

Cars and Light Trucks

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Agenda

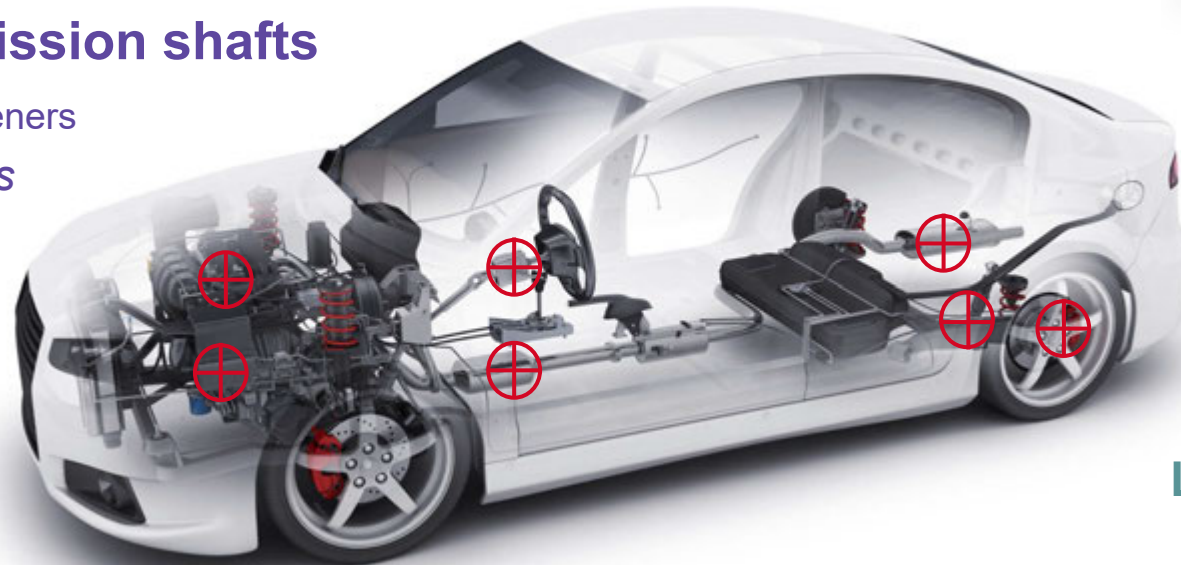
- Applications and heat treatment processes found on cars and light trucks
- Disruptive technology effects of electric vehicles
- Examples of electric vehicle powertrains and transmissions
- Bodycote's technologies
- Change brings opportunity

Bodycote Automotive

Moving the world



injectors ball studs
stampings *brake pistons*
rear axle rings **transmission shafts**
torque converters fasteners
pinion gears *brake discs*
transmission gears
air bag components
half shafts



Many types of treatment including

carburising
vacuum hardening
austempering **gas nitriding**
CiD[®] neutral hardening
induction hardening

Low Pressure Carburising
carbonitriding
brazing

Hundreds of millions of automotive components treated annually

Electric vehicles

- Battery Electric Vehicles (BEVs) and Plug-in Hybrid Vehicles (PHEVs) are expected to replace Internal Combustion Engines (ICEs)
- About £65m of car and light truck revenues are ICE specific
- 6 to 12 speed transmissions make up a significant portion of ICE specific sales
- PHEVs have complex drivetrains with numerous treatment requirements
- Growth in continuously variable transmissions (CVTs) for PHEVs and transmission technologies for BEVs provide significant market opportunities
- Components will be thinner, lighter, and built to tighter tolerances ... all good candidates for Bodycote treatments
- These opportunities for Bodycote are expected to significantly outweigh any loss of ICE specific sales



BEV powertrain

Treatment needs

Planetary gear set:

- Nitrided ring gear
- Low Pressure Carburising (LPC) and nitrided sun gear and pinions, and bevel gears
- CiD[®]-treated ductile-iron differential case

Drivetrain:

- Atmospheric carburising for U-joints (candidate for LPC oil quench)
- Plus CiD[®] for platform independent components

