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Rain erosion on the leading edge of wind turbines blades

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Introduction

Erosion is defined as the progressive material loss from a solid surface due to repeated impacts of solid or fluid particles. Unlike wear, in erosion, there is a fluid contribution to the mechanical phenomenon that is producing the material loss^[1].



Figure 1: Progressive damage stages caused by rain erosion on leading edge; a) pitting, b) cracking, c) cratering and d) delamination.

Behaviour of rain erosion on leading edge

According the ASTM G73^[2] test standard, the typical erosion exhibit three periods: firstly the incubation period with no significant mass loss, secondly a period with linear mass loss and thirdly a period with random behaviour usually causing catastrophic damage.

Incubation period

- **Surface finishing**
 - Roughness: effect of the different parameters
- **Leading edge protection (LEP) system**
 - Viscoelasticity: capacity of impact energy dissipation
- **Composite substrate**
 - Internal damage: NDT

Linear erosion period

- **Different LEP systems**
 - Gravimetric measurements: comparisons of mass loss and rate
- **Development of new (tribological) variables**
 - More information of test conditions

Random period

- **Composite substrate**
 - Delamination of biaxial material

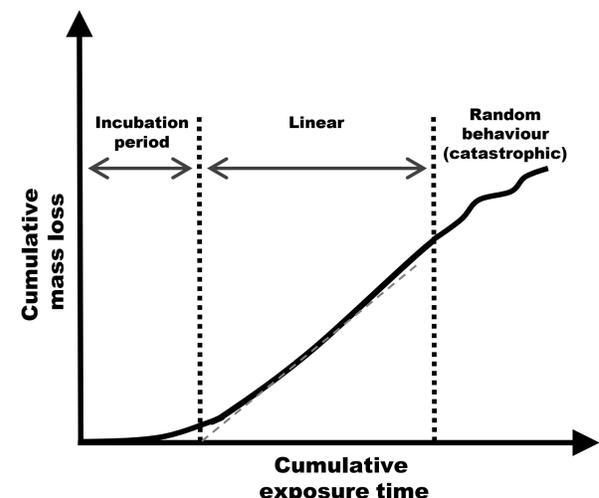


Figure 2: Typical erosion behaviour.

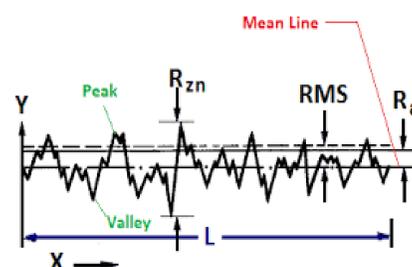


Figure 3: Surface roughness parameters.

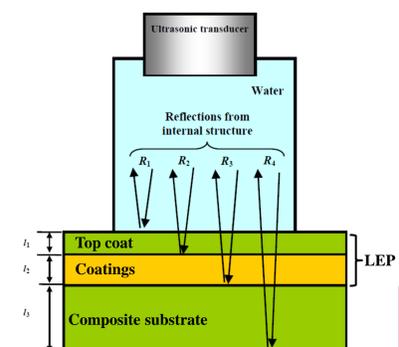


Figure 4: Diagram of NDT measurement on layered system (adapted from [3]).

Conclusions

- The rain erosion is a complex phenomenon dealing with material removal of coating systems.
- The scientific field of the rain erosion lacks of methodologies and parameters to carry out comparisons of experimental results.
- Experimental results with high quality are required to develop semi-empirical models with capacity of prediction of real-life erosion behaviours.

References

- [1] Budinski, K. G. Chapter 10: Erosion testing . *Guide to Friction, Wear, and Erosion Testing*. ASTM International, West Conshohocken (PA, USA) 2007.
 [2] ASTM G73-10, Standard test method for liquid impingement erosion using rotating apparatus. ASMT International, West Conshohocken (PA, USA) 2017.
 [3] Jasiuniene, E., Raisutis, R., Sliteris, R., Voleissi, A., Jakas, M. Ultrasonic NDT of wind turbine blades using contact pulse-echo immersion testing with moving water container. *Ultrasound*. Vol. 63, pp 28-32 (2008)