



Numerical Investigation of the Effect of Geometric Aspect Ratio on the Performance of Fibre-Glass/Talc Epoxy Composite

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Abstract: Numerical investigation of the effect of geometric aspect ratio on the performance of fibre-glass/talc filled epoxy composites used as insulators for the side handles of a domestic pot is carried out in this study. A transient computational fluid dynamics (CFD) model was developed in ANSYS Fluent to simulate coupled heat transfer and buoyancy-driven fluid flow within a partially filled stainless-steel pot subjected to constant heat flux boundary conditions. Ten post-cured composite formulations (50–150 °C) were evaluated across four aspect ratios ($H/D = 0.25, 0.5, 0.75, \text{ and } 1.0$) and benchmarked against Bakelite. Results indicate that geometric aspect ratio significantly affects thermal behavior due to changes in natural convection patterns and heat distribution within the pot. At lower aspect ratios ($H/D \leq 0.5$), selected composites demonstrated superior insulation performance compared to Bakelite, with composite 100-1C exhibiting the highest temperature drop between the heated fluid and handle surfaces. However, at an aspect ratio of 1.0, Bakelite outperformed all composite samples, suggesting that geometric configuration strongly governs insulation efficiency. Generally, the best performing composite at the domestic pot handles as simulated across all aspect ratio was the 100-1C composite. These findings reveal the combined effect of thermal properties and geometric optimization in tailoring insulation efficiency, and Fiber glass talc/epoxy composites can be effective alternatives to traditional insulating materials for domestic uses like cookware, particularly when subjected to applications at lower aspect ratios. Future work should incorporate uncertainty quantification and dimensionless analysis to further strengthen the predictive capability of the numerical model.

Keywords: Aspect Ratio, Bakelite, Computational Fluid Dynamics, Insulators, ANSYS Fluent

INTRODUCTION

Thermal insulation is essential in many engineering systems where heat transfer must be controlled, including domestic cookware, thermal management systems, and industrial processing equipment (Amir *et al.*, 2024; Zhoghao and Kian, 2024). For these uses, we need materials that have low thermal conductivity, good mechanical strength, low weight, durability, and are cost-effective as pointed out by (Basim, 2023; César, 2023). Conventional materials such as Bakelite have been widely adopted for cookware handles due to their moderate thermal resistance and ease of fabrication (Azeem and Zain-ul-Abdein, 2012; Chun-Han *et al.*, 2025). But these older materials often fall short when it comes to strength-to-weight ratio, thermal stability, and long-lasting durability in high-temperature situations according to (Ahmed *et al.*, 2025; steelwareparts, 2025) which has motivated the exploration of alternative materials (Callister and Rethwisch, 2018; Sabbrojjaman *et al.*, 2025). In recent years, polymer matrix composites have been explored by researchers as promising alternatives for thermal insulation

because they can be customized for thermal and mechanical properties (Brijesh *et al.*, 2025; Dobrotă *et al.*, 2025). By adding reinforcements like fiberglass and mineral fillers to epoxy matrices, we can adjust thermal conductivity, specific heat capacity, and diffusivity to fit specific needs (Begum *et al.*, 2020; Zelibe *et al.*, 2021). Epoxy-based composites are particularly suitable due to their strong adhesion, resistance to chemicals, and stability in size and this makes them useful for making lightweight and high-strength composite materials for use in the aerospace, automotive, and marine industries (Baraka *et al.*, 2025; Hamzat *et al.*, 2025). Fibre-glass/talc-filled epoxy composites have demonstrated favorable insulation characteristics arising from the combined effects of low thermal conductivity and phonon scattering induced by filler–matrix interfaces (Feng *et al.*, 2014; Rahima *et al.*, 2015; Adewumi *et al.*, 2021). Recent studies have also emphasized the importance of filler morphology, dispersion, and interfacial bonding in governing heat transfer mechanisms within polymer composites Udebuani *et al.* (2021).

