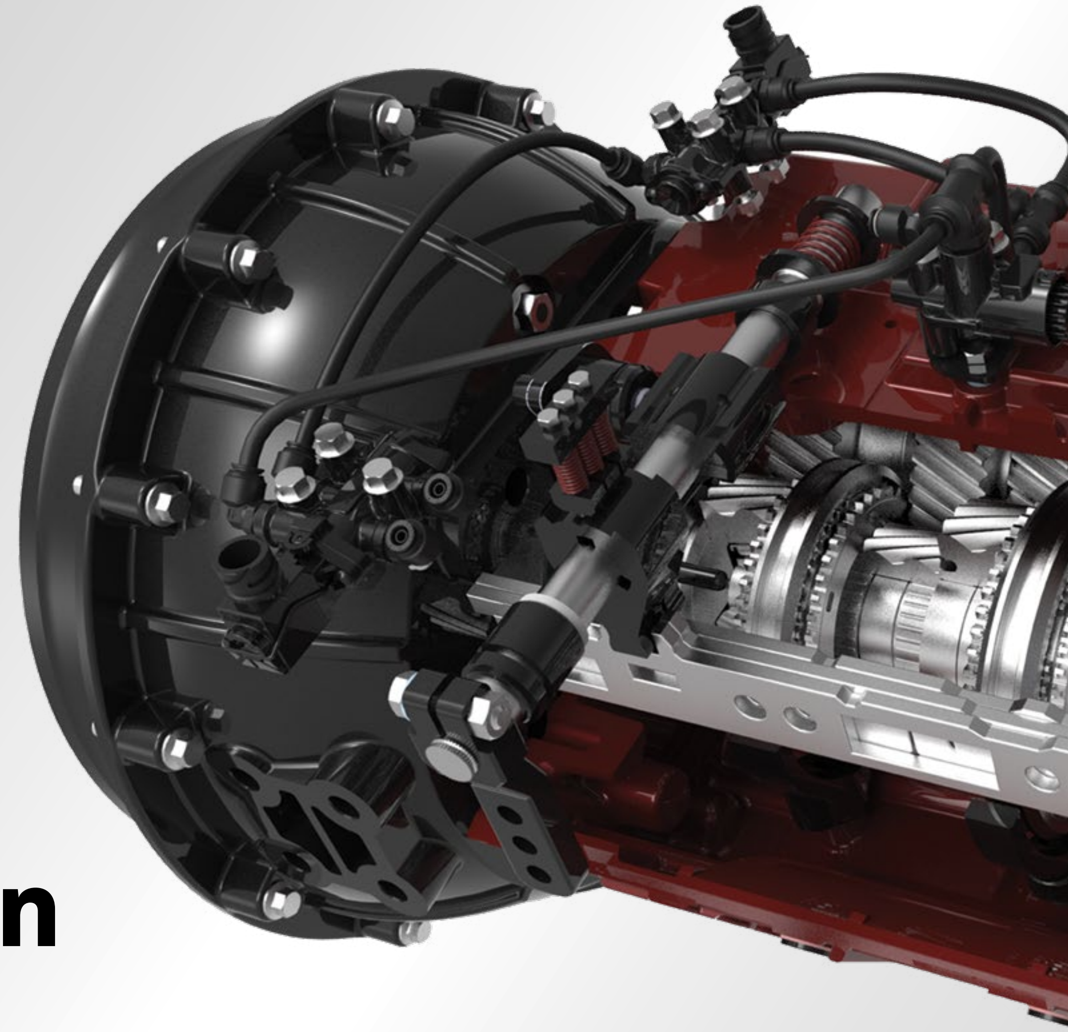


Tümosan

Tümosan use Romax Enduro to develop the next generation of robust automatic transmissions

