DRIVE SYSTEM DESIGN

Transmission Design Upgrade

As engine power increases there is a drive to get more performance out of transmissions without increasing the package size.

Drive System Design offer a variety of innovative approaches to address this requirement:

Using analytical tools and practical experience the weak points in a transmission design are determined. Design changes can then be focused where needed in order to increase the torque capacity.

Using the same toolsets it is possible to reduce the length of the transmission to fit into more challenging powertrain packages for transverse applications.

Legacy designs may be out of touch with new manufacturing techniques and components technologies. Improvements can be made to upgrade old designs for new applications.

Additional upgrades such as increasing the number of speeds from 5 to 6 or even up to 7 are possible.

A popular change in smaller manual transmissions is the addition of a braked or synchronised reverse gear.

Drive Your Products Forward

- Increased torque capacity
- Shift quality improvements
- Shorter axial length
- 5 to 6 speed conversions (manual)
- Synchronised reverse
- New transmissions designed for existing production lines

Benefits To Our Clients

Our expertise in new transmission technology means you can:

- Breathe new life into your transmission products keeping them at the forefront of client expectations
- Gain the maximum benefit from your existing transmission product by extending its lifecycle
- Reduce the cost of new product development

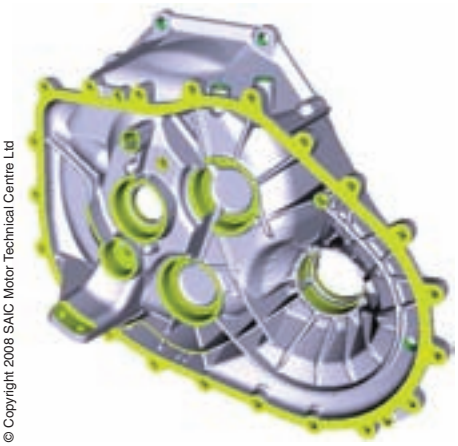
Torque Capacity

Drive System Design begin by reviewing the existing torque capacity of the transmission, or drive unit, to assess the maximum capacity against the range of potential applications.

Incremental changes required to improve the torque capacity are then proposed.

These changes are weighted against cost impact; changes with a low cost impact can be implemented immediately, whilst changes with a high cost impact are reviewed against the business case for the transmission product before implementation.

Low impact changes may be gear tooth geometry improvements or bearing roller profiling. Medium impact changes may include changing bearing size / type, material changes, lubricant changes and housing strengthening (new die tooling). High impact changes would be changes to centre distance and transmission package length.



Shift Quality

With higher torque capacity comes increased clutch capacity and therefore higher driven plate inertia. Because of this the synchroniser capacity will also need to be reviewed to ensure acceptable shift efforts.

New synchroniser technologies can be applied and upgrades can be made to friction materials.

A review of the selector mechanism design often allows gains in shift feel to be implemented.

Increasing Speeds

Changing the number of speeds in a manual transmission from 5 to 6 speeds has proven fuel economy benefits, especially for diesel engine driven vehicles. Diesel engine vehicles are now in the majority in the European market and increasing in popularity globally.

There is also a market expectation from vehicle manufacturers to increase the number of speeds in their transmissions. This is especially true in the high performance end of the market.

Drive System Design can develop concepts which complement the existing design with minimum impact on vehicle package.

The toolsets developed by Drive System Design allow a fast assessment of the upgrade potential of your transmissions.

We are able to guide you towards the upgrades which provide the highest benefit to cost ratio.

Our understanding of the transmission business means that we can provide not only the engineering expertise, but can also support the business planning activity for transmission upgrades, including conducting cost reduction analysis.

Our aim is to make your transmission products world class and ensure they have maximum return on existing investments in plant and materials.

To find out more about how we can help improve your existing transmission product please contact our design team.

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DRIVE SYSTEM DESIGN

Transmission Benchmarking

Competitor product knowledge is essential in any competitive market place. A large amount of useful data can be determined from a properly benchmarked transmission or drive unit.

Direct copying of a competitor design misses opportunities to learn. To gain the maximum benefit you need to determine the key decisions made in the design and development of the transmission and decode the designer's intent.

Drive System Design can provide you with the key to this useful information. Our expertise allows us to reverse engineer the design intent and determine areas in which the design could be improved.

Our methods allow accurate determination of transmission durability including the identification of weak points in the design.

Efficiency modelling and testing highlights competitor's position in the critical operating regimes, for example over EU drive cycle.

Future possible technologies can be extrapolated into technology roadmaps to guide the development of your own transmission products.

Learning by Example

- Reverse engineering of full transmission system
- Measurement and inspection of components
- Durability and reliability simulation
- Efficiency simulation and testing
- Identification of unique features and design solutions

Benefits To Our Clients

Benchmarking transmission products using Drive System Design's methodology allows you to:

- Establish competitive landscape based on attributes (weight, cost, efficiency)
- Keep up to date with emerging transmission technologies
- Understand the key development challenges overcome by competitors
- Understand the cost saving / warranty reduction design features in competitor products

Reverse Engineering

All transmission components are measured, weighed and catalogued. Material and manufacturing processes are determined and component cost estimates are then derived.

Identification of low cost manufacturing processes or new materials are particularly important. Gear geometry is reverse engineered and tooth topology measured.

CAE analysis is used to determine the theoretical durability and safety factors. For gear, bearing and shaft components state of the art rotating component analysis is used. Housings and gearshift mechanism components can be 3D scanned to allow finite element analysis to be carried out.

Attribute Analysis

The key attributes of a transmission can be broken down into:

- Baseline attributes:
  - Cost, weight, durability
- Vehicle attributes:
  - Efficiency, ratio flexibility
- Customer attributes:
  - NVH, shift quality

Unique features can be indentified in the transmission design which either deliberately or unintentionally affect these attributes. Attribute trend analysis can be used to directly compare similar transmissions.

Benchmark Testing

Efficiency testing of competitor transmissions can provide insight into methods used to minimise the system drag. This will have a large impact on the vehicle fuel economy.

Drive System Design use a testing methodology which correlates predicted efficiency against test data. This allows a full breakdown of losses for any torque or speed condition. The key contributors to drag can be isolated. Where there has been an obvious attempt in the design to minimise drag, this can be identified.

Shift quality benchmarking for manual transmissions is conducted using Drive System Design's gearshift measurement system. This system allows shift attributes such as impulse, shift effort and gate definition to be determined within the application vehicle or on a test stand. Theoretical shift impulse can also be calculated from measurement and inspection of the synchronisers and shift mechanism.

Technology Roadmaps

Compiling information from multiple transmission products allows Drive System Design to develop a view of the market place and current technical developments. Using this data it is possible to extrapolate future trends and work with our clients to develop technology roadmaps.

Benchmarking is an essential step in the development of new products. Understanding the current market position allows you to make the next step forward in technology or cost saving.

Baselining products in the market in this way is a continuous process. Drive System Design can help you to define a benchmarking strategy.

By examining the drivers in your markets and taking account of production volumes, we can customise your benchmarking strategy to determine trends in specific areas such as cost, fuel economy, performance and comfort.

Learning from the solutions of others means that development times can be significantly reduced.

To find out how we can help improve your competitive position in the market place please contact our design team.

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DRIVE SYSTEM DESIGN

Gear Design Technology

Creating the best possible gear design depends very much on which criteria your company and your market use to judge the design.

Market drivers in gear design are durability, low noise, high efficiency and cost of manufacture.

