new idea, and the means by which this is achieved in practice is simulation.

The Innovator's Toolbox

"Simulate early; simulate often" is the creed of the engineering innovator. The ability to weed out designs destined for failure through simulation is by far the most efficient way to win at the innovation game. However, there are some key principles of simulation that must be adhered to if our "Right First Time" philosophy is to be achieved. These principles cascade directly from the engineering demands and innovation challenges we have been discussing.

Fast to build; fast to solve

To simulate early and often you need to be able to get ideas from brain to computer as smoothly as possible and run simulations fast. You want to be able to identify if an idea is a go or no-go with the minimum of investment. If you are comparing many different competing concepts, time is just as important. Models must be quick to edit and update

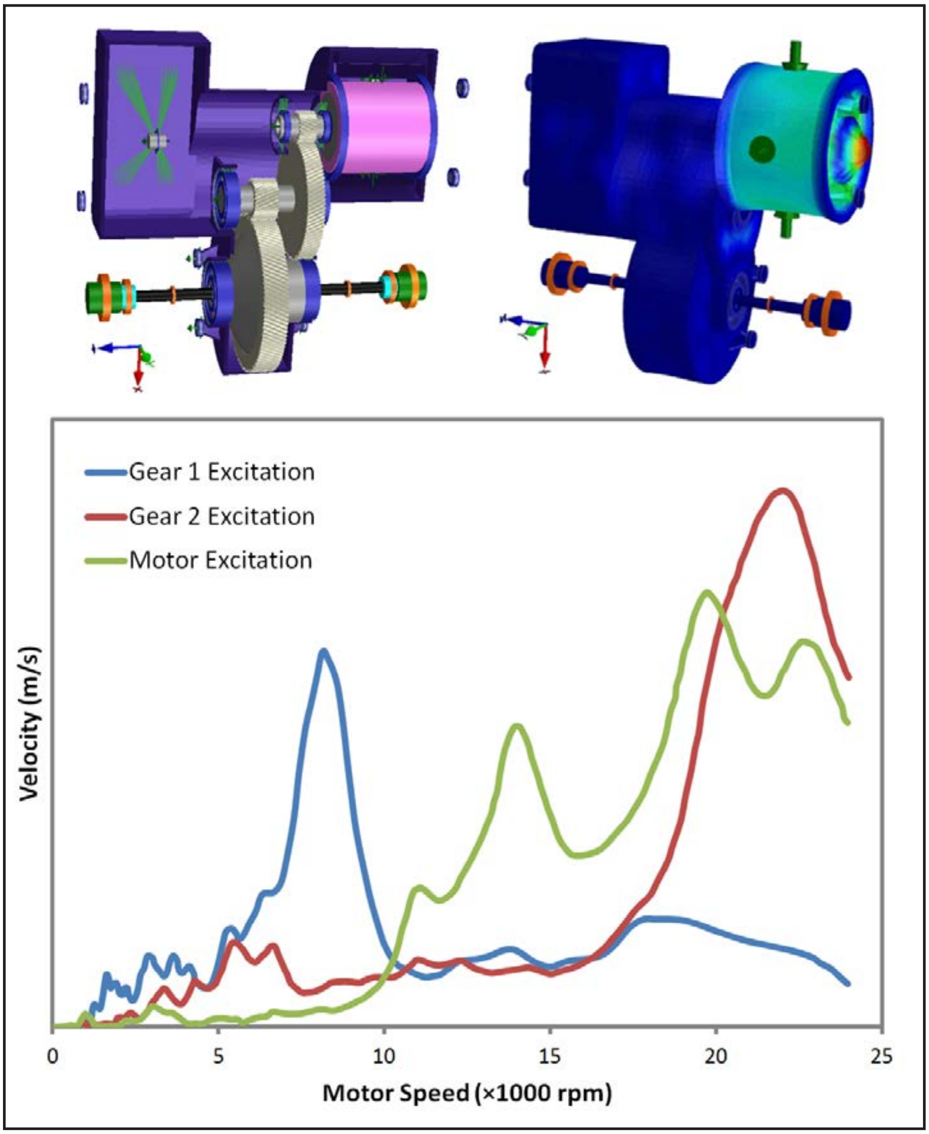

Figure 2 Internal details of the gearbox are finalized, but the housing is only a simple representation. Average housing vibration responses from different excitation sources have been calculated and a potentially problematic mode shape of the complete driveline has been identified.

as well if you want to do "what-if" studies, explore more of the design space or re-simulate as the design evolves.

