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TRANSMISSIONS NEWS

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A monthly bulletin
dedicated to
transmissions and drivelines,
hardware, research,
development,
components
and the
transmissions
industry
Notes

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**New Engine News**
Contents - summaries of main technical features of new engines of all types and applications

**Fuels & Lubricants News**
Contents - Developments in fuel and lubricants technology as applied in engines and vehicles

**Control & Electronics News**
Contents - control, electrical and electronic engineering. Practical applications and research & technology

**Alternative Powertrain News**
Contents – Fuel cell, hybrid and electric powertrains as well as alternative combustion systems

**Components News**
Contents - Internal combustion engine components, materials, research and design.

**Vehicle Engineering News**
Contents - All aspects of vehicle engineering including chassis, brakes, electrical, Powertrain and transmissions, including a review of new vehicles.

**Fuel Economy News**
Contents - Fuel economy improvement, weight reduction, practical examples of vehicle applications

**Gas Engine News**
Contents - Natural gas, LPG and biogas technologies and applications. Published quarterly.

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# Contents

| DRIVELINES | 4 |
| ALL WHEEL DRIVE | 4 |
| ELECTRIC DRIVELINES | 5 |
| TRANSMISSIONS | 6 |
| MANUAL TRANSMISSIONS | 6 |
| AUTOMATIC TRANSMISSIONS | 7 |
| AUTOMATED MANUAL TRANSMISSIONS | 8 |
| DUAL CLUTCH TRANSMISSIONS | 9 |
| CONTINUOUSLY VARIABLE TRANSMISSIONS | 11 |
| HYBRID TRANSMISSIONS | 13 |
| HYDROSTATIC TRANSMISSIONS | 15 |
| POWERSPLIT TRANSMISSIONS | 16 |
| TRANSMISSION ISSUES | 17 |
| SHIFTING | 17 |
| TRANSMISSION AND DRIVELINE COMPONENTS | 18 |
| APPLICATIONS | 26 |
| ALTERNATIVE POWERTRAIN VEHICLES | 26 |
| Electric vehicles | 26 |
| Hybrid vehicles | 27 |
| Range extender vehicles | 28 |
| PASSENGER CARS | 30 |
| OFF-ROAD | 31 |
| GENERAL TECHNICAL ISSUES | 32 |
| CONTROL | 32 |
| Actuation | 33 |
| DRIVELINE/VEHICLE RELATIONSHIPS | 35 |
| TORQUE DISTRIBUTION | 35 |
| TORQUE VECTORING | 36 |
| RESEARCH AND DEVELOPMENT ISSUES | 37 |
| FUEL CONSUMPTION | 37 |
| CO2 | 38 |
| NVH | 39 |
| SAFETY | 41 |
| TRIBOLOGY | 42 |
| RESEARCH AND DEVELOPMENT ACTIVITIES | 43 |
| CAE | 43 |
| OPTIMISATION | 44 |
| VALIDATION | 45 |
ADAPTIVE AWD SYSTEM FOR IMPROVED EFFICIENCY AND VEHICLE DYNAMICS

GKN

To prevent increasing greenhouse gas pollution, vehicle efficiency is always a major target for automotive engineers. AWD vehicles are particularly in focus because of higher weight and more rotating components, compared to FWD or RWD, therefore resulting in lower efficiency. Interestingly, market studies are showing a worldwide AWD demand increase. This can be explained by the benefits of AWD drivelines like better mobility, vehicle safety and handling. Driveline losses play a major role for efficiency. Therefore there is an ongoing development process to reduce driveline weight, bearing losses, oil splashing losses etc. Additional saving potential can be reached by disconnecting the AWD driveline when not required.

The adaptive AWD system described in this presentation gives our customers an excellent solution that is suitable for everyday use. The increased fuel consumption introduced by all-wheel drive systems can be reduced by up to 75% in real world driving conditions. This system is now available for the first time worldwide and has been introduced to the market on the Range Rover Evoque “Active Driveline,” MY 2014.

Covers – TWINSTER, CO2 savings, disconnect function, torque transfer, on demand lubrication, hydraulic actuation system, control algorithms, yaw damping.

ELECTRIC DRIVELINES

MODULAR ELECTRIC AXLE DRIVE IN A 48-VOLT ON-BOARD ELECTRIC SYSTEM

Schaeffler

In the entire automobile industry, there is a discernible trend towards hybrid vehicles in order to meet future CO2 requirements. The test cycles used for determining CO2 emissions favour vehicles with a long range of electric operation. Plug-in hybrid vehicles are increasingly appearing on the market, whose batteries can be charged using public or private power supply systems. The driving performance required from these vehicles requires relatively high levels of electric power with low space requirements. At the Schaeffler Symposium 2010, Schaeffler presented a technical solution for these vehicles with the first generation of the so-called “active electric differential”. Schaeffler has been consistently developing the electric axle drive ever since. The third generation currently being tested is matched to the topology of a plug-in hybrid vehicle with a front mounted engine and front-wheel drive. The drive unit is still designed to be fitted coaxially in the rear axle and is characterised by the following features:

Water-cooled electric motors in hybrid design (permanently excited synchronous motors with a high proportion of reluctance) are used. These meet automotive-specific requirements in contrast to the industrial motors used in the first generation.

The transmission is still in planetary design and now has two ratio stages.

The drive unit has increased power density and a modular design so that traction and active torque distribution can be offered as separate functions.

Covers - active torque distribution.

See vCD 224 Schaeffler_Kolloquium_2014_14_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 6pp.)
**TRANSMISSIONS**

**MANUAL TRANSMISSIONS**

**THE NEW AUDI ML XX2-6F MODULAR MANUAL GEARBOX**

*Audi*

The new MLxx2-6F manual gearbox module was developed with the goal of further improvement in efficiency and weight reduction as compared to the manual gearboxes currently in series production. This was achieved by revising the design, material substitution (magnesium alloy and plastic), torque-dependent module dimensioning and variation, significant reduction in splash losses, and minimising the friction in the rolling bearings and gearing.

Furthermore, the modular design allows the vehicle series to make intelligent and cost-aware use of the weight advantages.

Contents:
- Gearbox design
- Performance Specification requirements, development goals
- Modular gearbox design
- Lightweight construction measures
  - Gearbox housing development using Mg alloys
  - Further lightweight construction measures
- Improvement in gearbox efficiency.

Covers – lower viscosity gearbox oil, CO2 reduction.


**THE NEW GENERATION OF REAR WHEEL DRIVE MANUAL TRANSMISSIONS AT MERCEDES-BENZ**

*Daimler*

Mercedes-Benz developed a new generation of rear wheel drive manual transmissions because of increased CO2-requirements and further improvements of shift comfort. The new transmission generation was developed together with ZF Friedrichshafen and is based on the already known MT10 transmission. The modified architecture enables fuel savings of up to 8 gCO2/km in the NEDC.

The focus of developing the new transmission generation is based on reduced weight as well as a reduction in fuel consumption and on the new innovative Mercedes-Benz Clutch Protection System. Beyond this, Mercedes-Benz especially focused on an improvement of shift comfort, which will set a new benchmark in the premium segment. The new generation of rear wheel drive manual transmissions will be seen in various rear-wheel-drive models. The rollout already started with the new generation of the C-Class in March 2014.

Covers – Active Throttle Function, Clutch system, Dual Mass Flywheel, SG6-300.

AUTOMATIC TRANSMISSIONS

HOW COULD A CHINESE COMPANY MAKE AN 8AT FOR CHINA

Beihang University and Shengrui Transmission

Contents:
Chinese Automatic Transmission Market and Technical Route
Why an AT for China and Why an 8AT for Shengrui
From Concept to SOP of Shengrui's 8AT
Back ing from the Local and State Government
Covers - contract with Ricardo.

THE NEW 8 SPEED RWD AUTOMATIC TRANSMISSION FOR THE CADILLAC CTS

Adam Opel

GM's new 8 speed RWD Automatic Transmission (TL-80SN) was launched in the summer of 2013 in the Cadillac CTS with the 3.6-litre naturally aspirated engine and in the autumn of 2013 with the 3.6-litre Twin Turbo Engine.

It is the first entry of an 8-speed transmission in the General Motors Company. Its torque range will go up to 583 Nm. Besides adaptations to cope with the engine torque, main features of this new transmission are extremely fast and seamless shifts, better response and reduced vehicle CO2 emissions.

The focus of the development was to balance the high torque output of the engine with a low vehicle mass. The development includes paddle shift at the steering wheel and a series of driver-selectable performance modes.

There is also a fuel economy improvement compared to the predecessor 6-speed model. The wide ratio spread of the new 8-speed transmission enables lower rpm at vehicle speeds which contribute to lower cabin noise while not jeopardising the launch performance as the overall first gear ratio stays similar to the previous model's 6-speed transmission.

Gives - cross section, gear trains.
See vCD 216 35m_Sporleder.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 10pp.)

THIRD GENERATION OF GLOBAL FWD 6-SPEED AUTOMATIC TRANSMISSION (GF6)

Adam Opel, Punch Powerglide and General Motors

The next generation of fuel efficient FWD 6-speed Automatic Transmissions (GF6 Gen III) has been launched in North America in September 2013 in the Chevrolet Malibu and will be introduced in Europe at the end of 2014 for Opel/Vauxhall. With a torque capacity range from 175 Nm to 400 Nm this transmission family is an optimal solution for the majority of global applications, providing high efficiency, short shift times and high shift quality.

Improved fuel efficiency can be expected up to 2% compared to 2nd transmission generation. This additional reduction of fuel consumption has been achieved by transmission improvements, including the introduction of a new off-axis binary oil pump, variable lube flow and reduction of oil level. An external accumulator has been implemented to enable Stop-Start capability providing additional fuel economy.

Covers – off-axis vane pump.
AUTOMATED MANUAL TRANSMISSIONS

THE NEW AUTOMATED S-SPEED MANUAL TRANSMISSION BY OPEL

Adam Opel

Opel will launch a new 5-speed Automated Manual Transmission (MTA) at fall 2014. Due to huge progress in MTA actuation technology, a widely upgraded base transmission and perfectly tailored interaction with engine and vehicle controls, the launch and shift quality has been raised to unprecedented level for Transmissions of MTA Design Type. Auto Stop-Start is seamlessly integrated.

According statistical surveys, MTA vehicles have better Fuel Economy even compared to same vehicles with MT. Although the new MTA system is more extensive compared to predecessor, it will continue to be a widely affordable entry for automated gearboxes. Optimised torque and clutch management during shifts and sophisticated gear selection logic deliver leading drive and shift quality for this type of Transmission.

Covers – simulation, upshifts, downshifts, driveability, gear selection strategy.


AUTOMATED MANUAL TRANSMISSION WITH A TORQUE GAP FILLER PART 1: KINEMATIC ANALYSIS AND DYNAMIC ANALYSIS

Magneti Marelli Powertrain and Politecnico di Torino

This paper deals with a powershift automated manual transmission, i.e. an automated manual transmission with a torque gap filler, which essentially integrates, in a typical manual transmission layout, a torque gap filler assembly with the aim of reducing the torque gap that occurs during gearshifts. The torque gap filler consists of an additional mechanical link between the engine and the transmission output shaft, thus enabling the engine power to flow through this parallel path also when the launch clutch is disengaged, with clear benefits in terms of both sportiness and passenger comfort. This paper is the first part of a two-part study which, after a general description of the transmission architecture and its working principle, examines a practical implementation of the torque gap filler concept; the additional mechanical components and their integration into a traditional automated manual transmission are presented. Then, kinematic analysis and dynamic analysis of the transmission are proposed. The evolution of the transmission speeds are studied in the whole working range of the vehicle; the equations of motion are derived and used to show the effect of the torque gap filler on the torque transmitted to the wheels and consequently on the vehicle acceleration during gearshifts. The companion paper (Part 2) covers control issues and provides experimental validation.

