# PhD in failure models and tools for wind turbine transmissions

## *Investigation into bearing failure modes and their effect on lifetimes of gearbox bearings*

For a typical wind turbine, 20% of the downtime is due to gearbox failures, the majority of which initiate from bearings [1]. Most bearings fail within 10 % of their lifetimes predicted by current standards [2]. This PhD will investigate the causes of these failures and develop bearing failure models.

**Importance to industry**

- Identifying failure modes will lead to understanding of why bearings are failing prematurely.
- Bearings can be redesigned or used differently to increase their lifetime and ultimately the reliability of wind turbines.
- Improved reliability will lead to additional investment in the industry and wind energy will come at a lower cost.

**Critical Failure Modes to be investigated**

1. Overload impact leading to premature spalling

Premature failure by spalling has been observed well within expected bearing lifetimes. It is hypothesised that impact torque loads are the cause of this [3]. Overload impact occurs over a short time period, leading to localised subsurface heating, altering the steel microstructure. Stress fields build up around these areas and fatigue damage occurs at a lower threshold and over a less time [4].

2. White structure flaking

It is thought that overload impact may lead to WSF and it is possible that the two should be considered a single failure mode. Areas of altered microstructure could lead to brittle white structure development called a white etching area (WEA). If this WEA propagates to near the material surface, it may be weakened sufficiently to initiate spalling failure [2].

3. Slipping and skidding leading to smearing

When a bearing is lightly loaded and rotating at high speed, the friction between the roller elements and the raceways may be less than the resistance force caused by friction and lubricant drag. In this case, the rolling element and raceway surfaces will be moving at different speeds, causing the roller to “skid” along the raceway surface [5]. In a high-speed bearing, the rolling elements are additionally loaded against the outer raceway by a centrifugal force, leading to metal-to-metal contact. If the rollers are not rotating as intended, smearing is likely to occur on the outer raceway in high speed bearings [6].

**Figure 1: Spalling caused by WSF**

**Figure 2: White etching cracks**

**Figure 3: PhD outline plan**

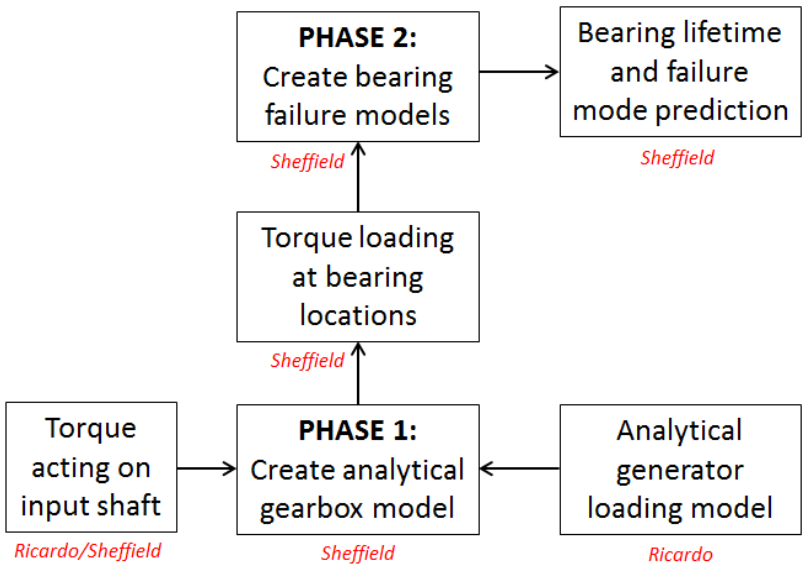
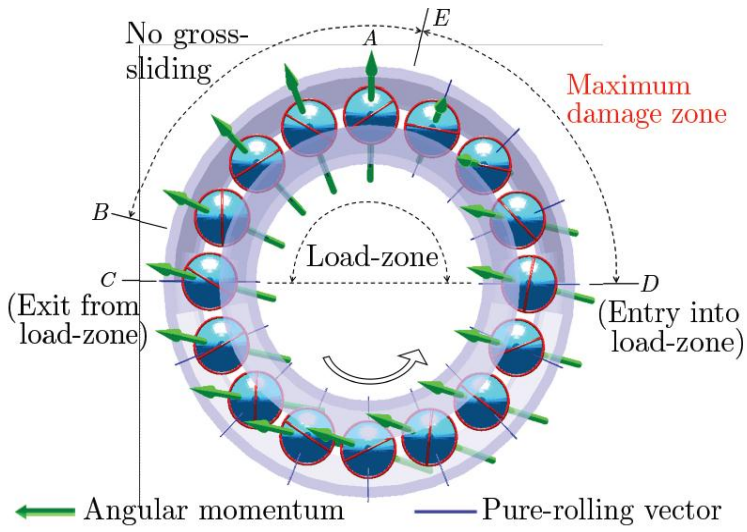



**Figure 4: Skidding process in roller bearings [1]**





**References**

[1] S. Jain and H. Hunt, "A dynamic model to predict the occurance of skidding in wind turbine gearbox bearings," in *Journal of Physics: Conference Series 305*, Cambridge, 2011.

[2] M. -H. Evans, "White structure flaking (WSF) in wind turbine gearbox bearings: effects of 'butterflies' and white etching cracks (WEC)," *Materials Science and Technology,* pp. 3-22, 2012.

[3] S. Sankar, M. Nataraj and V. P. Raja, "Failure Analysis of Bearing in Wind Turbine Gearbox," *Journal of Inforamtion Systems and Communication,* pp. 302-309, 2012.

[4] J. C. Wheals, "Wind Turbine Reliability Improvement," Ricardo, Leamington Spa, 2012.

[5] T. S. Nisbet and G. W. Mullett, Rolling Bearings in Service: Intepretation of Types of Damage, London: Hutchingson Benham, 1978.

[6] G. L. Doll, "Tribological Challenges in Wind Turbine Technology," 2011. [Online]. Available: http://www.nrel.gov/wind/pdfs/day1_session0_3_uakron_doll.pdf. [Accessed 22 08 2011].



**Project Supervisors**

Dr Hui Long: h.long@sheffield.ac.uk

Prof Rob Dwyer-Joyce: r.dwyer-joyce@sheffield.ac.uk

**Author**

Tom Bruce: t.bruce@sheffield.ac.uk