Right model at the right time

We want our simulations to be as accurate as necessary, not as precise as possible. There is no point building a detailed model or using a complex analysis method at an early stage in the process. Use simple models and methods early on; then move to more clever simulations when more detail about the design is available. Just because a simple model gives approximate results does not mean it is useless, especially when you are benchmarking multiple design candidates; a detailed simulation when there is so much uncertainty in the design wastes time and yields false precision.

One model for many purposes

The ability to use the same model to investigate many different performance criteria means that you only have to build the model once. The models that we create at Romax are based on a description of the transmission system from which we derive different mathematical models for investigating cost, durability, efficiency and dynamic performance. When the design changes, you only have to update the appropriate parameters in the system description and all of these targets can be re-assessed in minutes.

Give engineering insight.

Finally, we want our tools and methods to give engineering answers to engineering questions. Where possible the simulation tools used should not just give us reams of numbers; they should also give the engineer an idea of what to do next. The huge quantities of information CAE simulations produce need processing tools to help us explore the data, reduce it into manageable and meaningful reports and highlight problem areas. A simulation may tell me that the stress at point *x* is *y* but what does this actually mean? How does it relate to the targets that affect whether a customer will buy the transmission that I am developing?

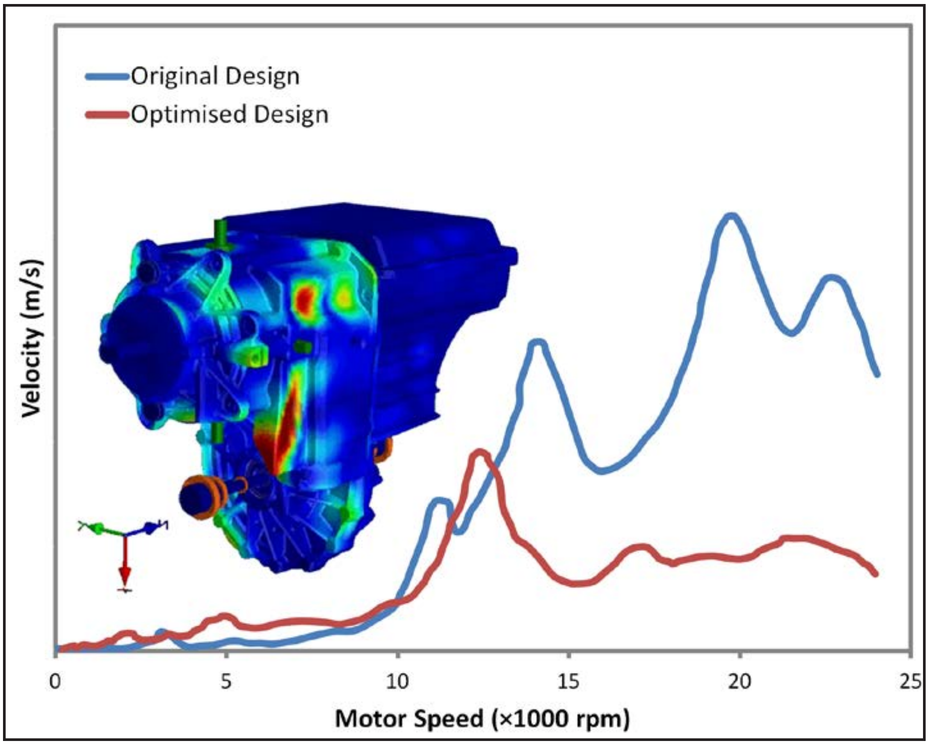

Figure 3 The detailed housing has now been defined. Quantitative predictions of housing vibration have been calculated and used to optimise the housing design. A significant vibration reduction has been achieved, giving confidence that all major problems have been avoided prior to prototyping.

ODIN-Romax in Action

ODIN (Optimised electric Driveline by Integration) is an EU-funded consortium whose aim is to develop new methodologies for the design of an innovative electric vehicle drivetrain. Romax's role in the consortium is to deliver the CAE tools and methods for the analysis of the complete system and to use them to influence the design process from beginning to end to deliver a product which is "Right First Time."

Concept selection

The first phase of the project was to identify the most promising of many proposed basic concepts based on key targets focused primarily on cost and dynamic performance. Romax's *Concept* software was used to rapidly iterate through all the proposed layouts to narrow down the field. Traditionally, predicting noise and vibration performance is considered to only be feasible once a detailed design is finalized. By using very simple models and simple metrics, the concept layouts could be benchmarked to identify those with the best chance of having good noise performance.

