Thermal Conductivity Calculator for Platelet-Based Composites

1. Introduction

This program is a **web-based computational tool** for predicting the **effective thermal conductivity (k_{eff})** of polymer composites filled with **anisotropic platelet-shaped fillers**, such as hexagonal boron nitride (hBN), graphene, and related two-dimensional materials.

The calculator integrates the effects of:

- Geometrical characteristics of platelet fillers
- In-plane and through-plane anisotropic thermal conductivities of fillers
- Filler volume fraction
- Filler-matrix interfacial thermal resistance (R_i)
- Filler-filler contact thermal resistance (R_c)
- Filler orientation factor ($cos^2\theta$)

It is designed for **rapid evaluation and parametric analysis** of thermal transport behavior in platelet-based composites under multi-parameter coupling conditions.

2. Model Description

The implemented model is based on **unit-cell analysis and equivalent thermal resistance network theory**, and distinguishes two filler loading regimes:

- **Low filler loading regime:** $V_f \leq \frac{d}{2a}$
- **High filler loading regime:** $V_f > \frac{d}{2a}$

Where a is the radius of platelet filler, d is the thickness of platelet filler.

The model independently calculates:

- **Through-plane effective thermal conductivity $k_{\perp}$**
- **In-plane effective thermal conductivity $k_{\parallel}$**

The overall effective thermal conductivity is obtained by orientation-weighted averaging:

$$k_{eff} = k_{\perp} cos^2\theta + k_{\parallel} sin^2\theta$$

3. Input Parameters

3.1 Filler Geometry

Parameter	Description	Unit
a	Radius of platelet filler	m
d	Thickness of platelet filler	m

Both **manual input** and **predefined typical dimensions** are supported.

3.2 Volume Fraction

Parameter	Description
V_f	Filler volume fraction

3.3 Thermal Conductivity Parameters

Parameter	Description	Unit
k_m	Thermal conductivity of matrix	W·m⁻¹·K⁻¹
$k_{f\perp}$	Through-plane thermal conductivity of filler	W·m⁻¹·K⁻¹
$k_{f/\!/}$	In-plane thermal conductivity of filler	W·m⁻¹·K⁻¹

3.4 Interfacial and Contact Thermal Resistance

Parameter	Description	Unit
R_i	Filler-matrix interfacial thermal resistance	m²·K·W⁻¹
R_c	Filler-filler contact thermal resistance	m²·K·W⁻¹

Note: The interfacial thermal resistance and the filler-filler contact thermal resistance can be obtained either from experimental measurements or directly calculated using theoretical or numerical models.

3.5 Orientation Factor

Parameter	Description
$cos^2\theta$	Orientation factor of platelet fillers

Note: $cos^2\theta$ = 1: fully through-plane aligned; $cos^2\theta$ = 0: fully in-plane aligned; $cos^2\theta \approx 1/3$: random orientation approximation.

4. How to Use

1. Open index.html directly in any modern web browser
2. Enter or select all required parameters
3. Click **"Calculate the effective thermal conductivity (k_{eff})"**
4. The calculated result will be displayed at the bottom of the page as: k_{eff}: XX.XX W/m·K

⚠ No message will appear if any parameter is missing.

5. Key Features

✅ **No backend required** — runs entirely on HTML + JavaScript;

✅ Supports both **continuous input** and **engineering-friendly preset values;**

✅ Automatically switches between low- and high-filler-loading regimes;

✅ Explicit separation of in-plane and through-plane thermal contributions;

✅ Independent control of interfacial and contact thermal resistances.

6. Notes and Limitations

- The model is applicable to **platelet-dominated heat conduction composites;**
- In the high-filler-loading regime, results are sensitive to R_i and R_c
- Input parameters should satisfy geometric and physical constraints
- The results are intended for **theoretical analysis and trend comparison**, not as direct substitutes for experimental measurements

7. Typical Applications

- Design of high-thermal-conductivity polymer composites;
- Optimization of platelet filler size and orientation;
- Analysis of interfacial engineering effects on thermal transport;
- Model-experiment comparison and validation.