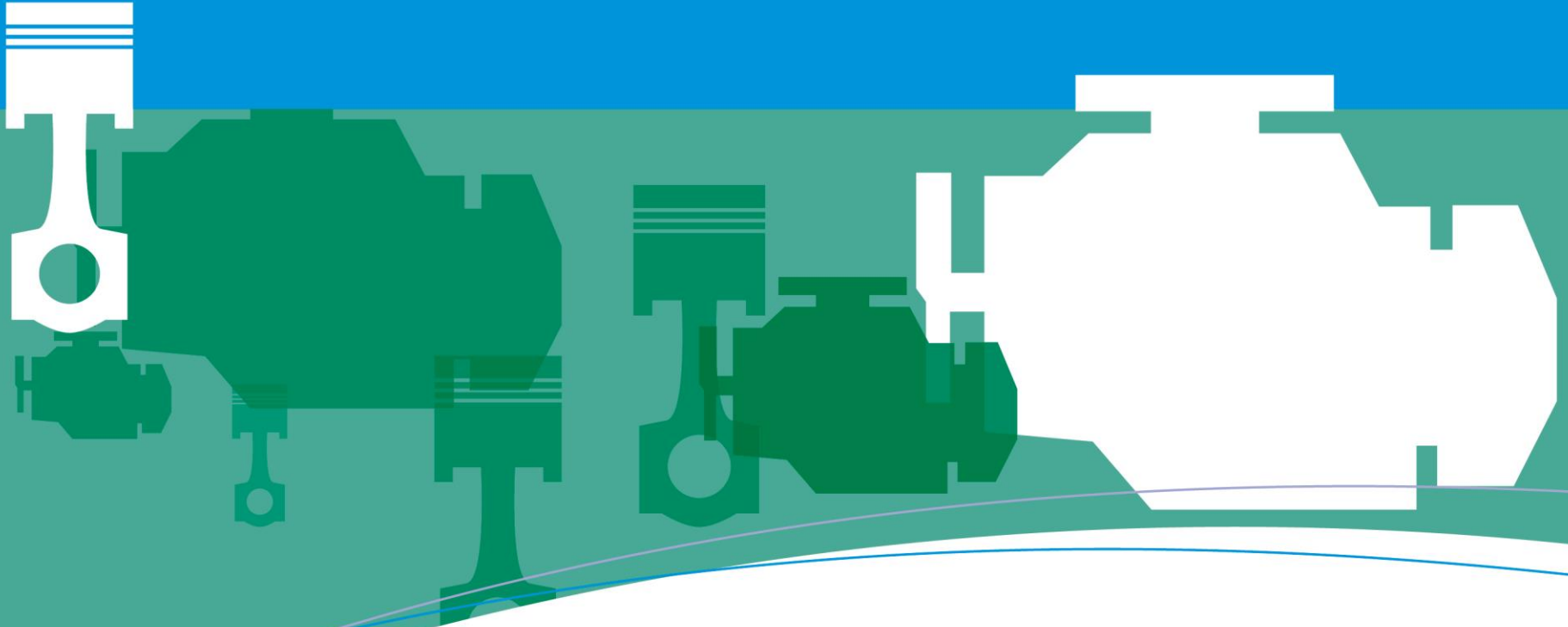


Performance you can rely on.

Power Transmission Fluids



InfineumInsight.com/Learn



Agenda

- 01 | **Transmission** and market **trends**
- 02 | **Hardware** and **fluid** requirements
- 03 | Transmission fluid **formulations**
- 04 | The **future** - electrification

Transmission Trend Drivers



Fuel Economy & Emissions

Development of CVT, DCT and Higher Gear Ratio spreads

Improvement of friction clutch, pump, seal efficiencies

Hybrid / Electrification

Low viscosity fluids



Driving Performance

Shift Quality:

Noise Vibration Harshness (NVH)

Comfort

Safety:

Fun-to-Drive

Sporty / dynamic driving style



Size and Weight

Smaller Transmissions:

Less fluid

Increased Torque Density

Types of Transmissions



Manual Transmission (MT)

Driver operated clutch and gear shifts. Can be automated using servos to disengage/engage the clutch and change gear automatically.



Stepped Automatic Transmission (AT)

Globally the most common automatic transmission. It uses planetary gear sets and a torque converter.



Dual Clutch Transmission (DCT)

Automatic transmissions that use manual gear box architecture with dual clutches and input shafts.



Continuously Variable Transmission (CVT)

Automatic transmission that uses variator pulleys with an unlimited number of gear ratios.



Power Split (PS)

Uses two e-motors to mimic the performance of a CVT.

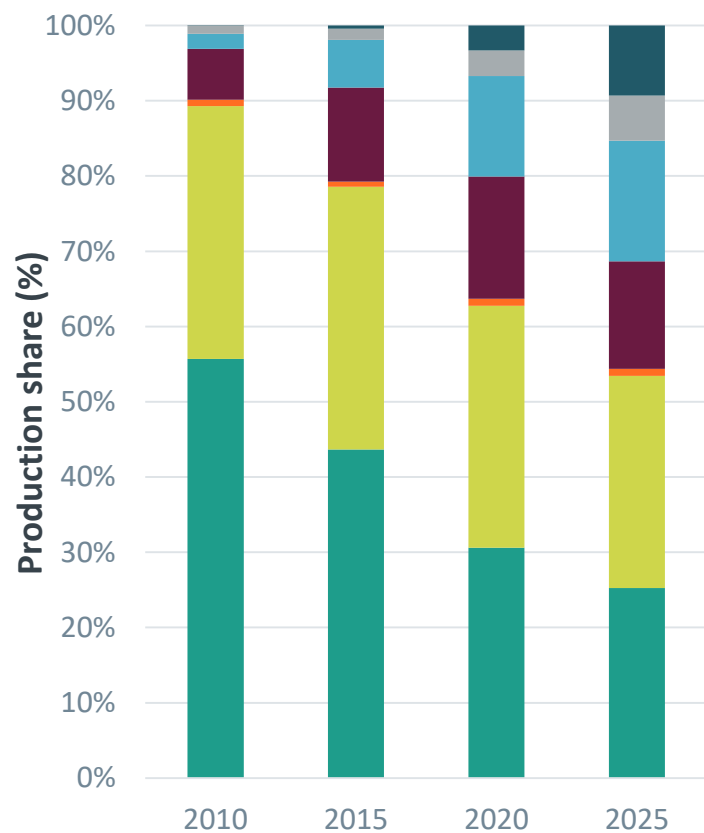


E-axle

Transmission used by electric vehicles. Sometimes referred to as reduction transmissions as the gear set reduces the rpm from the e-motor to drive the wheels.

Global Transmission Production

Transmission Installations



Source: IHS

E-Axle (Electric)

Large production increase, market share remains low

Power Split (PS)

Large hybrid production increase, market share remains low

Dual Clutch Transmission (DCT)

Large production increase, market share increase

Continuously Variable Transmission (CVT)

Large production increase, market share increase

Automated Manual Transmission (AMT)

Some production increase, market share low and stable

Stepped Automatic Transmission (AT)

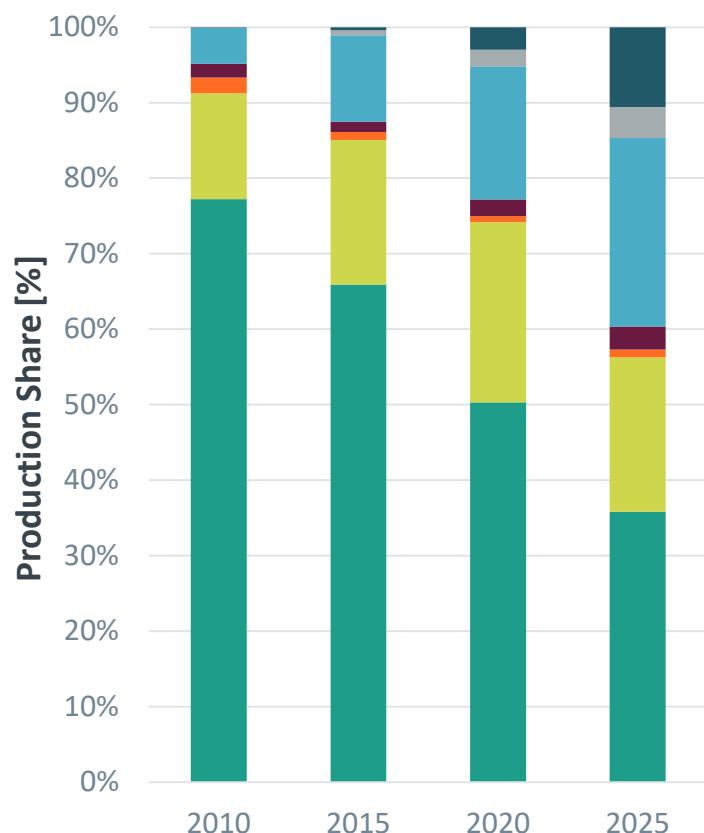
Production stable, market share decline

Manual Transmission (MT)

Market share declines, switch to automatic transmission

EMEA Transmission Production

Transmission Installations



Source: IHS

E-Axle (Electric)

Large production increase, market share to surpass CVT

Power Split (PS)

Large hybrid production increase, market share remains low

Dual Clutch Transmission (DCT)

Large production increase, large market share increase

Continuously Variable Transmission (CVT)

Production and market share increase, but remain low

Automated Manual Transmission (AMT)

Slight production increase, market share low and stable

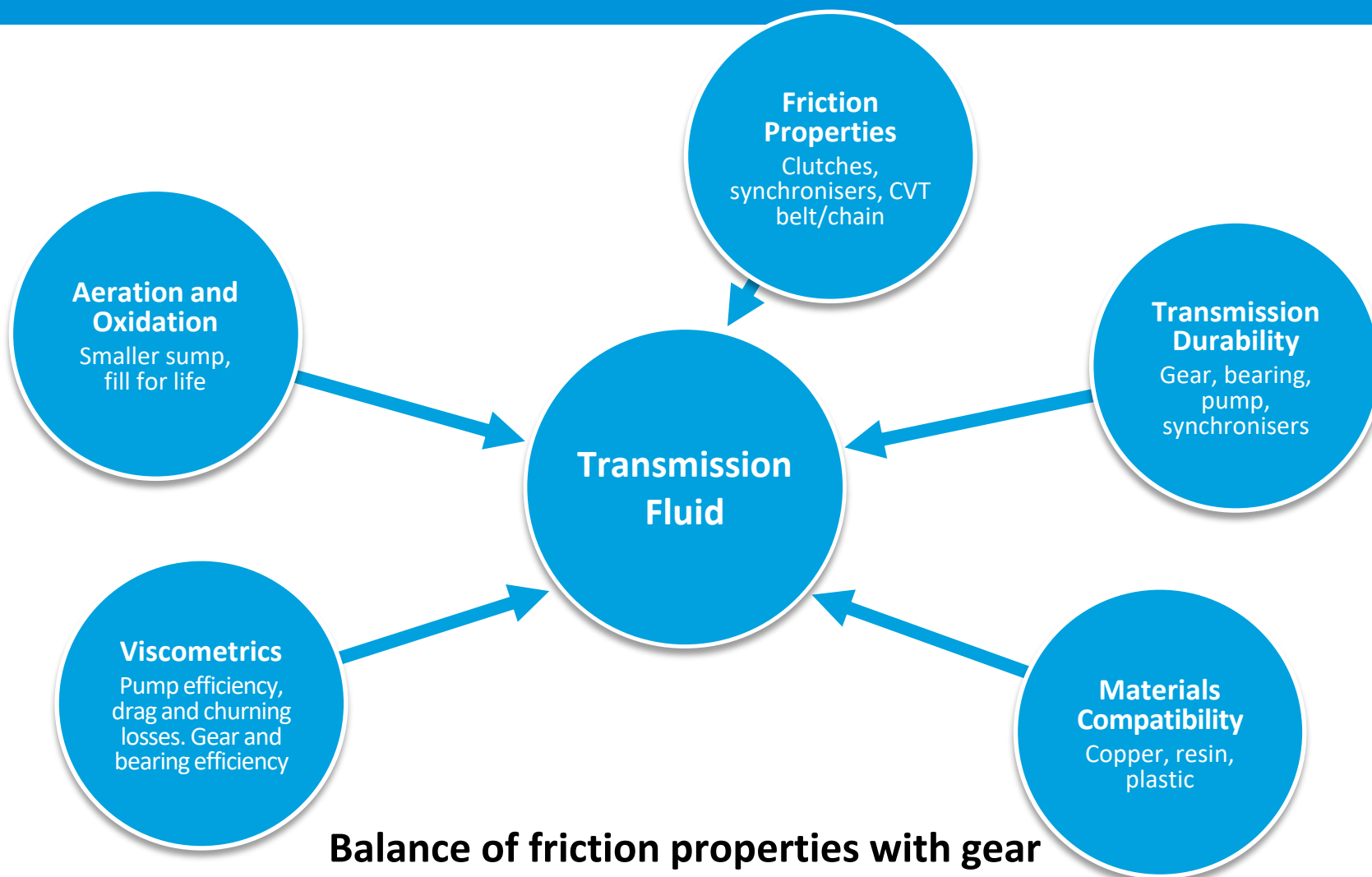
Stepped Automatic Transmission (AT)