These drivers are directly related to the main gear attributes:

- Strength in bending and contact
- Transmission error / NVH performance
- Mesh Efficiency
- Manufacturing / tooling cost
- Material costs

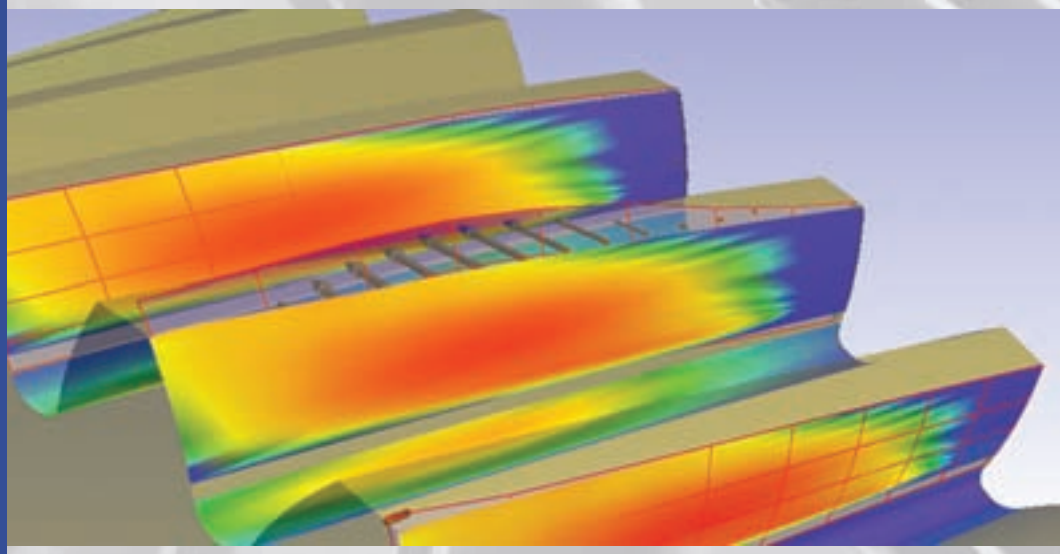
Drive System Design can ensure that you get the best performance from your gears based on the prioritisation of these criteria.

Drive System Design uses a number of advanced toolsets alongside extensive experience in gear design and manufacture.

This combination means we are able to offer you the best possible service in gear design and analysis considering all system, economic and environmental constraints.

Geared Towards Better Products

- Higher load capacity
- Efficiency optimisation
- Low transmission error
- Improved NVH performance
- Design for manufacturing process
- High quality gears at lowest possible cost



Benefits To Our Clients

Making use of Drive System Design's services in gear design and manufacturing technology will enable you to:

- Improve your gear design process to create more optimised gear sets
- Significantly improve gear durability and NVH performance
- Improve gear manufacturing quality with little or no investment

Helical Gear Design

Drive System Design understand which attributes are important in gear design. We have wide experience of different gear applications from automotive to industrial and wind turbines.

Bespoke tooling provides the option of optimised tooth root curves to maximise the bending strength of the gear. Such an optimisation can improve bending strength by 10% or more over standard full fillet radius tooling.

The choice of manufacturing process has a significant impact on the design of the gear. The tool must be defined alongside the gear design to ensure high quality.

Drive System Design are able to simulate manufacturing processes such as:

- Hobbing
- Shaping
- Shaving
- Grinding (generating)
- Grinding (full form)

Manufacturing

Manufacturing methods play a key role in the design of gears. Simulation of the manufacturing process and tool dynamic forces allows manufacturing quality issues to be determined early in the transmission design, allowing shorter production development cycles.

Drive System Design can help you by troubleshooting your gear manufacturing problems, using simulation and practical advice from our manufacturing experts. If you have a quality problem, we can solve it.

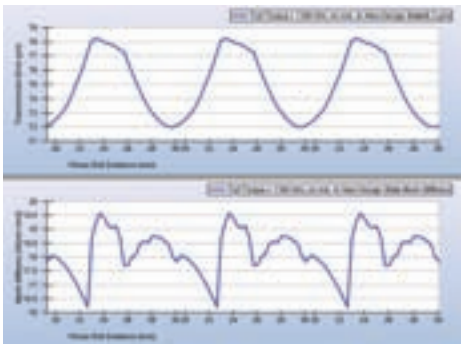
Bevel Gears

Design of bevel gears, particularly for automotive applications can be a challenge. Efficiency targets are high and package space can be limited.

Drive System Design offer a full design optimisation and analysis service for straight, spiral and hypoid bevel gears. Our expertise will ensure the best design for your application.

Tooth Contact Analysis

Accurately determining transmission error is an important part of ensuring low noise gears. The lower the transmission error the lower the noise is likely to be.



Drive System Design have tools to calculate loaded transmission error which allows both a 2D simplified analysis and a full FEA based 3D analysis. These tools also allow shaft, bearing and casing stiffness contributions to be included.

The 2D analysis can be used as part of the gear design development with the 3D analysis used as a final check and as part of the full system NVH analysis.

Drive System Design's experience in gear design methods and technology can help you to improve your existing gear design process.

We are also able to review your gear manufacturing process which, in many cases, can lead to improved gear quality with no additional investment.

Gear design is not a simple process. However, many companies use a fixed methodology which does not always result in the optimum gear design for the application.

We are also able to assist in the layout and design of new gear manufacturing facilities or the improvement of existing facilities.

To find out how we can help improve your gear design and manufacturing technology please contact our design team.

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DRIVE SYSTEM DESIGN

Concept Design

All too often insufficient time is allowed for concept design and initial designs become definitive before all risks are understood and mitigated.

Drive System Design have created a structured approach to concept design based on attributes.

Through detailed understanding of your current manufacturing techniques we identify where difficult tolerance requirements and quality issues exist.

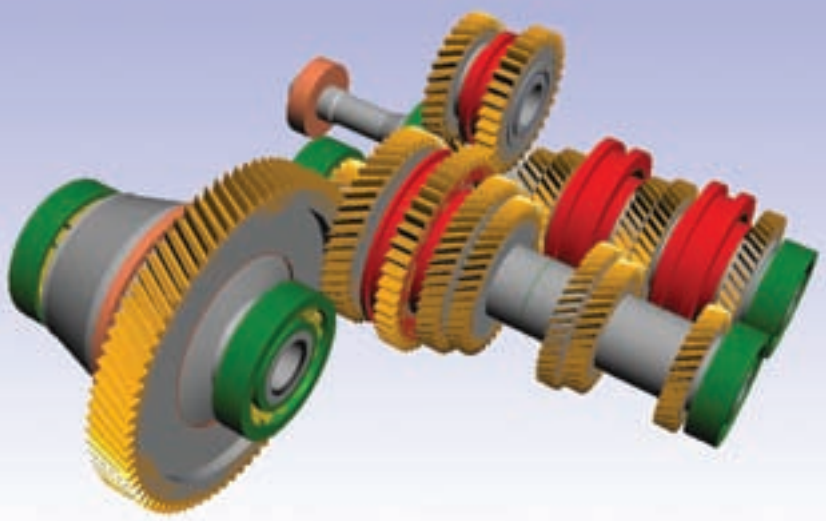
Drive System Design then use extensive analysis which outputs attribute predictions with increasing degrees of confidence i.e. gear / bearing life, NVH / transmission error, synchroniser effort / durability, efficiency, mass etc…

Each potential concept is then rated against its attribute performance.

This results in a preferred concept design which has the best fit with the manufacturing capability before the design concept becomes frozen.