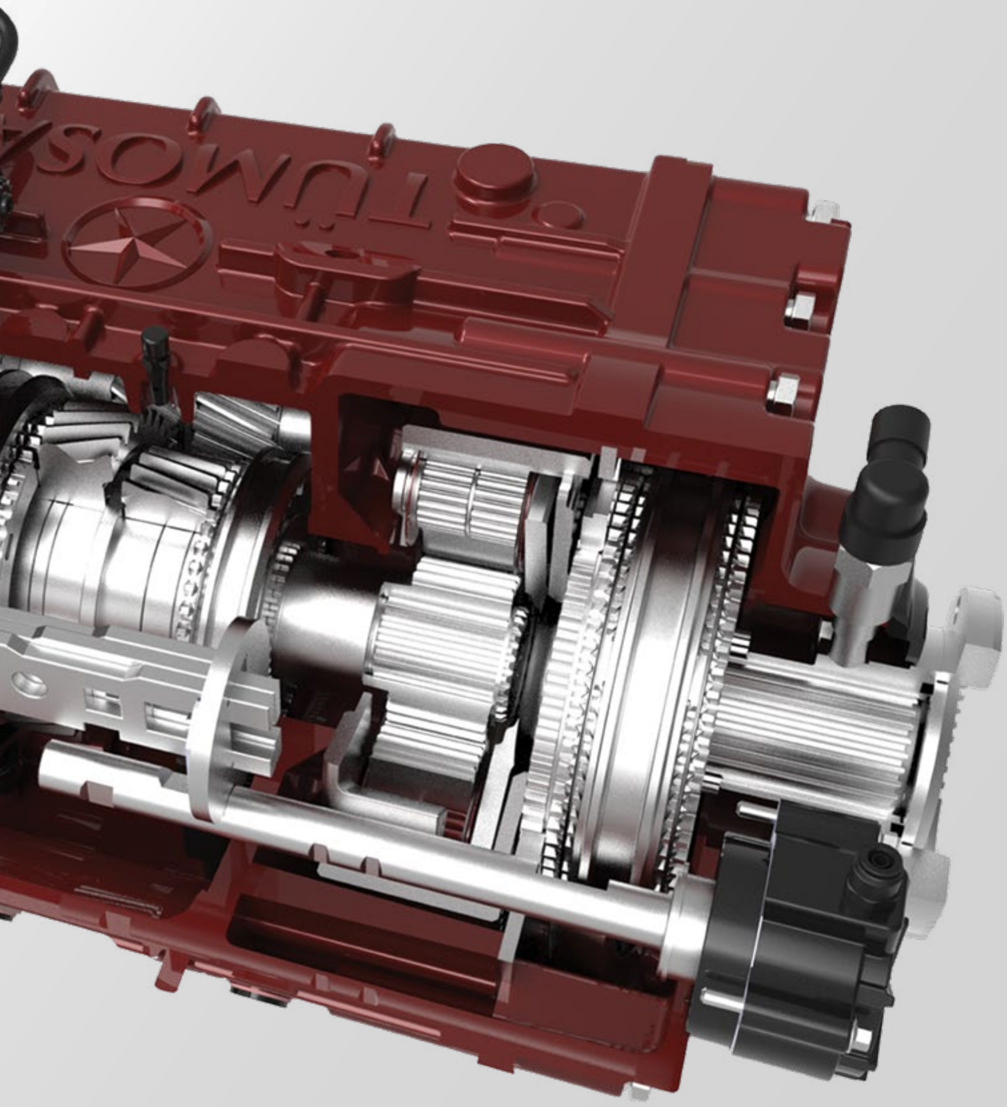
Client: Established in 1976 and headquartered in Istanbul, Tümosan were one of the first diesel engine manufacturers in Turkey. Having designed and manufactured their first driveline product in 2014, Tümosan continue to produce innovative, high-performing next-generation drivelines. Their product range includes agricultural tractors, automotive gearboxes and generators, with a capacity to manufacture 75,000 engines and 45,000 tractors annually.

Challenge: To design a next-generation AMT with an integrated torque converter, doubling the maximum torque on offer from their previous driveline product whist maintaining reliability. The main targets were to optimise gear geometry for durability while minimising transmission error (TE) over the whole operating cycle for a quieter transmission.

Solution: Romax Enduro for fast comparison of thousands of potential design candidates, optimisation for durability and robustness, and high fidelity simulation incorporating finite element (FE) models from an early stage using CAD Fusion. This approach allowed Tümosan to design a novel planetary system which exceeded performance targets.

