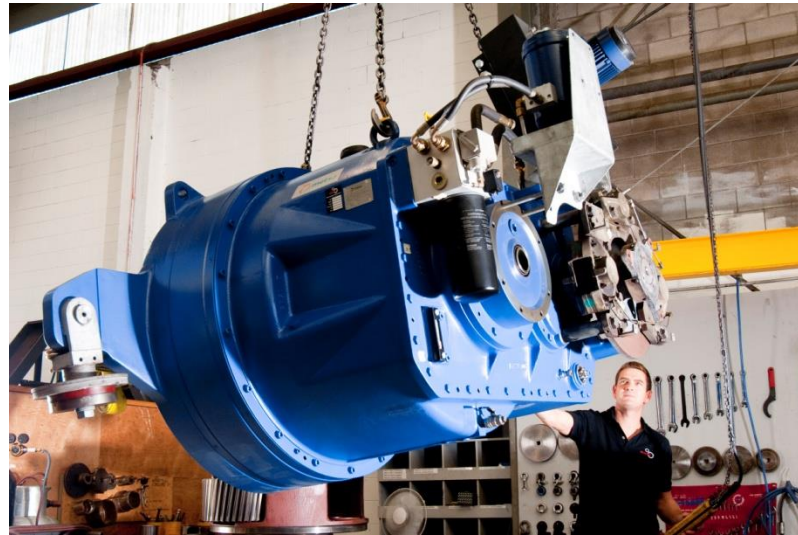


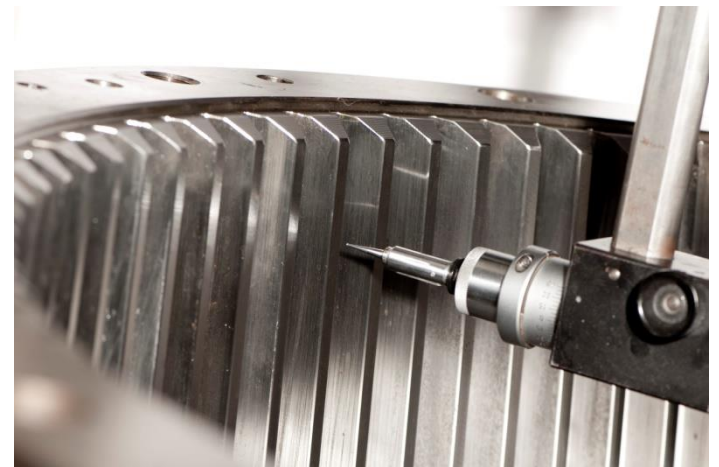


Maximising the potential of your Wind Turbine Gearbox



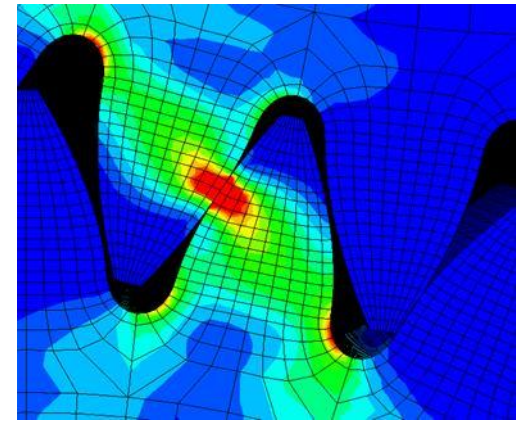
Introduction

- ▶ Background into Gearbox Design
- ▶ Gear Failure Modes
- ▶ Gearbox Condition Monitoring Methods
- ▶ How Wind farm Operators can influence gearbox life?
- ▶ Case Study – Yaw Drives



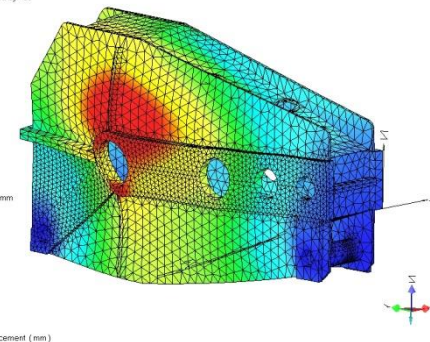
What does a designer consider when calculating gearbox life?