Robust Initial Designs

- Durability prediction
- NVH prediction
- Understanding of critical trade offs / risks
- Efficiency prediction
- Shift quality prediction
- Cost estimation



Benefits To Our Clients

Concept designs created using Drive System Design's methodology provide you with:

- Innovative solutions to constraints
- Robust concept designs with risks for future phases understood and qualified
- Manufacturing driven designs (closing the quality circle)
- Better understanding of the design trade offs

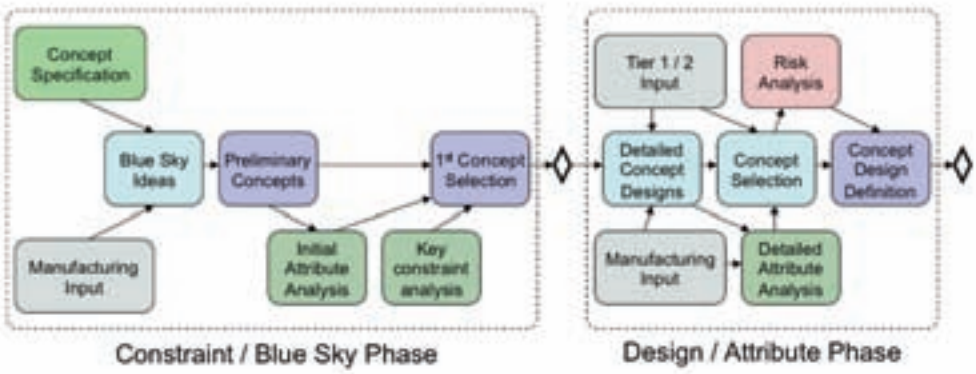
Concept / Blue Sky Phase

This initial phase concentrates on defining as many potential solutions as possible without over constraining the thinking. It delivers line diagrams supported by initial attribute performance. It also gives the key constraint analysis (for example in small transmissions, less than 150Nm, the ability to span between input and output is critical making twin layshaft unattractive).

Design / Attribute Phase

Focus on delivering approximately three potential 2D or 3D concepts with supporting attribute analysis for:

- Gear life (misalignments)
- Bearing life (misalignments)
- Efficiency (gears, bearings, seals)
- Shift quality / durability
- Weight analysis
- Cost estimation
- Shaft fatigue
- Ratio flexibility
- Risk analysis



Concept Specification

Key attributes are defined in discussion with you and will include ratios, weight, manufacturing process, duty cycle, product upgrade plans, cost.

Blue Sky Ideas

These are unconstrained ideas that meet the concept specification. Examples are the use of new materials, non-standard layouts and other unusual arrangements.

Manufacturing Input

We talk with your manufacturing teams to get a definition of:

- Current preferred manufacturing processes.
- Current quality issues
- Desired levels of automation

Attribute Prediction

Drive System Design use their toolsets to create a baseline attribute performance for gear and bearing life, shaft fatigue, ratio flexibility, shift quality, efficiency, weight and manufacturability. After the first phase of concept selection, the analysis models are refined to include loaded transmission error (with shaft, bearings and casing stiffness), cost estimates and weight estimates.

Risk Analysis

This considers not only technical risks but quality (robustness), development time, cost, manufacturing and assembly. It defines those issues which require further research or additional validation testing and considers their potential mitigation and contingency options.

Drive System Design's customers have benefited from our holisitic approach when applied to transmission and axle design, resulting in superior designs when compared with alternative approaches.

Concept design is a formal process which deserves full consideration to achieve the best designs. Using this process creates smaller, lighter and more efficient transmissions.

Drive System Design's structured approach coupled with a risk analysis reduces cost and avoids late emerging issues (NVH / shift quality)

To find out how we can help improve your concept design process please contact our design team.

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DRIVE SYSTEM DESIGN

Design Assessment & Audit

On completion of a new transmission concept design it is beneficial to seek a second opinion on the design strategy.

To maximise the benefit, the design audit should take place during the detail design phase of the transmission or axle. The purpose of the audit is to reduce the risk of development problems by allowing a fresh team of engineers to review and analyse the design intent.

Drive System Design offer a full design audit which can indentify potential issues within the design before the test and development stage.

Such an audit can save both time and money by reducing the risk of development problems.

Cost analysis is a critical part of the design process. This requires the design to be both simple to manufacture and simple to assemble.

This audit is a risk reduction exercise. Part of the process is the construction of a risk matrix. As the audit is completed, areas of high risk can be identified. This matrix will support the FMEA to define a targeted design validation plan.

A Fresh Perspective

- Technical auditing of new transmission designs
- Manufacturing and materials cost analysis
- Risk definition to enable a targeted design validation plan
- Durability and shift performance analysis
- Patent review for innovative features

Benefits To Our Clients

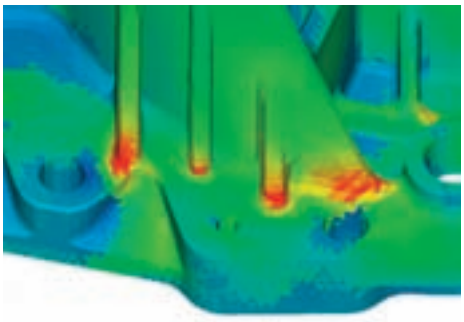
Drive System Design have extensive experience in auditing transmission designs. We provide:

- A fresh pair of eyes on your design to quickly indentify potential issues you may have missed
- Access to state of the art transmission analysis techniques
- Confidence that your design is ready for the test and development phase

Durability Analysis

The first stage of the audit process is to construct a full system analysis model to determine the deflection and misalignments under load. This model is used to determine the durability of the transmission components and evaluate the NVH performance in terms of loaded transmission error at the gear tooth meshes.

Finite element stress analysis is conducted on housings and other structural components. Structural efficiency is determined and guidance provided on increasing stiffness, reducing stress and reducing weight and reducing stress.



A full contact based non-linear finite element model of manual transmission selector mechanisms is also constructed to determine resilience to abuse loads.

Tolerance Analysis

All component manufacturing tolerances will be compiled into a max/min tolerance stack analysis. This indentifies any areas of the design that have critical dimensions. From the tolerance analysis, statistical analysis is used to determine the likely positioning of components, thus ensuring that the nominal dimensions and clearances in the transmission are correct.

Shift Quality Review

A key part of the tolerance analysis for manual transmissions will focus on the selector mechanism. Correct tolerancing of the selector mechanism is crucial in ensuring good shift quality. Cable runs and bend radii are evaluated.

Shift forks are evaluated for balance and against optimum stiffness targets. The design of clutches or synchronisers used in the shift system are assessed for torque capacity and thermal capacity. In the case of synchronisers the likely shift effort is calculated.

Manufacturing & Materials

For any design the focus must be on getting the highest performance for the lowest price. The selection of material and manufacturing processes plays a critical role in the cost of a new transmission.

Our manufacturing experts can assess the manufacturing cost of your transmission and guide your design towards the lowest cost solution for both production and prototypes.

Patent Review

With so many transmission products on the market it can be difficult to ensure that you do not infringe patents. Conducting structured patent searches during the design phase can provide early recognition of potential infringements.

Drive System Design can assess your design to determine unique innovations which may be patentable.

As part of the audit process Drive System Design can also provide benchmark transmission data to show how your design compares to others in the market.

Drive System Design's knowledge of the market and emerging technologies can not only help with your current design but also help you plan future design strategy.

To help you when you are looking to acquire new tools and techniques for transmission design, Drive System Design can provide technology transfer training sessions based around an audit of one of your transmission products.

Drive System Design methods and toolsets enable you to audit your current design tools and gain guidance in ways to improve your design process.

To find out how we can provide a fresh perspective on your design please contact our design team.

