



INTERNATIONAL SOCIETY OF
BIONIC ENGINEERING

Bionic Coupling Brake Hub Inspired from Dragonfly Wing

From Dragonfly Wing to the Brake Hub



The case was provided by the
Individual Member of ISBE (FM129)

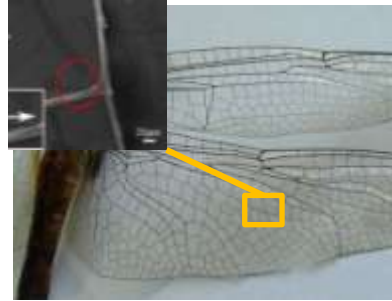
1. Biological prototype



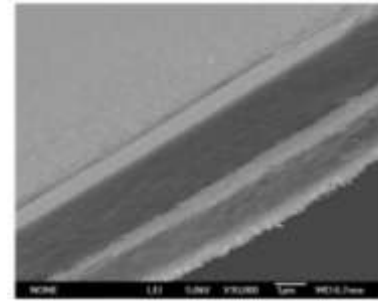
★ The wing of dragonfly (*Sympetrum Flaveolum*) has anti-fatigue performance



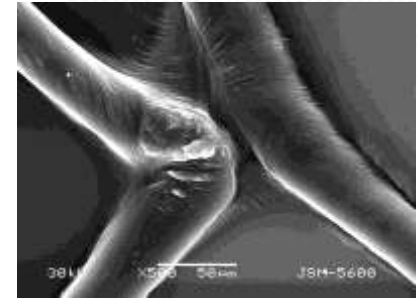
Dragonfly wing shows anti-fatigue property



Venation texture

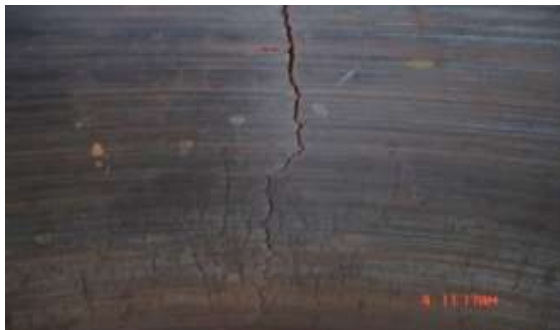


Layered structure



Flexible vein-joints

★ The thermal fatigue crack causes trouble to mechanical parts



Brake hub



Hot working die



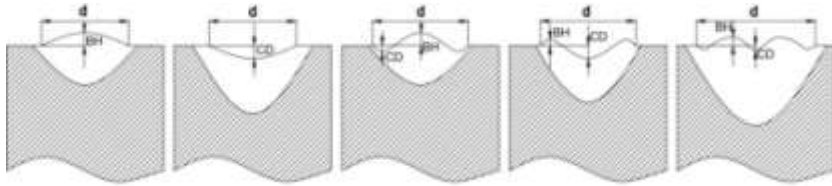
Brake disc

Anti-fatigue property is important for brakes

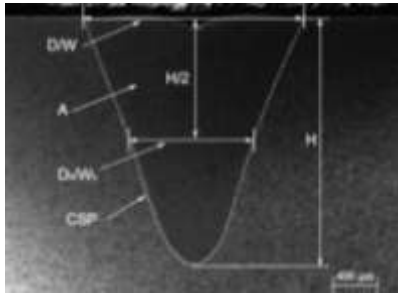
2. Bionic Study



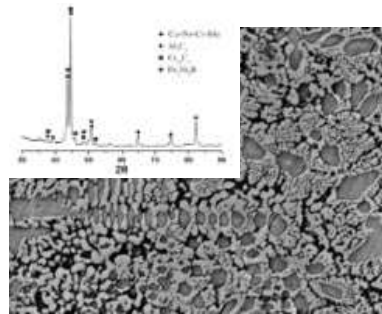
★ Bionic factors



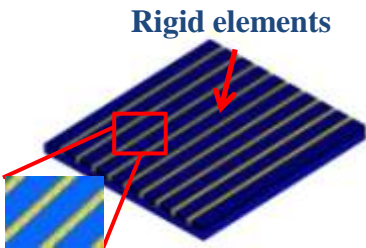
Morphology



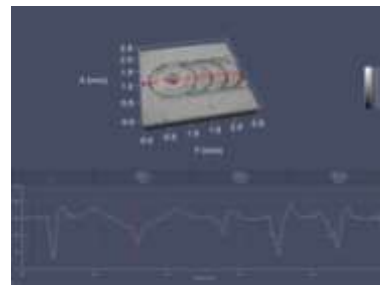
Structure



Microstructure



Rigid-soften alternant



Profile characteristics

★ Anti-fatigue mechanisms

✓ **Stress release effect** —Relieving stress concentration

$$\sigma_S = \sigma_U \cdot f_U + \sigma_M (1 - f_U)$$

✓ **'Dam' effect** —Reducing the growth speed of crack

$$\Delta \bar{k} = \left\{ \hat{D} \cos^2\left(\frac{\theta}{2}\right) + (1 - \hat{D}) \right\} \Delta K_I$$

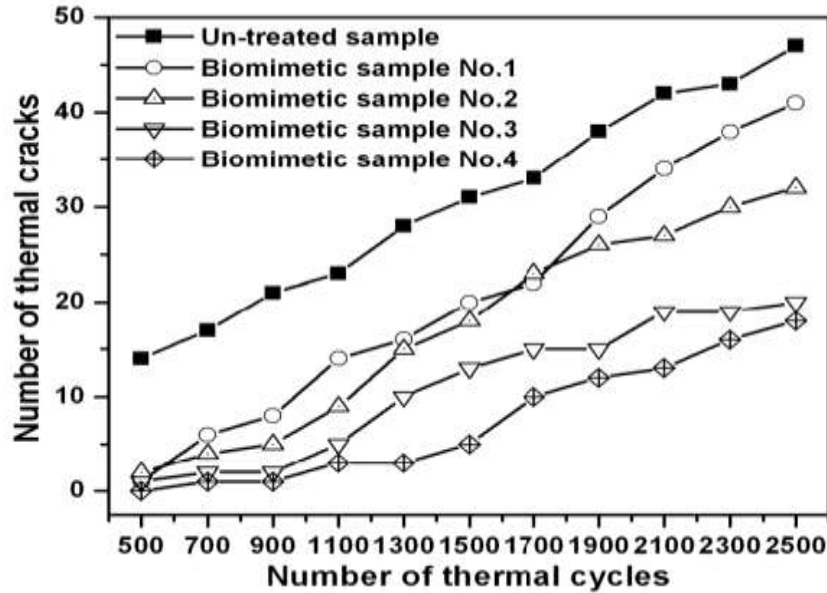
✓ **'Nail' effect** —Improving the absorbed energy of crack propagation

$$\Delta K_{\text{eff}} = Y \Delta \sigma_{\text{eff}} \sqrt{\alpha}$$

3. Design and Processing



★ Thermal fatigue tests



The thermal fatigue resistance of bionic samples is remarkably higher than common ones

Bionic manufacturing system

4. Achievements and Application



★ Application test after 35 thousand kilometers



Application on truck



Common hub



Bionic hub

- ✓ Fatigue life improved **30 percent**
- ✓ Manufacturing cost reduced **6.75 percent**



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The bionic anti-fatigue technique has been applied in heavy truck brakes.