Covers - transmission modelling.

DUAL CLUTCH TRANSMISSIONS

NEXT DCT - REVOLUTIONARY IDEAS WITH EVOLUTIONARY TECHNOLOGIES

Ricardo

Dual Clutch Transmissions (DCT) have revolutionised driveline technology, providing automatic transmission operation with excellent shift quality, producing dynamic operation and driving comfort together with high efficiency, resulting in low fuel consumption and CO2 emissions. Given the benefits, DCTs have an expanding if still a somewhat limited range of market applications, due to primarily high unit cost and increasing package and weight for higher ratio spreads.

Ricardo has developed a number of alternative DCT architectures and concepts, which address certain key constraints and enable expansion of DCT technology into both conventional and alternative market sectors. In this paper the latest developments in three new DCT technology families will be presented:

- Manual DCT: Ricardo has developed a cost reduced DCT concept utilising conventional mechanical systems, simplified clutches and simple hydraulics with no need for electronic control systems. This provides the driveability benefits of a DCT in a highly simplified transmission. Shifting is via manual application. Hardware has initially been developed for utility and farm vehicles with additional applications to a range of market sectors from motorcycles to entry level automotive vehicles through to high torque capacity on- and off-highway vehicles.

- HiTorque DCT10 for high performance vehicles and light commercial trucks: The configuration offers torque capacities of 950 Nm with high gear ratio spreads and next generation high pressure actuation technology yielding a power loss signature of a dry clutch DCT equivalent. The architecture family offers also 8, 9, 10 and 12-speed variants, allowing modification for desired ratio variation.

- MCA - Mono Clutch Automatic: It also needs to be considered whether there is an intermediate step - retaining the functionality of a DCT but with the price competitiveness of an automated manual transmission (AMT). Previously, the AMT has been rejected in some markets due to poor shift quality. However, the latest Ricardo ideas show that there are technical solutions to this conundrum. It has been found possible to have DCT functionality at AMT cost and that such a transmission will have characteristics acceptable to large parts of the passenger car and commercial vehicle market sectors.


THE NEW AUDI S TRONIC DUAL-CLUTCH TRANSMISSION

Audi

As the first type of the new S tronic platform Audi is introducing the new dual-clutch transmission DL382-7F. The seven-speed transmission is for use in vehicles from the modular longitudinal matrix (MLB). It is conceived for a torque of 400 Nm and for engine output of up to 200 kW. Top priority during development of the new S tronic was the increase in efficiency and thereby the reduction of fuel consumption and CO2 emissions. Through extensive simulations and optimisations and also through the use of innovative technologies, it was possible to reduce power dissipation and drag torque to terms of efficiency, the new S tronic power train sets new benchmarks. A transmission layout optimised for the engine characteristics, combined with decoupling of torsional vibration' which allows rotational speed to be reduced even further, are key factors towards reducing fuel consumption without having to compromise vibrational comfort. The sportiness of the brand and its vehicles is emphasised by the extremely dynamic shifting characteristics of the DL382-7F. The new S tronic has made it possible to optimally combine the requirements regarding sportiness, comfortable driving experience and efficiency. The electronics in the DL382-7F consist of (pre-)testable sub-components; they are robustly connected to one another via digital interfaces and bus systems and can be flexibly expanded. By using a common hardware and software architecture, the transmission control unit can be used in both the MLB and MLBevo modules of the Volkswagen Group. The extensive efficiency
requirements of the transmission are supported in the electronic system by numerous features. The selected control unit architecture fulfils the ASIL D requirements and allows a flexible development of driving strategy and valve actuation.


DOUBLE CLUTCH SYSTEMS: MODULAR AND HIGHLY EFFICIENT FOR THE POWERTRAIN OF TOMORROW

Schaeffler

Alongside the established stepped automatic transmission and CVT, the double clutch transmission in particular has achieved considerable market penetration in the last few years. Significant growth has been seen in the European and Chinese markets in particular, and current forecasts indicate that in ten years’ time, every fifth automatic transmission will be a double clutch transmission.

The following basic requirements apply to automatic transmissions in accordance with current definitions:
- Maximum comfort achieved through powershift capabilities combined with a dynamic driving experience
- Idea spreading and the highest possible level of efficiency across all operation modes
- Actuating mechanism operated with minimal losses and, where possible, without the need for additional effort while the combustion engine is turned off
- Function presented in the simplest and most flexible manner possible.

A double clutch transmission, which fulfils all of these requirements, including an integrated hybrid function, entered into series production in Japan at the end of 2013 under the name “i-DCD”. Covers - “dry or wet”, “dry and wet”, actuating mechanism.

Graph shows - Production volumes for different automatic transmissions (selected regions) 2013 and 2022.

See vCD 224 Schaeffler_Kolloquium_2014_15_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 3pp.)

WET DOUBLE CLUTCH: THINKING IN SYSTEMS

Schaeffler

In ten years, the number of wet and dry double clutch transmissions (DCT) will make up approximately 20% of the total automatic transmission market. Against this backdrop, customers are faced with the question of which double clutch system is right for their application. Both dry and wet double clutches have proven themselves in volume production. There are various designs and various forms of actuation within the two systems, with key differences being in the torque capacity, space requirements, weight and inertia of masses. A whole range of wet double clutch systems have since been developed by LuK in order to be able to serve a vast array of applications. The first wet double clutch went into volume production in 2013. In addition to the actual double clutches, other components such as dampers, centrifugal pendulum-type absorbers and actuators are also available. The focus is on a perfectly matched overall system that meets the target parameters of comfort, consumption and costs in the best possible manner. To do this, components and assemblies need to be standardised to pool volumes and thus be able to continue to offer appealing solutions in the future.

Throughout the development phase, various different concepts were analysed and compared on a broad basis. The clutch components were examined in detail and developed accordingly. The tribological system (comprising a friction plate, steel plate and oil), in particular, plays a key role in the design and comfort characteristics of the clutch. In addition to examining different friction linings and friction lining technologies, geometry, grooving, as well as the distribution of cooling oil and pressure are all important. Furthermore, the gathered findings and experience will be used to develop our own linings for wet clutches.

See vCD 224 Schaeffler_Kolloquium_2014_17_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 6pp.)
CONTINUOUSLY VARIABLE TRANSMISSIONS

CONTINUOUS SPREAD AND EVOLUTION OF CVTS

JATCO

Agenda:
- The history of Belt CVT spread to global market
- Remarkable promising market: Asia
- Transmission trend in Asian market
- The reason why CVTs are chosen in Asian market
- Further evolution expected for CVTs
- CVT efficiency
- CVT shift feeling
- Energy Regeneration
- Autonomous Driving.


Summary -
- CVT technology of European origin has been spreading continuously into global markets.
- CVTs are suitable for markets where there are few expressways and frequent vehicle speed change, like Asia.
- Customers in Asian markets, including Japan, tend to choose CVTs for their driving ease, good fuel economy and quietness in city driving, especially for small engine vehicle models.
- CVTs are continuing to evolve and have the potential to contribute significantly to future vehicles.
- To provide suitable transmission for promising Asian markets, let us re-evaluate and utilise CVTs, which are based on technology of European origin.


DEVELOPMENT OF A CVT FOR FRONT-DRIVE HYBRID VEHICLES

JATCO and Nissan

A mid the rising needs for both a reduction of CO2 emissions (fuel economy improvement) enhancement of driving pleasure, JATCO and Nissan Motor Company undertook a new hybridisation challenge and jointly developed the Jatco CVT8 Hybrid (the CW8 Hybrid) for front-wheel-drive hybrid vehicles.

The adoption of a compact, lightweight and highly efficient 1-motor 2-clutch (1M2CL) system enabled the CW8 Hybrid to continue the outstanding features of the base Jatco CVT8. As a result, the CVT8 Hybrid is truly a new-generation transmission that can meet various customer needs.

Covers – dry multiplate clutch, lubrication, cooling, friction material temperature, pulleys, control system of the CVT8, optimised shifting.


CVT: THE TRANSMISSION CONCEPT OF THE FUTURE

Schaeffler

Automatic transmissions are becoming more and more common in passenger vehicles and, at the same time, customers’ demands for comfort and reduced fuel consumption are increasing. Optimised fuel consumption is very difficult to achieve with manual transmissions. More than 20% of automatic transmissions will be CVTs by the year 2020. A significant advantage in terms of fuel consumption can be achieved in operation at partial load, and hybrid concepts can be seamlessly combined with the CVT. The CVT can also be manufactured cost-effectively, and when combined with torque converters, modern damping systems, and hybridisation, it offers level
of comfort that is difficult to surpass. New chain types allow significant increases in ratio spread and strength to be achieved, a trend which future generations of chains will continue. In addition, the ratio spread can also be expanded through the use of gear stages/range shifting to include ranges that conventional automatic transmissions will have difficulty in achieving comfortably. This means that CVTs can support the trend towards downsizing and downspeeding with no problems. If required, the efficiency of the transmission can also be further optimised through the use of direct gear stages. The CVT thus continues to represent one of the best technical solutions for the automation of the powertrain, particularly in the field of front transverse applications. Current developments and possibilities for further development will be looked at in detail in this paper. Covers - Single-range and dual-range concepts, high value CVT, single-range or dual-range structure, modular front transverse variator system, fixed-ratio gear stages, high value CVT multimode, chain 05 – the next generation, optimised acoustics through reduced pitch. See vCD 224 Schaeffler_Kolloquium_2014_34_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)
HYBRID TRANSMISSIONS

PLUG-IN HYBRID TRANSMISSION FOR MERCEDES-BENZ PASSENGER CARS

Daimler

This paper describes the new Mercedes-Benz Plug-in transmission. The overall architecture of the hybrid system remains basically similar to the full hybrid transmission presented in 2012. Nevertheless the hybrid specific parts are completely redesigned, due to the increased power of the electric motor (85 kW instead of 20 kW) and the increased inertia of the system. As in the 20 kW system rotor and stator of the electric motor both are cooled with transmission oil. The bearing layout and the torsion at damping system are modified, corresponding to the different load cases, excitations and inertias. The whole system layout focuses consequently on two aspects: fuel efficiency and vehicle package.

This paper describes the general design as well as specific details about the cooling system, the wet clutch and the damping system.

In addition, a brief comparison between parallel hybrid systems and power split systems is carried out, resulting in conclusions about powertrain architectures.

Gives sectional view of the 85 kW hybrid transmissions.


THE NEW PLUG-IN TRANSMISSION FROM ZF

ZF

Within the automotive industry, various paths are being followed in attempts to respond both to increasing fuel prices and to the necessity of reducing CO2 emissions to slow down global warming. The rigorous implementation of optimisation measures on combustion engines and transmissions as well as the increased use of hybrid technology offer the possibility of achieving short-term and medium-term CO2 targets.

In the medium-term, measures such as the development of alternative fuels and plug-in vehicles will influence the market. These measures complement each other and thus do not compete with each other. In a fictitious world of purely electric drivelines, conventional technologies would be replaced. In this scenario, hybrid technology - in its various solutions as full hybrid and plug-in hybrid - could be called a "transitional solution."

