EROSION MODELING OF 2D HOMOGENISED COMPOSITE MODEL

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INTRODUCTION

➢ **Erosion** – It is the wear process due to the impact of multiple solid particles on the target body.

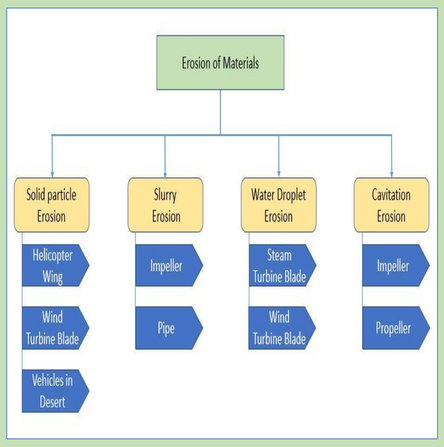


Figure - 1. Types of Erosion

➢ **Factor affecting Erosion –**

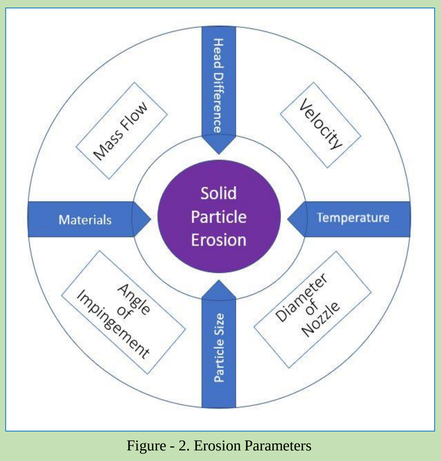


Figure - 2. Erosion Parameters

➢ **Erosion Phenomena–**

Constructive | Destructive

➢ **Theory of Erosion –**

- Ductile
- Semi Ductile
- Brittle

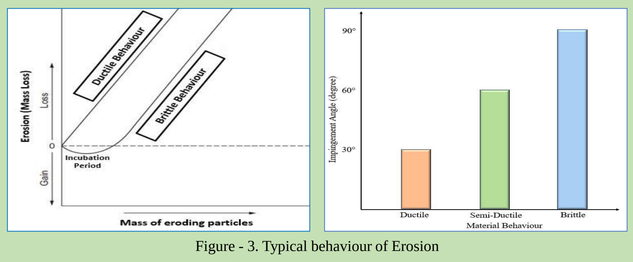


Figure - 3. Typical behaviour of Erosion
https://doi.org/10.1023/A:1019633515481

➢ **Composite Material –**

- Low density
- High Strength-to-weight ratio

⇨
- Reduces fuel consumption
- Improves efficiency

➢ Composites made of unidirectional (UD) glass fiber (GF) is highly erosion resistant than any other composite materials.
https://doi.org/10.1016/0043-1648(81)90337-9

➢ The 2D woven composites possess better elastic properties over the UD composite. It has better resistance to damage, high toughness, etc.
http://dx.doi.org/10.1016/j.compstruct.2019.110990