Production stable, market share decline

Manual Transmission (MT)

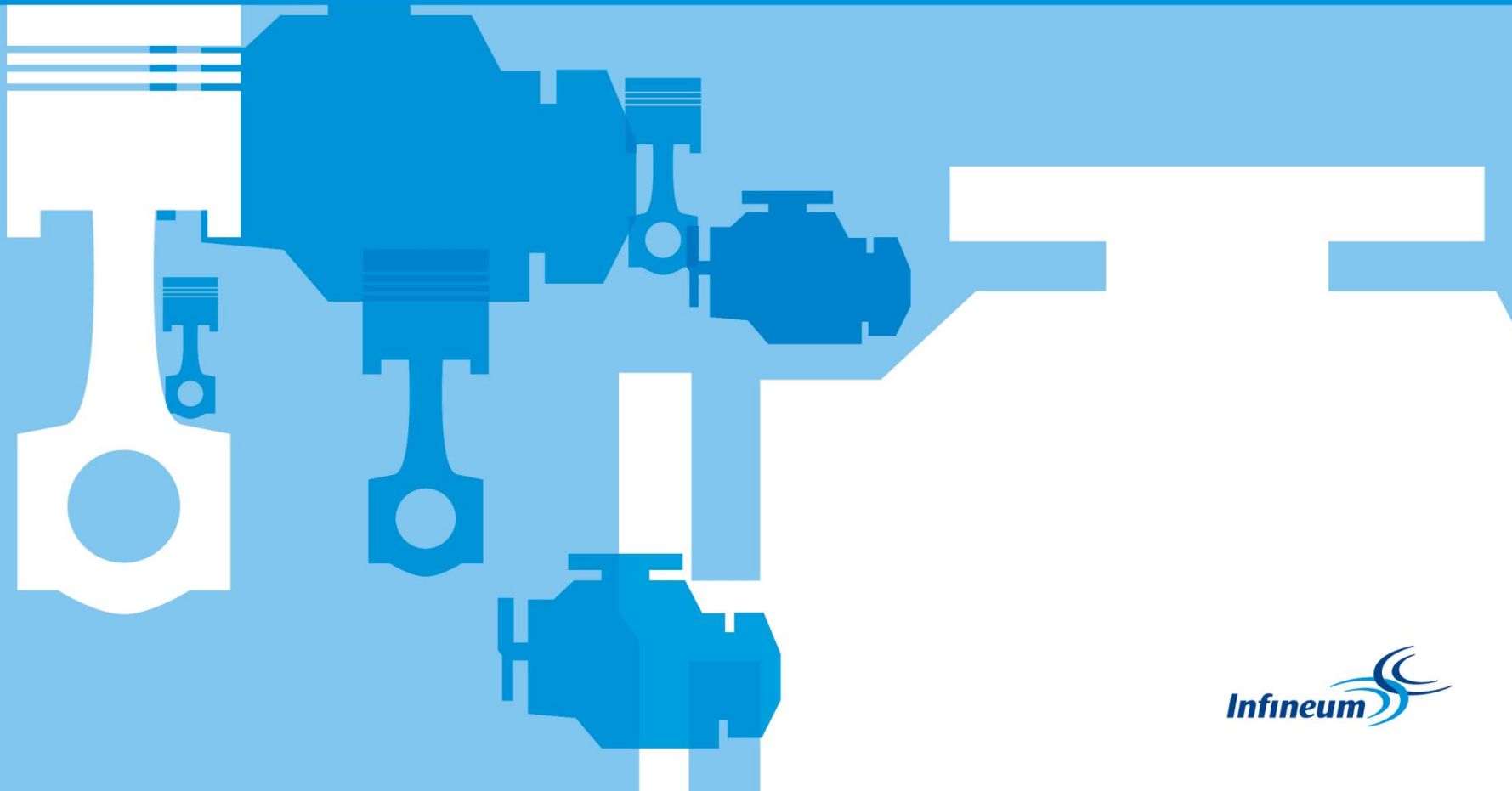
Market share declines, shift to automatic

Transmission Fluid Requirement



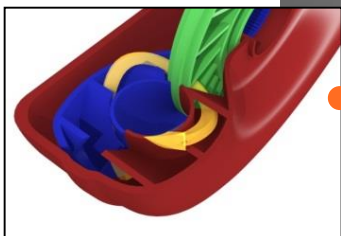
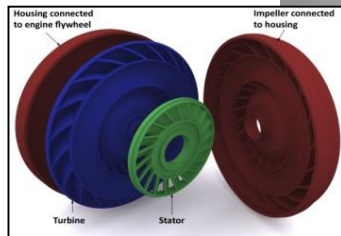
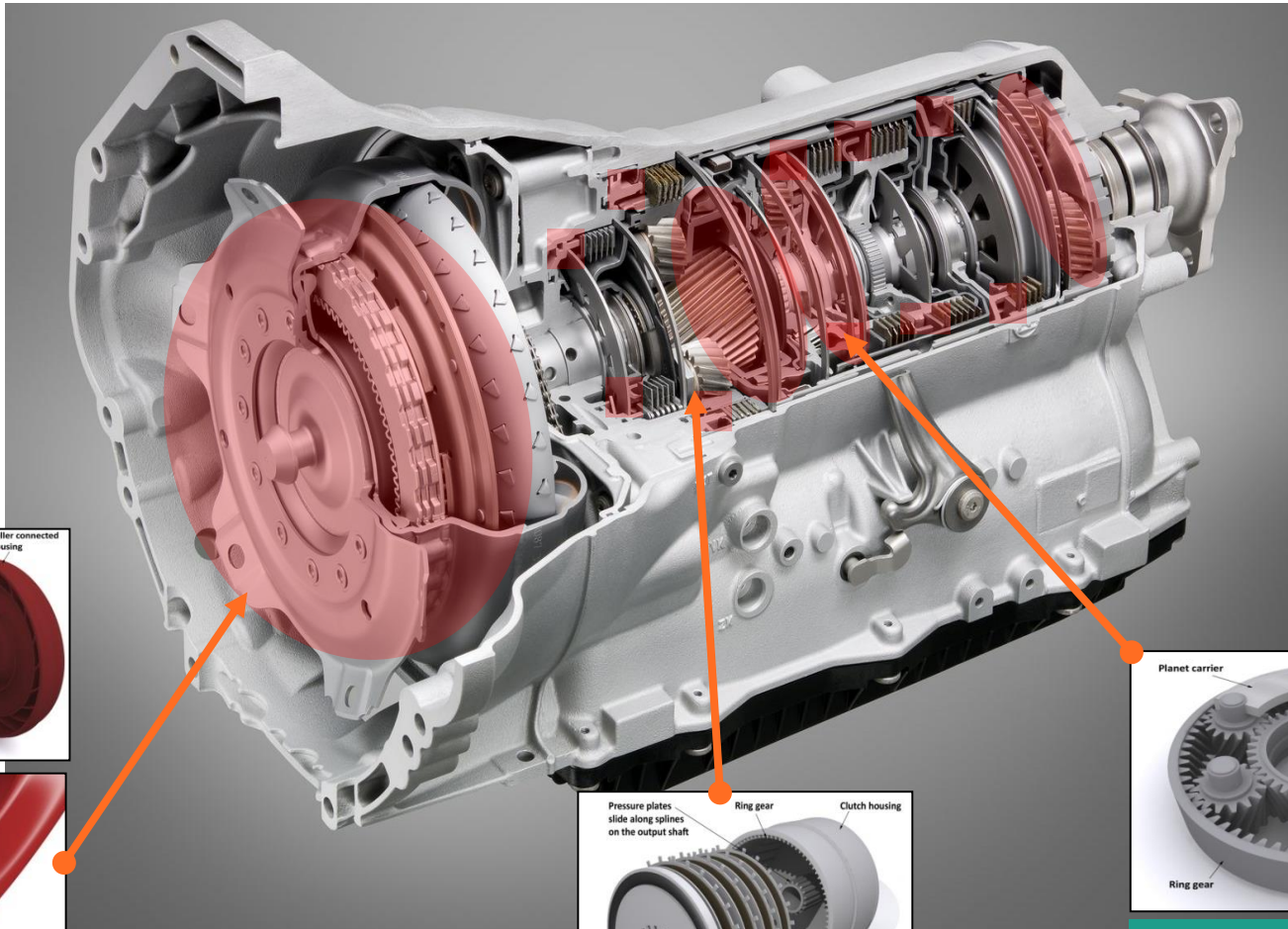
Balance of friction properties with gear protection and material compatibility

AT Hardware and ATF Performance Requirements

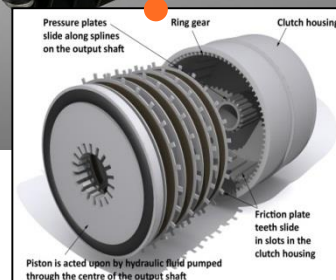


Stepped Automatic Transmission Hardware

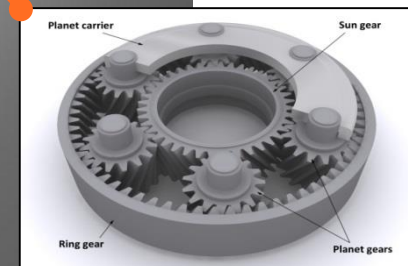
Photo source: BMWBLOG.COM



Torque Converter

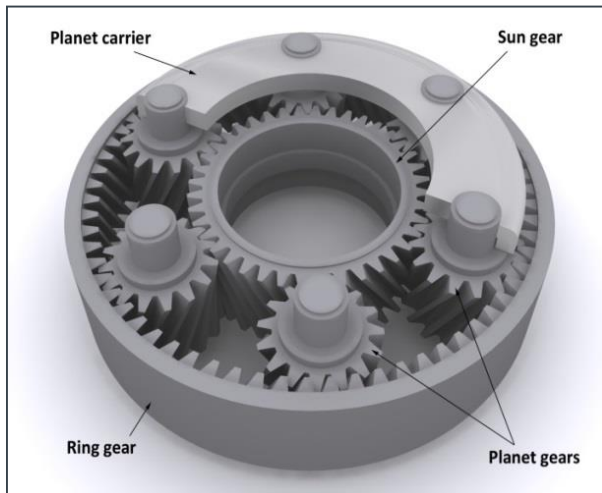
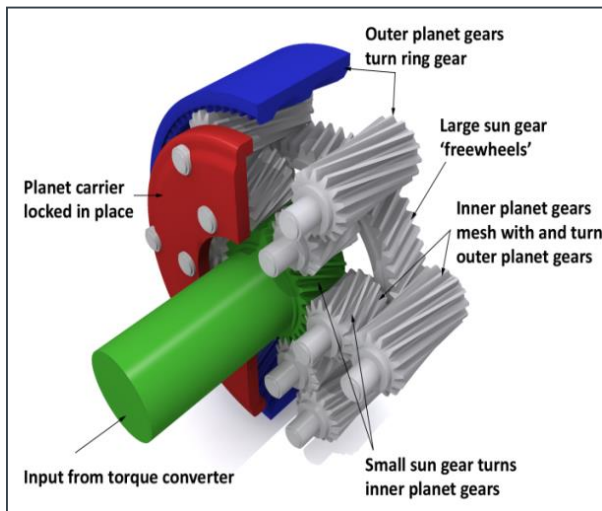


Clutches



Planetary Gear

Stepped Automatic Transmission Hardware



Three Main Components

- Sun gear
- Planet gears (and carrier)
- Ring gear

Gear Ratios

- Any component can be used as the input, output or locked in place to allow multiple gear ratios from one planetary gear set.