Today, however, many experts agree that a complete transition to electric vehicles will only come much later. In light of this assessment and of the slow volume development of hybrid vehicles, a modular concept to electrify transmissions is of essential importance. For this reason, ZF continues to pursue the development of the modular kit for hybrid transmissions. After the mild and full hybrid transmissions, development began on a plug-in transmission. This article describes the system architecture as well as various components such as the damper, separating clutch, electric motor and electric pump of the plug-in transmission.

Covers – ZF’s 8 speed 8P75PH transmission.

Gives cross section and technical data.

See vCD 216 23m_Hensel.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 14pp.)

AVL FUTURE HYBRID TRANSMISSION - THE HOLISTIC APPROACH FOR HYBRID DRIVETRAINS: THE NEW AVL 7-MODE TRANSMISSION

AVL List

Ongoing ICE development is improving the best specific fuel consumption and is enlarging the sizes of the ICE's sweet spot in the direction of higher and lower engine speeds and shifts it towards lower load operation conditions. This development reduces the fuel consumption benefit given by a wide transmission gear ratio spread as well as the need for small ratio steps. Thus the number of transmission speeds can be reduced. Countermeasures to solve potential driveability deficits by the increased gear ratio steps benefit from instantaneous torque availability of an electric
motor integrated into the hybrid drive train. With the "Future Hybrid" design AVL has taken a holistic development approach for all key components of the drivetrain and is able to demonstrate best fuel efficiency and cost effectiveness for outstanding vehicle customer acceptance. A shift in transmission development paradigm to also consider transient shift operations with more than two active shift elements allowed a multi-functional and compact transmission design. The Lepelletier planetary transmission with the EM integrated with the second ring gear of the modified Ravigneaux gear set provides a solution of low hardware complexity and product cost while increasing the demands on the control system to manage the transient shift operations.

HYDROSTATIC TRANSMISSIONS

HYDROSTATIC TRANSMISSION FOR OFF ROAD CONSTRUCTION EQUIPMENT

Bosch Rexroth and Dana Rexroth Transmission Systems

Topics:
- Fully hydrostatic transmission/low horse power range.
- Hydrostatic transmission with gear box/CVT and non CVT/medium horse power range.
- Power split transmission CVT/mechanical and hydrostatic/high horse power range.
- Covers - Hydromechanical Variable Transmission HVT-R2, Fuel consumption test details.

See vCD 221 Friedl_Roland.pdf (IQPC 4th International Conference Next Generation Off-Highway Engines, Cologne, Germany, 16-18 Jun 2014, 33pp.)
POWERSPLIT TRANSMISSIONS

MODE SHIFT CONTROL FOR A DUAL-MODE POWER-SPLIT-TYPE HYBRID ELECTRIC VEHICLE

Sungkyunkwan University

This paper presents a mode shift control algorithm for reducing the variation in the driveshaft torque for a dual-mode power-split-type hybrid electric vehicle. To evaluate the shift characteristics of this hybrid electric vehicle, dynamic models for the hybrid electric vehicle powertrain were developed. Using the dynamic models, a mode shift performance simulator was developed, and simulations were performed. To analyse the shift characteristics during the mode shift, bond-graph models for the transient state were constructed, and state equations were derived. From the bond-graph models and state equations, it was found that the transient torque occurs because of the inertia torques of the first motor-generator and the second motor–generator. Based on the transient torque, a mode shift control algorithm was proposed, which compensates for the transient torque. To evaluate the performance of the proposed control algorithm, a test bench for the dual-mode power-split-type hybrid electric vehicle was developed. From the simulations and test results, it was found that the variation in the driveshaft torque was reduced by the proposed control algorithm, which provides improved shift quality.


POWERSPLIT AS TORSIONAL DAMPING SYSTEM – INDUSTRIALIZATION IS COMING

ZF

Agenda:
Working principle “Extinction”
Status modular system MT
Status service-life tests
Boundary lines for torsional vibration damping and their impact on CO2
Status of powersplit in AT
Conclusion and outlook -
- Service life for the superposition gear proven
- Next prototype with serial-production features in progress for MT/DCT-FWD
- Boundary lines for torsional vibration damping for MT-RWD regarding engine characteristics available
- First measurements in AT-RWD HL confirm function in converter.
Next steps:
- Proof of function in MT FWD with modular system superposition gear
- Realization of modular system
- Optimisation of power split in AT.

TRANSMISSION ISSUES

SHIFTING

FUEL COST OF AUTOMATIC TRANSMISSION SHIFT

Ford

Motivation for Cost of Shift Analysis:
- It is known that small incremental energy losses occur during automatic transmission shift operations.
- These losses have also been assumed to be negligible in most vehicle fuel economy simulation program.
- Recent development of 8+ speed transmissions have highlighted the need for better understanding.
- High fidelity simulation tools available at Ford have been used to evaluate these losses. Covers – energy balance.

See vCD 216 34m_Jiang.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 8pp.)
TRANSMISSION AND DRIVELINE COMPONENTS

HIGH PERFORMANCE ELECTRIC FRONT AXLE (EAXLE) FOR THE PORSCHE 918 SPYDER

GKN Driveline International

The Porsche 918 Spyder is the world's first super sports car designed as a plug-in hybrid. It represents future sports car technology combining lowest fuel consumption and ultimate driving dynamics and performance. "Porsche premium development partner" GKN Driveline has developed and successfully launched the Porsche 918 Spyder's electric front axle (eAxle) which provides parallel hybrid, electric and all-wheel drive capability and contributes significantly to the superior vehicle dynamics and fuel efficiency.

The electric motor of the front eAxle provides a maximum power of 95 kW, a maximum torque of 210 Nm and runs with a maximum speed of 16000 rpm. The GKN Driveline electric front axle (eAxle) comes with a fixed gear ratio and is capable of delivering 1500 Nm of output torque for superior traction and all-wheel drive performance. A unique disconnect system allows the electric motor to decouple at vehicle speeds above 265 kph to maximise system efficiency, reduces drag torque and prevents over-speeding of the electric motor. The electronic disconnect differential (EDD) provides the seamless disconnect and re-connect function with minimised drag losses in ultra-compact packaging.

An advanced lubrication concept has been developed to minimise churning losses and provide proper lubrication of the sidshafts and disconnect differential in disconnect mode. To support the extremely challenging weight targets of such super sports cars the eAxle had to be designed for highest power density and lowest weight. State-of-the-art simulation and analysis tools have been applied to optimise the gear train in terms of NVH, efficiency and durability.


SCHAEFFLER HEAVY DUTY DIFFERENTIAL WITH AWD-DISCONNECT

Schaeffler Technologies

The Schaeffler lightweight differential was presented for the first time at the 2009 VDI Congress. At the time, the innovative aspect of the design centred around the reduced weight and smaller mounting space required for the ground-breaking differential concept. Since then, the lightweight differential has been further optimised in order to overcome the last of the concept’s drawbacks in comparison to the existing bevel gear differential. During the optimisation phase, the key focus has been to improve the rigidity of the differential, and reduce frictional losses in the main bearing arrangement. A further aim was to reduce the production costs. Today, this means that there is virtually no effect on costs, at least when the differential is operated within high torque ranges. For those who have not yet come across the Schaeffler lightweight differential, what follows is a brief explanation of how the component came into existence. Based on the most recently available sources, Alexander Timothy Brown can be described as the father of the "spur-gear differential", a category of differential that includes the Schaeffler lightweight differential.


NEW GENERATION OF LIGHTWEIGHT REAR AXLE DIFFERENTIALS FROM MERCEDES-BENZ

Daimler

The new Mercedes-Benz C-Class will be launched with an all-new generation of rear axle differentials. By focusing on realising an integrated lightweight design, engineers were able to reduce the weight of the component assembly by approximately 13 percent compared to the predecessor version. At the same time, transferable torque was increased up to one third. In addition to this improved performance, attention was also paid to devising optimised assembly routines while at the same time ensuring broad levels of component standardisation and a targeted load-stage concept.
Covers – bearings, gearing/gear set, hypoid oil, oil flow analysis.

See vCD 216 20m_Lisner.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 12pp.)

TURNING NEW DIRECTIONS: SURPRISING POTENTIALS IN PLANETARY TRANSMISSIONS

Schaeffler Technologies

To date all bearings and components in the planetary gear set unit that underlie high forces and torque are enhanced for friction reduction. This paper outlines the technical solutions to reduce friction in a planetary gear set. The return part analysis revealed, that even parts with lower load show frictional wear. This is evident for example with the thrust washer which braces the planetary gear. The necessary friction reduction caused by the axial thrust in the planetary gear is the main focus of this paper, supported by validated test results. Surprisingly is the significant share of friction power. A CO2 saving of approximately 1 g/km per automatic transmission with 4 planetary sets can be gained, by substituting the current thrust washers with thrust needle bearings. The challenge consist in the production of an adequate thrust needle bearing for the allocated space.

Covers – coatings based on zinc phosphate (Duratect Z) or manganese phosphate (Duratect M).


SPECIAL REQUIREMENTS TO PLAIN BEARINGS IN AUTOMATIC TRANSMISSIONS

Federal-Mogul

Content:
F-M Bearings at a glance
Requirements for plain bearings in automatic transmissions
Structure of plain bearings
Development process of plain bearings
F-M material portfolio for automatic transmissions
New Sinterbronze LF-7 - Development targets
F-M towing test
F-M axial thrust washer test
Summary.

Covers – lead free bearing materials, LF-7 sintered bronze. (Paper in German; Slides in English).


DRY RUNNING, PERMANENTLY ENGAGED STARTER SYSTEM (PES) FOR A COMFORTABLE START OF COMBUSTION ENGINES PROVIDING FURTHER POTENTIAL TO REDUCE FUEL CONSUMPTION

BorgWarner

Engine Start/Stop systems are becoming standard in almost every vehicle category to meet emission targets. However the end customers poorly accept conventional solutions with an engaging pinion starter due to their operational behaviour. To improve especially the starting performance of a combustion engine, this paper shows a one-way clutch (OWC) system for permanently engaged starter (PES), that can be integrated into the flexplate respectively (dual-mass) flywheel of a powertrain and disconnects the starter motor from the crankshaft after engine start. Designed as a robust, dry running system, it has low requirements in terms of installation space needed between the internal combustion engine (ICE) and transmission and also low effect on existing engine designs and installation processes of powertrains. Because of its innovative design and the permanently engaged pinion the dry PES has advantages in the operational behaviour compared to conventional solutions:
- "Change-of-Mind" capability (starter motor can be switched on anytime)
- Faster system response and better repeatability
- No additional drag torque and no wear at engine speeds above idle.
- Improvement of NVH behaviour during engine start
- Increase of ring gear durability for higher amount of engine stop/start cycles.
BorgWarner's dry PES system not only provides idem advantages compared to present Start/Stop systems, but also enables lot of potentials for future technologies in automotive powertrains with combustion engines:
- Advanced sailing and coasting functionality with early engine shut off. Hybrid applications with a high number of engine restarts
- No additional system required for cold start
- Reduction of crankshaft torque load during engine cranking.
With an almost unnoticeable shut off and restart of the combustion engine, these technologies besides saving fuel also provide the potential to obtain wide acceptance of Start/Stop systems by the end customers.
Covers – NVH behaviour, durability, drag torque, wear.