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DRIVE SYSTEM DESIGN

Synchroniser Design & Development

Synchronisers, although simple devices, have many interdependent tolerances.

Drive System Design has extensive experience designing, specifying and troubleshooting synchronisers and shift quality.

Drive System Design have undertaken projects ranging from clean sheet synchroniser design to managing Tier 1 suppliers.

Synchroniser design starts with material friction testing to establish basic friction characteristics across the range of operating conditions and throughout the synchroniser's life. Typically this includes accelerated step load testing and durability testing.

Once the basic friction data is established, synchroniser designs are undertaken, or existing designs audited, to ensure correct performance.

Drive System Design have created their own software to predict shift efforts and durability. This allows robust evaluation of the designs, considering clutch and ratio variations, within a transmission product.

Synchronise Your Knowledge

- Basic sizing
- Tolerance stack-ups
- Management of Tier 1 suppliers
- Concept design
- Detail design
- Test rigs and test specifications
- Training courses

Benefits To Our Clients

Drive System Design's involvement early in your synchroniser programmes ensures:

- Robust concept designs with risks for future phases understood and qualified
- Management and auditing of Tier 1 suppliers' work
- Low cost sourcing of parts with minimal risks
- Understanding of synchronisers and the parameters critical to their function

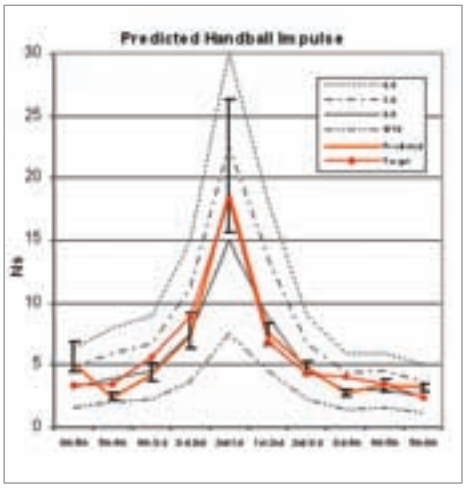
Materials

Drive System Design has experience working with the following synchroniser friction materials:

- Brass
- Molybedenum
- Sintered
- Composite
- Carbon

Friction Testing

The first step in synchroniser design is to establish the material / lubricant friction characteristics. Drive System Design have developed friction test specifications. These include a step test where a number of inertias / shift loads are considered and a durability test where a fixed load / inertia is run for 50,000 cycles. These tests give three friction coefficients: energising safety; dynamic; quasi static; and show their robustness over life and varying loads.



Analysis

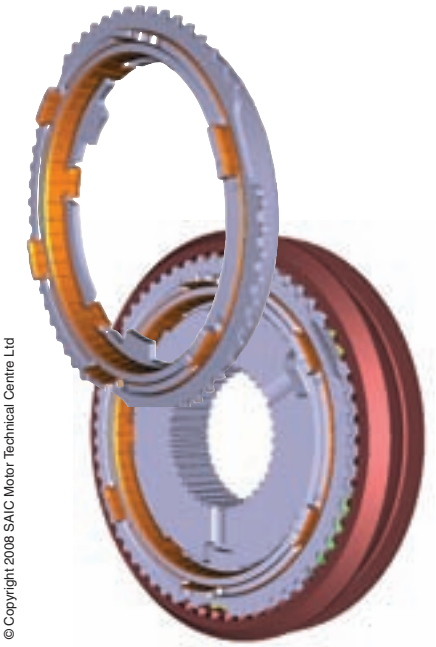
Drive System Design have developed software to predict:-

- Shift effort
- Required synchroniser size
- Durability
- Strut load
- Locking safety

Drive System Design's software compares these results against measured in-vehicle competitor data.

Concept Design

From the initial analytical work, critical parameters such as chamfer angle, cone angle and cone diameter are used to create 2D cross sections of the synchroniser pack. Dependent on materials and manufacturing methods, different ranges are used for the tolerance stacks, limits of chamfer angle, etc.



Detail Design

Once the concept is defined, detail work on each of the components is undertaken in parallel with tolerance stack-ups. This defines all critical characteristics including splines, chamfers, back rake and overlap.

Tolerance Stack-Ups

Critical dimensions are checked to ensure correct function including: Indexing; Proximity; Strut gap; Wear gap; Double engagement; Energising / Detent alignment.

Drive System Design's customers have benefitted from our synchronsier knowledge both in managing Tier 1 suppliers and selecting Tier 1 suppliers.

A growing number of customers are applying our extensive knowledge to troubleshoot difficult problems associated with premature failure.

Synchronisers are complex sub-systems which require a good understanding of the detailed tolerance stack-ups to ensure correct function.

Drive System Design have experience applying synchronisers within manual AMT and DCT transmissions.

Drive System Design's knowledge is also available in the form of synchroniser training courses which can be focused around a new design or existing problem.

To find out how we can help improve your synchroniser capability please contact our design team.

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DRIVE SYSTEM DESIGN

Test & Development

Drive System Design's experience covers a large number of transmission development programmes for new designs and the application of existing transmission units to new vehicle applications.

It is important to have a structured development plan for transmission and axle units. Creating a robust design validation plan is essential, although it is even more important to ensure that the plan is completed on time.

Development and validation of transmission units is completely focused on reducing the risk of problems with the production units. Drive System Design use a number of methods to measure the risk in a product, allowing the development plan to be targeted to the high risk areas.

Testing is only meaningful if controlled procedures are used which can be compared to actual usage in the vehicle. Drive System Design can provide expertise to help you to define new test procedures for rig and vehicle tests.

Determining correct duty cycles for durability testing is of prime importance. We can help with road load data collection and analysis to define the test duty cycles.

Testing Your Metal

- Development and administration of design validation plans
- Rig testing for durability, shift quality lubrication and efficiency
- Road load data collection and development of test duty cycles
- Gearshift and clutch actuation attribute testing

Benefits To Our Clients

Our experience gained over a large number of transmission development programmes will ensure:

- Definition of robust development and validation plans using a risk based approach
- Targeted development that provides high confidence for production launch
- Swift resolution of development problems using advanced analytical toolsets
- Clear and succinct management of design validation plans

Development Planning

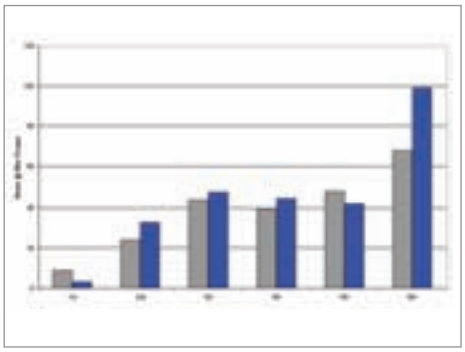
The validation plan needs to be based upon the likely risks in the design. Validation must concentrate on reducing the risk in the design.

Normally the validation plan is based upon a structured risk assessment such as FMEA (Failure Modes and Effect Analysis). Drive System Design use a more direct risk assessment based upon common issues. It is a more straightforward methodology than FMEA and the risk analysis can be completed in a shorter time.

Drive System Design will produce and manage the design validation plan (DVP). The DVP contains the list of required testing and CAE analysis required to validate the design.

Duty Cycle Development

The development of test duty cycles is best achieved by collecting road load data from benchmark vehicles with similar engine torque, weight and type (passenger car, SUV, truck etc).



Drive System Design can help with both the instrumentation of the vehicle and the collection of the data itself.

The data is then processed into torque and speed bins to determine the required number of test hours in each gear.

Using data interpolation from previously benchmarked vehicle data, Drive System Design can also create estimated test duty cycles, based on the application engine torque and vehicle weight.