Stepped Automatic Transmission Hardware

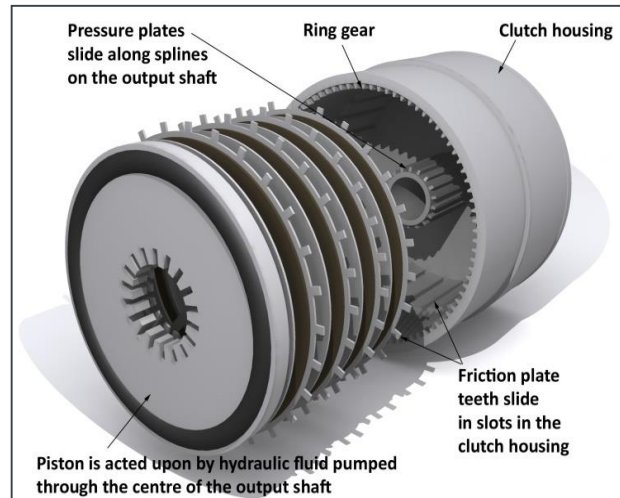
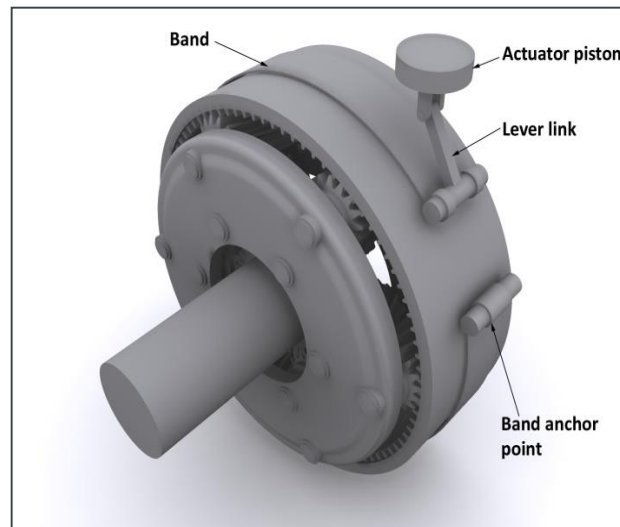
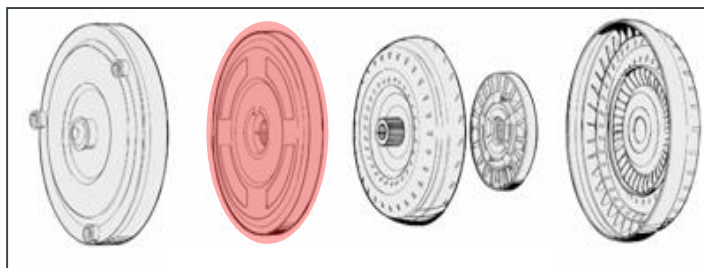
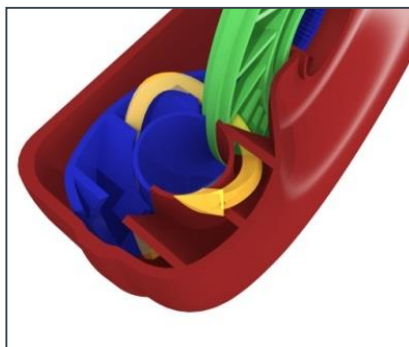
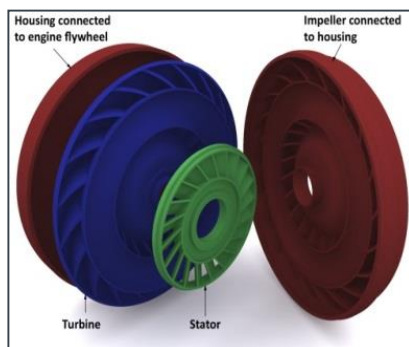


Plate clutches comprise alternating friction and steel plates and are used to lock sun and planetary gears.



Band clutch wraps around the outside of the ring gear and when engaged locks the ring gear in place.

Stepped Automatic Transmission Hardware



Torque Converter Lock-Up Clutch



Four Main Components

- Pump
- Turbine
- Stator
- Lock-up clutch

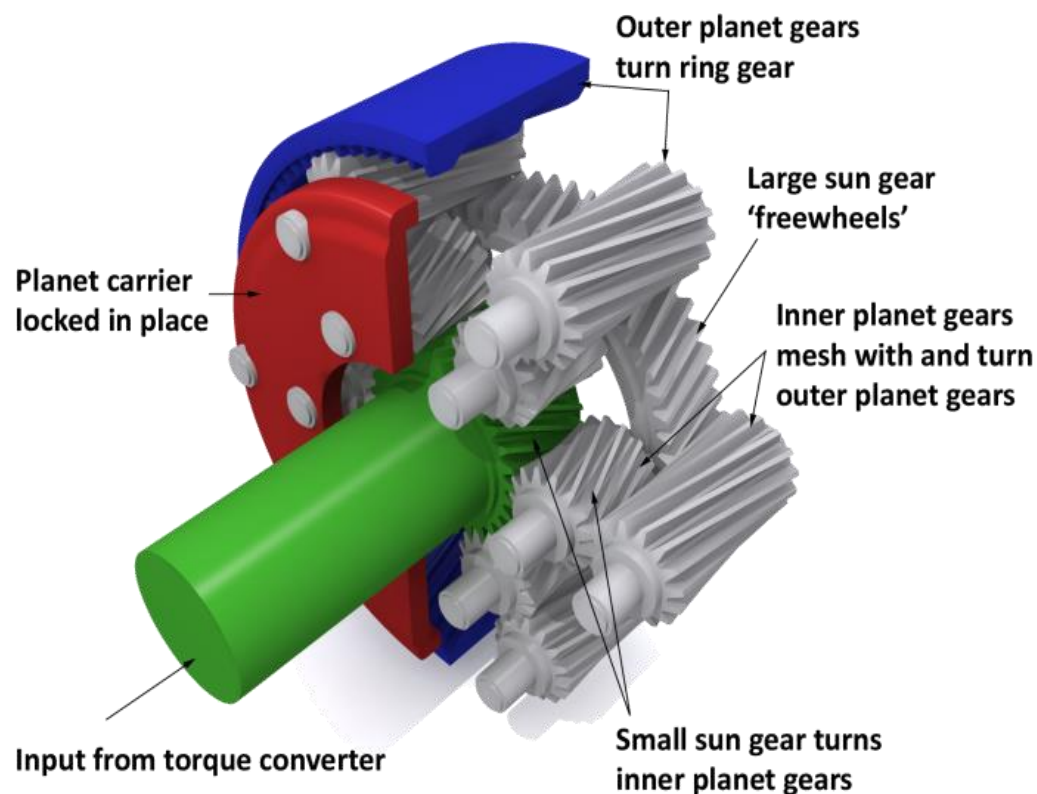
Stator enables torque multiplication.

Lock-up clutches added in 1970s to improve fuel economy.

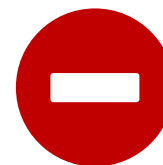
Stepped Automatic Transmissions

Advantages and disadvantages

Stepped Automatic



- Torque capacity
- Fuel efficiency in ≥ 6 -speed applications
- Launch feel



- Fuel efficiency in applications ≤ 5 -speeds
- Packaging size

Stepped Automatic Transmissions

Fluid requirements



Wear Protection

- Protect planetary gear sets and bearings

Paper On Steel Friction

- Friction control and durability for torque converter lock up clutch, plate and band clutches

Shear Stability

- Resist shearing from planetary gears and oil pump

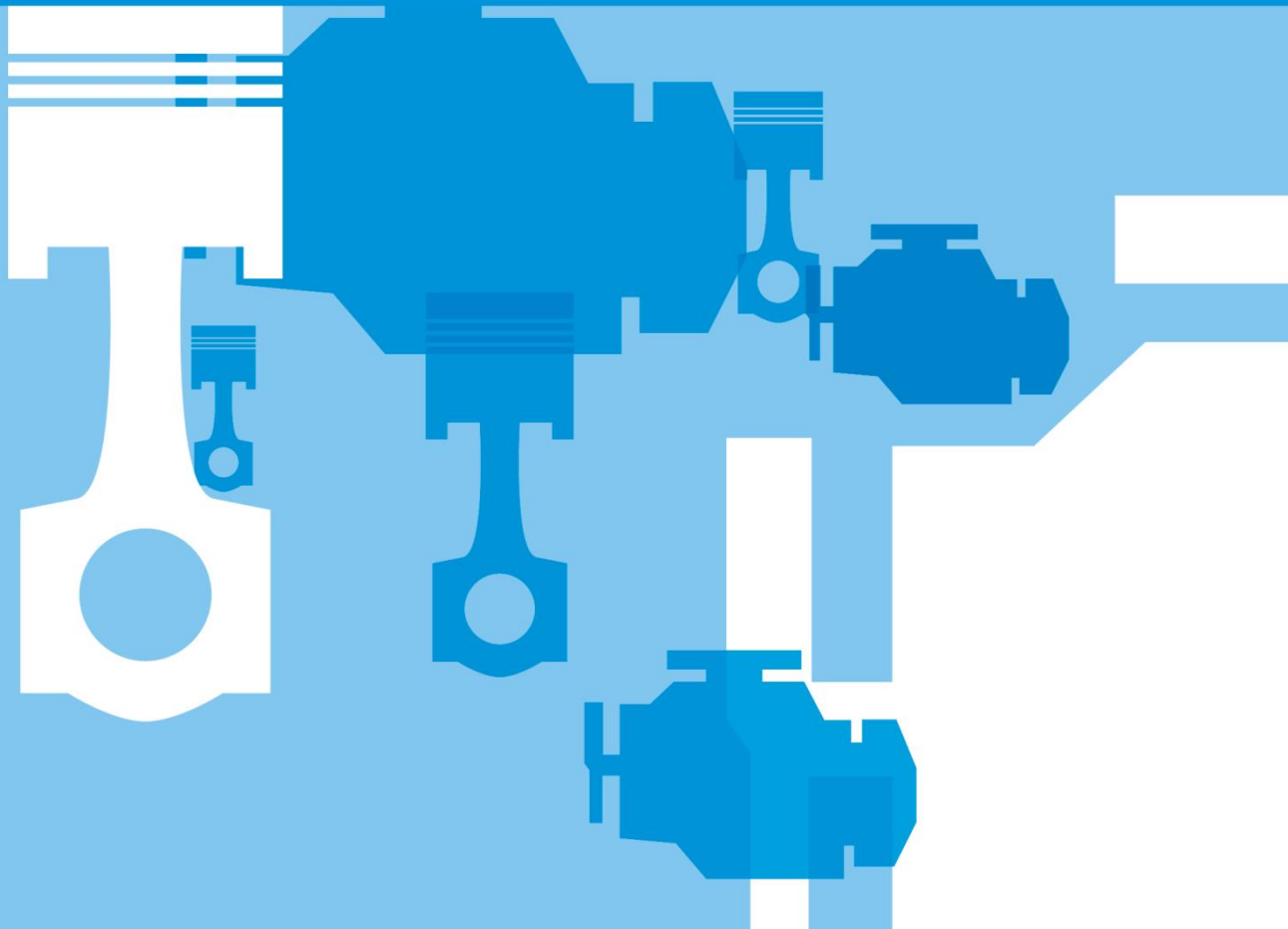
Oxidation

- Resist high temperatures generated in the clutch packs and torque converter
- Fill for life

All Other Conventional Transmission Fluid Properties

- Hydraulic performance
- Antifoaming properties
- Transmission coolant
- Seal compatibility
- Non-corrosive
- Large operating range (-40 to 170°C)

Dual Clutch Transmissions (DCT)

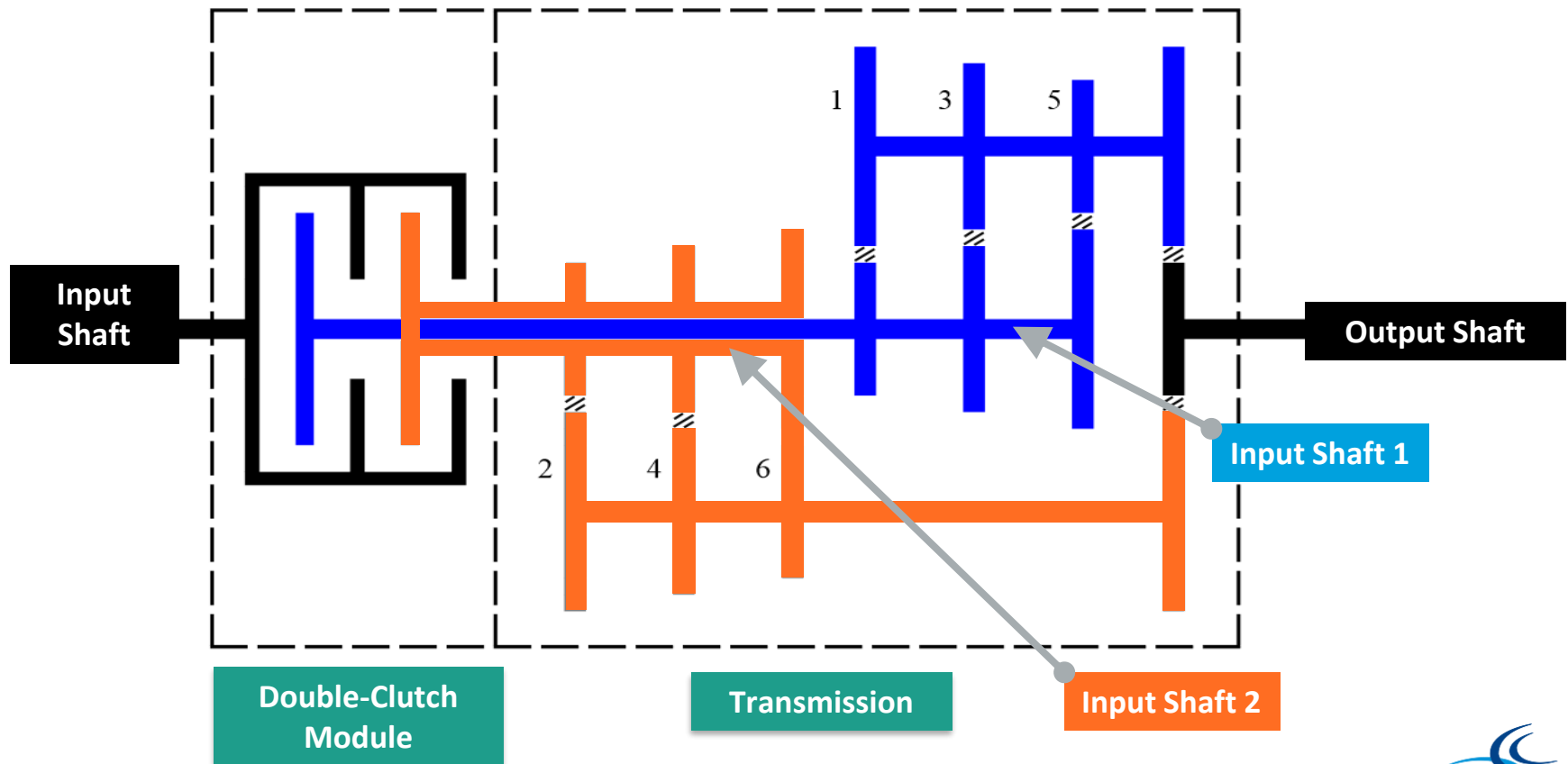


Dual Clutch Transmissions

How they work

2 input shafts are connected to two different clutches

- Odd gears connected to one
- Even gears connected to other



Dual Clutch Transmission Applications

Wet and dry clutch systems



Dry DCT Applications

Used in medium segment car market



- Simplicity
- Use only gear oil
- Higher efficiency



- Heat and friction losses
- Drivability
- Torque limitation



Wet DCT applications

Used in high torque demanding vehicles



- Higher torque capacity
- Improved friction, controllability and heat dissipation
- Faster shifts