INFLUENCE OF CONE-ANGLE-DIFFERENCE ON PERFORMANCE OF SYNCHRONIZERS WITH CARBON FRICTION LININGS

Technische Universität München
At the Research Centre for Gears and Gear TU Munich, the thermal behaviour of a commercial-vehicle synchroniser with carbon friction linings was investigated. Detailed temperature measurements showed that the positive cone angle difference of the serial design between blocker ring and steel cone leads to a very irregular pressure and temperature distribution over the width of the blocker ring. This is induced by a self-reinforcing process due to thermal isolation of carbon friction linings and therefore local thermal widening of the steel cone. By changing the design to a smaller cone angle at the blocker ring contrary to known design guidelines, a significant increase in the lifetime of the synchroniser at damage relevant low to medium high loads was gained.


SYNCHRONIZER MANUFACTURERS RESPOND TO FUTURE CHALLENGES WITH INNOVATIONS

Hoerbiger
This paper provides an overview of the approaches and concepts that manufacturers of synchronisers pursue to respond to the challenges of the future.
While the manual transmission market still commands the highest sales volume, the majority of gains in the lower and mid-range torque segments of the growth markets will come from the Asian region. The success of DCTs in Europe and Asia additionally creates new markets, which increasingly demand customised solutions for synchronisers. With this in mind, manufacturers of synchroniser systems and components are under pressure to ensure that their developments offer solutions for the specific requirements with regard to performance, efficiency and cost effectiveness. Using the example of the development of the Hoerbiger CompactLINE, it will be shown what trends will be crucially important for future synchronizers and what approaches can be used to address them.
Leading manufacturers respond to these trends with varying concepts.
- Synchroniser capacity can be increased by servo systems, force amplification or minimised cone angles.
- Minimisation of loss relates both to the reduction of drag torque and the implementation of lightweight construction concepts.
- NVH problems in the synchroniser are addressed with spring and coupling elements.
- Efforts to shift functions into the control unit in the case of automated transmissions are still in their infancy and goals for additional development work are being formulated.
- Measures aimed at cost optimisation are paramount. In addition to localisation, the focus here is primarily on reducing the model variety through modular concepts. Additionally, the competition for
different materials and manufacturing processes will result in further cost reductions. The outlook highlights where more research is needed and how developments are implemented at Hoerbiger from the idea to the validated product with the market in mind. See vCD 216 49m_Back.pdf and 49p_Back.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, Paper – 13pp, Slides – 25pp.)

WEIGHT REDUCTION AND INCREASE OF POWER DENSITY WITH INNOVATIVE SYNCHRONIZER SYSTEMS - COMPONENTS WITH SUSTAINABLE IMPACT ON THE OVERALL SYSTEM

Schaeffler Technologies

Enhancing the design envelope by means of individual components is a difficult task to realise. Significant reductions on the axial design envelope of synchronisation systems can only be achieved by combining several newly developed components. Schaeffler’s strut-in- sleeve concept for the selector sleeve unit proves to be the key component when it comes to reducing a design envelope. Other innovations such as the sheet metal selector hub and high-performance carbon-based friction linings are important prerequisites. These innovative products pave the way towards the production of synchronisation systems with a higher power density. A narrow synchronisation system makes it possible for the transmission manufacturer to achieve a reduction in weight or even to optimise the strength of other components in the transmission. See vCD 216 50m_Kohtes.pdf and 50p_Kohtes.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, Paper – 12pp, Slides – 26pp.)

MULTI-MODE CLUTCH MODULE DEVELOPMENT

BorgWarner

BorgWarner Multi-Mode Clutch Module is a multi-mode rotation device. The flexible design can provide up to four different modes and combinations.
1) Overrun Mode: freewheel in both rotation directions with very low drag
2) Lock Mode: transmits torque in both directions similar to a dog clutch or engaged friction clutch pack
3) One-way Clockwise Mode: clutch race freewheels in clockwise rotation direction and locks in opposite direction
4) One-way Counter Clockwise Mode: clutch race freewheels in counter clockwise rotation direction and locks in opposite direction.

How the Multi-Mode Clutch Module works:
The Transmission Control Unit (TCU) selects the operating mode. The actuator indexes the cam plate to block or unblock the locking element or engagement notch.

Technical Features and Advantages:
Improved fuel economy, High torque capacity, Flexible engagement control, Better shift feel, Low system total mass, Low rotating mass, Optimal mode biasing plate flexibility, Engaging or disengaging locking elements, Simplified manufacturing (Bearing grade steel NOT required), Small cross-section required - axially and radially, High torque density, Can reduce total number of clutches in transmission.

GREATER EFFICIENCY THANKS TO MILD HYBRID INTEGRATED APPROACH

Continental and Schaeffler

A holistic approach opens up new opportunities to increase the efficiency of vehicles with combustion engines. In the Gasoline Technology Car (GTC) joint project, Continental and Schaeffler demonstrate that mild hybridisation with a high degree of functional integration can bring about additional efficiency gains due to the associated synergy effect. Covers - e-clutch, 48V Eco Drive System, XL3.1 injectors, EGR, Thermal management. See Doc.145944 (MTZ Worldwide, Sep 2014, pp32-36.)
CLUTCH RELEASE SYSTEMS: FROM SYSTEM KNOW-HOW TO A SUCCESSFUL VOLUME PRODUCED PRODUCT

**Schaeffler**

More than 100 years after the invention of the automobile, it seems as if the technology of clutch release systems, is a mature one, without the necessity of changes. However, even in this seemingly evolved family of products, the innovation dynamic remains high. Current developments aim to further increase robustness, replace existing materials with polymer materials, and integrate sensors in the master cylinder.

Master cylinders with integrated sensors have only been used in a few cases in the past. The proliferation of systems such as start/stop or the electronic parking brake is now leading some car manufacturers to consider such sensors in the master cylinder as obligatory. The sensors make it possible to measure the travel on the clutch pedal and thus determine the driver’s intent.

Materials too are evolving. While for decades cast iron or aluminium alloys were dominant, in new applications, master cylinders, pipes and slave cylinders are almost always made of plastic. Initial problems with the use of polymer materials, such as master cylinder squeaking, high adhesive friction and volume expansion, have since been resolved. The technologies necessary for use of plastics have been constantly refined and are now solid and economical. Even in double clutch systems, which have higher, continuous loads, plastic cylinders are gradually becoming established. Current developments are focused on using plastic in the pedal box.

Ultimately, the robustness requirements for the components used in clutch operation have risen significantly. Even just a few years ago, one million cycles was the going operating load specification for release systems. Now, it is not unusual to require two to three million cycles – accompanied by increased requirements regarding the ambient conditions of temperature, water and contaminant exposure.

Covers – integrated sensor system, Clutch pipes and installation elements, Slave cylinder – plastic prevails, pedal boxes.

**See vCD 224 Schaeffler_Kolloquium_2014_06_en.pdf** *(10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 9pp.)*

THE CLUTCH COMFORT PORTFOLIO: FROM SUPPLIER’S PRODUCT TO EQUIPMENT CRITERION

**Schaeffler**

As technical developments frequently have a mutual influence on each other, innovations realized for one component more often than not necessitate adaptations to other systems. The same applies to automotive clutch systems, which greatly facilitate driving comfort and convenience. Increased torque or ignition pressure in the engine, for example, leads to more pronounced axial vibrations along the crankshaft. To ensure that this inherent tendency does not compromise the driving experience by inducing strong pedal vibrations, high pedal forces, or creating disturbing noise levels, the clutch systems installed must be adapted accordingly.

Covers – comfort, clutch pedal, travel-adjusted clutch, or TAC, cover fixed release system, or CFR, comfort of launch, vibration isolation shifting comfort, comfort at high stress, comfort at engine startup, electrification, motorcycles.

**See vCD 224 Schaeffler_Kolloquium_2014_07_en.pdf** *(10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)*

HOLISTIC DEVELOPMENT OF SYNCHRONIZING SYSTEMS: SHORT, LIGHT AND CONVINCING

**Schaeffler**

Currently, the value added chain of manual transmissions is characterised by the fact that major automobile manufacturers in the triad (EU, USA, Japan) buy their individual synchronisation system components from different suppliers. However in new markets, manufacturers have for some time preferred to work with suppliers who design and develop the entire synchronisation system and deliver it ready to install.

Schaeffler is prepared for this new situation. The final module required at the component level is
the development of efficient friction linings for synchronisation systems and this has already been completed. Typically, synchroniser manufacturers need to limit the size of their systems to the space available between the gears to be shifted. Schaeffler has additional expertise in the design of the connecting components – such as the bearings supporting the shafts and speed gears – as well as gear teeth in general. In addition, there is comprehensive power transmission expertise available throughout the Group. Thus, from the clutch to the transmission output, the power transmission system can be tuned so that from a systemic point of view an optimum is reached in terms of cost, space, weight and gearshift comfort.

Covers - Carbon-based friction linings, STC 300 – Carbon-based composite friction material, STC 600 – Carbon fibre friction material. Oil sensitivity and wear, weight reduction.

See vCD 224 Schaeffler_Kolloquium_2014_08_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)

TURNING NEW DIRECTIONS: SURPRISING POTENTIAL IN PLANETARY TRANSMISSIONS - PART 1: PLANETARY GEAR SET

Schaeffler

The automotive industry and suppliers have implemented numerous innovations with the objective of reducing the CO2 emissions of individual transport. Examples are general lightweight designs and optimisations to the exhaust gas system as well as numerous detailed solutions for engine technology. For many years, transmission technology has also been contributing to the continuous reduction of fuel consumption and emissions. This has usually been accompanied by an increase in the number of gears.

With the increased number of gears, the number of planetary gear sets in automatic transmissions also tended to be increased. This trend was not linear in relation to the number of gears due to the intelligent control of the flows of force. The design envelope of the transmission, however, remained the same. The individual transmission components therefore had to become smaller and more compact. This requirement often created special challenges for the design and dimensioning of components. At the same time, the requirements for the materials and manufacturing technologies used have increased. Schaeffler has been able to make significant contributions to reducing emissions and fuel consumption by continuously optimising planet gear bearings and axial needle roller bearings. Recent analyses have shown that even inconspicuous new developments can offer great potential. The most recent example is the new axial needle roller bearing support for planet gears. This development is considered a first in rolling bearing technology and can contribute to reducing CO2 emissions by up to 1 g/km with low additional costs.

Covers – power losses, reducing frictional power, planet gear bearings in general, cage design, coating, planet gear design, latest findings from axial bearing supports for planet gears.

See vCD 224 Schaeffler_Kolloquium_2014_18_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)

TURNING NEW DIRECTIONS: SURPRISING POTENTIAL IN PLANETARY TRANSMISSIONS - PART 2: SHIFTING CLUTCHES

Schaeffler

The wet friction shifting clutch was developed in the 1930s and has been very successful. Multi-plate wet clutches are used in large volumes not only for shifting automatic transmissions and CVT’s, but also as launch devices in some CVT and DCT transmissions. The early development of this technology was so successful that it has met the needs of industry with relatively few changes in basic construction for many years. Current trends in the market however, are placing new demands on shifting clutches. The number of speeds in automatic transmissions is increasing dramatically. The demand for improved shift comfort is likewise stronger than ever. The push for sustainable mobility continues to increase and includes the environmental effects of manufacturing processes. Finally, fuel economy standards are rising steeply around the world, making drag torque and mass reduction ever bigger problems.