Rig Testing

Drive System Design manage the transmission development using a number of approved test houses throughout Europe. Our knowledge of working with these companies over many years, ensures that you will get the best value from your development programme.

Attribute Testing

Drive System Design specialise in measuring transmission attributes related to the driver / vehicle interface.

Drive System Design use specially developed test equipment to measure:

- Clutch pedal load loops
- Clutch stall position
- Gear shift definition
- Gear shift effort

Transmission attribute assessments can be provided as a stand alone service covering NVH issues such as: whine, rattle, clatter, tizz, shift quality.

Making use of Drive System Design test and development services provides you with high confidence that your product is ready for production launch.

A significant benefit of working with Drive System Design is that, should development problems arise during your testing phases, we are well positioned to provide swift resolution.

Our innovative approach enables us to create test solutions for component level issues.

We use a structured root cause analysis combined with advanced toolsets to ensure minimum impact to your timing plan.

We pride ourselves on our expertise in finding solutions to late emerging issues.

To find out how we can help in the development of your transmission please contact our development team.

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DRIVE SYSTEM DESIGN

Transmission NVH Improvement

Transmission NVH (noise, vibration and harshness) issues are often caused by a combination of manufacturing process control and noise transfer paths, with only a small number caused by fundamental design issues.

Drive System Design use a combination of experience, measurement and analytical tools to understand the root causes, whether caused by design, manufacturing or vehicle installation sensitivity.

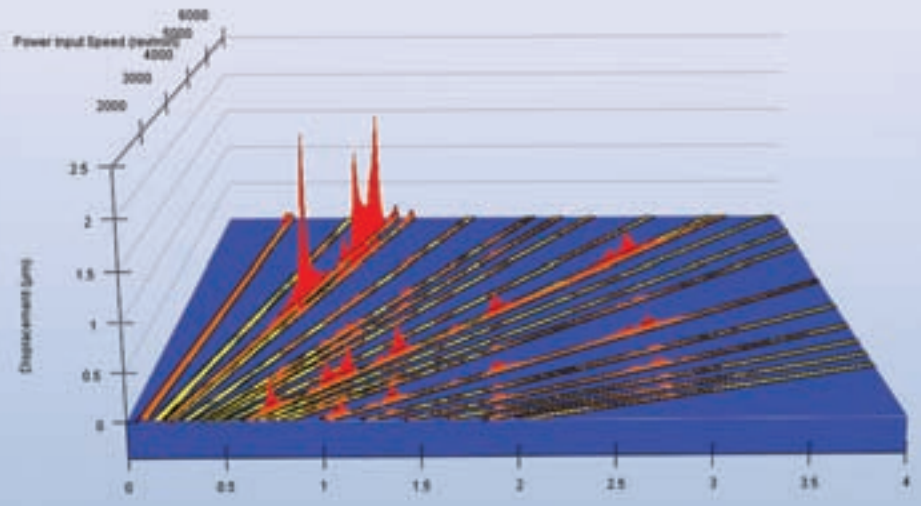
Solutions have been found by a combination of:

- Improving design robustness
- Changing manufacturing tooling
- Changing assembly processes
- Improving vehicle installation noise transfer paths

A structured methodology is used which eliminates potential causes until the root cause or causes can be identified.

Quietly Does It

- Poor or average shift quality performance improved
- Selector mechanism tizz reduced
- Gear whine noise root cause identification and solution
- Clatter analysis and reduction
- Gear rattle excitation and transfer path isolation



Benefits To Our Clients

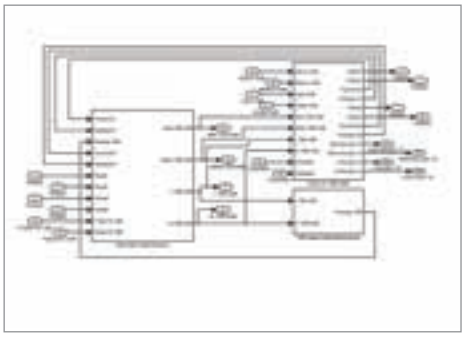
- Rapid identification of root causes using Drive System Design's unique toolsets and our engineers breadth of experience in design, manufacturing and vehicle installation
- Improved robustness through manufacturing simulation and process evaluation
- Resolution of difficult to solve refinement issues

Gear Rattle

Rattle is caused by engine torsional vibrations. Most approaches only consider 1D simulation which is insufficient. Engine to transmission interface alignment and the effects of imperfect alignment can be simulated. Solutions to rattle can often be engineered through improved powertrain assembly techniques and improved shift cable isolation. Rattle frequencies are often close to diesel combustion noise and hence transfer path solutions, involving shift cables especially, can often yield further benefits.

Clatter Noise

Clatter is caused by driveline modes exciting speed gears and synchronisers within the transmission, especially during shutdown or near stall events. A similar approach to rattle is used although 3D modelling of gear body movements is necessary.



Boom Noise

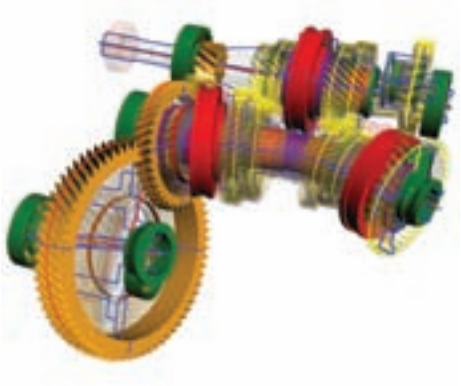
Boom is often caused by out of balance forces within the driveline of RWD and 4WD vehicles and requires careful consideration of drivetrain mounting methodologies and component balance targets. Robustness and insensitivity are often achieved by improved drivetrain layouts.

Selector Mechanism Tizz

Tizz is typically solved by adding mass to the gear knob although in some cases this is insufficient. Drive System Design start by reviewing the synchroniser and shift system design with particular focus on detents and end stops. Once the forcing mechanism is established, cable design and routing are reviewed. Finally handset design and gear knob weight and isolation are reviewed.

Gear Whine

Whine is simulated at design level by loaded transmission error simulation which includes real time gear, shaft, bearing and casing stiffness. Excitation frequencies are compared to system mode shapes.



This provides a guide to whether there are any design errors, although solutions are often found by examining the production process closely and identifying the processes which cause tooth geometry errors. These geometry errors can be caused by processes such as generating worm grinding or shaving with high force variation. Both result in tooth surface “hollows”. Simulation of the shaving process is used to reduce the force variation.

Axle whine resolution requires understanding of noise transfer paths into the vehicle body and an understanding of propshaft modes within the driveline.

Shift Quality

Shift Quality is improved through: measurement and benchmarking of existing shift feel; detailed component and sub system review; kinematic analysis and through dynamic modelling driven by response surfaces.

Driveline NVH is the process of identifying and solving transmission and axle related problems and considers forced excitation and transfer paths.

Drive System Design can help your NVH teams by providing an understanding of the forcing excitation and put this into context relative to competitor vehicles.

Often issues are identified in the manufacturing and assembly areas which Drive System Design can address directly.

Increasingly solutions can be applied using improved control algorithms or calibration. Drive System Design can provide support ranging from guidance to efficient dynamic models that assist your control and calibration teams.

To find out how we can help solve your transmission NVH problems please contact our development team.

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DRIVE SYSTEM DESIGN

Dynamic Simulation & Robustness Optimisation

Dynamic Simulation is a powerful tool which when used correctly gives a potentially huge saving in time and cost.