Most past research on polymer composites has been about boosting thermal conductivity for applications such as electronic packaging and heat dissipation systems (Yu *et al.*, 2010; Tan and Yuan, 2024; Jun-Wei *et al.*, 2025). However, fewer studies have focused on the opposite goal of enhancing thermal insulation performance especially for home use and low-temperature industrial applications. In cookware design, the thermal performance of handle materials is particularly important for ensuring user safety while maintaining efficient heat utilization within the vessel according to (Sugeet and Savita, 2022). The thermal transport behavior of polymer matrix composites is fundamentally governed by a variety of factors, such as the type of filler used, the size of the particles, the amount of filler, the orientation of the fibers, the temperature during curing, and the conditions after post curing (Carbas *et al.*, 2014; Siu, 2018; Ramkumar *et al.*, 2023). Post-curing is especially important because it impacts the cross-link density in epoxy matrices, which in turn alters thermal conductivity and specific heat capacity (Sambayi and Heyns, 2023; Zelibe *et al.*, 2026). Additionally, the geometric setup of the system where the material is applied can greatly change how heat is transferred, thanks to shifts in convection patterns and thermal gradients (Mustafa *et al.*, 2019; Burak *et al.*, 2025). In addition to material properties, system geometry plays an important role in heat transfer behavior. The aspect ratio (H/D) of a cylindrical vessel influences buoyancy-driven flow patterns, which can significantly alter temperature distribution within the fluid Omariba *et al.* (2025). While there has been a lot of research on material properties, the combined impact of the thermal properties of composites and the geometry of the vessel on insulation performance has not been explored as much.

Computational Fluid Dynamics (CFD) has emerged as a valuable tool for examining heat transfer in complex shapes. The finite volume method used in ANSYS Fluent allows for precise predictions of temperature distribution, convection currents, and surface heat flux under specific boundary conditions (Zlatko *et al.*, 2012; Wenkai *et al.*, 2018). Previous numerical studies have shown that CFD is effective in assessing composite materials for thermal applications as discussed by (Mazlan *et al.*, 2013; Adewumi *et al.*, 2021; Ganesh *et al.*, 2025; Mohammad, 2025; Zelibe *et al.*, 2026). Despite these advances, limited attention has been given to the combined influence of composite material properties and geometric aspect ratio on insulation performance in cookware applications. Addressing this gap is essential for optimizing both material selection and structural design. Therefore, this study numerically investigates the effect of geometric aspect ratio on the thermal insulation performance of fiber-glass/talc-filled epoxy composites post-cured at different temperatures. The performance of these composites is compared with that of Bakelite to determine the conditions under which they can serve as effective alternatives for domestic pot handle applications.

MATERIALS AND METHODS

2.1 Materials and Composite Preparation

In carrying out this investigation, post cured Fiberglass Talc filled Epoxy Composites fabricated by Omotinuola *et al.*, (2017) were utilized. The fabrication was done by sieving Talc filler into average particle sizes of 75 μm and 106 μm using a mechanical sieve. The fiber glass was cut into short pieces

of approximately equal length, with an aspect ratio of 0.08. Figs. 1 and 2 below show the test sample fabricated which were considered in the numerical investigations carried out in this study.

Table-1 Loading of specimen for 75 microns' filler size

Particle	Epoxy (%)	Fiber glass (%)	Particle (%)	designation
75 microns	100	0	0	A
	90	5	5	B
	80	10	10	C
	80	15	5	D
	80	5	15	E

Table-2 Loading of specimen for 106 microns' filler size

Particle	Epoxy (%)	Fiber glass (%)	Particle (%)	designation
106 microns	100	0	0	A
	90	5	5	B
	80	10	10	C
	80	15	5	D
	80	5	15	E

After fabrication, this Fiberglass talc filled composites were post cured to elevated temperatures of 50°C, 75°, 100°C, 125°C and 150°C at a constant holding time of 120 minutes each.

Table-3 Post cured temperature with constant holding time

S/No.	Curing Temp. (°C)	Holding time (min)
1	50	120
2	75	120
3	100	120
4	125	120
5	150	120



Fig. 1 Cure sample after 24 hours



Fig. 2 Post Cured Samples

These post cured composites were numerically investigated using the computational fluid dynamics tool (ANSYS 15.0) by, *Zelibe et al., (2026)* as thermal insulated insulators for the handles of a domestic pot. Forty of these post cured composites were compared with an existing material used (Bakelite) as domestic handles of a pot. From the result gotten from their investigation, ten (10) of these composites performed better than Bakelite as thermal insulators of the pot handles. A thermal property analyzer (KD2 Pro) was earlier used to get the thermal properties of the composites in their study. *Table-3* shows these 10 Post cured Fiberglass talc filled composites and Bakelite along with their thermal properties.

