NEW LUBRICATION DEVICE TO MINIMIZE WEAR AT THE PITCH GEAR

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1 INTRODUCTION

The wind rose distribution generally has 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 induces oscillations into the system due to the continuously moving pitch when the thrust and the wind speed change. 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 excessive wear as defined ANSI/AGMA 1010-E95; 1995 [1] in the zero position as reports Holierhoek [2].

Patented solutions to minimize the gear wear at specific points like the 0º pitch position exist. The proposed solutions essentially tune parameters such as surface state [3-4], stress, mechanical contact [5] and tribology [6-8]. However, the solutions presented in [3-4] cannot eliminate the preventive maintenance, while the solutions in [5-6] require expensive parts such as another pinion and a compressor. The solution in [7] requires programed stops of the turbine which cause generation losses, and the solution in [8] is difficult to integrate in ongoing wind turbines due to the necessity of pinion replacement.

In spite of these issues, the most used solution is the lubrication pinion presented in [7], therefore the new lubrication device is a complement that can avoid the lubrication programed stops and consequently increase the electricity generation.

2 APPROACH

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, so is a **new solution that allows wind turbines to increase electricity generation**. 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.

3 MAIN BODY OF ABSTRACT

The new device contribute to mitigate the excesive wear at the pitch zero position reported by Holierhoek [2] as a critical failure mode.

To manufacture the new device micro-fabrication technology is used. The main challenge in theses dimensions is the control of the grease flow dynamics in dimensions smaller than 1 mm, which has not been previously studied. Our previous studies [9] showed that the device has an appropriate performance for gear modules greater than 12, commonly used at wind turbines of 2MW. The dedendum free space increases as the gear module increases, so the device will be useful at wind turbines greater than 2MW approximately.

Therefore, to validate the new lubrication device Micro Particle Image Velocimetry (µPIV) is used to analyze the flow behavior of a NLGI grade 1 and 2 greases in channels that can be integrated in a 12-module gear. Samples of the injected grease were collected to verify that grease had not degraded during flow in the micro-channel. Furthermore the influence of the temperature at the lubrication device behavior is validated at temperatures greater than -20ºC using greases NLGI grade 1 and 2, useful for wind turbines that operate under cold climate conditions.

The µPIV results and the cold climate operation behavior are used to define how to integrate the lubrication device in the wind turbine lubrication circuit and define a lubrication strategy to inject fresh grease at the pitch zero degree position

A novel test bench is built to reproduce the phenomena of the excessive wear at the 0º 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 [10] is preassembled to the blade and a 0.034º 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 0º 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.

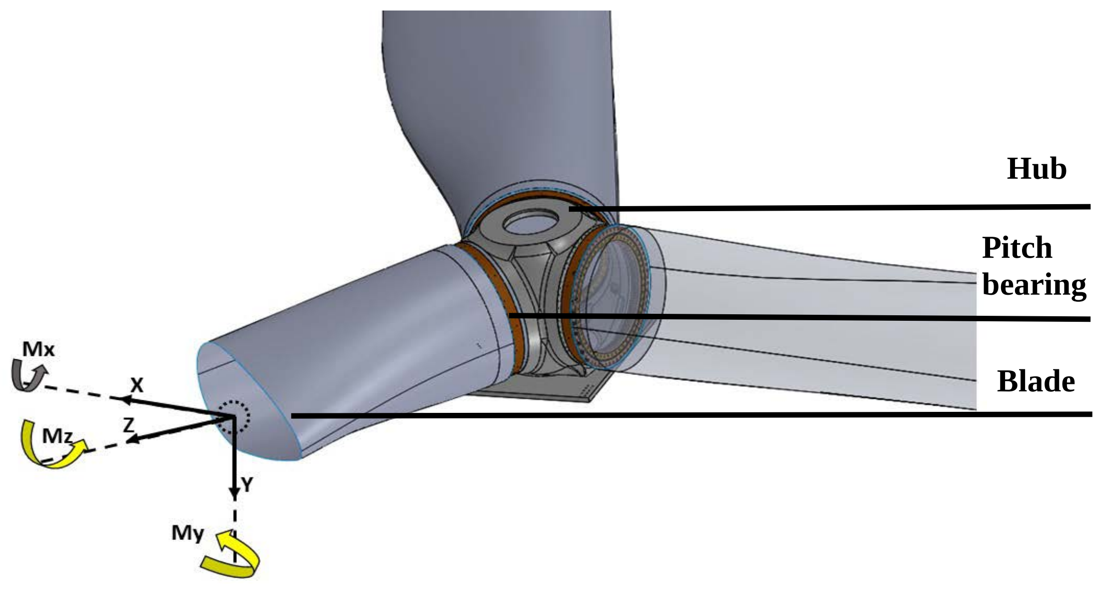

Figure 1: Test bench setup. Yellow arrows shows the movement of the test bench to simulate the wind turbine operation.

4 CONCLUSIONS

This study demonstrates that the novel device can properly lubricate pitch teeth at zero degree position and reduce gears wear while the wind turbine operates. The technology is easy to implement in all ongoing wind turbines and the current automatic lubrication systems. These characteristics improve the low efficiency of current lubrication systems that generates energy generation losses. Furthermore, these losses will increase in future wind turbines; this novel technology is a key element in the contribution to make the new multi megawatt wind turbines more profitable. The technology presented also becomes essential in offshore wind turbines where the maintenance reduction is of high importance.

5 LEARNING OBJECTIVES

A novel wind turbine pitch lubrication solution to mitigate the excesive wear at zero position and reduce gear preventive and corrective maintenance, and as a consequence increase the wind energy generation since the lubrication is done while the wind turbines is in operation.

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