Dynamic simulation is a means to an end – solving the problem or understanding the phenomenon studied.

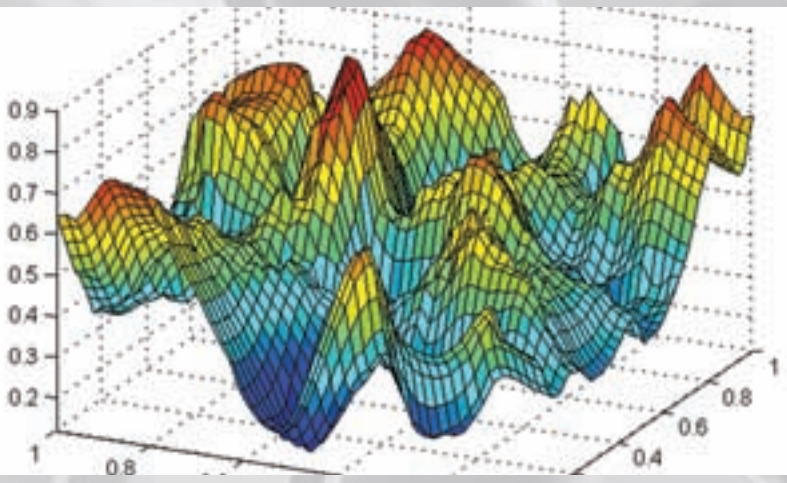
Drive System Design often use dynamic simulation through detail design and development. This allows better delivery on attributes such as shift quality and rattle.

Drive System Design's optimisation methods significantly reduce solve times, generating solutions in a fraction of the time used by other optimisation approaches.

The use of Design of Experiments (DoE) coupled with emulation models allow hundreds if not thousands of potential modifications to be evaluated far cheaper and more quickly than could be realised through hardware testing. This methodology delivers high quality, efficient solutions to complex problems.

Dynamic Solutions

- High fidelity dynamic simulation
- Concept design guidance
- Product development
- Problem resolution
- Robustness against manufacturing tolerances
- Understanding of complex physical phenomena
- HiL and SiL models



Benefits To Our Clients

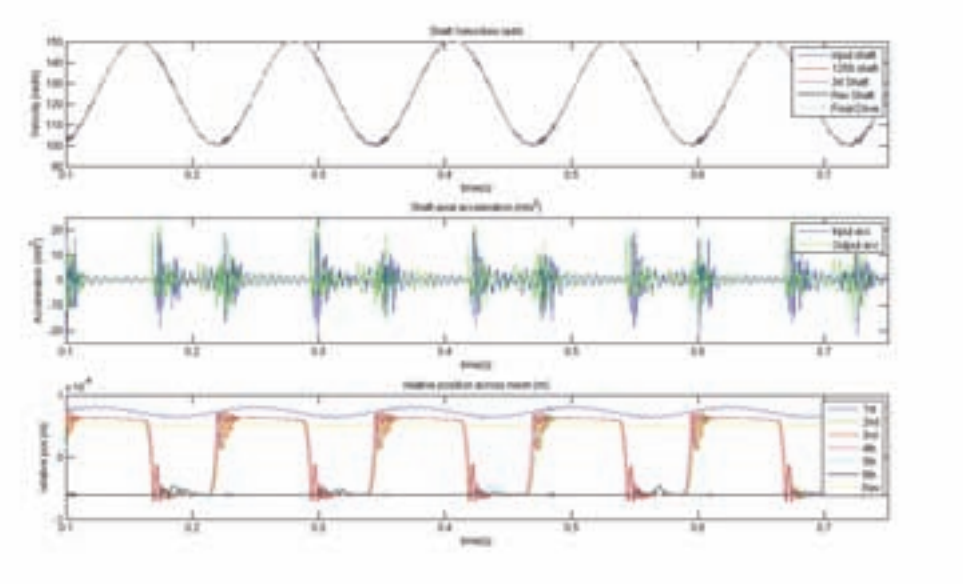
- Drive System Design have a wealth of experience in building transmission related models, meaning that practical solutions are delivered quickly
- Drive System Design optimisation methods lead to greater solution robustness
- Using dynamic modelling is often the only way to solve complex NVH issues (Shift Quality, Rattle, Clatter)
- Dynamic models allow understanding of complex issues

Modelling Philosophy

Application of the correct fidelity model is highly important in developing a model which can accurately capture the dynamics of the problem or attribute of interest. The interactions to the surrounding subsystems must be taken into account.

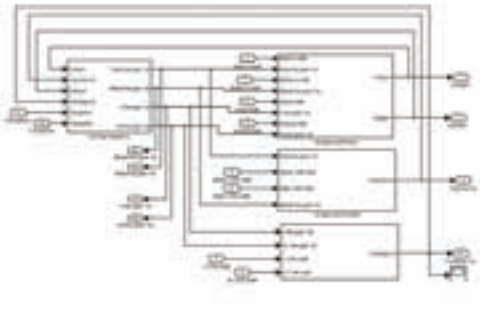
Toolsets

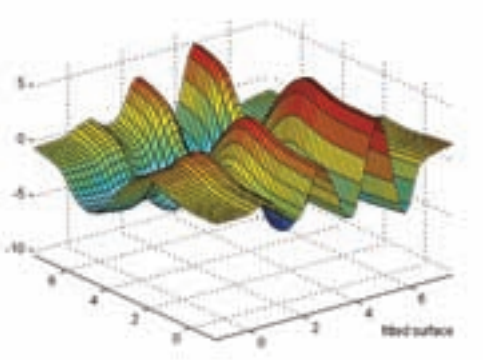
Drive System Design use both Matlab / Simulink and AmeSim. The experience of Drive System Design engineers results in the correct level of model being selected giving the benefits of accuracy and speed.

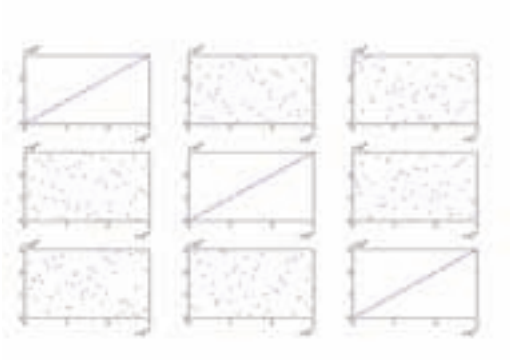


Optimisation

To make full use of the simulation model, Drive System Design use a combination of Design of Experiments (DoE), Emulator modelling and response surfaces yielding an efficient optimisation technique. This provides a much better understanding of parameter interactions, the significance of each parameter and the sensitivity of the design to any potential modification.







Using this approach, more robust solutions can be found because the effects of manufacturing tolerances on the design can be studied quickly. The optimisation methods (emulator modelling) used are not exclusive to Matlab / Simulink but can be applied to any other dynamic simulation code.

Dynamic Simulation and Robustness Optimisation applications include:

Clutch simulation:

- Actuation system efficiency
- Engagement dynamics
- Thermal effects

Manual transmission:

- Gearshift quality
- Synchroniser design
- Shift system kinematics
- Shift quality development

Hydraulics:

- Hydraulic circuit simulation

Lubrication:

- Flow of oil to bearings, gears through oil galleries etc

Whole system dynamics, including clutches, synchronisers, brakes, hydraulics, actuators etc can be evaluated for:

- Automated manual transmission
- Dual clutch transmission
- Supported shift AMT
- Automatic transmission

HiL – SiL Models:

- High fidelity models of gear and clutch engagement and synchroniser actuation systems

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DRIVE SYSTEM DESIGN

Shift Quality Development

Shift Quality is an increasingly important attribute used to differentiate vehicles. Defining attributes that are important to shift quality remains an area of research for a number of vehicle OEMs.