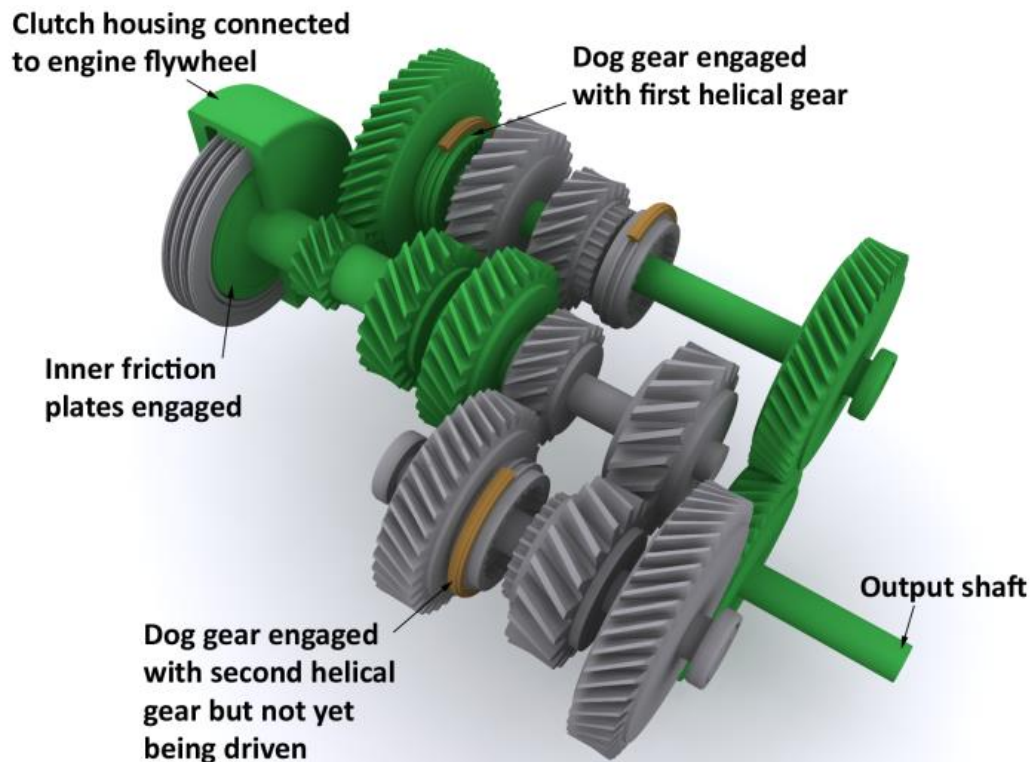


- Challenging fluid environment that requires special DCT fluid
- Cost

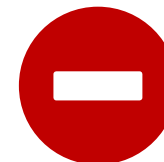
Dual Clutch Transmissions

Advantages and disadvantages

Dual Clutch



- Torque capacity
- Fuel efficiency
- Shift feel
- Can use existing MT manufacturing sites



- Launch feel not as smooth as stepped AT

Dual Clutch Transmission Technology Trends

Wet and dry clutch systems



Dry DCT Requirements



Performance Requirements

- Gear and bearing protection
- Friction and wear control for synchronisers
- Corrosion resistance
- Material compatibility
- Oxidation control

MTF can typically meet dry-DCT needs

Performance Requirements

Same as for Dry DCT, but adding / balancing:

Paper On Steel Friction

- Clutch friction control
- Anti-shudder durability

Transmission coolant

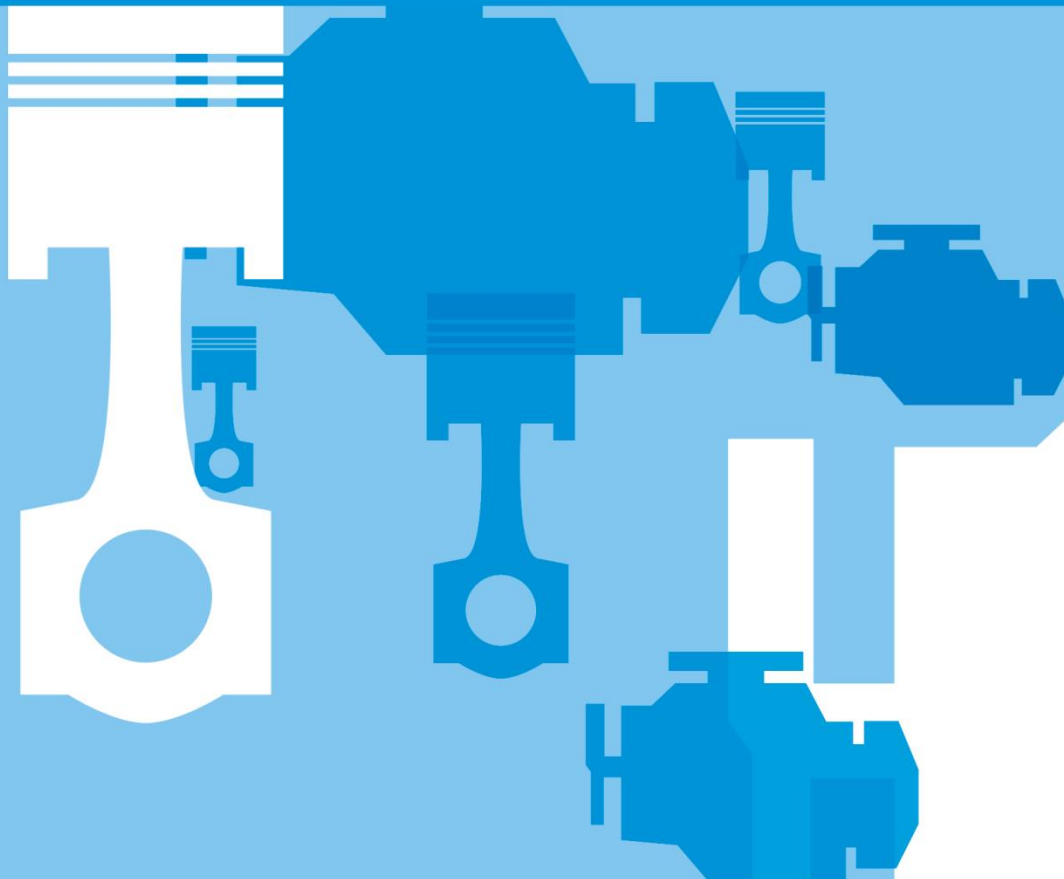
Enhanced material compatibility

Enhanced oxidation stability

- Due to high temperatures generated from the dual clutches

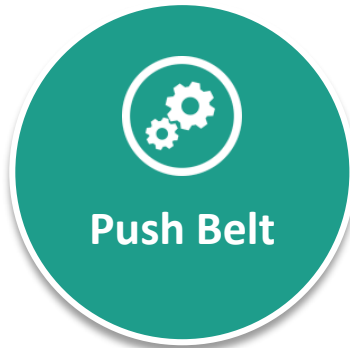
Wet-DCTs require a specialised fluid

Continuously Variable Transmissions (CVT)

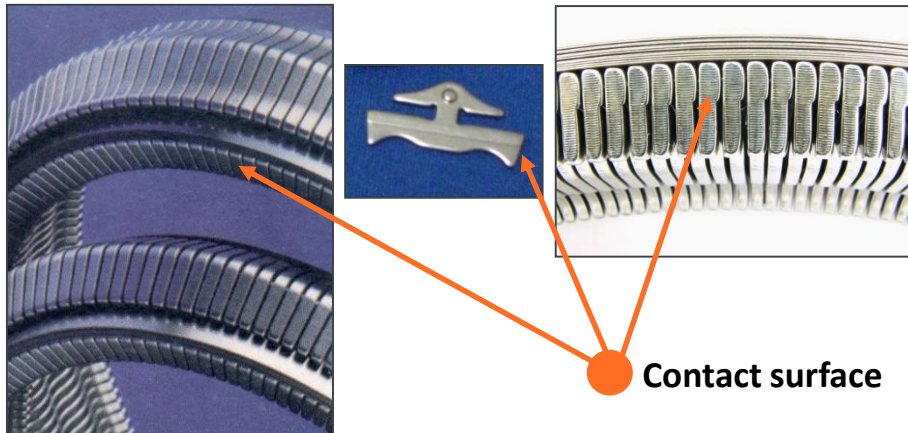
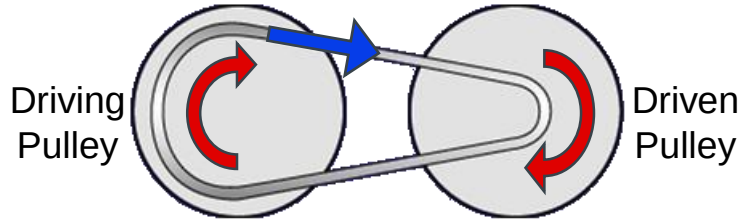


Continuously Variable Transmissions

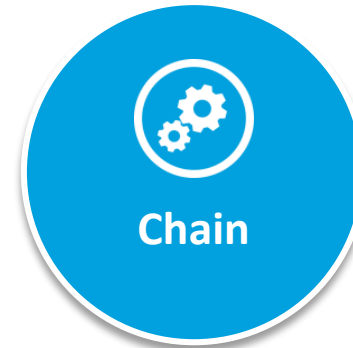
Drive belts



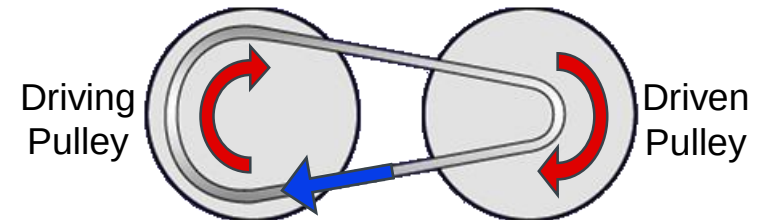
Force transmitted by compressional forces between belt elements