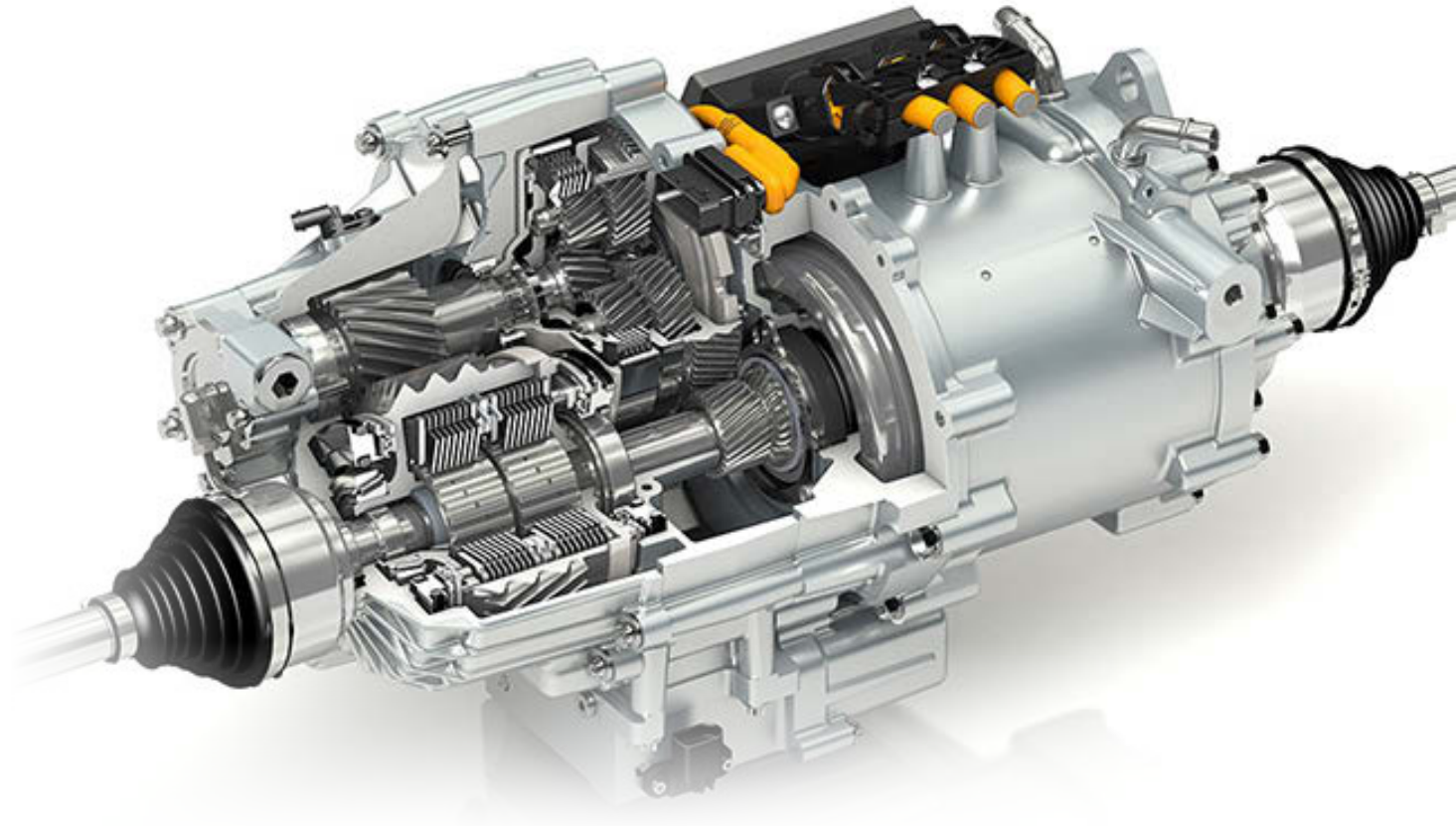


Chevrolet Bolt powertrain

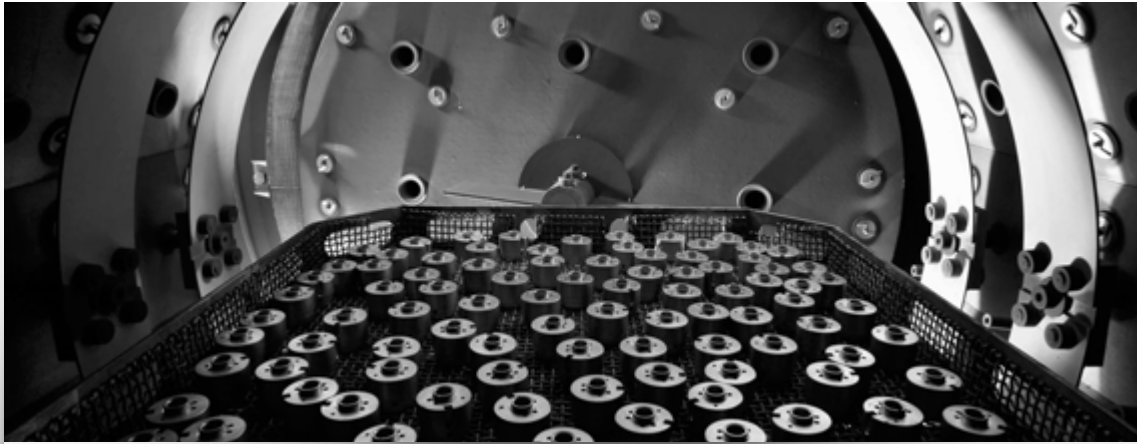
BEV transmission

A continuing evolution

- Multi-gear transmissions like GKN's eTwinsterX are being developed to resolve issues typically seen from the single geared BEV design
- Like its planetary geared sibling, a multi-geared e-transmission provides better top speed performance at lower RPMs, drawing less current from