Drive System Design engineers have a long history of studying and solving shift quality issues for vehicle OEMs around the world.

Drive System Design use a combination of experience, measurement and analytical tools to understand the root causes whether caused by design, manufacturing or vehicle installation sensitivity. Drive System Design use a structured approach that considers the subsystems in both isolation and combined situations.

Working from drawings and hardware, various parameters are measured and benchmarked against Drive System Design's expected performance criteria for:

- Handsets
- Cables
- Cable routing / bracketing
- Internal shift mechanism
- Shift forks
- Synchronisers
- Clutch torsional damper
- Driveline

Shift Quality Expectations

- Feel issues identified and improved
- Gate definition and tolerance design
- Cable / lever efficiency and kinematics
- Detent alignment and tolerance design
- Synchroniser / fork / internal mechanism optimisation
- Dynamic modelling used to solve complex issues

Benefits To Our Clients

Drive System Design's expertise and services enable you to confidently:

- Outsource difficult to solve shift quality issues
- Benchmark shift quality
- Resolve root cause issues (between clutch, transmission, driveline and handset)
- Apply our methodology for assessing shift quality
- Efficiently improve gearshift robustness

Shift Quality

Four key areas are considered when studying shift quality:

- Ergonomics
- Gear definition
- Cross gate feel
- Into gear feel

Ergonomics

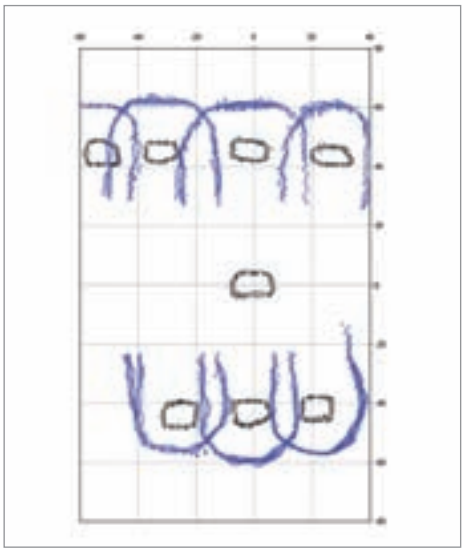
This puts the gearshift in context from a driver perspective. Key factors it considers are:

- Gearknob position relative to H-point
- Clutch pedal attributes
- Knob size, shape and tactility
- Other vehicle control efforts (especially steering)
- Knob vibration or tizz

Gear Definition

This looks at the repeatability of the gearknob position from a driver's expectation perspective including:

- Shift start / shift end position tolerance
- Gear overlaps
- In-gear voids
- Lateral and longitudinal stiffness of in gear positions



Cross Gate Feel

This considers force / displacement in the lateral plane specifically:

- Neutral void
- Force / travel profile
- Endstop stiffness
- Speed of return to neutral
- Hysteresis

Into Gear feel

This analyses force / displacement data into key parameters including:

- Shift effort (impulse)
- Pull out force
- Static detent effort
- Travel
- Double bump

Approach

Typically the first step is to assess the gearshift both objectively and subjectively. The results are then assessed against each of Drive System Design's four main shift quality criteria.

Subsequent steps are driven by the results of the initial stages. The focus of Drive System Design engineers is to identify all travel and force losses between the handball and synchroniser sleeve. It is often necessary to test the gearshift cables both straight and with correct routes to assess travel and force efficiency losses.

All mechanism kinematics are studied from an efficiency perspective using Drive System Design toolsets where required.

For into gear issues, Drive System Design use a dynamic simulation approach. Drive System Design couple the dynamic modelling with a response surface based optimisation that allows efficient study of all the necessary parameters.

For some gearshift problems it is necessary to undertake tolerance stack-ups of the synchronisers.

Drive System Design use dynamic modelling from the concept design phase of new transmission designs to ensure good shift quality during early transmission design phases.

Shift Quality is an important characteristic especially in smaller vehicles. Drive System Design engineers have many years of experience measuring, analysing, simulating and improving vehicle shift quality.

To fully understand your requirements, our approach is to view shift quality from a driver's perspective in addition to the pure engineering aspects.

Solutions for shift quality improvements are often achievable in production without significant additional cost.

Drive System Design can support you from concept through development, ensuring good shift quality is delivered.

To find out more about our approach and how we can improve your shift quality please contact our development team.

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DRIVE SYSTEM DESIGN

Clutch Attribute Measurement Systems

Clutch Attribute testing is a process all vehicle OEMs perform to different extents. This is normally undertaken with general test equipment. The general nature of this test equipment means there is much work to do to generate the key parameters from the acquired data.

The Drive System Design test equipment is different. It is a stand alone system which allows rapid installation and removal from a vehicle. The software is focused on generating results. From installation to formal report of the results takes approximately 30 minutes.

The basic clutch loop equipment measures force and position. The standard equipment measures force, position and adds an accelerometer at the clutch pedal for vibration assessment and an inclinometer to ensure that gauge reliability and repeatability can be achieved. Further data channels are possible (e.g. pressure, slave cylinder travel, temperature).

The pedal speed test equipment provides a calibrated linear actuator to establish the pedal speed at which the vehicle will stall in millimetres per second.

Clutch System Assessment

- Fast evaluation of clutch attributes
- Benchmarking of competitor products
- Evaluation of stallability
- Production auditing
- Vehicle development confirmation testing

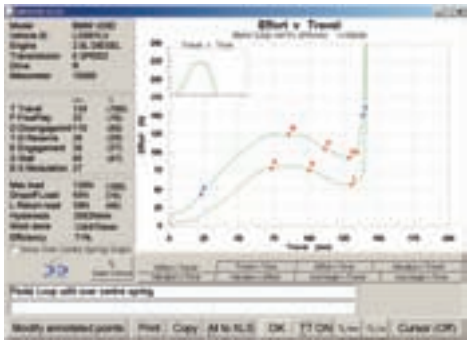
Benefits To Our Clients

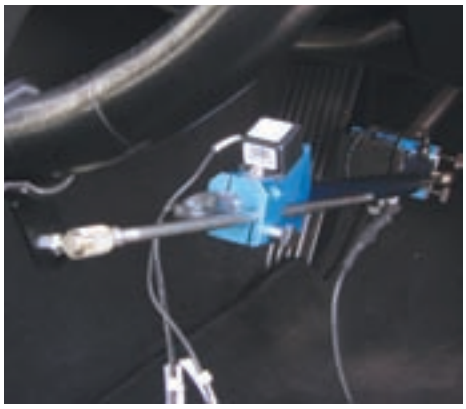
Drive System Design has developed test equipment working with vehicle manufacturers. The equipment is focused on fast delivery of attribute data to support development testing at all vehicle build levels:

- Rapid installation and removal of equipment
- Simple to use software dedicated to generating results and reports for critical attributes

Pedal Loop System

Travel measurement range: 200mm
Force measurement range: 200N
Power supply: 9-36 V DC
Laptop: user defined