Contact surface



Force transmitted by tension on chain links

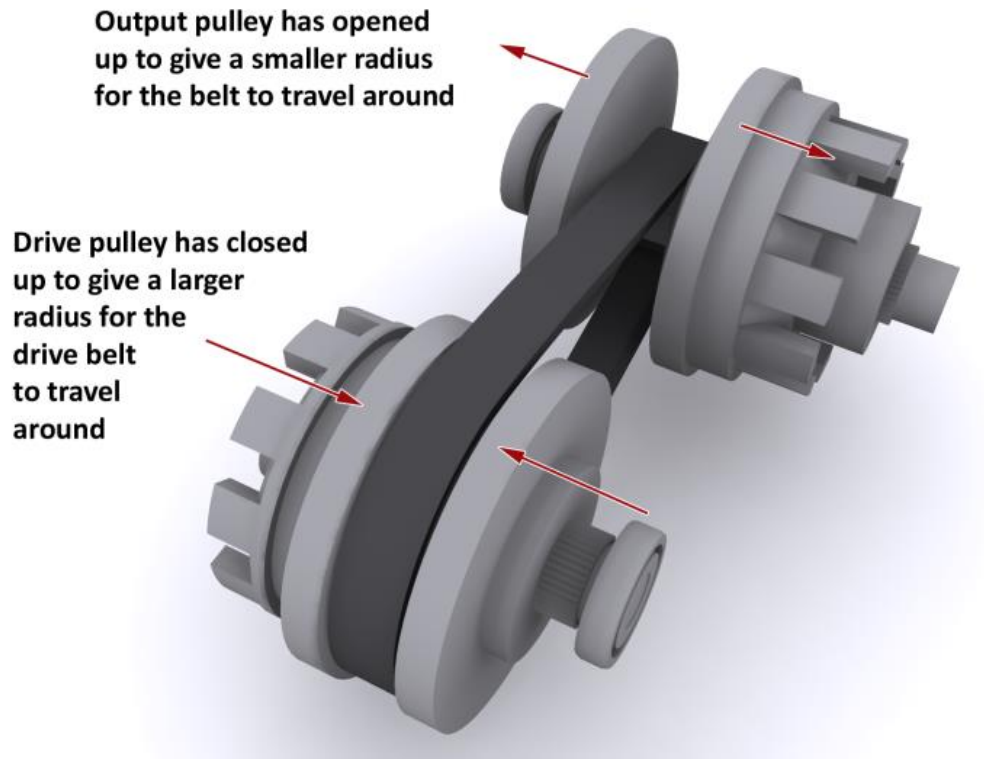


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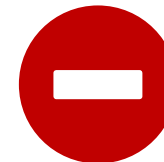
Continuously Variable Transmissions

Advantages and disadvantages

Continuously Variable



- Comfort due to no shifting
- Fuel efficiency



- Torque capacity
- Cannot utilise existing stepped AT manufacturing sites

Continuously Variable Transmissions

Fluid requirements



Steel On Steel Friction

- Transfer torque between pulleys and drive belt
- Wear control

Shear Stability

- Resist shearing from belt contact and oil pump

Oxidation Stability

- CVTs run hot
- Fill for life

Paper On Steel Friction

- Starting clutch
- Torque converter lock up clutch
- Forward-reverse clutch

All Other Conventional Transmission Fluid Properties

- Gear and bearing protection
- Hydraulic performance
- Antifoaming properties
- Transmission coolant
- Seal compatibility
- Non-corrosive

Fluid Requirements Comparison

CVTF vs DCTF vs ATF

OEM Requirements	CVTF	DCTF	ATF
Steel On Steel Friction	✓	✗	✗
Wear Protection	✓	✓	□ / ✓
Paper On Steel Friction	□ / ✓	✓	✓
Oxidation	✓	✓	✓
Air-release	✓	✓	✓
Gear Protection	□	✓	✓
Material Compatibility	✓	✓	✓



: Major



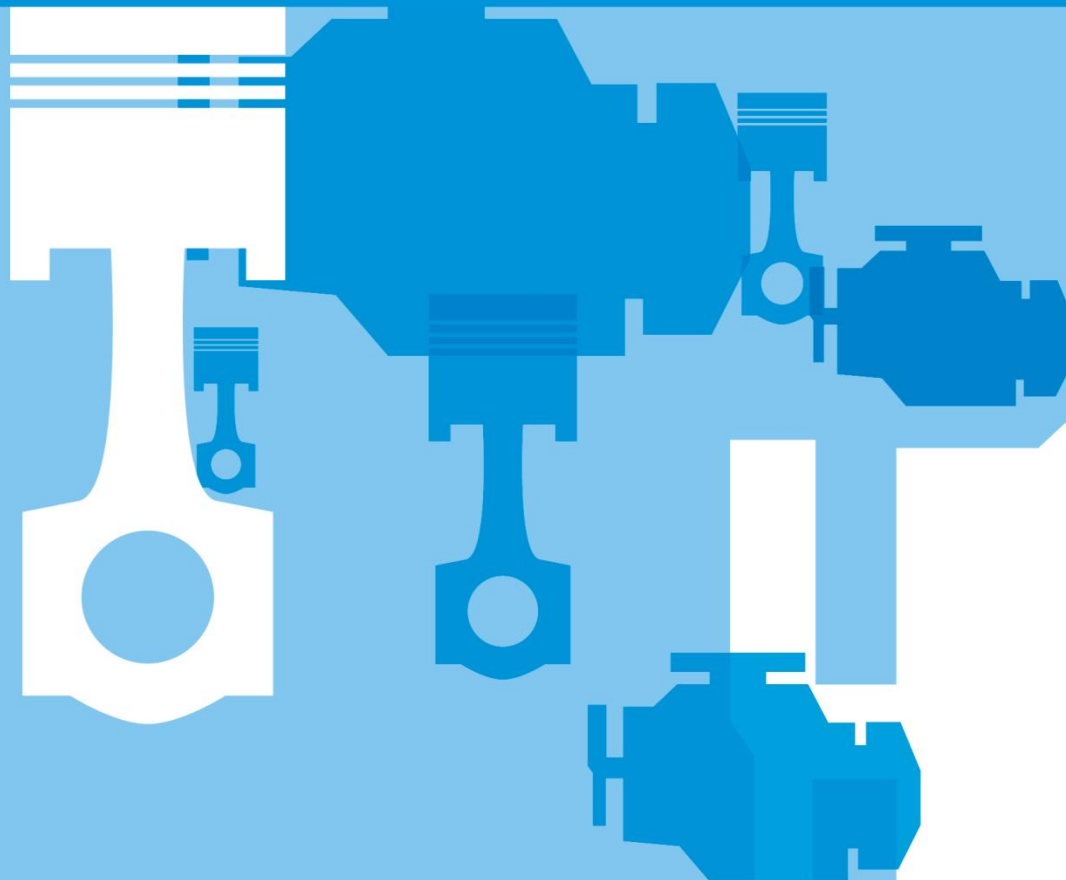
: Minor



: Not Required

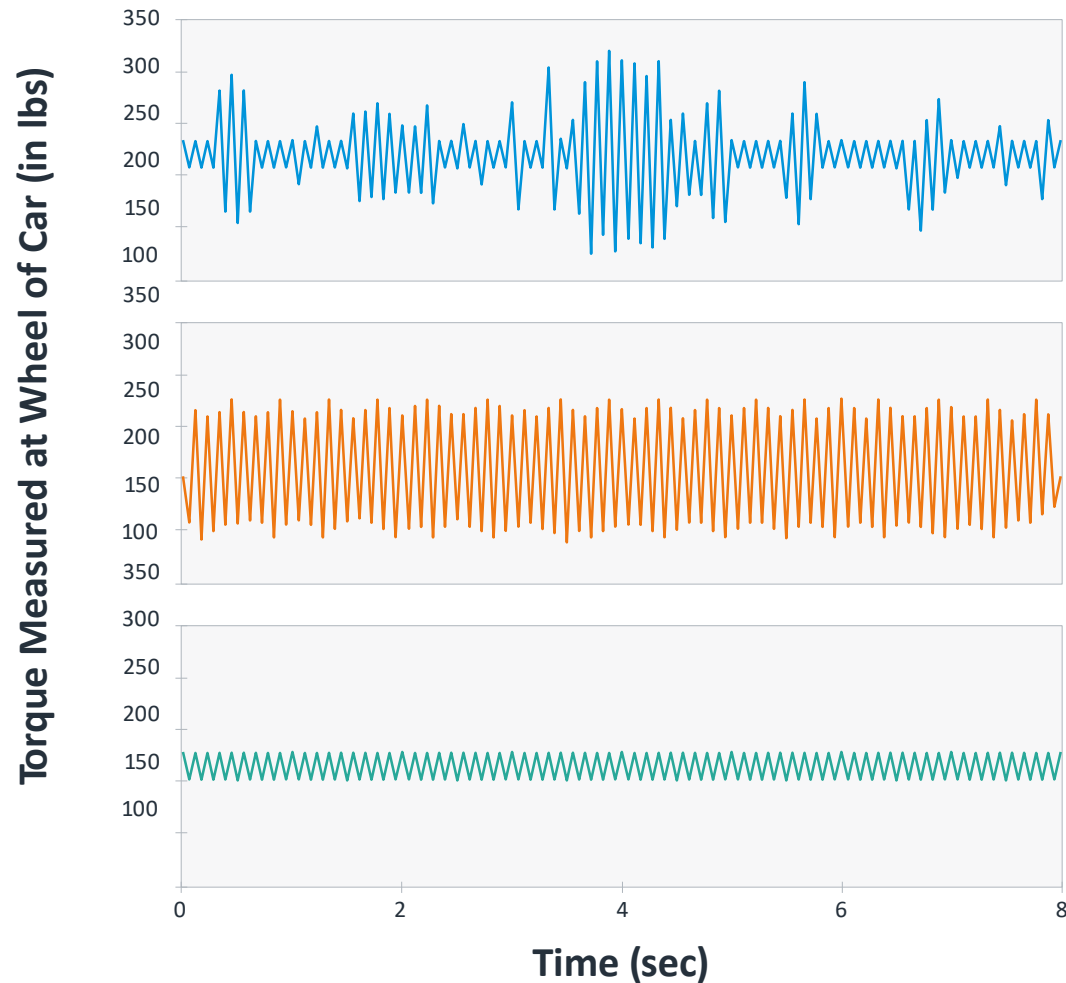


Shudder / Drive Feel



Clutch Friction Deterioration and Shudder

Self-Excited Driveline Vibration



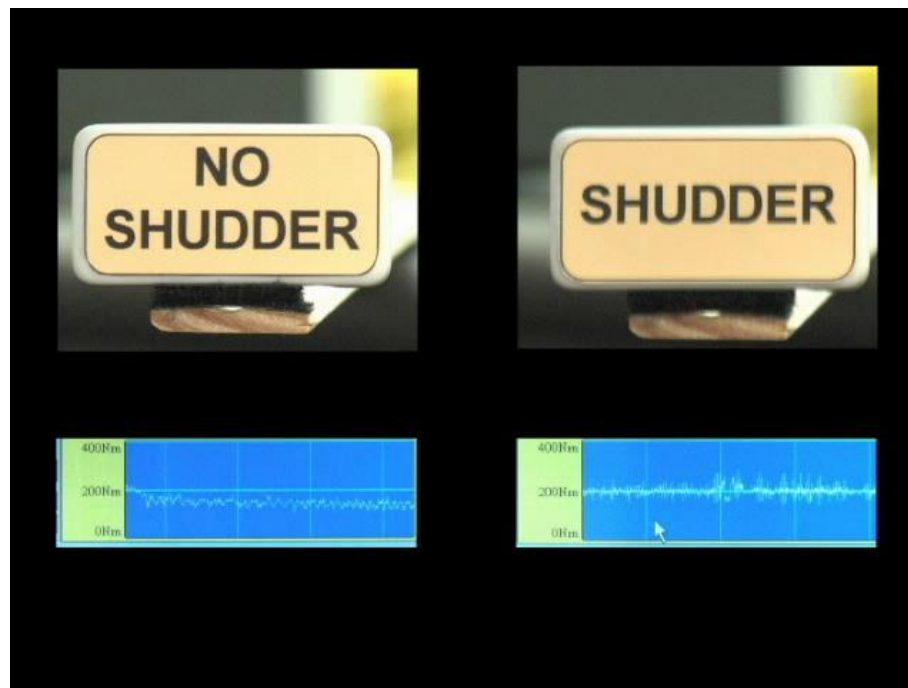
Intermittent Shudder

Continuous Shudder

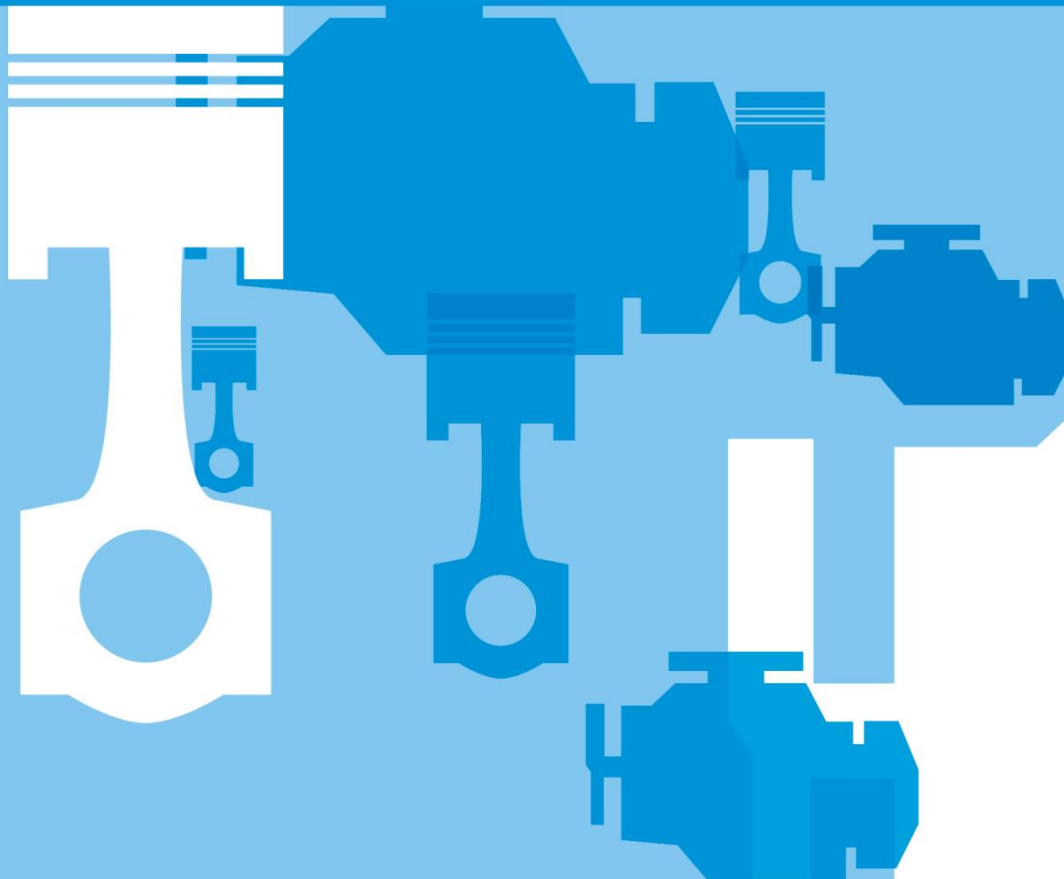
No Shudder

Sh-h-h-udder Occurs!