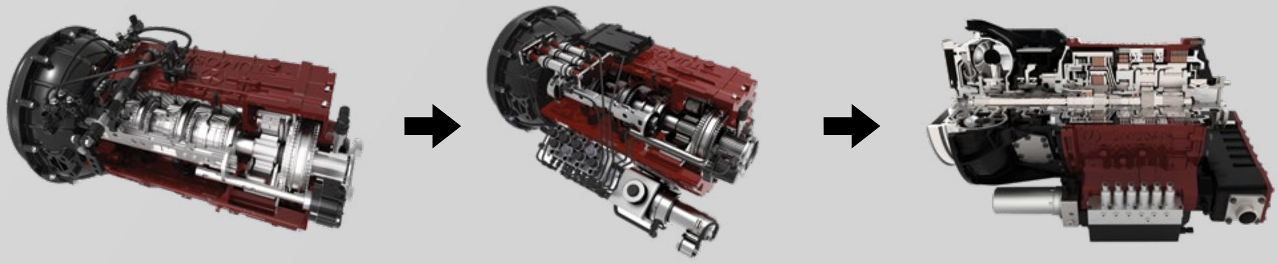
Benefits: Tümosan reduced their detailed design cycle by weeks and were able to improve product quality, quickly producing innovative designs to maintain their strong market reputation and customer satisfaction.

Tümosan develop a range of fuel efficient tractors, tractor transaxles and front axles, as well as a family of engine and transmission products, and a complete Tümosan driveline, including a transfer case, differential, and wheel hub. Durability is a key performance metric to Tümosan, who are so confident in their build quality that all Tümosan tractors come with a 2-year warranty. Their primary aim is to make robust designs with efficient architectures; however, their products also have an impressive appearance thanks to their dynamic, powerful and aesthetic profile. Tümosan offer a range of layouts and transmission types and have recently been developing a 2500Nm 6+1 automatic transmission, which includes 3 planetary gear sets, an electro-hydraulic shifting system and a torque converter, with a maximum speed of 3300rpm. The higher maximum torque requirement means that the gears had to be designed to take higher loads, whilst maintaining design reliability in order to uphold their industry reputation.



In order to develop robust and novel transmission systems in a competitive marketplace, Tümosan use multiple software products from Romax, including Romax Enduro, Romax Concept and CAD Fusion. Arda Alpan, Head of the Transmission Simulation Department comments, “Having used other software tools in the past, we found that Romax software differed by offering a seamless user experience for transmission design, with products tailored to deliver robust results at every stage of the process, be it prototyping various low-fidelity concept design candidates or analysing deflections of FE components and calculating gear ratings. Particularly for our needs, the GBTE and optimisation features were appealing, since they allow us to assess thousands of design candidates, leading to rapid design iterations despite high model fidelity.”

TMSN 1308 MT 8+1 Manual Transmission	TMSN 1308 AMT 8+1 Automated Transmission (Electro-Hydraulic Control)	TMSN 2506 AT 6+1 Automatic Transmission (with Torque Converter)



Completed in 2018	Completed in 2020	at Validation Stage to be completed by the end of 2021

Figure 1: Some of Tümosan’s product range

Dealing with complex vehicle data sources and optimising gear geometry

One of the initial challenges Tümosan experienced was in applying their agricultural tractors' mission profile data in order to size and analyse the system appropriately. Although these profiles don't conform to standard vehicle duty cycles, Romax's Duty Cycle Generator allowed Tümosan to convert and use this data in system analysis. The mission profile was converted into a condensed duty cycle, with load case bins for accelerated system analysis in order to assess many duty cycles and perform load testing within simulation.

Once duty cycles were generated, Romax Enduro was used to perform initial system design, including layout definition, definition of module and number of teeth, bearing selection, and gear macro-geometry optimisation. Initially in any planetary gearbox design, multiple parameters must be considered, such as number of teeth, module, pressure and helix angles, number of planets, and many more. There are also multiple design targets, such as safety, damage, life, packaging space, etc. Using the Monte Carlo and optimisation features within Romax Enduro, Tümosan were able to assess thousands of design candidates and look at parameter variability to select the appropriate design. At this stage, an early stage NVH assessment was also done to see whether the planetary gears were factorising or non-factorising. This determines whether all the planets enter mesh with the sun at the same time and mesh with the ring at the same time - i.e. that the system is 'in-phase'. Combining the optimisation process with factorisation checks allowed Tümosan to very quickly whittle down thousands of design candidates into a single candidate, the performance of which they could assess against targets. Alpan comments, "Enduro's gear geometry optimiser and parametric studies saved weeks of man-hours for Tümosan, allowing us to assess multiple parameters across three planetary gear sets for multiple objectives, rather than relying on design loops driven by intuition and estimation."