the electric motor thereby increasing the time and range between charges



Our technologies



Bodycote is the world's largest supplier of gas nitriding

Low Pressure Carburising (LPC)

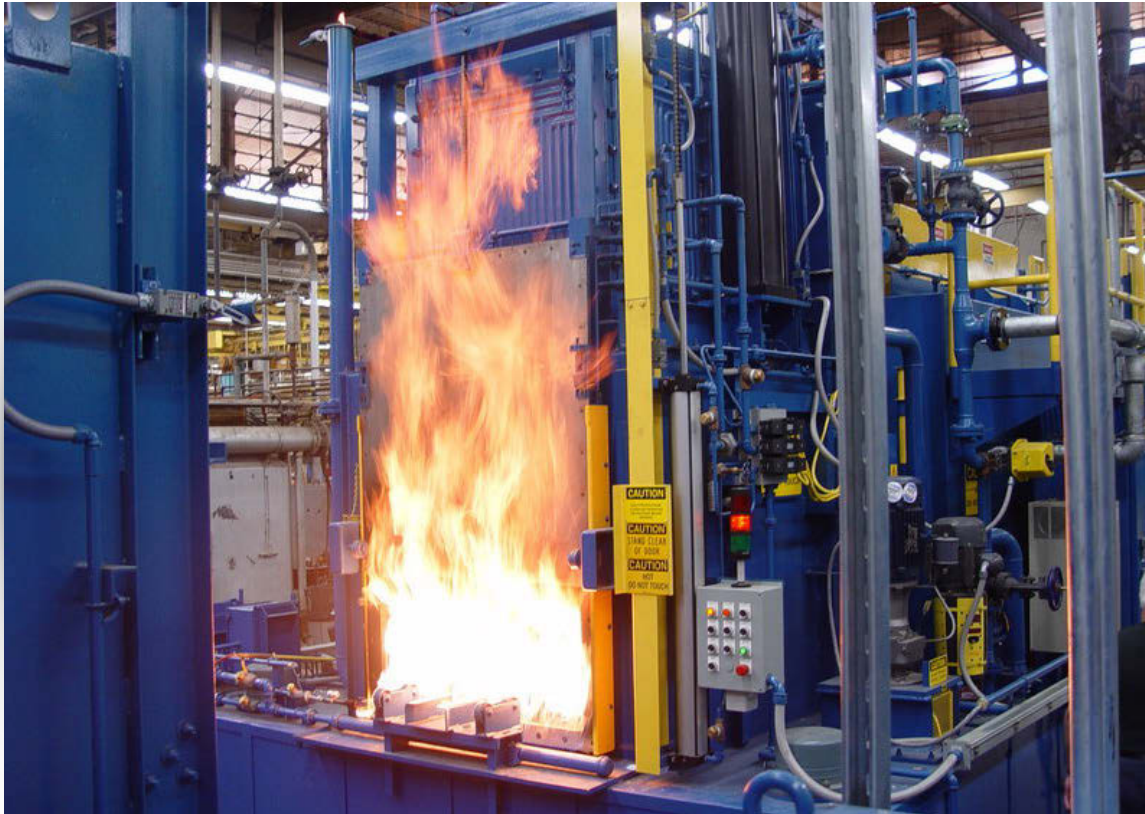
- Specialist technology giving high hardness below the surface compared to atmospheric carburising
- Clean, vacuum process with minimal distortion and improved material properties
- Environmentally-friendly

