Smart Braking System for Modern Wind Turbines

Introduction

The brake system built in a Wind Turbine (WT) plays a very critical role in keeping WT operate normally and safely. Any malfunctions or failures can lead to some serious consequences and even catastrophe. For example, the crash accident of a Vestas WT happened in 2008 in Hornslet, Denmark, was caused by excessive load from the mechanical brake system which further caused fatal failure of the gearbox.

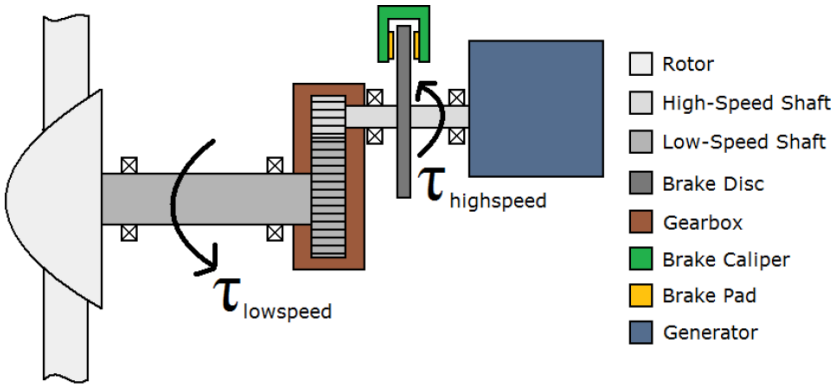

Fig.1 Sketch of a typical WT brake system configuration

Within a typical WT, the brake system consists of an aerodynamic braking system and a mechanical brake system. As shown in Fig.1, the mechanical brake system is normally placed on the high-speed shaft, consisting of a brake disc and a number of calipers driven by a hydraulic system. The aerodynamic brake system uses the pitch control to feather the blades aligned with wind direction so as to brake the rotation. During the entire braking period, both brake systems are employed for braking. One typical (soft-) braking process in terms of rotor shaft torque, blade pitching angle and generator shaft speed is illustrated in Fig.2.