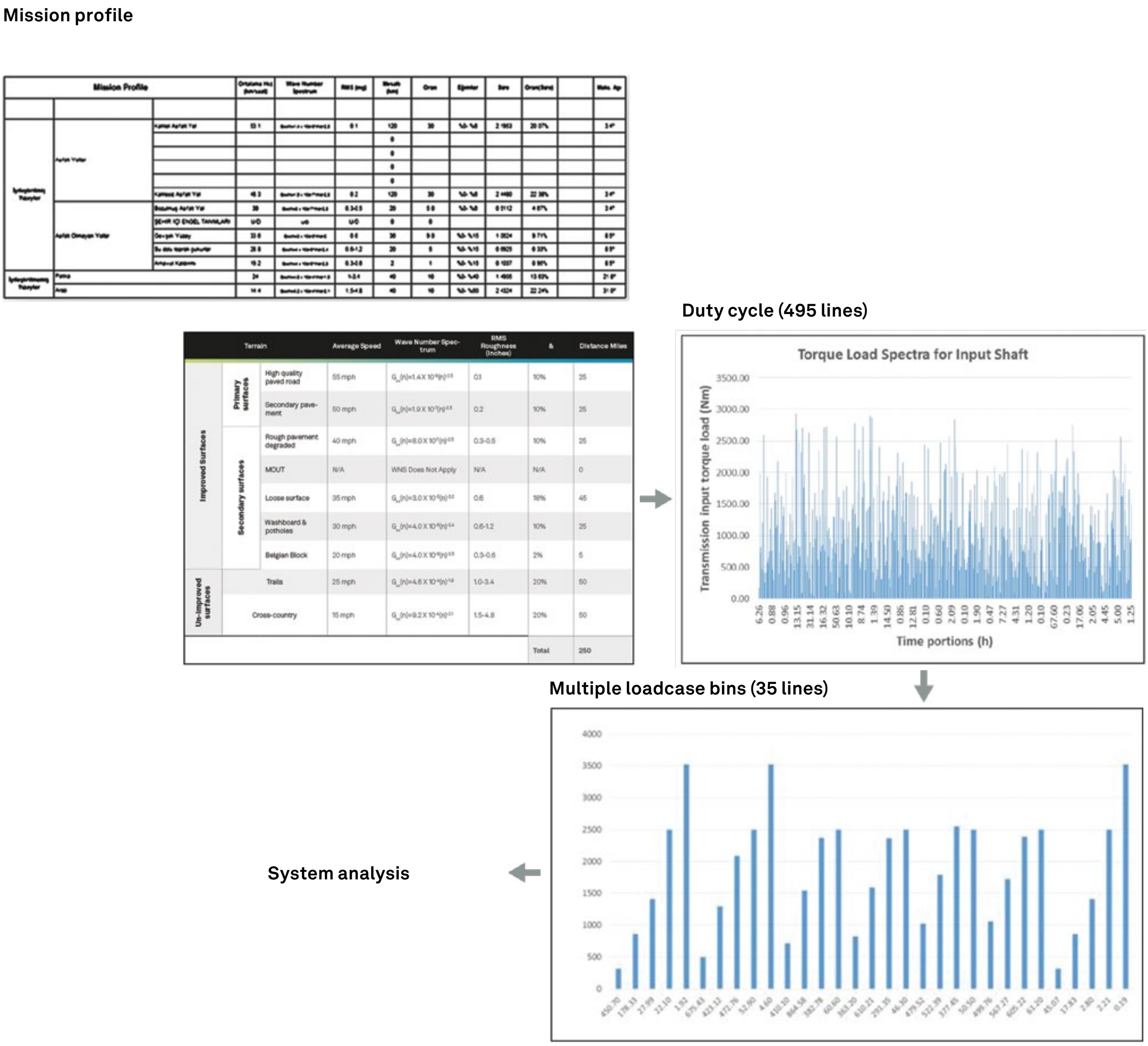


Figure 2: Design process using Romax Enduro

From low to high-fidelity

Once the Romax model had been built and analysed for macro-geometry optimisation, Tümosan were able to include more detail using Romax CAD Fusion to transfer FE housing and planetary carrier models from CAD software into Romax Enduro. This led to more accurate and high-fidelity system deflection studies and subsequent improvements in mesh misalignment, resulting in differences of almost 100%. By using CAD Fusion throughout the design process to facilitate the transfer of 2D and 3D geometry between Romax CAE software and CAD packages, Tümosan were able to include more detail in the CAE model earlier in development, allowing their designers and analysts to collaborate more effectively .