See vCD 224 Schaeffler_Kolloquium_2014_19_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 5pp.)
iTC - INNOVATIVE SOLUTIONS FOR TORQUE CONVERTERS PAVE THE WAY INTO THE FUTURE

Schaeffler

The torque converter has been a stable choice as a launch device for automatic transmissions for several decades. Global vehicle production in 2013 is estimated to be 83 million, with 43% of the vehicles being equipped with a torque converter. In particular, the North American and the Asian market show a high ratio of torque converters in new vehicles. Additionally, the European market is experiencing a trend away from manual transmissions as some vehicles – especially in the luxury and higher torque segment – are offered only with planetary automatic transmissions and a torque converter. The choice of transmission type is largely driven by its impact on the powertrain efficiency and comfort. With stricter regulation on CO2 emissions and the prospect of further tightening of emission regulation, the automotive industry has made designing for fuel efficiency a core goal, resulting in drag reduction, more defined combustion processes and increased electrification. Despite electrification, internal combustion engines are a core element of powertrain strategies and their optimisation will drive improvements in the drivetrain.

Despite development in areas such as double clutch or automated manual transmissions, the majority of automatic and continuously variable transmissions are equipped with torque converters. This success of the torque converter raises the question of its origin and development potential for the future.

Covers – history of the torque converter, torque converters and fluid couplings in ships, improved torque converter controls, mass production torque converter, torque converter dampers, drivers for torque converter development, centrifugal pendulum absorber for torque converters, torsional vibration damper with centrifugal pendulum absorber, 2nd generation centrifugal pendulum absorber for torque converters, 3rd generation centrifugal pendulum absorber for torque converters: track-optimised and spring-loaded, CPA and cylinder deactivation, iTC measurements, iTC advantages, iTC modularity, one way clutch.


LIGHT, COMPACT AND EFFICIENT: SCHAEFFLER DIFFERENTIAL SYSTEMS SET THE PACE

Schaeffler

The Schaeffler lightweight differential was presented for the first time at the 2010 Schaeffler Symposium in Baden-Baden, Germany. At the time, the innovative aspect of the design focused on the reduced weight and smaller mounting space required for the ground-breaking differential concept. Since then, the lightweight differential has been further optimised in order to overcome the last of the concept’s drawbacks in comparison to the existing bevel gear differential. During the optimisation phase, the key focus has been to improve the rigidity of the differential, and reduce frictional losses in the main bearing support. A further aim was to reduce the production costs.

Today, this means that there is virtually no effect on costs, at least when the differential is operated within high torque ranges. For those who have not yet come across the Schaeffler lightweight differential, what follows is a brief explanation of how the component came into existence.

Covers – optimising a CVT, optimising a manual front transverse transmission, Wildhaber-Novikov differential, Oliver Saari’s differential, spur gear, Schaeffler heavy-duty differential with all-wheel drive disconnect system.

See vCD 224 Schaeffler_Kolloquium_2014_26_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)

OPTIMIZATION OF THE GEAR RATIOS IN AUTOMATIC TRANSMISSION SYSTEMS USING AN ARTIFICIAL NEURAL NETWORK AND A GENETIC ALGORITHM

Khajeh Nasir Toosi University of Technology and Sharif University of Technology

One of the most important tasks in designing an automatic transmission system is to find the gear ratios and the corresponding number of gear teeth. In this paper, an artificial neural network and a genetic algorithm are used for this optimisation with regard to an epicyclic gear train. First, MATLAB and an artificial neural network are employed to model the system, and the results depict
the accuracy of the artificial neural network calculations. Then, using the same software and with
the aid of a genetic algorithm, the optimised speed ratios and gear ratios are obtained. It can be
seen that a series of gear ratios is produced. Another genetic algorithm was used to calculate the
optimised gear ratio and the corresponding number of gear teeth. A Simpson gear train is used to
demonstrate the methodology. The proposed model is very accurate and efficient, such that the
resulting numbers of optimised gears have an error of less than ±0.3%. This method is much easier
and has a lower computation cost than solving the related equations.

Covers - Simpson gear train.

228, pp1338-1343.)
APPLICATIONS

ALTERNATIVE POWERTRAIN VEHICLES

MODULARITY ASPECTS FOR HYBRID ELECTRIC POWERTRAiNS ON THE EXAMPLE OF THE TWO-DRiVE-TRANSMiSSiON

Technische Universitat Darmstadt

The Two-Drive-Transmission (TDT) is a novel, highly efficient powertrain concept for electric or hybrid-electric vehicles. It comprises two relatively small electric machines that are each attached to a two-speed-transmission. According to the requirements either only one or both electric machines can drive the vehicle. This results in a more efficient operation of the electric motors when the vehicle is driven with low power demands. As in this case, only one of the electric motors drives the vehicle and is therefore being operated at higher loads, which increases the efficiency of the motor. Both subtransmissions use the technology of automatic manual transmissions. An interruption of traction force can be avoided by driving the vehicle with only one electric motor during a gear shift. In the meantime the other subtransmission can shift into the next gear. The TDT is not only a highly efficient powertrain concept but also shows some interesting modularity aspects. Starting from a basic variant of the TDT for electric vehicles, very promising powertrain concepts for electric range extended vehicles (E-REV) and plug-in hybrid-electric (PHEV) vehicles can be derived. An innovative transmission layout, which includes a parking lock function, allows increasing the number of gear ratios from two to four without having to install additional clutch sleeves. In hybrid electric variants of the TDT, these additional speeds improve the efficiency and the comfort when operating the internal combustion engine (ICE).

In this paper different variants of the TDT will be presented and discussed. Subsequently, the focus will be laid on hybrid operation of the TDT. The benefits of increasing the number of speeds in the ICE's subtransmission will be examined. Furthermore the efficiency of the series hybrid mode will be studied and discussed. Another important issue is the acoustic behaviour of the ICE. This can be considered in the control-strategy and can thus be seen as another modularity aspect of the TDT. Modularity and flexibility concerning the hardware and the software of the TDT make it a suitable powertrain concept for different vehicle segments and degrees of electrification. Consequently the TDT is a very promising concept for electric and hybrid electric vehicles.


Electric vehicles

OPTIMIZATION OF MOTOR AND GEARBOX FOR AN ULTRA LIGHT ELECTRIC VEHICLE

Ghent University

The integrated design of the drivetrain of a single person ultra-light electric vehicle powered by batteries is optimised towards high efficiency and low mass. The drivetrain of each front wheel consists of an outer rotor permanent magnet synchronous motor (PMSM), a gearbox and the power electronics with converter and control print. The complete drivetrain is optimised for the New European Driving Cycle and the Federal Test Procedure. For the optimisation of the complete drivetrain analytical models are used to calculate the losses and the efficiency. The analytical models are fast, and useful for designing a good PMSM in combination with a gearbox. The optimisation of the drivetrain over the driving cycles makes it possible to choose the optimal combination of motor and gearbox for different gear ratios in order to have high efficiency and low weight. Comparing a single-stage gearbox with a two-stage gearbox, a single-stage gearbox has a higher efficiency, but also a higher weight than a two-stage gearbox with the same properties. The optimisation of the dynamic behaviour of the drivetrain over the driving cycles yields a compromise between the total efficiency and the total mass of the drivetrain. The optimum choice will depend on the intended use of the vehicle (drive cycle).

See vCD 212 F2014-EPT-075.pdf (FISITA, Maastricht, Jun 2014, 7pp.)
MACHINE INTEGRATED GEARBOX FOR ELECTRIC VEHICLES

Eindhoven University of Technology

The speed range that can be obtained with an electric machine is initially limited due to the finite supply voltage of the inverter. A winding reconfiguration method named dynamic machine operation is presented, capable of increasing the speed range and speed ratio by altering the configuration of the modular power electronics drive circuit as a function of the machine speed. An electric machine integrated equivalent of a gearbox for electric vehicles is realised in this manner. The theoretical analysis of the proposed dynamic machine operation principle is detailed and compared to conventional drive methods. Furthermore, the electric machine efficiency for different speed and torque levels is researched for each operating mode. Finally, the experimental verification demonstrates that the intended improvement of the speed range and speed ratio can be achieved.

See vCD 212 F2014-EPT-092.pdf (FISITA, Maastricht, Jun 2014, 10pp.)

Hybrid vehicles

INNOVATIVE FUNCTIONS OF THE HYBRID POWERTRAIN IN THE BMW i8

BMW

BMW introduces the first hybrid vehicle with street coupled drivetrains - a combination of an electric motor with a two-speed automatic transmission on the front axle and a newly developed turbocharged 3-cylinder gasoline engine with a six-speed automatic transmission on the rear axle. Hybrid specific modifications of the automatic transmission and an overview of the vehicle powertrain network are described, as well as the newly developed functions which contribute to performance and outstanding efficiency supporting the BMW EfficientDynamics strategy. Covers – shift performance and characteristics, re-engagement strategies.


SMART PLUG-IN HYBRID CONCEPT FOR SMALL AND MID-SIZE VEHICLES

FEV

Reduction of fuel consumption and CO2-emissions is the major driver of new technologies in the automotive industry worldwide. Therefore the electrification of powertrain is mandatory to achieve the targets. This will not be limited to the premium and SUV segment. In these segments the sales numbers and the contribution to fuelled consumption are comparable low. The small and mid-size vehicle segments have higher sales volume but these segments are also much more cost sensitive and more limited in package constrains. In this paper FEV will present a compact and low cost hybrid concept, which allows an extended usage of electric driving also in sub-compact up to mid-size vehicles.

With only one electric machine, a smaller battery due to efficiency improvement of the e-motor by two gears and a low mechanical transmission complexity the costs of this layout is lower than comparable concepts. At the same time this concept provides excellent comfort during launch and ICE-restart. The compact design allows east-west installation even with high power electric motors to achieve sufficient driving performance.

Covers - PREX Plug-In Hybrid Concept, shift strategy.

See vCD 216 13m_Kirschstein.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 10pp.)

P2 HYBRID MODULE AS A MODULAR SOLUTION FROM THE ENTRY HYBRIDISATION TO THE PLUG-IN HYBRID

Schaeffler

The second generation of the modular P2 hybrid module represents the integration of a highly compact unit into a substantially unmodified classical design of drive train. The complete system comprises a damper, a decoupler integrated in the rotor with an actuator unit and an electric
machine. The increase achieved in performance density forms the basis for integration with an optimum design envelope in existing transmissions and also opens up potential for realising a further increase in the extent of hybridisation. The module is this suitable for hybrids of the mild, full and plug-in variety, both in longitudinal as well as transverse mounting. For many years, active damping of vibrations by means of the electric machine has been discussed as an additional benefit of the module. Current results in this respect are presented. In addition to the second generation hybrid module, further development work is proceeding in which various approaches are required to address special requirements. The focus here is on development of entry hybridisation on the basis of 48 V systems, especially in conjunction with manual transmissions. The requirements specified at vehicle level have given rise to both coaxial and axially parallel solutions, which are then developed and presented individually.

See vCD 216 22m_Reitz.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 12pp.)

48 V: HOW MUCH HYBRIDIZATION IS POSSIBLE WITH THE NEW VEHICLE POWER?

Getrag

With the tough CO2 targets for 2020 of the European legislation, the automotive industry has to find affordable technical solutions that can be rolled out to their vehicle fleets. One of these key elements is the new 48V vehicle power. This paper deals with various 48V solutions and outlines the benefits as well as the disadvantages. As a base for this comparison the all new GETRAG 7DCT300 PowerShift transmission as well as its hybrid version the 7HDT300 HybridDrive transmission is used. In a comparison between integrated e-machines and belt-driven solutions are evaluated regarding different attributes. The realisation of the hybrid kit for different power levels visualises the high degree of scalability from 48V hybrids to Plug-In hybrids. Covers – torquesplit hybrid system.

See vCD 216 31m_Blessing.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 12pp.)