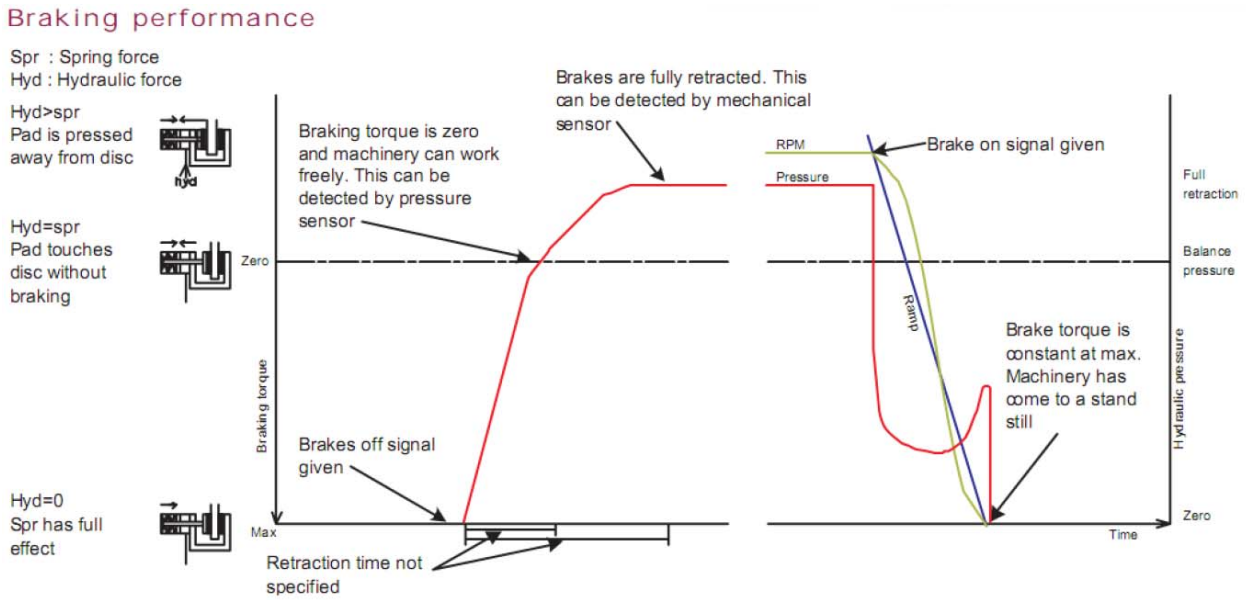

Fig.2 a soft braking performance curve

It's no doubt that the soft-brake system behaviors much better than the hard-brake system, especially regarding the smoothness of the generator speed. The oscillation of the rotor torque is also reduced. Nevertheless, the remaining oscillation of the rotor shaft torque still adds extra stress to the gearbox. Moreover, this oscillation continues for a long while after the generator shaft is stopped. This is mainly due to the fact that all the existing soft-brake systems only take the generator shaft speed/torque into consideration, and no dedicated effort is paid to the rotor shaft side. This phenomenon can be observed in Fig.3.

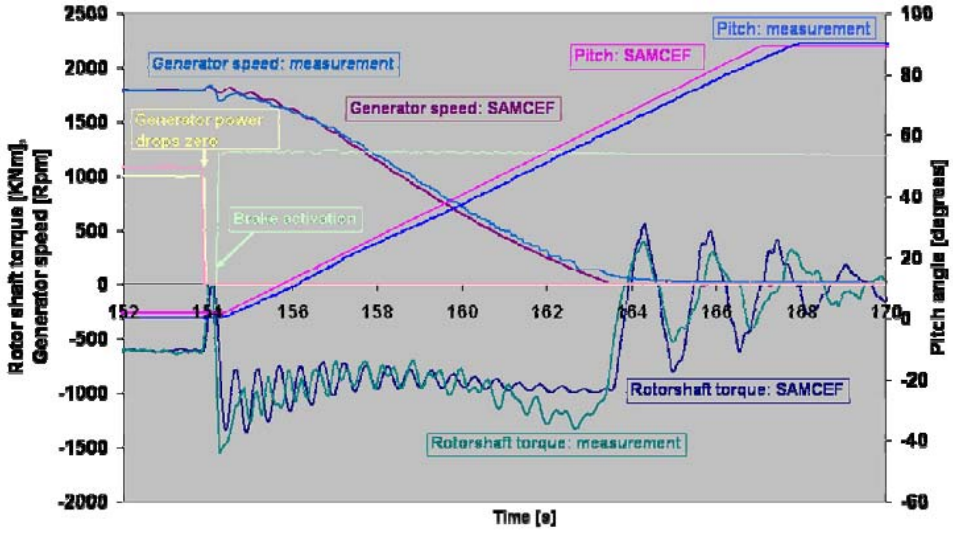

Fig.3 Recorded rotor shaft torque, pitch angle and generator shaft speed during a (soft-)braking

Objective

This research work aims to propose a new electro-hydro-mechanic braking system for WTs, named {\it Smart Braking System (SBS)}. This system includes an intelligent control and monitoring system that commits the braking functionality in a more efficient and reliable way, in terms of smooth braking performance, less fatigue loads to gearbox, and capability of early Fault Detection and Diagnosis (FDD) of the drive-train system.

The SBS acts as a high-level autonomous system. Once the SBS is initiated, it will automatically perceive the operating conditions, calculate the best braking sequence, generate the reference braking torque/speed curve, and carry out the real-time monitoring and FDD as well.

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References

[1] Jepsen, Frank; Søborg, Anders; Yang, Zhenyu. "**Disturbance Control of the Hydraulic Brake in a Wind Turbine.**" In: Energy Conference and Exhibition (EnergyCon), 2010 IEEE International . IEEE Press, 2010. p. 530-535.