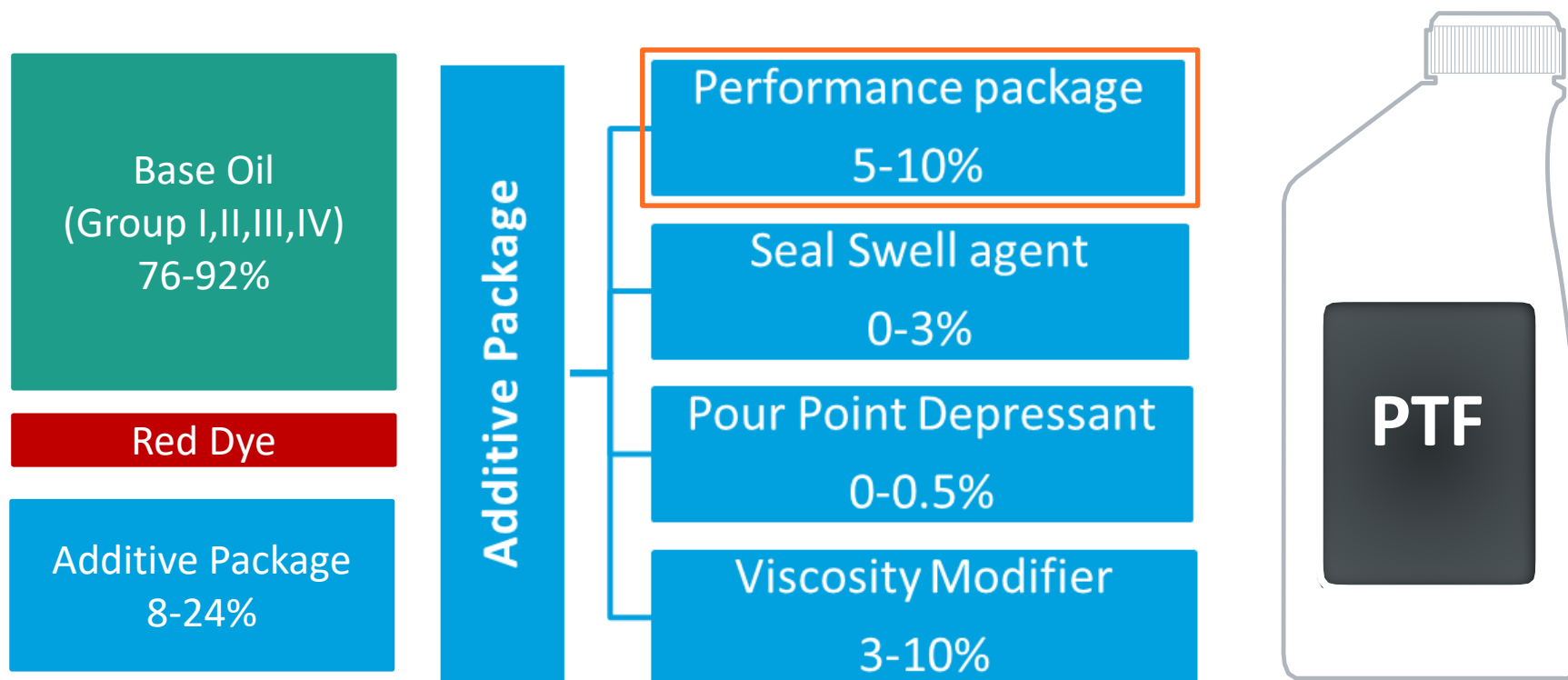
Power transmission fluids must deliver specialised friction requirements



PTF Formulations



Typical Transmission Additive Treat Levels



Typical Transmission Additives



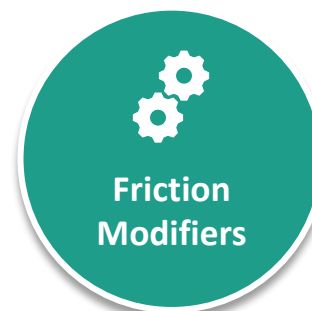
Sludge & Varnish
Control



Oxidation
Control



Gear, bearing,
Synchro, drive belt,
pulley and pump
wear control

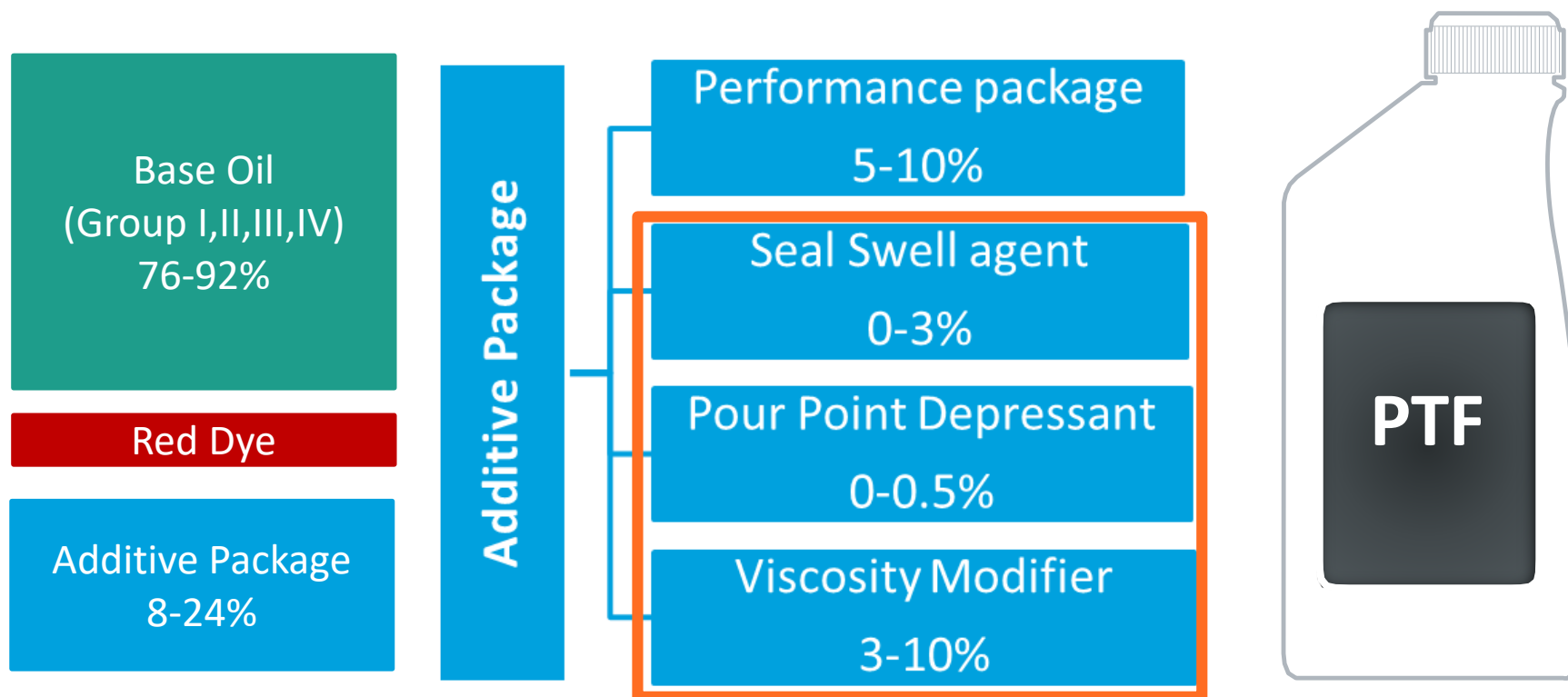


Control clutch,
synchro and drive
belt friction



Prevent corrosion
of bearings and
copper containing
elements

Typical Transmission Additive Treat Levels



Typical Transmission Additives



Seal Swell

Control swelling,
hardness
& tensile strength
of elastomers



**Pour Point
Depressant**

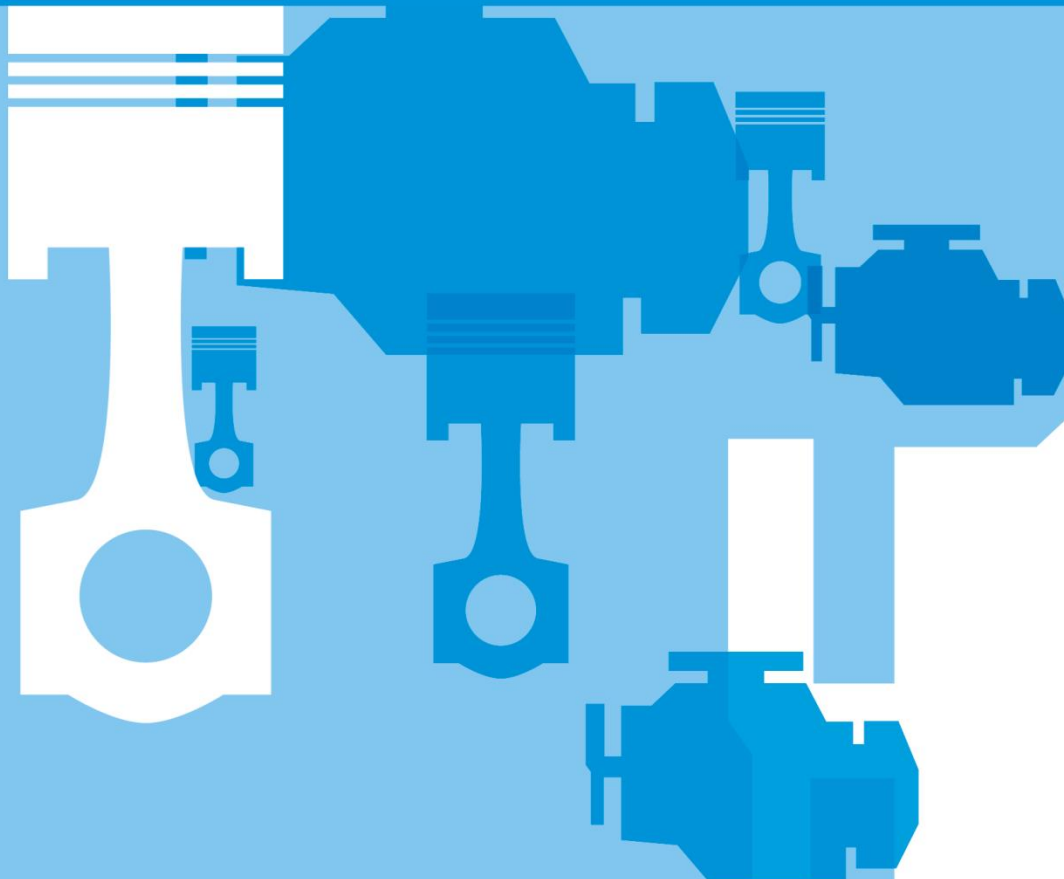
Lowers
temperature at
which fluids starts
to gel