FURTHER DEVELOPMENT OF THE SCHAEFFLER HYBRID MODULE

Schaeffler

Hybrid vehicles permitting one to two kilometres driving using electric power – so called full hybrids – are primarily found in upscale vehicle segments at present. These vehicles were equipped with automatic transmissions even before electrification, and the bell housing has prevailed as the installation location for the electric drive unit since this does not require the existing vehicle architecture to be fundamentally adapted. A module consisting of an automated disconnect clutch and an electric motor is incorporated between the internal combustion engine and the transmission. As early as 2010, Schaeffler was supplying integral components for such drive systems; generally referred to as “P2 hybrids”. The purpose of this paper is to demonstrate what stage of development Schaeffler has attained to date. The next step planned is to make use of the high fidelity control of an electric motor incorporated in the powertrain in order to cancel out undesired torsional vibrations from the internal combustion engine. Finally, we will show that the chosen hybrid module design is also suitable for use with a 48-volt on-board electric system in combination with a manual transmission.

See vCD 224 Schaeffler_Kolloquim_2014_29_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)

Range extender vehicles

SIMPLIFIED HYBRID TRANSMISSION WITH RANGE-EXTENDER CHARACTERISTICS- ENABLING COMBUSTION BASED LONG-DISTANCE DRIVING WITH ONLY ONE ELECTRIC MACHINE

Schaeffler Technologies

For realising the goal of affordable e-mobility, a powertrain architecture is presented which is
characterised by its functional but simple mechanical structure and the use of only one electric machine. The transmission architecture enables the equivalent comfort and performance levels as a battery electric vehicle, but with the capability of an increased range. A compact electrified gearbox was created based on an analysis of hybrid powertrain architectures and by considering the anticipated customer expectations. The hybrid architecture can be successfully implemented in vehicles, which are mostly used in urban areas. Additionally, the system enables these vehicles to cover long driving distances and high speeds efficiently due to the direct mechanical drive of the internal combustion engine to the front wheels. This means the known weaknesses of serial hybrid architectures are avoided. The drive configuration offers multi-gear all-electric operation over the complete speed range. The combination of an electric machine and an internal combustion engine enables a large part of the operational map of conventionally-powered vehicles to be covered in hybrid operation. Furthermore, the internal combustion engine can be operated in several gears as a direct drive, and, driving comfort can reach standards close to an automatic transmission despite of the simplicity of the transmission. These approaches are discussed and are presented in comparison with the known P2 hybrid architecture.


ELECTRIC DRIVING WITHOUT RANGE ANXIETY: SCHAEFFLER´S RANGE-EXTENDER TRANSMISSION

Schaeffler

Schaeffler's range-extender concept is based on adding a special transmission to an existing internal combustion engine to produce a full hybrid. A simple automatic spur gear transmission and an electric motor are used instead of a conventional automatic or double clutch transmission. The typical range of driving conditions for an electric vehicle can be completely covered at low system costs. A powertrain architecture with a direct mechanical linkage of the internal combustion engine improves the efficiency balance of a vehicle over long distances. In addition, Schaeffler's range-extender transmission allows automobile manufacturers to implement a modular drive strategy without carrying out fundamental changes to the vehicle architecture. Covers – operating conditions, generator mode, vehicle launch and reverse driving, hybrid city driving, hybrid drive at moderate speeds, accelerating to high speeds, driving at high speed, operating strategy, simulation.

See vCD 224 Schaeffler_Kolloquim_2014_28_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)
PASSENGER CARS

AUTOCAR ROAD TEST NO. 5175: MERCEDES-BENZ C-CLASS

Mercedes-Benz

Road test of the Mercedes-Benz C Class C220 Bluetec AMG Line diesel passenger car covering acceleration, aerodynamics, boot, brakes, dimensions, engine, fuel consumption, handling, interior, performance, power, price, ride, rivals, safety, steering, suspension, torque, 7-speed automatic transmission, turbocharging, turning circle, tyres, visibility, wheels.

See Doc.145928 (Autocar, 23 Jul 2014, pp58-65.)
OFF-ROAD

CHINESE CONSTRUCTION EQUIPMENT MANUFACTURERS’ COOPERATION AND DEVELOPMENT WITH DRIVELINE SUPPLIERS

Liugong

Content:
Global CE Overview
Chinese CE Manufacturers’ Market and Product Strategy
Liugong’s Focus and Targets
Cooperation between Liugong and ZF
Present and Future Driveline Technology Development Demand -
Machine request on driveline technology: energy saving, comfortable, reliable, low use cost and low service cost
- For energy saving: good matching with engine, hydraulic and brake system, etc, for effective response; distributing and using the engine power efficiently.
- For comfort: focus on starting, stopping and shifting performance; shifting convenience, vibration and noise.
- High reliability: low use cost and low service cost to improve customers' satisfaction.
Present driveline technology needs to focus on:
- Low speed driveline technology
- Powertrain matching technology
- Driveline control technology
Future development needs to focus on:
- CVT
- Hybrid
- Large driveline technology on above 10T wheel loader.

GENERAL TECHNICAL ISSUES

E4WD VEHICLE CONTROL STRATEGY BASED ON OPTIMIZATION OF OVERALL HEV POWERTRAIN EFFICIENCY

Guangzhou Automobile
Stick to its technology development roadmap towards HEV industrialisation, GAC Engineering has developed a E4WD (electric 4-wheel drive) hybrid electric vehicle, where an ISG motor is integrated between the engine and transmission and propels the front wheels together with the engine through an AMT, and a ERAD (electric rear axle drive) motor propels the rear wheels through a reduction gear. Comparing to other full hybrid of the same configuration (and hence the same number of motors), this concept has an additional 4WD function which adds more value for customers. This paper presents a control strategy for this configuration which will improve not only fuel economy but also drive comfort. For the ease of our description, the concept of OHPE (Overall HEV Powertrain Efficiency) and virtual pedal are introduced. By OHPE we consider not only the efficiency of engine, but also that of electric motors, power battery, and transmission. While the real acceleration pedal represents the torque demand of the whole vehicle, the virtual pedal reflects the real torque demand of the front axle and hence serves more proper for gear selection based on AMT gear shifting look-up table. Our control strategy is based on the optimisation of OHPE which, under the constraint of meeting the torque demand for a given pedal position at certain vehicle speed, evaluates the overall HEV powertrain efficiency for every possible set of torque split and gear selection and picks up the best as the control target. In addition, the regeneration braking strategy and gear shift assist strategy using ERAD motor are also developed for this E4WD HEV. The NEDC cycle test and several road tests in Guangzhou have shown significant improvement of both fuel economy and the drive comfort.

See vCD 212 F2014-EPT-053.pdf (FISITA, Maastricht, Jun 2014, 10pp.)

ARCHITECTURE AND FUNCTION OF THE ELECTRONIC CONTROL FOR AUDI DL382 TRANSMISSION

Continental
Continental has developed a new integrated transmission control unit (TCU) for the new generation of Audi Hytronic DCT. By implementing new technologies a very effective and compact solution could be realised. New novel concepts for the design of the control electronics had to be developed due to both the very high environmental requirements and the direct activation of an additional electric oil pump in the required power class.

Covers - BLDC motor control, safety requirements - ISO 26262, substrates.


CONCEPT OF A MINIATURIZED HYDRAULIC TRANSMISSION CONTROL FOR OPTIMIZED FUEL EFFICIENCY AND PACKAGING

Robert Bosch
State of the art automated step transmissions (AT) support with their specific advantages like high number of gears, good mechanical efficiency of modern planetary gearsets and high torque density a good overall powertrain efficiency and low consumption. In this thesis a control method is shown, that enables with on demand actuation and package reduced hydraulics to further minimise the transmission losses.

The principle idea is to use a leakage free system to completely avoid the hydraulic losses in clutches, rotary pressure feed troughs and the hydraulic circuit. For control issues simple bleed solenoid valves with tight seats are to be used to gain the advantage of a leakage free valve closing. Inevitably that induces to use two solenoids, one for pressurising and one for depressurising the clutches or brakes. An additional disadvantage is the reduced control accuracy
of this solenoid type compared to typical variable force solenoid valves, which has to be compensated by dedicated control algorithms and a pressure sensor. Under the precondition of oil tight system the power density of the hydraulics can be increased by a high system pressure up to 160 bar to ensure the required dynamics and reduce the packaging. In total the chosen layout enables to use components and technologies from ABS mass production.

To cover the control requirements for a strong non-linear system like a wet clutch in an AT model based control software has been used, that linearizes the control valves systematically. A scheduler ensures that always only one valve is opened at the same time to avoid any direct leakage via two open valves. With this model based approach a dynamic set point for both solenoid valves can be generated and the remaining control algorithm is designed as a robust error and disturbance handler. Possible changes of the model, by production variance or wear, have to be identified systematically by adaption functions. The performance of the model based control is demonstrated by measurements.

The achievable consumption reduction has been simulated for an 8 step AT in an upper class vehicle of about 3% in NEDC. At the same time the size of the hydraulic valve body can be reduced due to the small solenoid diameter and the reduced parts (no amplification valves due to the high pressure).

The use of 2/2 valves with tight seats in combination with an intelligent control concept and the increase of the system pressure enable an additional reduction of fuel consumption and installation space compared to current solutions. At the same time it's possible to build new functionalities to adapt production variance, wear or systematic changes over life time.

See vCD 216 17m_Frei.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 16pp.)

SAFETY SIMULATION IN THE CONCEPT PHASE: ADVANCED CO-SIMULATION TOOLCHAIN FOR CONVENTIONAL, HYBRID AND FULLY ELECTRIC VEHICLES

AVL

Modern vehicle powertrains include electronically controlled mechanical, electrical and hydraulic systems, such as double clutch transmissions (DCT), powerful regenerative braking systems and distributed e-Machines (EM), which leads to new safety challenges. Functional failure analysis of events such as the sudden failure of a DCT or EM, and the development and the validation of suitable controllers and networks, can now be evaluated using co-simulation techniques, from the early stages of product development. A co-simulation toolchain with a 3D vehicle and road model, coupled with a 1D powertrain model, is used to enable the definition of hardware and software functions, and also to support the rating of the Automotive Safety Integrity Level (ASIL) during hazard analysis and risk assessment in the context of ISO 26262. This innovative approach may be applied to a wide range of powertrain topologies, including conventional, hybrid electric and fully electric, for cars, motorcycles, light or heavy-duty truck or bus applications.

Covers - functional safety, controllability.

See Book 10661 XB:A4B: pp153-164 (Advanced Microsystems for Automotive Applications 2014 - Smart Systems for Safe, Clean and Automated Vehicles, Germany, Jun 2014, VDI/VDE/IT.)

Actuation

TRANSMISSION ACTUATORS - REDUCING COMPLEXITY OR INCREASING PERFORMANCE?

Schaeffler

Transmission actuators have a significant influence on the size, costs and efficiency of transmissions. The latest electromechanical actuation systems used in transmissions from Getrag, Hyundai and Honda have demonstrated very impressively that it is possible to produce transmission actuators with an average power consumption of less than 20 W and excellent controllability and dynamics. The Honda sport hybrid i-DCD currently sets the benchmark mark for double clutch transmissions with an average power consumption of 12 W. The costs of electromechanical actuators increase with the actuation performance at an exponential rate. The reduction of the actuation energy required to actuate is therefore very important for an efficient actuator system. The above mentioned systems have already achieved the development targets
for a number of transmissions applications; the current question is: how said systems can be optimised further?
Covers – modular system architecture, reduced number of power drives, one actuator for two clutches, Bi-rotational pump, active interlock transmission actuator with one power drive, hydraulic active interlock transmission actuator (HGA), double clutch transmission actuated with two actuators, double-motor DCT (2M DCT), double-motor DCT with combined shift and clutch actuation drums, integration variants of 2M DCT actuators, 2M DCT with bi-rotational pumps and HGA, modular system of components, control units, electric motors and sensors, mechanical components, new compact actuator for the automation of clutches.