Gas Nitriding

- Thermochemical surface hardening process – diffuses nitrogen into surface without affecting core material
- Significantly improves wear resistance and fatigue life
- Environmentally-friendly
- Related process: CiD[®] - provides an added benefit of corrosion protection

Classical atmospheric carburising vs LPC

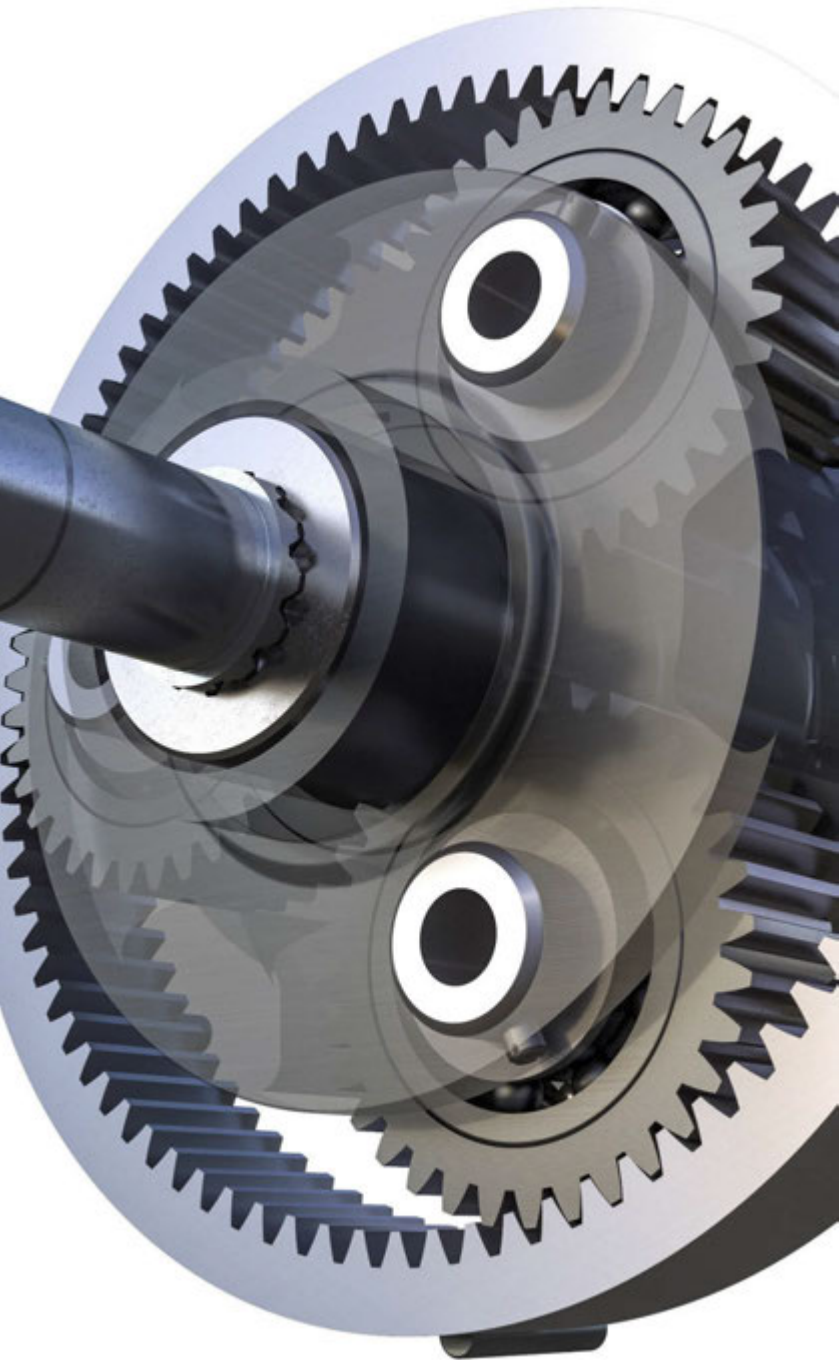
LPC similar to atmospheric carburising, but done under vacuum