Alpan comments, "We know as simulation engineers that our models are only as good as the detail we include in them. The CAD design engineers whom we work with are constantly iterating, so it is extremely important that we can import their CAD designs into CAE software like Romax quickly. Without a process such as this, engineers have to re-create these models manually. Using CAD Fusion we can quickly update, mesh and solve complex FE geometry, allowing us to see more precise and accurate analysis results from an earlier stage. Most importantly, the software is accessible and easy to use - it gives us a streamlined and integrated process which saves time in model building and reduces the chance of errors in data re-entry. We continue to use CAD Fusion to create accurate models earlier in the process, resulting in fewer iterations and a faster project turnaround or, alternatively, an opportunity to do more iterations!"

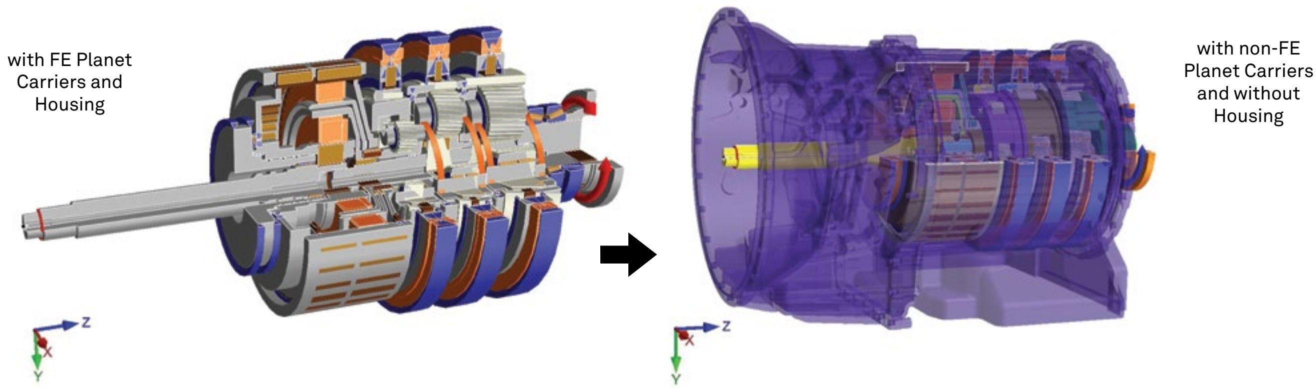


Figure 3: Tümosan's model with and without FE components

A closer look at the details: optimising micro geometry

Optimising gear micro geometry required Tümosan to once again optimise the design for multiple objectives, such as which profile/ lead modifications provide the best transmission error results, contact patterns, and peak loads or stresses. Tümosan used Romax Enduro's Design of Experiments (DoE) capability to find the answers to these questions, running parametric studies to quickly cycle through and score thousands of candidates in order to minimise transmission error, dynamic load and thus achieve a design with low noise. When designing and analysing planetary gear sets, it is critical to consider the load sharing and coupling between all gear meshes in the planetary system. Romax Enduro achieves this by rotating the entire transmission, using a feature named Gearbox Transmission Error (GBTE), rather than just calculating the transmission error for a single gear set. Alpan comments: "Romax Enduro's GBTE and DoE features allowed us to reduce the peak-to-peak TE amplitude by up to 45% within hours, a process that could otherwise take weeks of manual optimisation and calculation for all mesh points in a planetary gear set. While reducing transmission error, we simultaneously reduced peak loads and improved contact patterns between the gear meshes - something which we had been unable to do previously."