- ▶ What has changed in 100 years
- ▶ Load Table – Accuracy and relevance
- ▶ Deflection and Running accuracies
 - ▶ Tooth and Shaft Deflection
 - ▶ Torsional Windup
 - ▶ Bearing Clearances
 - ▶ Machining tolerances
- ▶ Powerful simulation software available for accurate life calculations



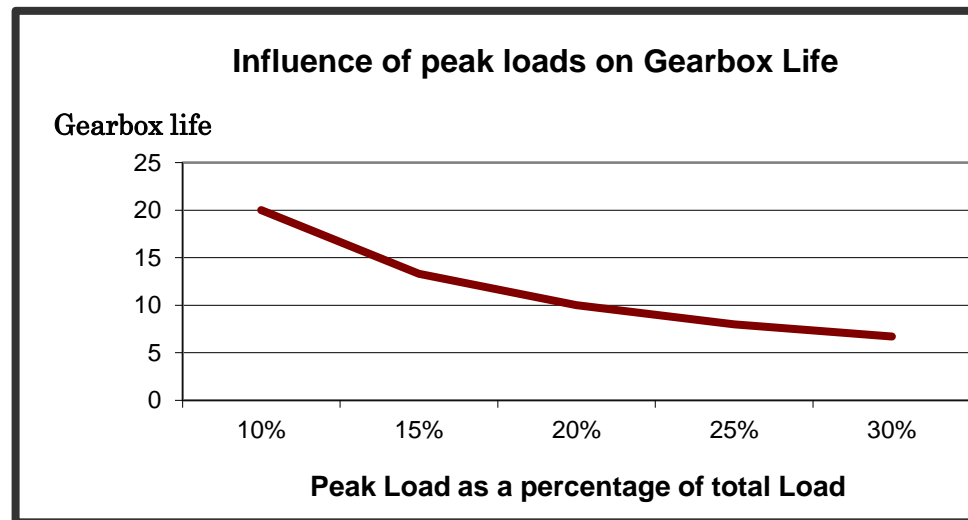
Deformations scaled by 489
Load Factor = 1

Max. Value = 0.291 mm
0.255
0.238
0.221
0.204
0.187
0.17
0.153
0.136
0.119
0.102
0.085
0.068
0.051
0.034
0.017
0
Delta_MAG Displacement (mm)



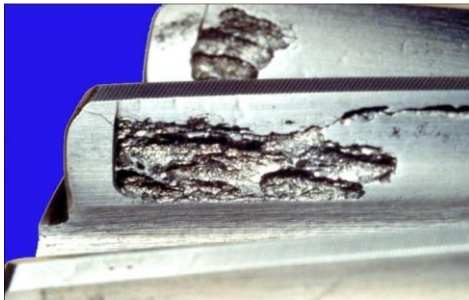
New Zealand Versus European Conditions

- ▶ Higher average wind speeds
- ▶ Greater Capacity Factor
- ▶ More Turbulence
- ▶ How does higher loads effect gearbox life

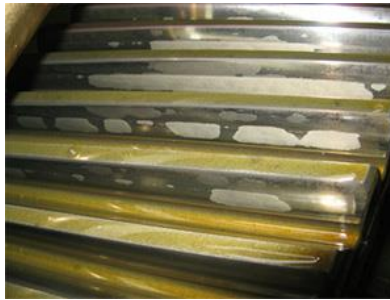


Gear Tooth Failure Modes

- ▶ Classes of Failure
 - ▶ Overload – Sudden due to shock load
 - ▶ Bending Fatigue – Low Cycle or High Cycle $>10,000$
 - ▶ Hertzian Fatigue – Macro and Micro Pitting
 - ▶ Wear – Mechanical, Chemical or Electrical
 - ▶ Scuffing – Metal Adhesion from one surface to another
 - ▶ Cracking – Material flaws or improper processing



