NEW SOLUTION TO PREVENT EXCESSIVE WEAR IN WIND TURBINE GEARS

TRACK OR CATEGORY

Wind Turbine Tribology

AUTHORS AND INSTITUTIONS

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INTRODUCTION

The wind rose distribution generally have more than 60% of the time averaged at the position of lower wind speeds in the wind turbine power curve, called the pitch zero degree position. At low wind speeds the pitch system works at the 0º position without movement. When the wind turbine approach its nominal power the pitch system starts to actuate which induce oscillations into the system due to the continuously moving pitch as the thrust and the wind speed changes. The dynamic operation during long periods in the same position reduces the lubricant thickness between the teeth and consequently causes direct contact between the two metal surfaces. This factor together with the lower crown surface hardness causes wear as defined in ANSI/AGMA 1010-E95; 1995 [1].

Patented solutions to minimize the gear wear at specific points like the 0º pitch position exists. The proposed solutions essentially tune parameters such as surface state [2-3], stress, mechanical contact [4] and tribology [5-7]. However, the solutions presented in Refs. [2-3] cannot eliminate the preventive maintenance, while the solutions in [4-5] require expensive parts in form of another pinion and a compressor. The solution in Ref. [6] requires a stop of the turbine which causes generation losses, and the solution in [7] is difficult to integrate in ongoing wind turbines due to the necessity of pinion replacement.

METHOD

A distinguishing feature of this new device compared to the solutions introduced above is that it can lubricate the teeth while they are in contact and the wind turbine is generating electricity. The present solution is easy to integrate into all gears distributing the grease homogeneously in the tooth working flank. Furthermore, this novel device is compatible with the automatic lubrication devices and it can be easily integrated. The main challenge to use a micro-fabricated part is the flow dynamics of grease which for dimensions smaller than 1 mm has not been previously visualized or modeled. Therefore, Micro Particle Image Velocimetry (µPIV) has been used to analyze the flow behavior of a NLGI2 grease in channels possible to integrate in a 12-module gear. Samples of the injected grease were collected and analyzed using infrared spectroscopy and consistency analysis to verify that grease had not degraded during flow in the micro-channel. A novel test bench was built to reproduce the phenomena of the
excessive wear at the 0° position of the pitch. The main factors needed to reproduce the excessive wear due to the wind turbine dynamic operation in the test bench are (cf. Figure 1):

- The blade micro movements caused by the gearbox backlash and the torque caused by the aerodynamic forces of the blade to turn around its axis. To simulate this, a constant torque $M_z$ [8] is preassembled to the blade and a 0.034° oscillation (0.5 mm of backlash in the crown of M12 and Z139) is applied through an electric motor.
- The stress cycle traction and the compression on the blade when the pitch works in the 0° position. This is simulated in the test bench by $M_x$ and $M_y$ at 0.3 Hz to simulate the blade revolution in operation.

![Figure 1: Test bench setup. Yellow arrows shows the movement of the test bench to simulate the wind turbine operation.](image)

**CONCLUSIONS**

![Figure 2: Grease injection with different length of the grease injectors. (a) The grease injectors of 2 cm, 4 cm and 3 cm respectively. (b) The grease](image)
µPIV results show the feasibility of the grease flow in the micro channel and the analytical tests of infrared spectroscopy and consistency analysis that physical and chemical composition of the grease injected remained unchanged after device operation. Moreover the test bench results showed that Injector B guaranteed grease distribution and eliminated wear; see Figure 2.

According to the results, the novel lubrication approach presented in this conference is easy to integrate in the gears, even in all ongoing wind turbine models, and can lubricate pitch 12 module gears used in 2MW wind turbines. Furthermore the presented novel technology allows the wind turbine to lubricate and generate at the same time while the wind turbine is properly lubricated. These are the key differences compared to previous technologies.

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REFERENCES


KEYWORDS
Power Generation, Gears, MEMS Devices, Open Gears, Grease Application, Greases, Abrasive Wear, Corrosive Wear, Oxidative Wear.