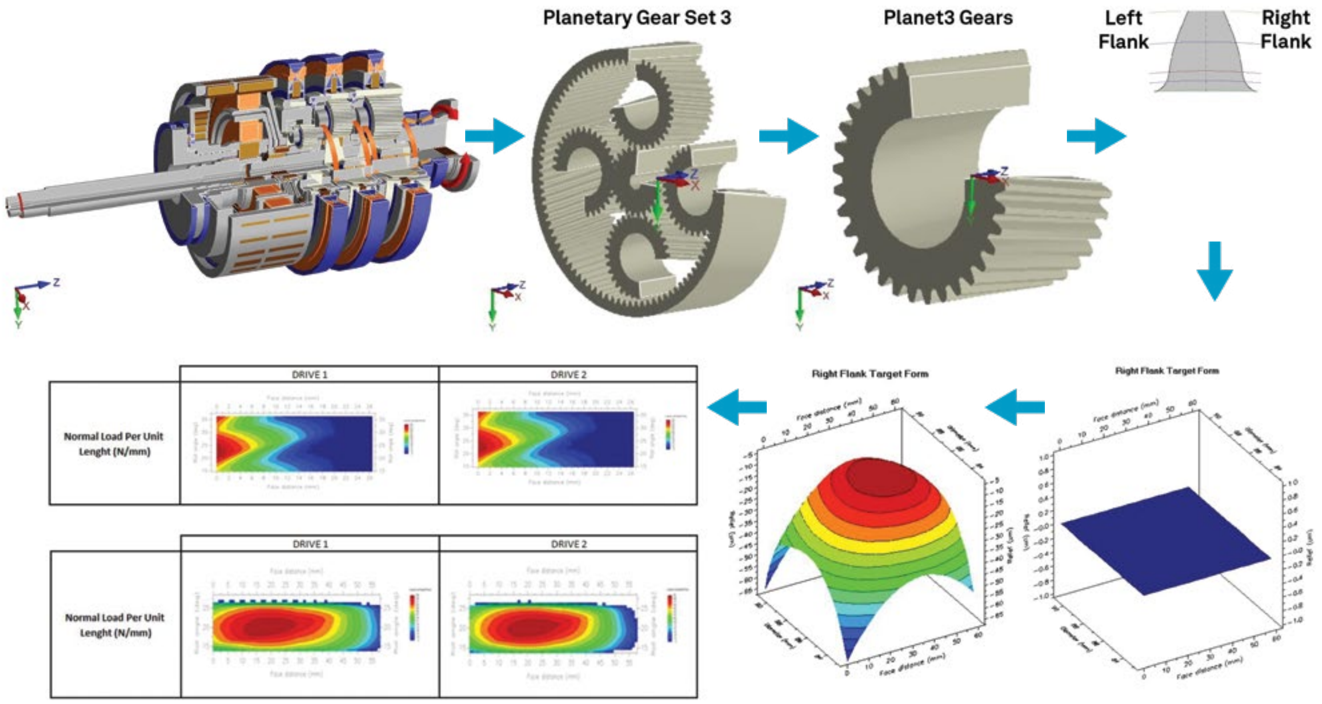


Figure 4: Micro geometry optimisation in Romax Enduro

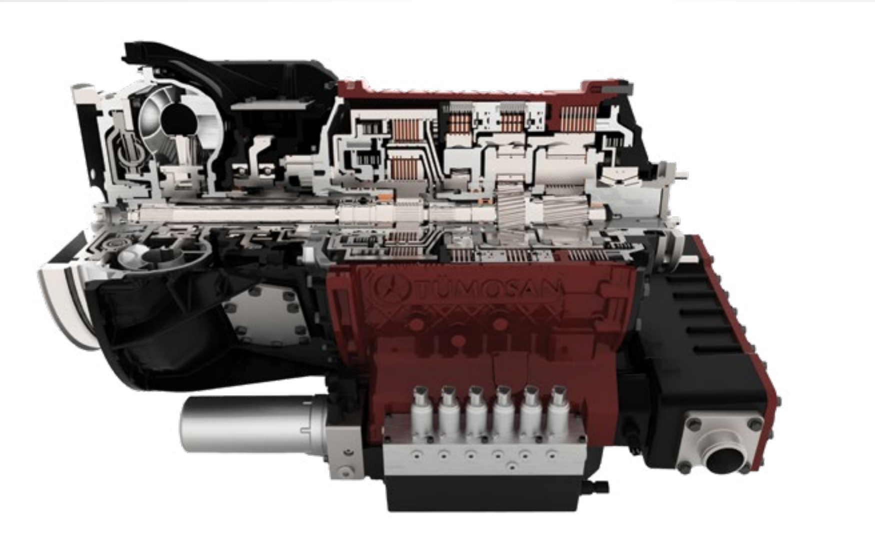


Figure 5: TMSN 2506 AT. 6+1 Automatic transmission (with torque converter)

Success

Alpan concludes, "Using Romax's unique set of software tools, we've been able to create a seamless design process with the Romax software suite at its core. We have been taking our ideas to market in record time, testing and incorporating new technology easily, as well as ensuring targets are met for durability, efficiency, and compliance. Being in the agricultural domain brings a unique set of challenges, however all of our design needs were fulfilled by Romax. We're gained a lot of value by working with such a versatile software firm, and hope to bring more durable and robust products to market using the Romax toolchain."

Learn more about Romax Technology:
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