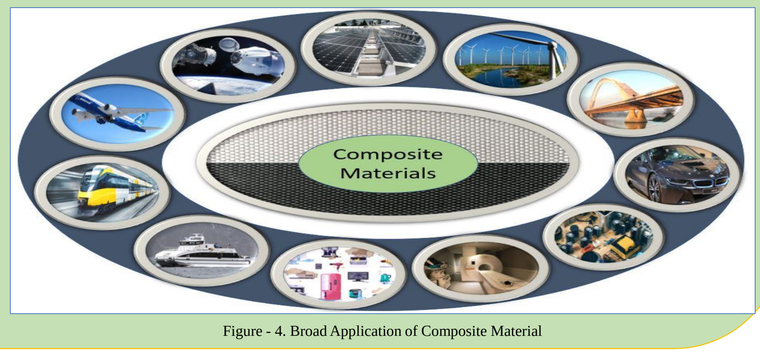


Figure - 4. Broad Application of Composite Material

MOTIVATION

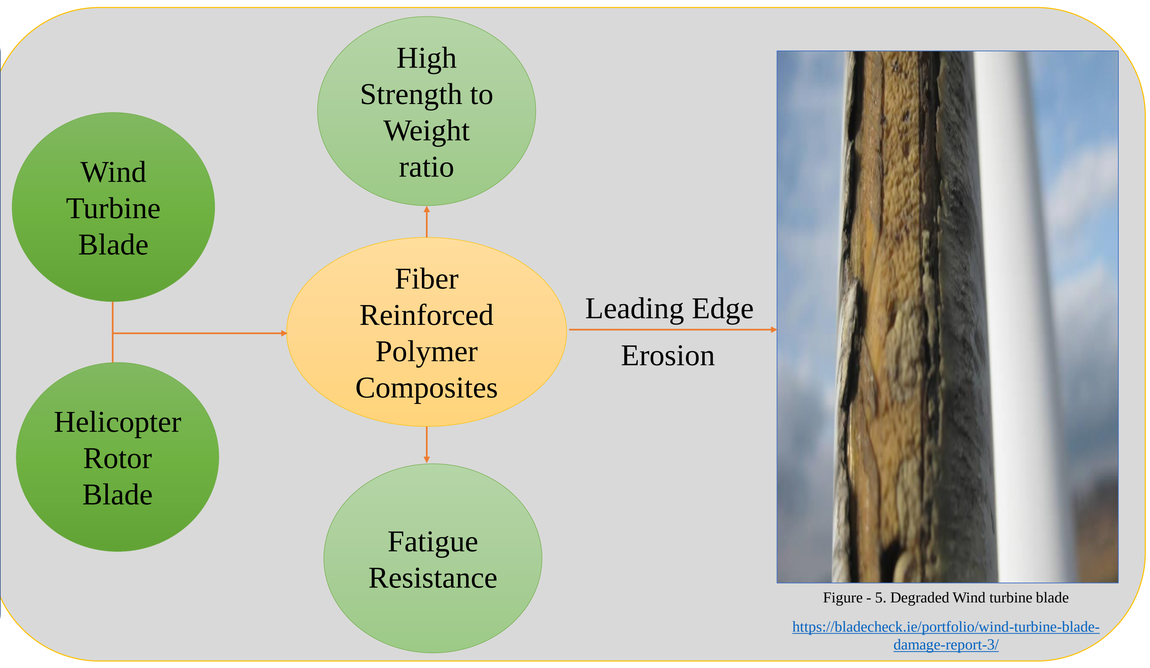
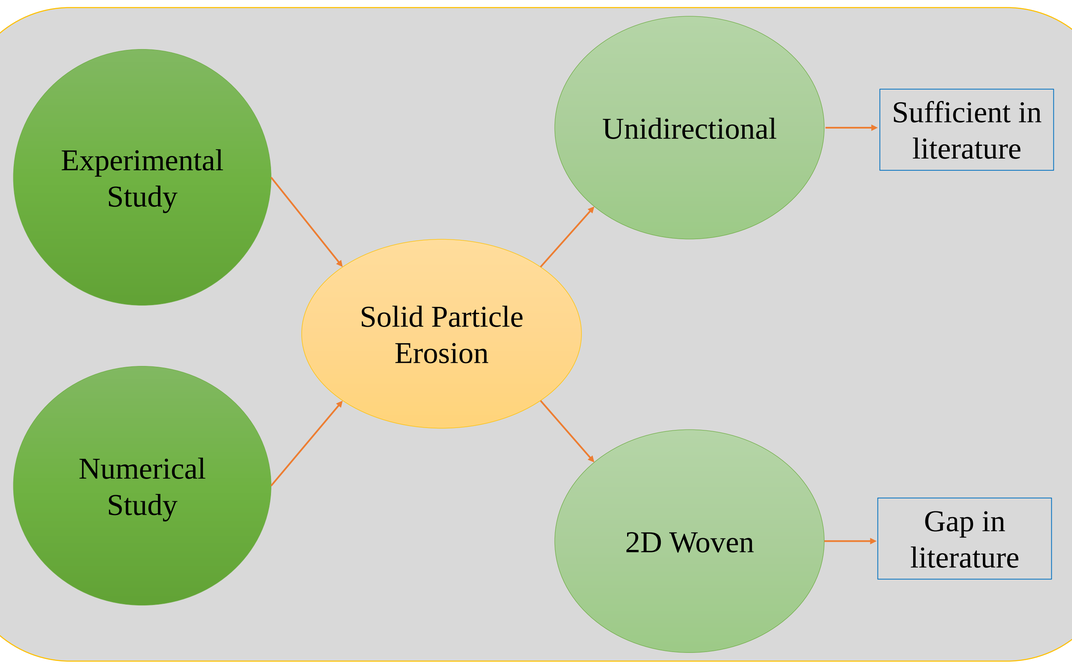


