Master thesis -

Influence of hydrogen on the formation of white etching crack on a dual hardening steel for bearing applications

Background

The energy sector is experiencing rapid growth in renewable energies, particularly with wind turbines and offshore wind farms. In the European economic area, plans aim to increase installed capacity to 397 GW by 2030 [1]. This target supports Europe's climate and energy goals, which include a significant reduction in gas emissions by 55%. However, meeting these ambitious goals presents challenges, especially in the wind turbine sector.

One major challenge is the issue of degradation of mechanical properties and rolling contact fatigue (RCF) in turbine bearings. RCF causes microstructural changes in the material, leading to altered mechanical properties and the initiation of fatigue and cracks. A specific concern is the formation of white etching cracks (WECs), which are particularly problematic in hydrogen-rich environments. These cracks can propagate to the surface, resulting in white structure flaking (WSF), and ultimately compromising the efficiency and longevity of wind turbines [3] [4] [5].

Hydrogen can be generated due to factors like lubricant degradation, standstill corrosion, water ingress, and exposure to hydrogen gas. For example, research has shown that WSF can form from hydrogen release during lubricant degradation, promoted by high slip and boundary lubrication [6]. This degradation, through tribo-chemical reactions with the steel surface, produces hydrogen and other products [7] [8].

In corrosive environments like those with water in the lubricant, hydrogen generation speeds up, especially during RCF, leading to WECs formation. Corrosion reactions with electrolytes can form an oxidized layer, potentially acting as hydrogen sources in bearing steels. Additionally, water modifies lubricant behavior, leading to degradation and hydrogen production. Addressing these factors is crucial for mitigating WECs and improving the reliability of wind turbine bearings [9].

To address these challenges, novel materials are required to withstand the harsh conditions encountered by rolling element bearings, particularly in hydrogen-rich environments. Hybrid 60, a new alloy steel with low density and high strength, emerges as a promising candidate. Recent research indicates that Hybrid 60 exhibits superior microstructural stability under RCF compared to conventional bearing steels [11]. Additionally, Hybrid 60 is less sensitive to hydrogen during rotating bending fatigue, making it a potential alternative for rolling element bearings [12] [13].

Aim

The specific objectives of this project are to:

- Develop a method for hydrogen charging of steel samples, trough lubricant degradations, water contamination or electrochemical charging.
- Investigate the microstructural and mechanical degradation of Hybrid 60 steel when subjected to hydrogen environments.
- Feasibility to apply the methodology for RCF applications.

Activities and project timeline

Activity	2024/2025				
	Month 1	Month 2	Month 3	Month 4	Month 5
1. Literature survey					
2. Equipment design and implementation of Hydrogen charging- KTH					
3. Sample preparation for hydrogen charging - KTH					
4. Hydrogen measurement in samples- KTH					
5. Mechanical properties characterization in charged samples- Ovako					
6. Material characterization and analysis- Ovako/KTH					
7. Thesis writing					
Plant visits & trials Ovako		*	*	*	

Starting date: As agreed in autumn 2024 or beginning of 2025.

Duration: 5 months
Location: Ovako (Hofors) and KTH
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Examiner: Peter Hedström

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