Table-4 Thermal Properties Composites and Bakelite

Post Cured Temperature	Type	Thermal Conductivity (K) W/m.k	Specific Heat (c_p) Kj/kg.k	Thermal Diffusivity (D) m ² /s	Density(ρ) g/cm ³
50	2E	0.491	2.191	0.224	1.00044
125	2E	0.964	2.654	0.364	0.997872
75	1D	1.913	2.911	0.657	1.000247
"	2B	0.589	3.098	0.190	1.000646
"	2D	1.578	1.543	1.023	0.99969
150	2B	0.613	3.068	0.200	0.999022
"	1D	0.083	0.834	0.100	0.995204
100	1D	0.660	1.676	0.394	0.999479
"	1C	1.618	2.596	0.623	1.000428
"	1B	0.578	2.387	0.242	1.000599
BAKELITE		0.2	0.920	0.200	1.360

where A-E denotes the composite designation percentages of epoxy, fiberglass and talc, the numbers 1 and 2 represents the micron filler sizes in tables (1) and (2); numbers 50, 75, 100, 125 and 150 are the post cured temperatures of each composite.

2.2 Overview of the Pot used for Modelling

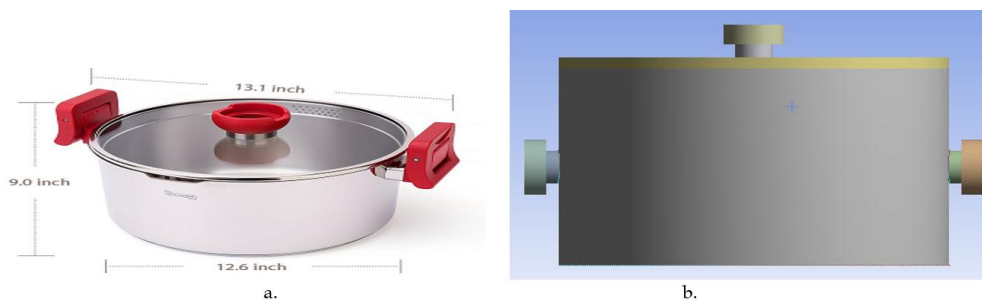


Fig. 3 Geometry to Be Used (a) Model Pot (b) Modelled Pot Using ANSYS CFD Solver

The top handle and side handles of the pot re modelled as insulators, as Bakelite and fiber-glass/talc filled composites. The body of the pot was modelled as Stainless steel ($C_p = 0.468 \text{ kj/kg.K}$; $k = 15 \text{ W/(m.K)}$ and $\rho = 7.9 \text{ g/cm}^3$) and the top cover as glass. Time to complete heating was 600-time steps with a variable time step of 0.001, and Volume of fluid (water) was 7239.168 cm^3 which is to be heated occupies half of the pot. The computational model and grid are generated using ANSYS 15 by, [Zelibe et al., \(2026\)](#). The fluid to be heated is assumed to be incompressible, homogenous and at a single-phase state, with constant thermal properties. The temperature of water at normal state is 0°C and a uniform heat flux of 2 MW/m^2 is applied to the bottom wall. Boundary conditions are applied to the left and right side of the domain.

2.3 Validation of the CFD Code

The validation of this work, is carried out by a simple experiment of measuring the maximum temperature of fluid (water) after it is heated in a pot with a specified heat flux of 2 MW and a measuring thermometer. The result gotten from this simple experiment is compared with the numerical result gotten from the ANSYS platform using the same parameters. Both validations were run for a time of 10 minutes (600-time steps on the CFD solver). The temperature of the fluid after heating for 10 minutes was recorded to be 78°C on the thermometer.



Fig. 5 Experimental procedures (a) heating of fluid (b) measurement of heated fluid

2.4 Grid Refinement Test

For the numerical validation, a grid refinement test was carried out which is applied to select a mesh size with negligible changes in temperature difference ΔT is obtained.

Table-5 Grid Refinement Study

Number of Elements	Maximum Water Temperature (°C)	% Change
45,320	77.42	-
65,658	78.18	0.98%
98,745	78.51	0.42%

A mesh size of 65 658 elements was selected after running the CFD code for a time step of 600. This is because the maximum temperature of water obtained was 78.18°C which was in good agreement with the experimental value already obtained (when compared to other mesh sizes from the grid test), with a percentage difference of 0.23%. Therefore, the mesh elements were selected as the optimal grid for subsequent simulations.