Figure - 5. Degraded Wind turbine blade
https://bladecheck.ie/portfolio/wind-turbine-blade-damage-report-3/

OBJECTIVE



MODELING

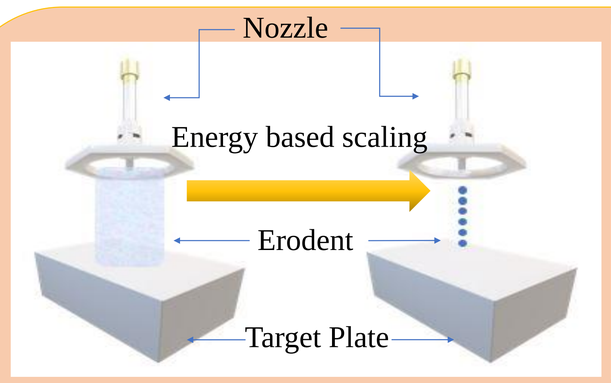


Figure - 6. Scaling of Erodent's for Erosion modeling

$$N_s = \frac{m_e v_e^2}{m_s v_s^2} \cdot \frac{A_s T_s}{A_e T_e} \cdot N_e \quad \text{Equation - 1}$$

$$D = N_s * D_1 * \eta_s * \eta_k \quad \text{Equation - 2}$$

Where, Ns = Number of particle to be modeled
η_s = Substrate property ratio
η_k = Kinetic energy ratio

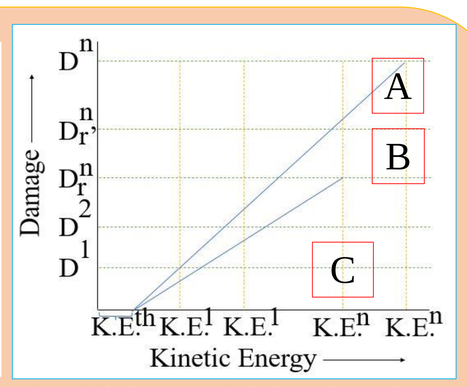


Figure - 7. Plot showing proportionality between damage & kinetic energy

Zone A – Damage reduction due to surface degradation
Zone B – Damage reduction due to the interaction of particles
Zone C – Kinetic energy loss due to interaction of particles
https://doi.org/10.1016/j.wear.2020.203525

Homogenised Composite Model (HCM)

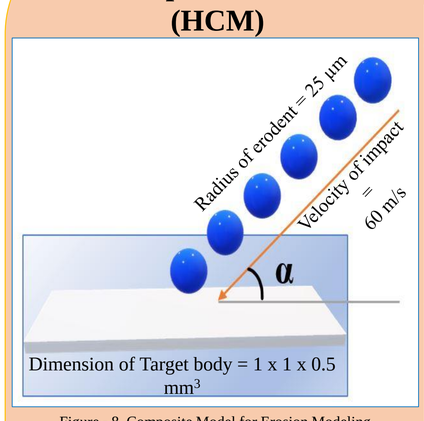


Figure - 8. Composite Model for Erosion Modeling

➢ All five sides of the target body is restrained against deformation except top side.

Material Properties (Woven GFRP)

Limit	Properties	Symbol	Unit	Values
Elastic	Density	ρ	g/cm³	1750
	Modulus of Elasticity	E_{11}	GPa	20.8
		E_{22}		20.8
		E_{33}		8.7
	Modulus of Rigidity	G_{12}		3.92
		G_{13}		4.2
		G_{23}		4.2
	Poisson Ratio	v_{12}	nil	0.173
		v_{13}		0.279
		v_{23}		0.279
Strength	Tensile Strength	σ_{T1}	MPa	250
		σ_{T2}		250
		σ_{T3}		27.1
	Compressive Strength	σ_{C1}		183
		σ_{C2}		183
		σ_{C3}		140
	Shear Strength	τ_{12}		28
		τ_{13}		28
		τ_{23}		28