**Viscosity
Modifiers**

Reduce rate of
change of
viscosity with
temperature

Electrification

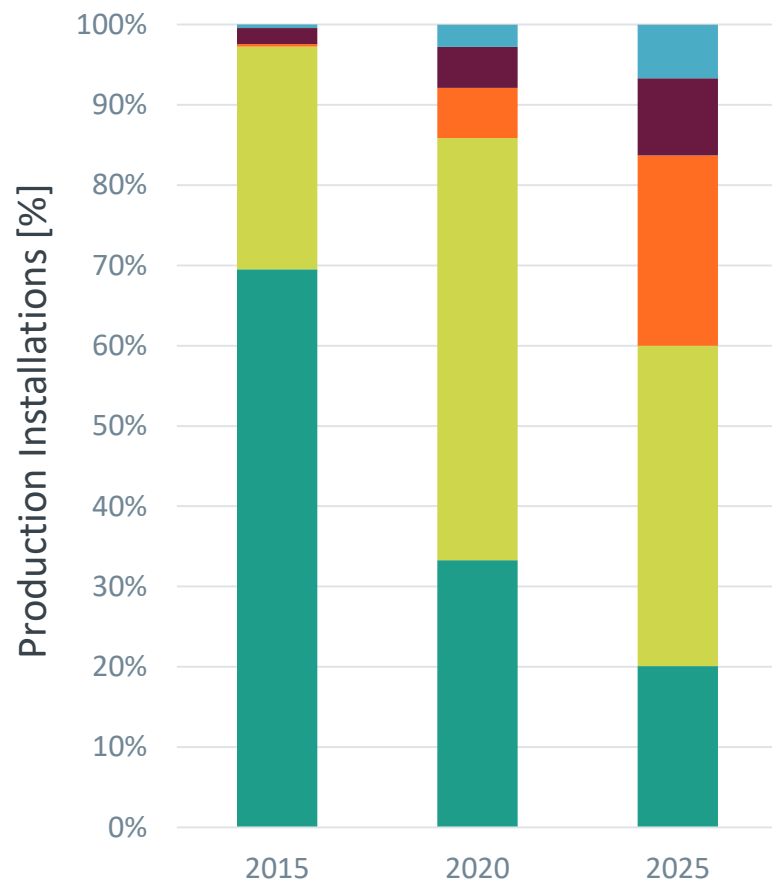


Vehicle Electrification Architectures

Vehicle Electrification Architecture		ICE	Motor	FE %
Stop/Start Micro Hybrid	   	Propulsion	ICE Starting if Equipped	2-4
MHEV Mild Hybrid	   	Propulsion	ICE Assist	8-11
HEV Full Hybrid	   	Propulsion	Propulsion	20-35
PHEV Plug-In Hybrid	    	Propulsion	Propulsion	50-60 Equivalent
EREV Ext. Range Electric	    	Range Extension	Propulsion	60-70 Equivalent
BEV Battery Electric	  	None	Propulsion	70-80 Equivalent

Global Transmission – Electrification Split

Propulsion System Design



Fuel Cell

Market share very low

Electric

Production increase, market share gain

Hybrid-Full

Production increase, market share increase

Hybrid-Mild

Large production increase, market share increases

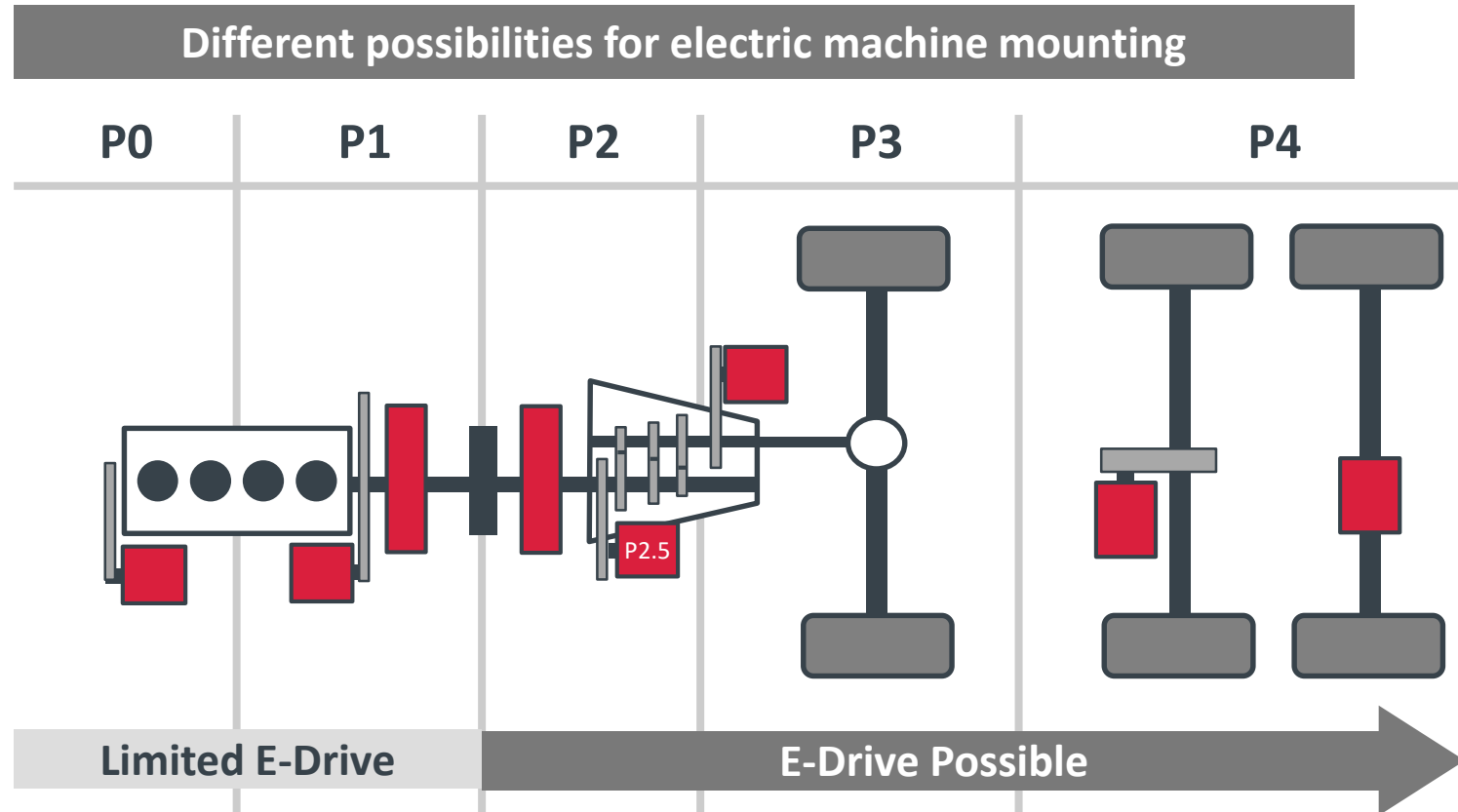
ICE: Stop/Start

Production stable, market share decline rolls to hybrid mild

Internal Combustion Engine (ICE)

Market share declines, switch to ICE/stop-start

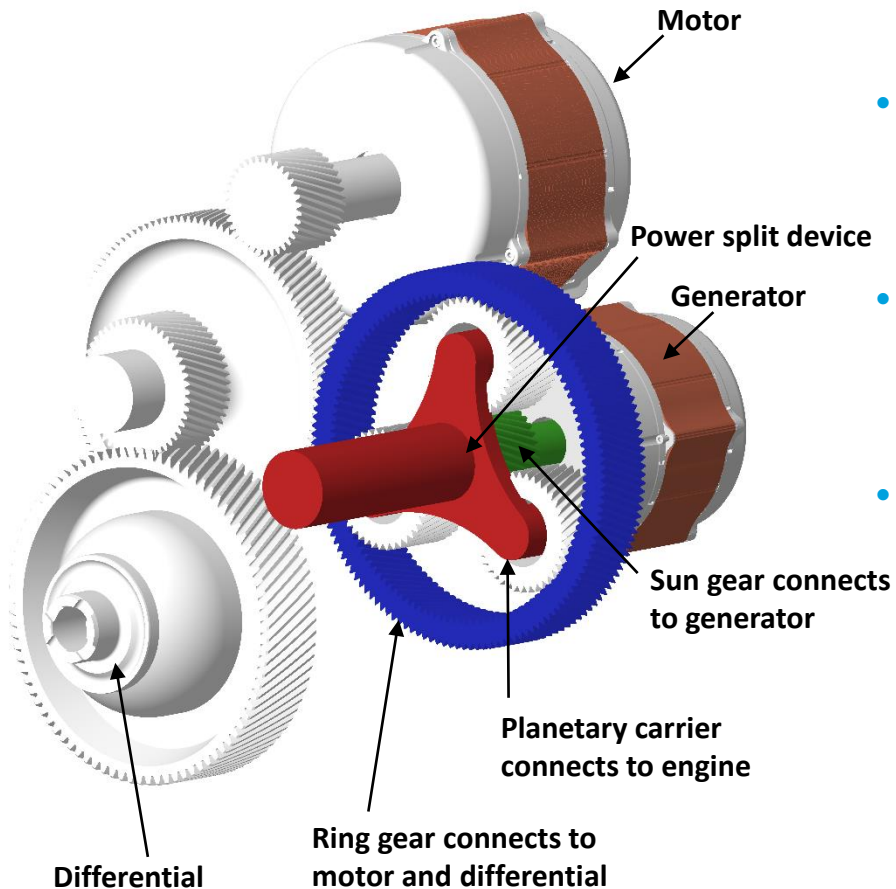
Classification of Parallel Hybrid Topologies



Most parallel hybrids in the market are P2 designs

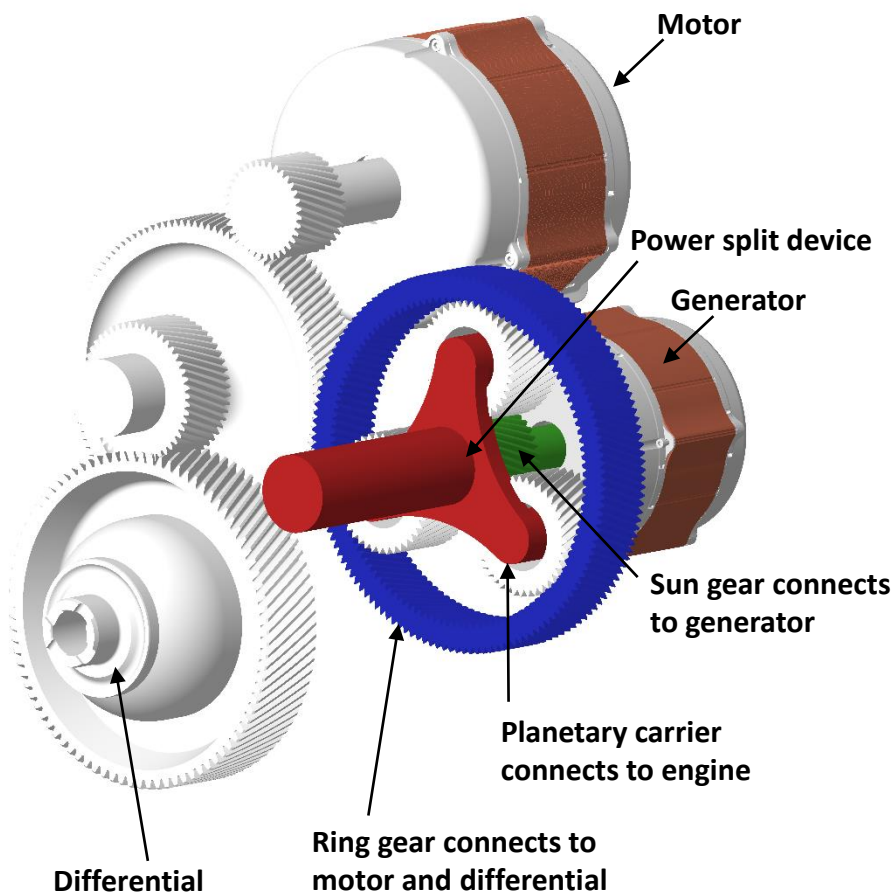
- Allows electric only drive
- Gear ratios can be used to optimise efficiency

Power Split Design

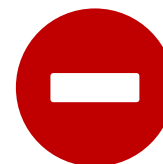


- Combines the ICE with 2 e-motors via a power split device to power the car
- The power split device enables the transmission to perform like a continuously variable transmission
- The E-motors are able to boost the ICE output or charge the batteries depending on the driving mode
- Driving modes
 - E-motor only is used for launch and low speed driving
 - ICE output is boosted by the e-motors during acceleration
 - ICE drives the vehicle and e-motors charge the battery during cruising
 - ICE disconnected and e-motors charge the batteries during breaking

Power Split Advantages and Disadvantages



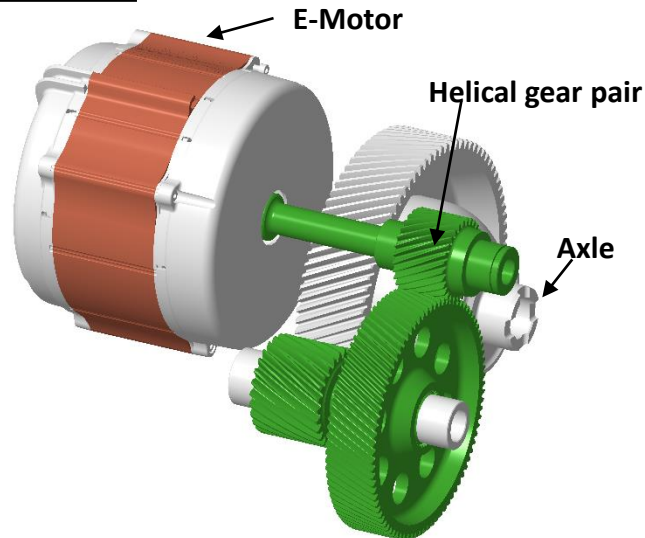
- Fuel efficiency
- Comfort due to no shifting
- Electric only driving is possible