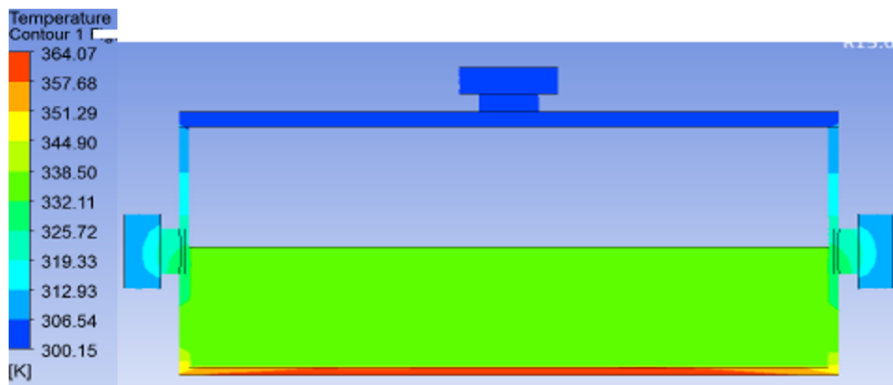


Fig. 6 Pot after 10 minutes of heating from the CFD solver

From what is known of our main geometry from the work done by *Zelibe et al., (2026)*, Height of pot $H = 18\text{cm}$; Diameter of pot = 32cm , therefore, the ratio of the height of pot to its diameter = $18\text{cm}/32\text{cm} = 0.5625$, which is the aspect ratio of the original pot which was investigated. Table 6 shows other aspect ratios of the pot as well as other parameter used in the pot geometry which were considered in this study.

Table-6 Parametrization of the Aspect Ratios of Pot Geometry

Aspect ratio(H/D)	Inner diameter (d)	Outer diameter (D)	Outer height (H)	Inner height (h)	fluid height
	cm	cm	cm	cm	cm
0.25	40.932	41.932	10.483	9.983	5.2415

0.5	32.281	33.281	16.641	16.141	8.3205
0.75	28.074	29.074	21.805	21.305	10.9025
1	25.415	26.415	26.415	25.915	13.2075

Five different aspect ratios of a domestic pot were numerically investigated to ascertain the thermal insulation properties of the ten (10) fiberglass talc epoxy filled epoxy composites and their comparison against existing material Bakelite.

2.5 Limitations

This study is based on numerical modelling with simplified assumptions. The fluid was treated as incompressible with constant properties, which may not fully represent real temperature-dependent behavior. The composites were assumed to be homogeneous, whereas actual materials may exhibit non-uniform filler distribution. Interfacial thermal resistance between components was not explicitly considered, and the applied heat flux represents an idealized condition. Further work should include variable material properties and more realistic boundary conditions to improve accuracy.

RESULTS AND DISCUSSION

The thermal performance of the selected fibre-glass/talc epoxy composites was numerically evaluated for four geometric aspect ratios ($H/D = 0.25, 0.5, 0.75$ and 1.0) using ANSYS Fluent. The maximum water temperature (TW), maximum handle temperatures (LH and RH), and insulation potential ($TW-LH$ and $TW-RH$) were used as performance indicators. Higher $TW-LH$ and $TW-RH$ values indicate better insulation performance.

3.1 Governing Equations

Heat transfer from the hot water to the composite is modelled as a free convection problem. The governing non-linear partial differential equations for fluid flow and heat transfer is shown in Equations (1) to (3). These equations are solved using a ANSYS Fluent computational fluid dynamics tool which employs the finite volume method and results obtained are presented in this section. The fluid is assumed to be a Newtonian incompressible fluid with temperature dependent properties. (Adewumi, 2021).

$$\nabla \cdot \mathbf{V} = 0 \dots \quad (1)$$

$$\rho \frac{D\mathbf{V}}{Dt} = \rho \mathbf{g} - \nabla p + \nabla \cdot (\mu \nabla \mathbf{V}) \dots \quad (2)$$

$$\rho c_p \frac{DT}{Dt} = \nabla \cdot (k \nabla T) + q''' + \nabla \mathbf{V} \cdot \boldsymbol{\tau} \dots \quad (3)$$

At the walls the velocities u , v and w are all zero.

3.2 Numerical Results for the Aspect Ratio of 0.25

The pot is simulated for aspect ratio of 0.25 with only the height and diameter of the pot changed while the volume of the fluid is kept constant. Analysis is run for Bakelite and the ten selected composites.