Table - 1. Properties of Material
https://doi.org/10.1016/S0266-3538(99)00183-9

Convergence Study

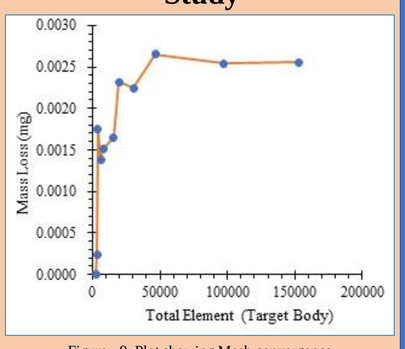
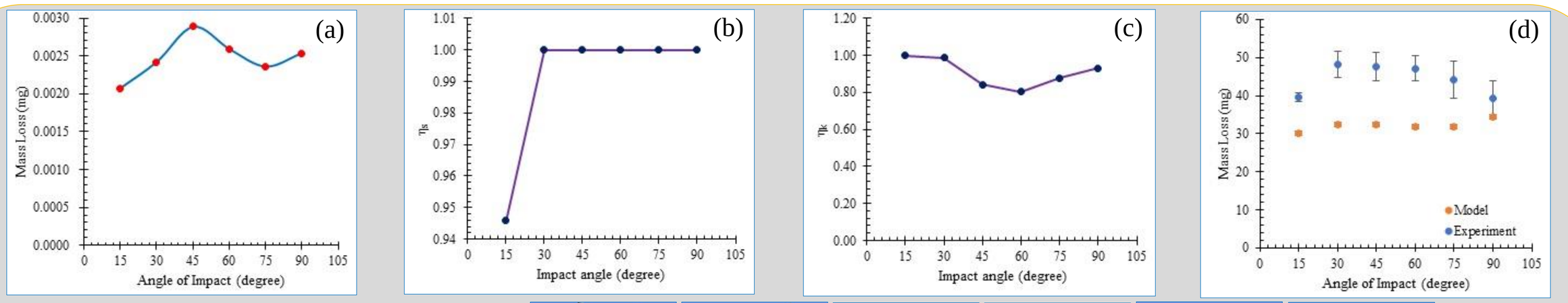


Figure - 9. Plot showing Mesh convergence

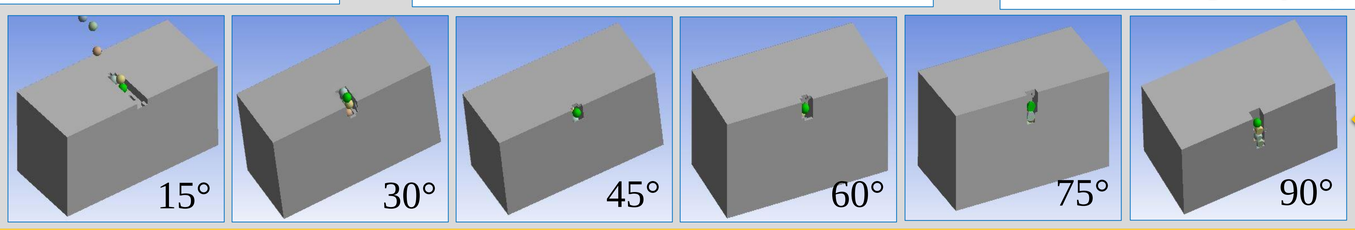
➢ Mesh size = 17.5 µm (linear brick pattern).
➢ The total number of impacts to be modeled (N_s) is 95804 to match the trend with experimental results.

ANALYSIS

RESULTS



(a). Cumulative mass loss with respect to different impact angles.
(b). The plot showing variation of Substrate Surface Property ratio.
(c). The plot showing variation of Kinetic Energy ratio.
(d). Full-scale prediction of mass loss.



CONCLUSIONS

➢ Numerical studies have been carried out to predict the erosion of Homogenised composite models (HCM) made with 2D woven Glass fiber composite.
➢ The maximum mass loss occurs at an impact angle of 30° which shows that the mode of erosion is ductile.
➢ The model is able to capture the trend of mass loss with experimental results.
➢ The prediction of mass loss may have a better fit with experimental results if we use a large number of eroding particles.
➢ The increase in particle-to-particle distance could be another possibility to have a better fit with the experimental results, as interacted particles can cause plastic deformation on HCM.

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