DRIVELINE/VEHICLE RELATIONSHIPS

TORQUE DISTRIBUTION

VEHICLE MODELING AND PERFORMANCE EVALUATION USING ACTIVE TORQUE DISTRIBUTION

National University of Sciences & Technology and Abasyn University

The main aim of researchers, to prevent the spinning and drifting of vehicle, is to monitor the yaw stability control strategy. The yaw stability control system is incorporated with active torque distribution. A lot of work is done on torque distribution between right and left wheels using active differential to distribute torque to each drive wheel. Control algorithm based on different control strategies were used for torque distribution. In this study, active torque distribution strategy is incorporated via central transfer case between front and rear axle. A 4WD vehicle is used with 50-50 torque ratio amongst front and rear axle. The controlling parameter is the understeer and oversteer behaviour of the vehicle. A combined slip model approach used by Burckhardt is used for a 10 DOF vehicle modelling using MATLAB. The simulated results will be compared against a multibody nonlinear simulation software, i.e. CarSim. For implementation, J-turn test and Double Lane Change (DLC) were used.

See SAE 2014-01-0103 (2014, 12pp.)
TORQUE VECTORING

TORQUE VECTORING CONTROL FOR DISTRIBUTED DRIVE ELECTRIC VEHICLE BASED ON STATE VARIABLE FEEDBACK

Tongji University

Torque Vectoring Control for distributed drive electric vehicle is studied. A handling improvement algorithm for normal cornering manoeuvres is proposed based on state variable feedback control: Yaw rate feedback together with steer angle feedforward is employed to improve transient response and steady gain of the yaw rate, respectively. According to the feedback coefficient's influence on the transient response, an optimisation function is proposed to obtain optimum feedback coefficients under different speeds. After maximum feedforward coefficients under different speeds are obtained from the constraint of the motor exterior characteristic, final feedforward coefficients are calculated according to an optimal steering characteristic. A torque distribution algorithm is presented to help the driver to speed up during the direct yaw moment control. Simulations performing multiple manoeuvres are carried out: The transient response and the steady gain of the yaw rate are improved; the direct yaw moment control can rectify the understeering caused by accelerating, balance the utilisation of the road adhesion between two axles, and increase the lateral stability margin of the vehicle.

See SAE 2014-01-0155 (2014, 10pp.)

STUDY OF TORQUE VECTORING CONTROL FOR ACTIVE SAFETY IN REAR-WHEEL-DRIVEN VEHICLES

Korea Advanced Institute of Science and Technology

Torque vectoring control is the one of the recent chassis control system for vehicle active safety, and has been widely used in high-performance vehicles to obtain better traction and cornering ability. New torque vectoring control is proposed in this paper to maximize its stability control performance during the lateral manoeuvre of a vehicle. To maximize the performance, torque reduction scheme at the proper point is adopted to aid the conventional torque vectoring scheme, reducing lateral force loss at a minimum. Lateral force loss of tyres causes torque vectoring effect to diminish and also decreases cornering ability, which induces an unnecessary side slip angle. Performance of proposed method is evaluated through simulation using vehicle dynamics software Carsim and Simulink, and simulation conditions are mainly focused on lateral dynamics. Proposed method is compared with conventional control scheme to validate supremacy of proposed one.

See vCD 212 F2014-IVC-089.pdf (FISITA, Maastricht, Jun 2014, 10pp.)
RESEARCH AND DEVELOPMENT ISSUES

FUEL CONSUMPTION

ECOMAX - NEXT GENERATION FUEL EFFICIENT TRANSFER CASE

Magna Powertrain

As legislation continues to mandate improved fuel economy, further improvements are needed in the driveline to minimise losses. In the future, more rear wheel drive based 4WD/4WD vehicles will utilize disconnected secondary drivelines. Based on these drivers, a new transfer case design is required to further reduce parasitic drag in this 2WD mode. The Magna powertrain ECOMAX single speed transfer case was conceived with a new architecture to provide the lowest possible drag in 2WD mode to improve fuel economy and reduce CO2 emissions.

The ECOMAX will be Magna Powertrain's next generation transfer case using new, innovative features to meet the demands of the customer. This particular ECOMAX design is a pumpless design allowing a stationary chain in 2WD, revised sprocket support, and a dry multiplate clutch. A new fully on-demand preemptive actuation system, operating in a dry cavity, was developed specifically for this application. Parasitic drag is significantly reduced across the temperature and speed range, therefore improving fuel economy beyond today's systems. Overall architecture, design details, and development results of the ECOMAX single speed transfer case are discussed in this paper.


WHAT TRANSMISSION SYSTEMS CAN DO FOR DOWNSIZING AND DOWNSPEEDING OF POWERTRAINS AND CYLINDER DEACTIVATION

LuK

The reduction of fuel consumption and CO2 emissions by optimisation of the whole powertrain is shown by introducing measures in the transmission system supporting the ICE to operate in areas of better specific consumption. One of the topics is the optimised damper technology for achieving downsizing and high turbocharging pressures along with effective downspeeding.

As a result of investigations of cylinder deactivation in engines with different number of cylinders a new approach is introduced for implementing "RCD 1.5" rolling cylinder deactivation for three-cylinder engines to attain 1.5-cylinder operation or "RCD 2.5" for five-cylinder engines.

The resultant torsional vibration excitation of 0.75th order in I3 or 1.25th order in I5/V5 engine with rolling cylinder deactivation is controlled by the innovative damper technology, which entails a dual mass flywheel with an optimised characteristic and the use of centrifugal pendulum-type absorbers on the secondary DMF mass that are matched to the main excitation order. The fuel economy improvement including optimised cylinder filling by flexible valve control will be more than 6% in NEDC.

Covers – friction losses in the transmission systems, CVT, launching elements, hydrodynamic torque converters.

CO2

ENGINE, TRANSMISSION AND DAMPER SYSTEMS FOR DOWNSPEEDING, DOWNSIZING, AND CYLINDER DEACTIVATION

Schaeffler

Besides hybridizing the powertrain, which is especially advantageous in city traffic, efforts must be made to improve the efficiency of conventional powertrains in order to reduce traffic-based CO2 emissions.

This will first require measures to directly reduce friction losses in internal combustion engines, transmissions, and chassis systems, such as the use of friction-optimised bearing supports and seals as well as coatings to lower the friction coefficient. Furthermore, slippage losses in startup elements need to be reduced. Hydrodynamic torque converters with lock-up clutches are a notable example of this, as they can be engaged even at very low engine speeds by means of optimised damper systems. Double clutch systems with reduced passive clutch drag torque losses of wet or – even better – dry running design are important contributions as well.

The aim of this paper is also to report on improvements to the system as a whole, in which changes on the transmission side lead to an efficiency increase in the internal combustion engine. Examples of this include transmissions with an increased spread of gear ratios, resulting in lower engine speeds even at higher travel speeds. Optimised damper systems serve to further reduce and/or insulate torsional vibration excitation introduced into the entire powertrain by cyclical combustion in the engine and facilitate downspeeding of drive systems in order to reduce fuel consumption.

At the same time, advanced damper systems permit the design of downsizing systems that reduce engine friction with a lower number of cylinders and substantially increased torsional vibration excitation without having strong NVH issues in the entire powertrain. Finally, a rolling cylinder deactivation system is introduced that enables engines with three cylinders to run effectively on 1.5 cylinders (“RCD 1.5”). The measures taken on the engine and transmission system side to prevent excessive torsional vibrations along the entire powertrain are described in detail.

Covers - planetary automatic transmissions, CVT, hydrodynamic torque converters, double clutch systems and their actuators, new electrically operated hydrostatic clutch actuator (HCA), centrifugal pendulum-type absorber.

See vCD 224 Schaeffler_Kolloquium_2014_02_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 9pp.)

THE FUTURE OF THE MANUAL TRANSMISSION

Schaeffler

The internal combustion engine will continue to be the dominating force behind individual mobility for some time to come. The biggest challenge in this context, however, revolves around lowering fuel consumption in line with ever more stringent legal requirements while at the same time maintaining driving comfort and pleasure. All aspects of the engine and transmission must be revisited with equal attention, whereby driving strategies that minimize consumption are key to achieving designated performance targets. To improve on these aspects, the transmission must be further automated and coupled with electrification measures. The conventional manual transmission is therefore coming under pressure and runs the risk of being "overrun" by other designs at least in the developed markets. On the other hand, manual transmissions remain attractive for cost reasons and may continue to play a key role in the future if a way is found to develop systems that also enable “sailing” and other efficient drive modes to be achieved in vehicles equipped with a standard transmission. Adopting a partially automated setup for the manual transmission would also open the door to integrating comfort, convenience, and safety-oriented functions without additional cost. Fuel consumption could then be further reduced by opting for longer gear ratios, for example. Misuse, or abuse of the clutch, causing it to overheat, can be reliably prevented thanks to the partially automated setup.

See vCD 224 Schaeffler_Kolloquium_2014_04_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 11pp.)
NVH

ANALYSIS OF GEAR RADIAL AND TILT TOLERANCE STACK UP AND CORRELATION WITH GEAR MICRO GEOMETRY

Volvo and Eicher Commercial Vehicle

Tolerance stack up is one of the most important exercises of design team to ensure the interchangeability of the components and the sub-assemblies in the product having a large product family. Optimised allocation of tolerances between the components in a product helps to reduce the conflicts between the designer and the manufacturer.

Automotive gearbox is one of the most important and critical aggregate of any vehicle in which the assembly of gear train performs the function as required. In the gear train, numbers of gears are meshed with each other and transfer the torque on wheels as per the required performance of the vehicle. When the gears are meshed and rotates some noise would generate because of the rolling and sliding action of the gears. This noise is known as “whine noise”. Nowadays this whine noise is increasingly becoming an important subject for the transmission designers. Gear whine is a total noise that is noticeable to passengers and makes them uncomfortable. Whine noise can be controlled to some extent by optimise the gear micro geometry to reduce the transmission error TE. But only optimisation of the gear micro geometry is not sufficient to reduce the transmission error and whine noise. Proper position and assembly of gears in the gear train assembly is also important to improve the gear micro geometry and whine noise. Radial and angular clearances between the two meshed gears, contributes a significant role in increasing the efficiency and performance of gears in terms of noise, vibration and harshness. In this paper we have taken 6-speed manual transmission and shows how the gear radial and tilt stack up analysis helps to reduces the transmission error and increase the efficiency and performance of gear pair in terms of strength, noise, vibration and harshness.

See SAE 2013-01-1491 (2013, 10pp.)

SIMULATIVE PREDICTION AND OPTIMIZATION OF TRANSMISSION NOISES

Universitat Stuttgart

An important performance characteristic of automotive transmissions is their noise behaviour. Methods for simulating and optimising the emitted rattle and whine noises are presented within this paper, with the focus being on the emitted structure-borne noise. The simulations are based on elastic multi-body models. Simulation methods for gear wheels, synchronisers, plain and rolling bearings are presented; in doing so, the lubrication fluid film at these contacts is considered in addition to material stiffness. Therefore, an evaluation of lubrication conditions is possible. A comparison with measurements is done to validate the methods. Afterwards, noise reduction measures are shown; they comprise the insertion of housing structures with damping effects or the application of special damping and decoupling measures. The measures are investigated, both simulatively and experimentally. Some of the simulations are done with a complete dual clutch transmission in order to show the practical suitability of the methods developed for simulating complex transmission systems.