Table-7 Numerical Results for Composites at Aspect Ratio of 0.25

Composite Type	Temp-Max (T_w)	Temp-Max (LH)	Temp-Max (RH)	T_w-LH	T_w-RH
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	°C	°C	°C	°C	°C
Bakelite	84.03622	66.9056	67.24789	17.13062	16.78833
50-2E	86.60534	66.20648	65.93893	20.39886	20.66641
75-1D	86.37853	63.54489	63.20422	22.83364	23.17431
75-2B	86.19305	64.88766	64.69595	21.30539	21.4971
75-2D	83.97054	64.79101	64.76141	19.17953	19.20913
100-1B	84.0873	64.70992	64.72384	19.37738	19.36346
100-1C	86.5722	63.32195	63.33941	23.25025	23.23279
100-1D	84.71758	65.09115	65.16848	19.62643	19.5491
125-2E	87.33856	65.26531	65.22906	22.07325	22.1095
150-1D	87.24545	68.16424	68.37701	19.08121	18.86844
150-2B	86.75298	65.00005	64.74691	21.75293	22.00607

Results presented in Table-7 indicate that the composite materials generally produced higher maximum fluid temperatures compared to Bakelite. (84.04°C). The highest water temperature was recorded for composite 125-2E (87.34°C), closely followed by 150-1D (87.25°C). while 75-2D recorded the lowest (83.97°C). However, insulation performance is better evaluated using the temperature difference between the water and the handles (TW-LH and TW-RH). Therefore, in terms of insulation performance (TW-LH): the best performing composite was 100-1C (LH insulation: 23.25°C and RH insulation: 23.23°C compared to Bakelite insulation (LH: 17.13°C and RH: 16.79°C). This represents approximately 35% improvement in insulation performance over Bakelite. Although some composites produced slightly higher water temperatures than Bakelite, their superior insulation performance is primarily due to reduced heat conduction toward the handles. The lower handle temperatures observed for 100-1C indicate improved resistance to heat transfer, which is desirable for domestic cookware applications. The results show that at low aspect ratio (wide and shallow geometry), fibre-glass/talc epoxy composites exhibit significantly enhanced thermal insulation capability compared to the existing Bakelite material. Fig. 5 shows the temperature distribution in the simulated domestic pot.

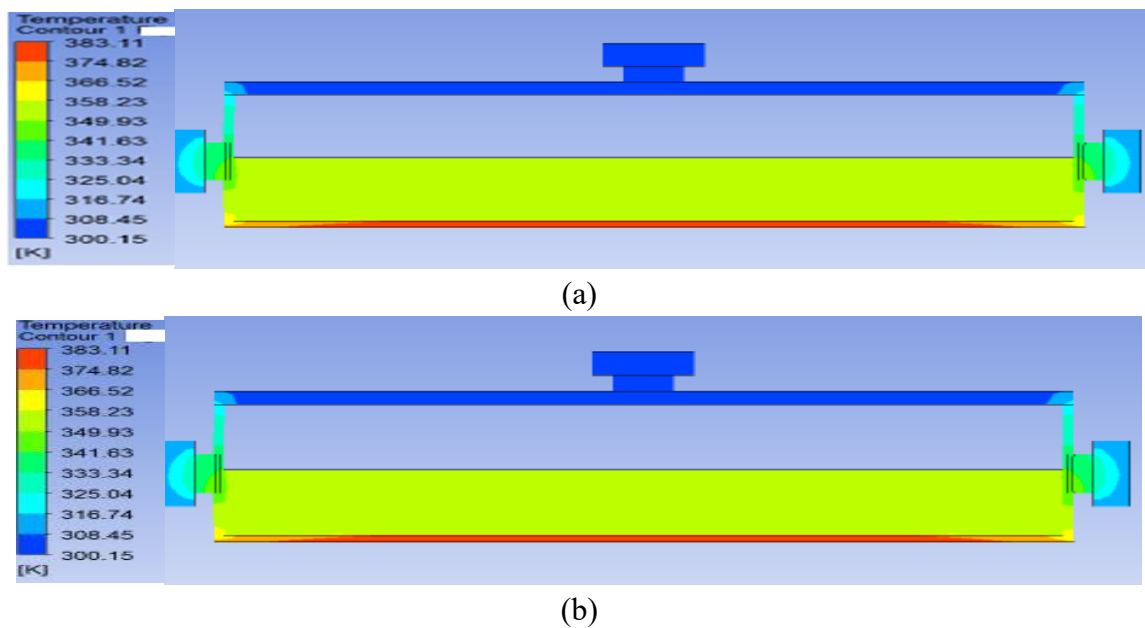


Fig. 5 Temperature contours in the pot for (a) Bakelite (b) 100-1C handles for aspect ratio of 0.25

3.3 Numerical Results for the Aspect Ratio of 0.5

The pot is simulated for aspect ratio of 0.5 with only the height and diameter of the pot changed while the volume of the fluid is kept constant. Analysis is run for Bakelite and the ten selected composites.