Concept development

At a later stage in the concept development phase, Romax was able to use *RomaxDesigner* (A CAE tool for the detailed simulation and analysis of transmissions for durability, efficiency and dynamics) to compare two different layouts for the assembly of the combined motor, transmission and control system. Here, the housing design had not yet been finalized, but a simplified housing was used to identify the best arrangement and to highlight areas which had the potential for problem vibrations. This information was used to guide the detailed design of the housing.

Detailed design

With the first detailed design of the housing in place and all internal gear, shaft and bearing and motor details finalized, it was then possible to simulate the first quantitative predictions of noise and vibration caused by gear and motor forces. Again problems were identified and ways to adjust the design were identified and applied.

Next steps

The next stage of the project, which is currently in progress, is to prototype the design and test its performance against the original design targets in a real electric vehicle. By using simulation of noise and vibration to lead the design right from the start, an innovative concept with the best chance of success has been selected, and potential problems have been identified and remedial action taken to avoid them long before the detailed design was finalized. Finally the detailed simulation of the final design has predicted that the targets will be met before any metal has been cut. Of course there may be further challenges to overcome once the prototype has been tested, but the risk of a significant problem derailing the project has been vastly reduced by applying CAE tools which comply with the principles of innovative software outlined in this article and by simulating early and simulating often to give the best chance of getting it "Right First Time."

Facing Your Fears

Hopefully you have seen that innovation is nothing to be scared of. Yes, there are organizational challenges and there may be resistance to making changes to the old ways of working, but there is no magic to it. It just requires careful planning and continual monitoring of risk. Central to this risk management are the CAE tools and methods which allow us to quantify that risk through the assessment of design performance.

Romax engineers have made many innovative advances in transmission and driveline engineering over the last 25 years by applying these principles to the creation of CAE tools that we and others use to design and optimize across all engineering sectors. In four years we were able to reduce the time taken to design wind turbine drivetrains by 70%. With over 30 certified designs — more than any other organization — we continue to be radicals in a conservative world and are all the more successful for it.

Visit *www.fp7-odin.eu* for more information on the ODIN project.

Dr. Michael Platten is a noise and vibration specialist with 20 years of experience. For the last eight years he has worked in the dynamics of transmissions and drivelines and as a Product Manager he is responsible for all noise, vibration and dynamics software at Romax Technology.

Simulate Early to Speed the Design Process

Interview with Andy Poon, CEO, Romax Technology

Randy Stott, Managing Editor

Romax Technology would like to change the way simulation software is used by the design community. According to company CEO Andy Poon, using software to simulate mechanical systems earlier in the design process gets engineers to better designs, faster.

"A lot of simulation companies focus solely on the accuracy of their simulations," Poon says, adding that although accuracy of simulation is something Romax is well known for, "we're much more interested in how simulation can better inform the design process."

Romax has been developing simulation software for 25 years. Over that time, the company has engaged in consulting work with engineers responsible for developing automobile transmissions, wind turbines and aerospace drives, among other things. Many of the features of their software have come out of that consulting experience, allowing Romax to continually increase the accuracy and detail that go into their simulation software.

A significant amount of their work has been in the automotive industry, where a lot has changed over the last decade, Poon says. Not only do automakers have to contend with demands for increased efficiency, reduced weight and reduced noise, they also have to deal with an increasing variety in the types of transmissions available, from increased speeds in automatic transmissions to hybrid-electric drivetrains and more. All of those options and demands have made the engineer's job much harder, Poon says.

"Simulation earlier in the design process is the key to producing the most accurate and best designs," Poon says.

Dynamic Fusion software from Romax uses dynamic multibody dynamic modeling to help engineers model and optimize transmissions quickly. Unlike traditional simulation software, which could take days to generate a single model, *Dynamic Fusion* is optimized to generate models in minutes. This allows it to be used much earlier in the design process, Poon says. Also, it can be tailored to tackle very specific design issues, such as gear rattle or driveline shunt.

But the real power of using simulation early in the process, Poon says, is that it can help engineers quickly determine whether their initial designs have any problem characteristics, and it can help them focus on the issues that are of most importance, such as noise or efficiency. Early simulations also help designers better evaluate the trade-offs that come with design choices.

"Simulations that take days and days to run are of limited use in design," Poon says. "You need to be able to compare the different trade-offs."

Part of Romax's mission is educational, Poon says. "Where we're most successful is when the client is open to talk about their design process. Simulation *can* be just a glorified calculator, but it's far more powerful when integrated into an overall design philosophy."

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