Covers – oil film, gear wheels, shifting elements, bearings, shafts and housing, structure-borne noise, noise reduction.


DYNAMIC BEHAVIOR OF STEEL-POLYMER-COMPOUND-GEARS

Technische Universitat Munchen

Compound-Gears combine the advantage of a lightweight design with the possibility to influence the dynamic system behaviour of a gearbox. Due to the hybrid design it is possible to combine different materials to a lightweight component for the use in powertrains. Furthermore the structure borne noise can be influenced by the hybrid structure. In this article an injection moulded Compound-Gear will be shown. The dynamic behaviour of this gear type is investigated and
compared to a state of the art steel rim gear. The damping characteristics of these different gear types are shown. At the end of this article hints for an advanced gear design can be found.

Covers – load dimensions.

See vCD 216 41m_Nitsch.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 14pp.)

ISOLATION IS THE KEY: THE EVOLUTION OF THE CENTRIFUGAL PENDULUM-TYPE ABSORBER NOT ONLY FOR DMF

Schaeffler

A key task that has concerned the automotive industry in recent years has been to reduce consumption. One effective measure for achieving this goal is to exploit even lower engine speeds for driving. Torque is increased to achieve this without losing power. Doing so allows the engine to run only very slightly above idle speed and therefore in an extremely consumption-efficient range. One challenge is to achieve adequate powertrain isolation even for these low engine speeds and thus provide drivers with their usual level of comfort.

The evolution of the centrifugal pendulum-type absorber in conjunction with overall damper tuning improved the isolation achieved by DMFs to such an extent that it can also cope with higher engine torques and cover today’s three-cylinder and even twin-cylinder engines. Furthermore, they still have further potential, as regard to isolation, for dealing with the expected further increase of engine torque from idle speed upwards. However, close interaction between powertrain design and damper concept is absolutely essential if this potential is to be achieved. Locating the centrifugal pendulum-type absorber on the clutch disc succeeded in providing a long-awaited solution halfway between a simply damped clutch disc and a DMF. For trucks, arranging the CPA on the single mass flywheel also leads to reduced strain on the gearbox and the belt drive. Impact situations can be managed through early optimisation of the engine control unit and the use of High Capacity springs. No additional protective measures must then be implemented in the DMF; the system comprising DMF and centrifugal pendulum-type absorber can be designed specifically for maximum isolation.

Covers - Centrifugal pendulum-type absorbers for trucks, influence of the engine control unit when stalling, the high capacity spring.

See vCD 224 Schaeffler_Kolloquium_2014_05_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 8pp.)

THE DRY DOUBLE CLUTCH FACES THE CHALLENGE

Schaeffler

The competitive environment facing the dry dual clutch has already been introduced. A large number of series-production applications highlights the fact that dry double clutches have proven successful in the market. The dry double clutch system also provides an ideal alternative for future, automated powertrains used in compact and mid-sized vehicles on account of its very high level of overall efficiency and the fact that oil cooling is no longer required for the clutch system. One challenge is that the NVH and comfort demands placed on the powertrains will continue to increase and the mass moment of inertia of the double clutch system should be kept to a minimum as regards the driving dynamics. In order to face this challenge, further development of dry double clutch systems and the associated vibration damping concepts is required. New friction linings tailored specifically to requirements and advanced software functions contribute to a large optimisation step for the overall system. For instance, by operating the clutches via appropriate software control strategies, vibrations on the powertrain can be eliminated (anti-judder control system). Additional potentials for improving comfort are also brought about by electrical launches when used with hybridised powertrains.

Covers - Damping powertrain vibration using the anti-judder control system, optimising the tribological system for dry double clutch applications, Stage 1 – enrichment of inorganic substances in the friction layer, Phase 2 – enrichment of casting wear particles in the friction layer, reducing geometric torque excitation, directly actuated double clutch system with hydrostatic control.

See vCD 224 Schaeffler_Kolloquium_2014_16_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 7pp.)
SAFETY

A GLOBAL APPROACH TO FUNCTIONAL SAFETY: AN OPTIMISED APPROACH TO ISO 26262

Getrag

The ISO 26262 has a high impact on the development of electric and electronic vehicle components that are considered safety relevant. The effort needed to fulfil the normative requirements depends heavily on the method used for system analysis. A global approach also considering the interaction of vehicle systems has many advantages in comparison to a local approach only considering single functionalities at a given time. Changes in functionality can be carried out in most cases without change of the safety elements; safety functions developed once can be ported to new projects easily. In addition the global approach covers failure modes easily overlooked if a local approach is chosen. The safeguarding of bus communication via CAN is given as an example for this additional benefit of the global approach.

Covers - safety critical systems, FMEA.

CONSISTENT INTEGRATION OF THE SAFETY GOALS OF THE ZF 9HP TRANSMISSION CONTROL UNIT WITH RESPECT TO THE ELECTRONIC PARTS, BASED ON ISO 26262

ZF Friedrichshafen and Infineon Technologies

The introduction of the ISO 26262 leads to an increased complexity of the control units and controllability of the overall system. Thus the requirements on the underlying development process and the used methods further increased. Based on an ISO 26262 risk analysis a safety concept under consideration of the requested safety targets was created. The resulting requirements have been consistently implemented with adequate hardware components and basis software.

Covers - Functional risks according ISO 26262 of the ZF 9HP transmission control unit, AudoMAX PROSIL Safety Concept, TriCore audoMAX microcontroller, SafeTCore.
See vCD 216 16m_Wolf_Trinkberger.pdf (VDI Congress - Drivetrain for Vehicles 2014, Friedrichshafen, Jun 2014, 10pp.)
TRIBOLOGY

FRICITION TAILORED TO YOUR REQUIREMENTS: YOU WISH, WE DELIVER

Schaeffler

In any discussion about reducing fuel consumption, attention quickly turns to powertrain hybridisation. However, the fact that a saving of 15% can be achieved simply by minimising friction is often overlooked. This has been demonstrated by Schaeffler in various studies over the past few years. The costs required to reduce CO2 emissions by 1 g/km can be kept well below those of electrifying the drive.

Covers – basic principles, tribological system, friction in tribological systems, surface technology, energy efficiency through minimised friction, influence of bearing designs, coatings for specific requirements, Triondur diamond-like carbon (DLC) layer, functional friction, dry running friction linings for clutches, friction materials, wet linings for twin clutches, challenges for friction linings in synchronisation, tribotronics, thin-layer sensor Sensotect.

See vCD 224 Schaeffler_Kolloquium_2014_23_en.pdf (10th Schaeffler Symposium, Herzogenaurach, Apr 2014, 8pp.)
RESEARCH AND DEVELOPMENT ACTIVITIES

CAE

COMPUTER AIDED TRANSMISSION SYNTHESIS OF COUNTER SHAFT AND PLANETARY CONCEPTS ("OPTIMIZER")

innoVision-engineering and Technische Universitat Darmstadt

The “Optimizer” is a software product which is mainly made to support the development of transmission drive lines which are dedicated to be used in vehicles. This tool can be used also to find solutions for all other technical questions in case it is possible to describe these by equations. The “Optimizer” is not a commercial product and innoVision-engineering is not intending to sell the software. innoVision-engineering uses this tool to develop new and outstanding transmission concepts and to find clever solutions for value improvement in regard to existing transmission products.

Covers – dual path transmission based on a counter shaft structure (multi criteria question), power shift module based on a planetary structure (value improvement).


THE GEAR SYNTHESIS PROGRAM OF ZG GMBH

ZG GmbH

Present and future gears are facing higher and higher demands. In addition to the increasing number of gears and the accompanied development, which results in increased spread, hybridisation and gear efficiency grade are the main focal points. As a result of their complexity, it is no longer productive to "manually" determine the gear structures to meet the demands which are best fulfilled by the conflicts between efficiency grade, comfort (including acoustics) and cost. A systematic and extensive computer-aided gear synthesis is required. The gear synthesis programs introduced so far have been based on the principle to link and analyse a given number of gear elements in all (respectively many) possible ways. On the one hand elementary planetary gears (3 shaft gears with 2 central wheels) are the known gear elements as well as gear unit stages are known as units even smaller. Even direct reduced complex compounded planetary gearsets such as, for instance, the Ravigneaux Gearset can be synthesised by means of these gear unit stages. Since gear structures are assembled from their smallest components, the number of variants can only be calculated in a limited way even by using modern high performance computers. Basically, it is better to enlarge the smallest elements which are to be connected in order to significantly reduce the variants. However, no meaningful solutions must be ignored. The enlargement of the elementary elements to be combined is carried out by the "planGear" Gear Synthesis Program, an in-house development of the ZG GmbH, a program based on an analogue procedure. A considerably shorter calculating time can be achieved for a great number of gear structures by means of this program.

In the course of the lecture, the basic structure of the synthesis program will be presented, the analogue procedure will be explained and the efficiency of the program will be demonstrated with the help of a selected example.

OPTIMISATION

STRUCTURAL OPTIMIZATION WITH CONTACT CONSTRAINTS APPLIED TO THE DESIGN OF AUTOMATIC TRANSMISSION OF VEHICLES

AW Engineering Co, Aisin AW and Vanderplaats R&D

A design process to improve the structural performance under contact conditions of automatic transmission of vehicles is presented. The proposed process uses newly developed nonlinear contact optimisation techniques. Additionally, useful structural optimisation techniques such as 3D topography and the beta method are described. As a demonstrative problem, we consider the improvement of a 6-speed AISIN FWD automatic transmission which is subjected to static loadings and nonlinear contact conditions. See SAE 2014-01-0407 (2014, 6pp.)
VALIDATION

VERIFICATION & APPLICATION CHALLENGES IN GLOBAL MARKETS WITH VARIOUS CUSTOMERS

Getrag

Contents:
- Market trends and Global Challenges – product development challenges, market differences, Getrag DCT.
- Number of transmission variants and applications, Getrag MT – number of transmission variants and applications, package and weight trends.
- Requirements and verification – requirements include fuel economy, comfort and performance.
- Robustness – Durability design limits and test strategy.

Internal Combustion Engines – Basic
Dates: 8 Jul, 9 Sep, 14 Oct, 18 Nov
Location: Ricardo Shoreham Technical Centre
Price: £650 per person

Internal Combustion Engines – Advanced
Dates: 9-10 Jul, 10-11 Sep, 19-20 Nov
Location: Ricardo Shoreham Technical Centre
Price: £750 per person per day

Hybrid & Electric Vehicle Systems
Aimed at policy makers, chief technical officers & strategists
Dates: 24 Sep
Location: Ricardo AEA, Marble Arch, London
Price: £995 per person

Hybrid & Electric Vehicles Systems
Aimed at engineers, researchers & analysts
Dates: 15-16 Oct
Location: Ricardo Shoreham Technical Centre
Price: £750 per person per day

Automotive Transmissions – Basic
Dates: 9 Oct
Location: Ricardo Midlands Technical Centre
Price: £650 per person

Automotive Transmissions – Advanced
Dates: 12-13 Nov
Location: Ricardo Midlands Technical Centre
Price: £750 per person per day

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“This course has provided a valuable detailed insight into engine construction and market drivers. But more than that it was a thoroughly interesting course at a world class organization”

“Excellent knowledge transfer from the enthusiastic presenters at the cutting edge of their field”

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