Draft Thesis Chapters

**Introduction**

**Chapter 1 - Literature Review**

* Current state of the art high-speed bearing models
* Elastohydrodynamics
* Dynamic models

**Chapter 2 – Experimental and Numerical Tribodynamic Analysis**

* Using experimental high speed bearing test rig to obtain boundary conditions for tribological models.
  + Introduction of rig
  + Tribological Model
  + Numerical EHL model
  + Results
  + Conclusion
* Conclusion:
  1. Identified the need for implicit inclusion of the EHL lubricant film based on the operating conditions of electrified powertrains – low load, high speed.

**Chapter 3 - Flexible Lubricated Bearing Model**

* Numerical tribodynamic analysis using component model inside simple flexible shaft/housing system
  + Methodology
    - Component level model methodology
    - System level model methodology
    - Co-simulation methodology
    - Co-simulation (code coupling multi physics approach)
  + Results
    - Dry vs lubricated comparisons
    - Detailed lubrication analysis – EHL distributions, EHL regime, friction
  + Validation
    - Adapt current rig to better match the simple flexible shaft model and validate if possible
* Conclusion:
  1. Numerically shows the necessity of having a lubricated bearing model and flexible multi-body dynamic modelling
  2. Introduces the co-simulation methodology of implementing this in a flexible multi-body environment.
  3. First time incorporating high speed lubricated bearings with flexible multi-body analysis
  4. Explains the necessity of flexible systems to capture dynamic response of system and interactions of all system components

**Chapter 4 – System Level flexible multi-body dynamics including lubricated bearing model**

* Numerical tribodynamic analysis in a high-speed flexible system level model.
  + Introduce system level model – gears and motor
    - Introduce excitation of gear pair and electromagnetic excitation
    - Add friction as reaction torque
    - Shows interaction with gears and electromagnetic excitation
* Acoustic analysis
  + Flexible MBD allows for acoustic analysis of the transmission and motor housing
    - Dry vs lubricated analysis and effect of this on acoustic levels and frequencies
* Conclusion:
  1. Shows the effect of a lubricated bearing model on a full system level model
  2. Observer effects of

**Chapter 5 – Durability Analysis**

* Sub-surface stress analysis of the contact based on EHL distributions and sub-surface stress model.
  + Show benefits of lubricated models and full numerical EHL for life prediction.
  + Pitting wear and cyclic life predictions
* Conclusion:
  1. Shows the benefit of accurate contact load prediction coupled with EHL to obtain pressure, film, and viscosity distributions.
  2. Pressure profile differs with lubricated compared to dry Hertzian assumption, therefore sub-surface stresses are affected

**Chapter 6 - Numerical EHL predictions using Machine Learning**

* Using machine learning to predict film and pressure distributions in EHL contacts.
  + Explicit inclusion of numerical EHL (AI generated) in dynamic model if possible.
* Conclusion:
  1. Numerical EHL is a time-consuming process. This is, however, required for the analysis proposed in the thesis. Machine learning can make the

**Chapter 7 - Conclusion and Future Work**

**Validation**

* EHL Model
  + Validated against open literature (Khonsari and other case studies)
* Experimental and Numerical Tribodynamic analysis
  + Experimental rig used for boundary conditions (displacements)
* Flexible system level model
  + Strive to validate using high speed rig and flexible bearing brackets
  + Replicate content of Chapter 3 on rig