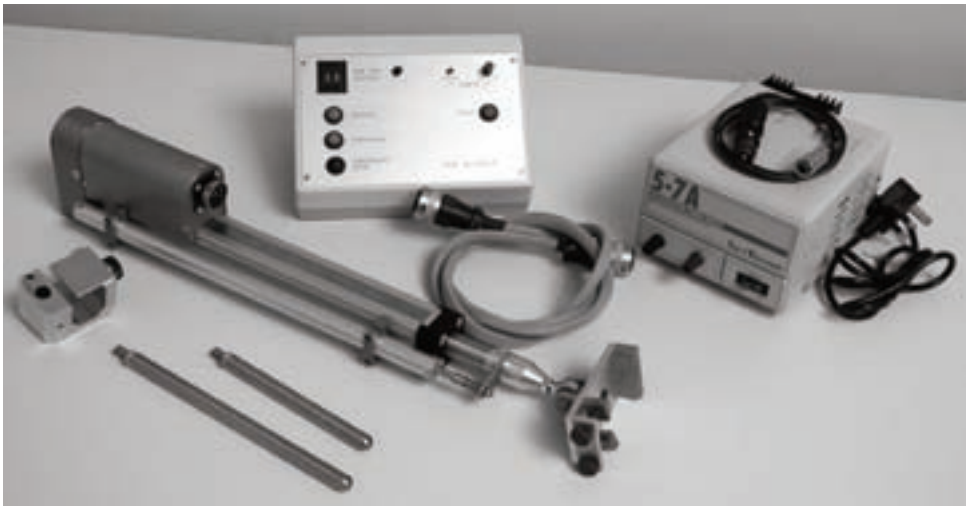




Once installed between the steering wheel and clutch pedal the user is prompted to enter vehicle / test details. The user then acquires a clutch loop by depressing and releasing the clutch pedal. The user is then prompted to record four separate points: free play; stall point; dis-engagement point and engagement point. From these points the software generates the key attributes of the clutch under test. The data can then be plotted graphically. Drive System Design's software contains the ability to over-plot different tests. In order to review over centre spring contributions it is possible to subtract one test from another i.e. subtract a test without a spring from a test with a spring.

Pedal Rate System

This consists of an electrical actuator installed between the steering wheel and the clutch pedal. The actuator is controlled by a separate box, no laptop is required. The control box allows entry of an actuation velocity in millimetres per second. Once installed in the car the system is used to find the rate at which the vehicle launches rather than stalls. This is an effective and useful metric. It considers more than just the clutch system – it includes the engine stallability calibration and the effects of components such as dual mass flywheels.



Attribute measurement is now an essential part of the clutch design and development process.

Drive System Design test equipment allows rapid evaluation of these attributes enabling engineers to spend more time improving the clutch system rather than spending time measuring it.

Drive System Design engineers are available to discuss measurement data and ways in which to use it to improve your clutch system.

Design System Design's systems are customisable and are in use in a number of Tier 1 suppliers and vehicle OEMs.

Our systems are supplied, complete with a calibration certificate in a durable, air tight, hard plastic cases to protect them when in transit and preserve them when not in use.

To find out more about our test equipment please contact our development team.

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DRIVE SYSTEM DESIGN

Transmission Efficiency

Fuel economy is now more important than ever. Increases in fuel costs and the pressure to lower the impact to the environment by lowering CO2 emissions, are key drivers in the current market.

Increasing the efficiency of transmissions and axles is essential to ensure lower emissions in the future.

The least efficient transmissions are currently Automatics, CVT and DCT (85-95% efficient) due to the requirement for hydraulic actuation systems.

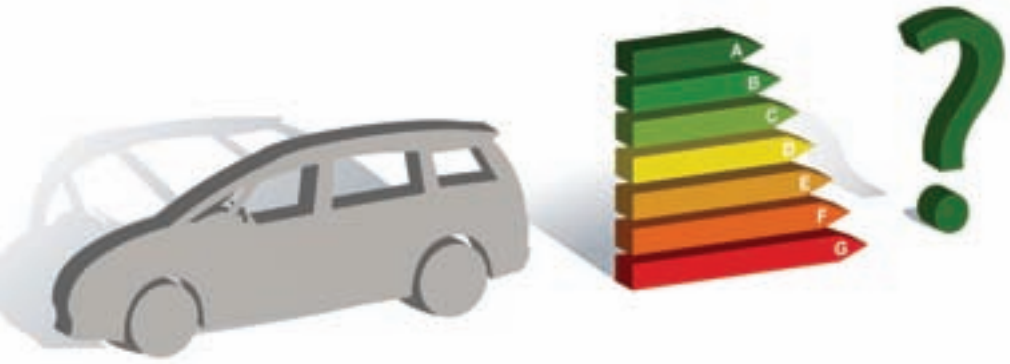
Although manual transmissions have efficiencies above 95% there is still scope in most cases to gain an extra 1% or 2%.

Axles using hypoid gear sets can have efficiencies as low as 93%. There is significant scope for improvement in these cases.

Drive System Design have proven tools and methodologies for identifying the components contributing to the highest drag losses. From this we can guide you in finding the most cost effective methods of increasing the efficiency of your products.

Cutting Your Losses

- Design of transmissions and axles for increased efficiency
- Optimisation of lubrication systems for lower churning losses
- Simulation of component losses: gear, bearings, seals, synchronisers and pumps
- Efficiency testing of transmissions and axles



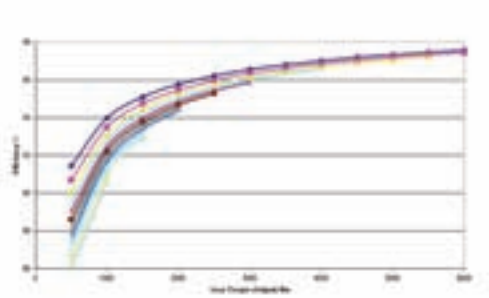
Benefits To Our Clients

Working with Drive System Design in the development of higher efficiency transmissions provides:

- Cost focused reduction of mechanical losses
- Full understanding of the component contributions to the losses within the transmission
- Lower vehicle emissions and higher fuel economy

Efficiency Simulation

The improvement of transmission and axle efficiency requires a full understanding of the existing contribution of individual components.



Efficiency simulation will be correlated against test data in order to provide an accurate breakdown of losses by component. Efficiency models need to include not only the gears and bearings but also seals, synchronisers, clutches, oil pumps and the lubricant properties.

Correlated efficiency models can be used to determine which changes will give the highest improvement at minimum cost.

Design for Efficiency

There is an increasing trend to design transmissions and axles for higher efficiency which includes efficiency optimisation of gears. Ball bearings are replacing taper roller bearings in new designs.

Many modern transmission and axle designs use oil pumps to create hydraulic pressure or to assist in lubrication. In some cases where, an oil pump is present, it can account for over half the losses in the system. Designing to eliminate the use of a pump has a significant benefit.

Better Lubrication

Lubrication of a transmission is arguably the most important part of the design process. Minimising the quantity of oil required will minimise the churning and windage losses.

Drive System Design has experience in the best practises for correct lubrication of transmissions.

Efficiency Trade Offs

Increasing efficiency can create additional challenges that Drive System Design can help with.

For example, changing to a lower viscosity synthetic oil or reducing oil volume will affect the durability of gears and bearings. Reducing the volume will also increase the risk of NVH problems such as gear rattle.

Efficiency Testing

Rig testing to determine the efficiency of a transmission or axle is an important part of the development process.

Drive System Design use a multiple test process, eliminating certain components in a structured way, which allows isolation of the high drag components.

Reduction of mechanical losses in transmissions and axles is now an essential part of the design and development process.

Drive System Design can work with you to improve an existing design or create new designs which minimise the losses.

We have developed strategic action plans which makes your transition to efficient design straightforward.

Drive System Design are also researching leading edge technologies which will help improve the efficiency of transmissions further in the future.

To find out how we can help improve your fuel economy and emissions by increasing transmission efficiency please contact our design team.

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