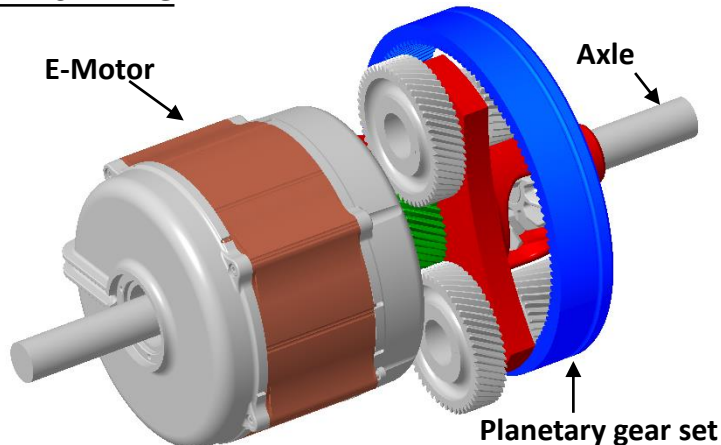
- Cost
- Requires new manufacturing setup

E-Axle Design

Off-Axis E-Axle



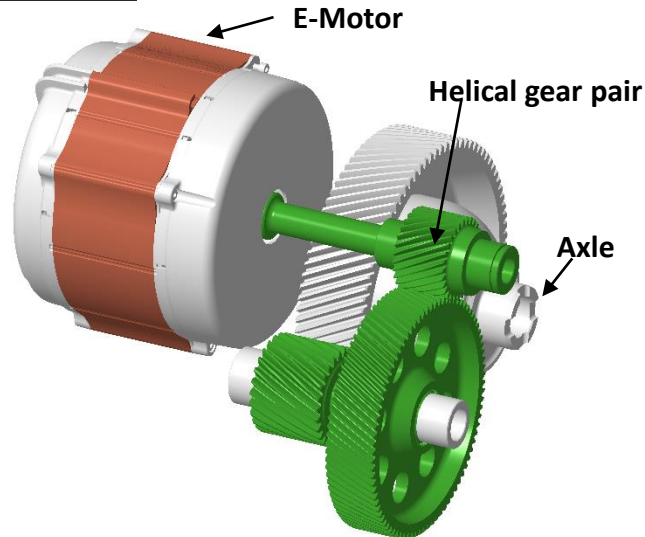
On-Axis E-Axle



- High speed E-motor provides power to the wheels via a reduction gear set
- Architectures:
 - Helical gear set with e-motor situated parallel to the axle.
 - Planetary gear set with the e-motor situated on the axle.
 - Single or multiple gear ratios:
 - Due to high torque at low RPM a single reduction gear ratio is possible
 - Multiple reduction gear steps can also be included to improve efficiency
 - Has to be balanced with drag losses
- Uses:
 - Battery and extended range electric vehicles
 - Used in combination with a conventional drive train to provide hybridisation and 4-wheel drive

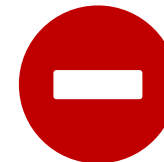
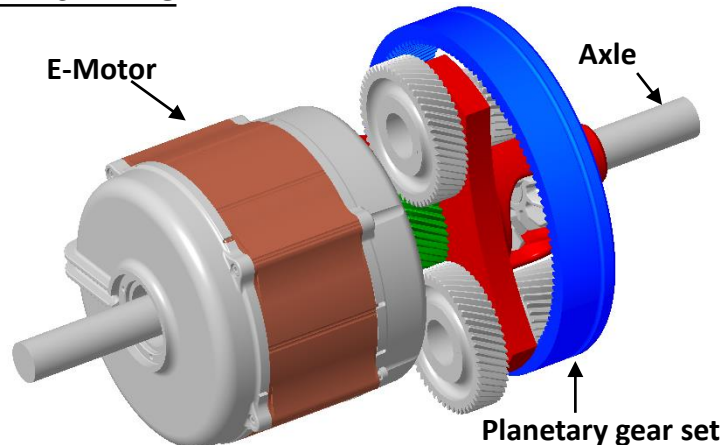
E-Axle Advantages and Disadvantages

Off-Axis E-Axle



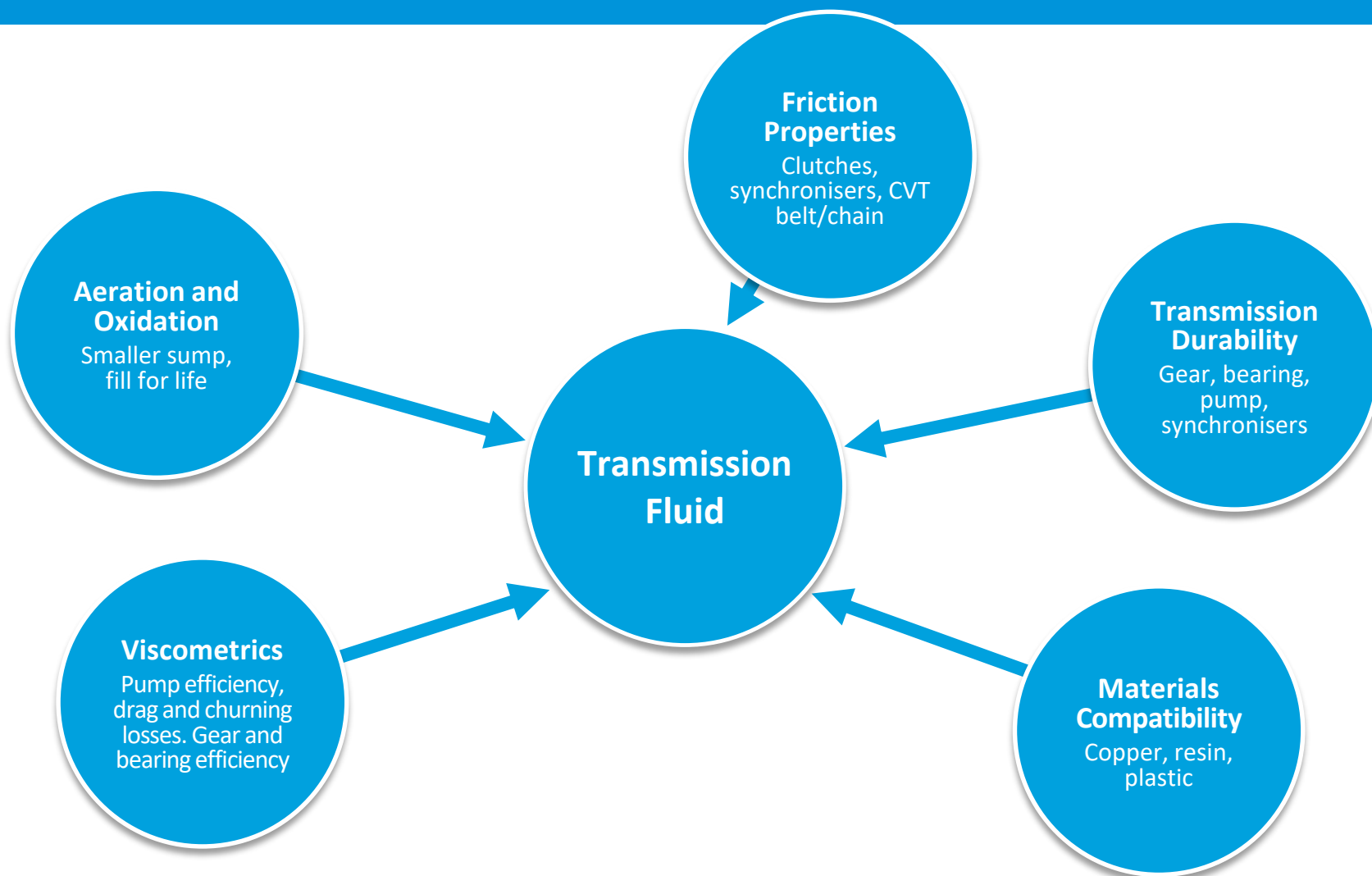
- Fuel efficiency
- Acceleration
- Fully electric vehicle
- Packing size

On-Axis E-Axle

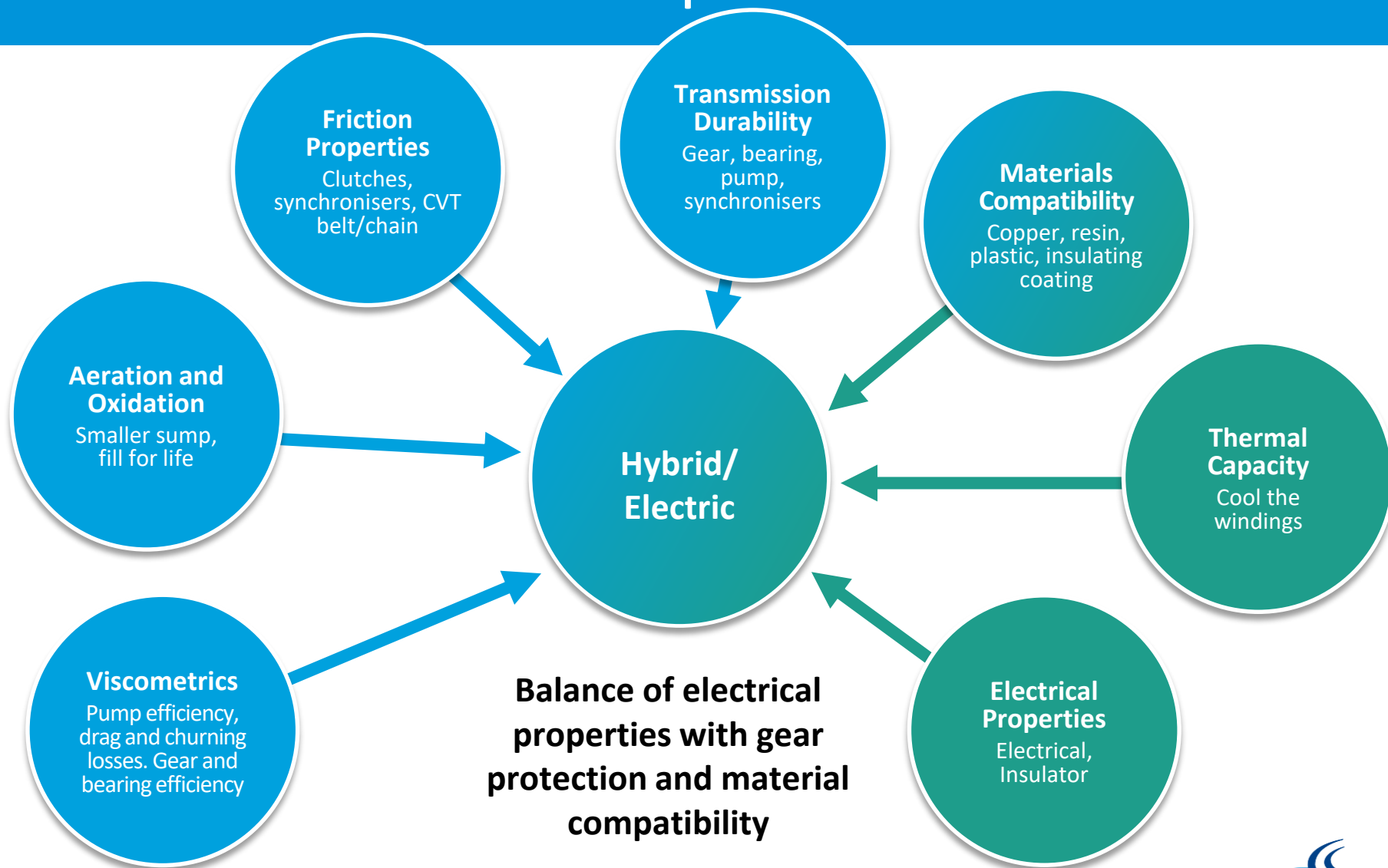


- Cost
- Requires new manufacturing setup

Transmission Fluid Requirement



Transmission Fluid Requirement



Fluid Requirements Comparison

OEM Requirements	CVTF	DCTF	ATF
Steel On Steel Friction	✓	✗	✗
Wear Protection	✓	✓	□/✓
Paper On Steel Friction	□/✓	✓	✓
Oxidation	✓	✓	✓
Air-release	✓	✓	✓
Gear Protection	□	✓	✓
Material Compatibility	✓	✓	✓

✓ : Major □ : Minor ✗ : Not Required

Conclusion

- 01 | Efficiency and electrification
- 02 | Introduction to different transmission designs
- 03 | Transmission fluid formulations and requirements

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