Macropitting



Micropitting

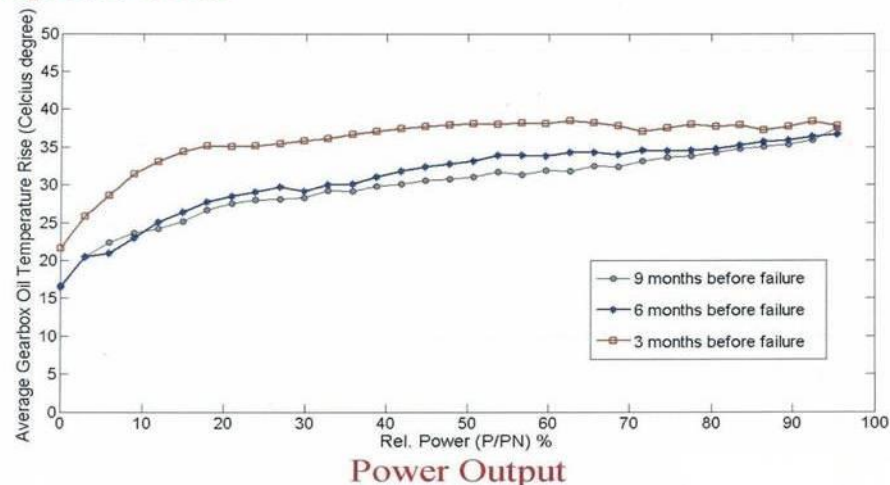


Bending Fatigue

Gearbox Inspection Methods

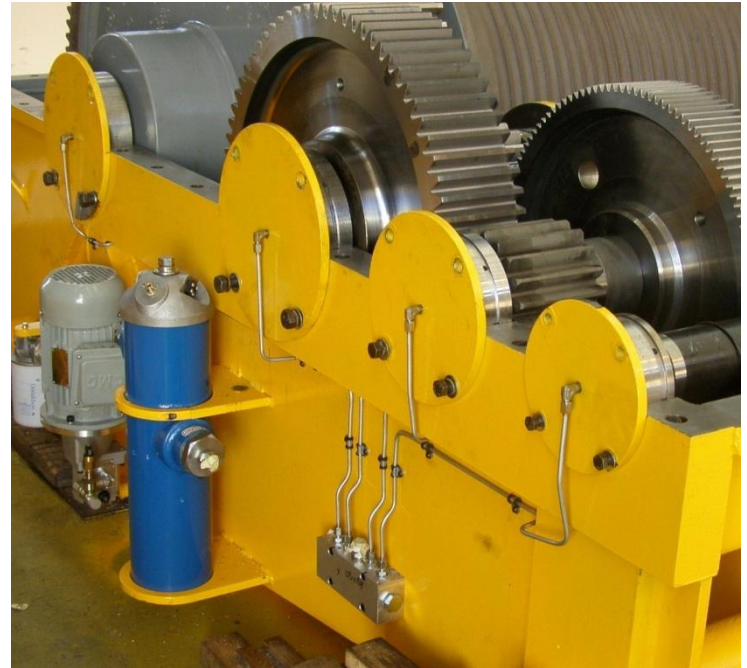
- ▶ Magnetic – Dip stick and sump outlet
- ▶ Oil Sampling – Before and after filtration
- ▶ Vibration Monitoring – Intermediate and high speed stages
- ▶ Endoscope – Planet Bearings
- ▶ Scada Analysis – Low power efficiencies

Oil Temperature Rise



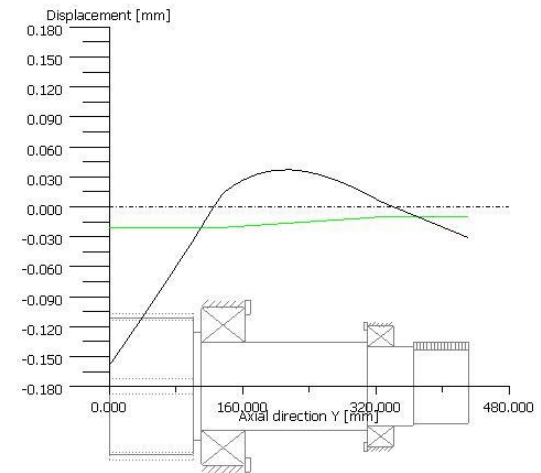
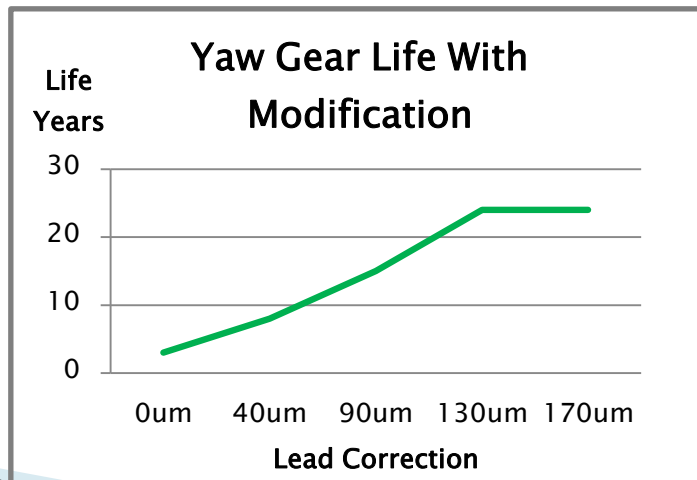
How can wind farm operators influence the life of a Gearbox?

- ▶ Before Refurbishment
 - ▶ Loads – Reduce input power
 - ▶ Oil – Quality and Viscosity
 - ▶ Filtration
- ▶ During Refurbishment
 - ▶ Minor gear tooth modifications
 - ▶ Internal lubrication distribution
 - ▶ Bearings



Case Study – Yaw Drive Modification

- ▶ Typically cantilevered pinion design
- ▶ Deflection varies with load
- ▶ Life of yaw gear increase with lead modification





The End