Atmospheric carburising



Low Pressure Carburising (LPC)



LPC

Technical advantages

- **Increased durability**
Better fatigue characteristics, resulting in a longer product life
- **Lower distortion and more dimensionally consistent**
Minimising the need for post-heat treat machining and reducing total overall cost to manufacture
- **Cleaner components**
No post-treatment cleaning required, reducing total overall cost
- **High barrier to entry**
LPC is more technically challenging to run than alternate processes, and has a high capital entry cost

Gas Nitriding & CiD®



Gas Nitriding

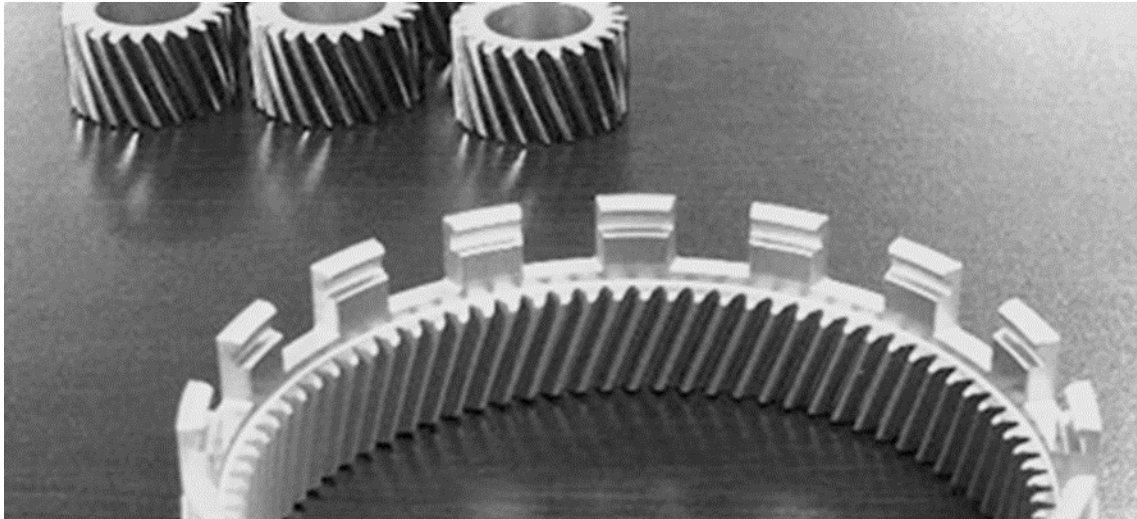
- A low temperature thermochemical surface hardening process
- **Nitrogen** is added to the surface of steel using ammonia as the source resulting in a very hard surface
- It provides a surface that is resistant to wear for applications subjected to heavy loading where corrosion is not an issue

CiD®

- A low temperature thermochemical surface hardening process
- In addition to nitrogen it adds **carbon** and a stable **oxide layer** to the surface of steel
- It provides a surface that is resistant to wear for low-load applications and it also provides the added benefit of **corrosion** protection

Gas Nitriding & CiD®

Technical advantages



Transmission ring gear – Nitrided

Gas Nitriding – Reduced wear and contact fatigue

- In powertrain components, such as planetary ring gears that are immersed in oil, where non-corrosive sliding wear and contact fatigue are issues



Brake pistons – without and with CiD®

CiD® – Reduction in warranty costs

- In exposed chassis components, such as brake pistons, where corrosion and sliding wear are issues



Change brings opportunity



- Growth in continuously variable transmissions (CVTs) for PHEVs provides extra sales opportunities
- In time, transmission technologies for BEVs will provide even greater sales growth from increased market share through LPC, gas nitriding and CiD®

...and also, some OEMs likely to offload conventional classical heat treatment for ICE engines to Bodycote when they transition to new BEV product offerings

CAPITAL MARKETS DAY

2019