Table-8 Numerical results for composites with aspect ratio of 0.5

Composite type	Temp-max (T _w)	Temp-max (LH)	Temp-max (RH)	T _w -LH	T _w -RH
	°C	°C	°C	°C	°C
Bakelite	69.16091	51.81814	51.67297	17.34277	17.48794
50-2E	69.15872	51.24425	51.03326	17.91452	18.12546
75-1D	70.85522	49.86367	50.014	20.99155	20.84122
75-2B	71.65411	50.98834	51.10189	20.66577	20.55222
75-2D	72.58795	52.30349	51.97915	20.28446	20.6088
100-1B	70.73669	51.43994	51.57342	19.29675	19.16327
100-1C	65.48226	47.7785	47.69949	17.70376	17.78277
125-2E	69.46377	50.39437	50.20535	19.0694	19.25842
150-1D	69.57421	52.33337	52.31133	17.24084	17.26288
150-2B	69.03631	50.44531	50.37518	18.591	18.66113

At a height-to-diameter ratio (H/D) of 0.5 (see Table-8), we noticed a drop in the maximum water temperature compared to the 0.25 ratio. This suggests that the geometric changes led to better heat dissipation. The highest temperature recorded was 72.59°C for the 75-2D composite. For Bakelite, the temperature was 69.16°C. The top-performing insulating composite at this ratio turned out to be the 75-1D composite with LH insulation at 20.99°C and RH insulation at 20.84°C. When we compare this to Bakelite's performance (17.34°C), it shows an impressive insulation improvement of about 20–22%. On the flip side, composite 100-1C, which excelled at the 0.25 ratio, didn't perform as well here, with insulation efficiency dropping to around 17.7°C. This highlights how much geometry can influence performance. In general, all the composites except the 150-1D still outperformed Bakelite at this aspect ratio. The figures below show the temperature distribution in the pot and the handles of the pot for composite 75-1D and Bakelite.

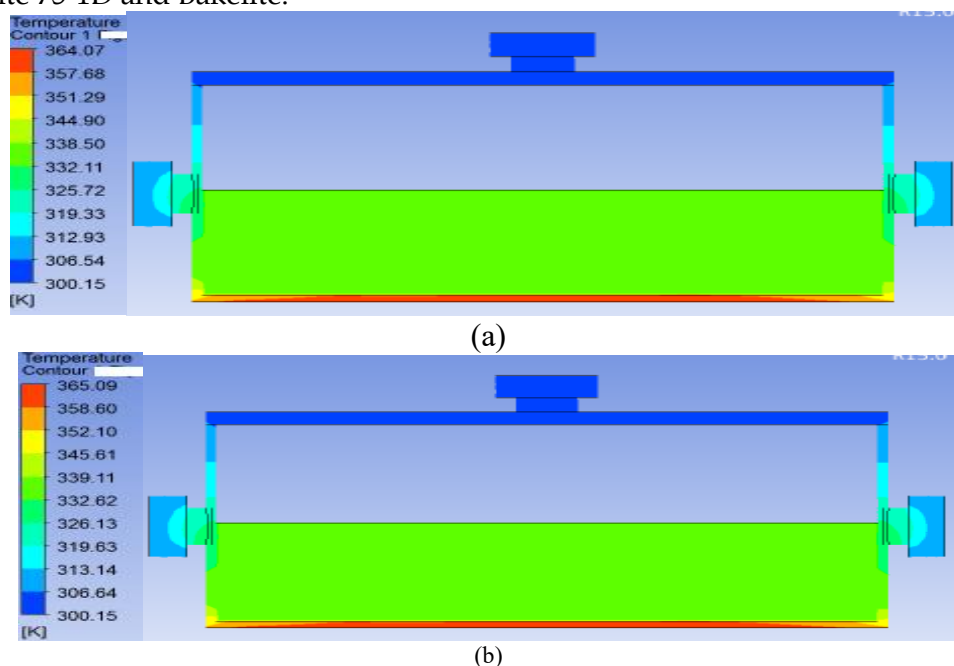


Fig. 6 Temperature contours in the pot for (a) Bakelite (b) 75-1D at aspect ratio 0.5

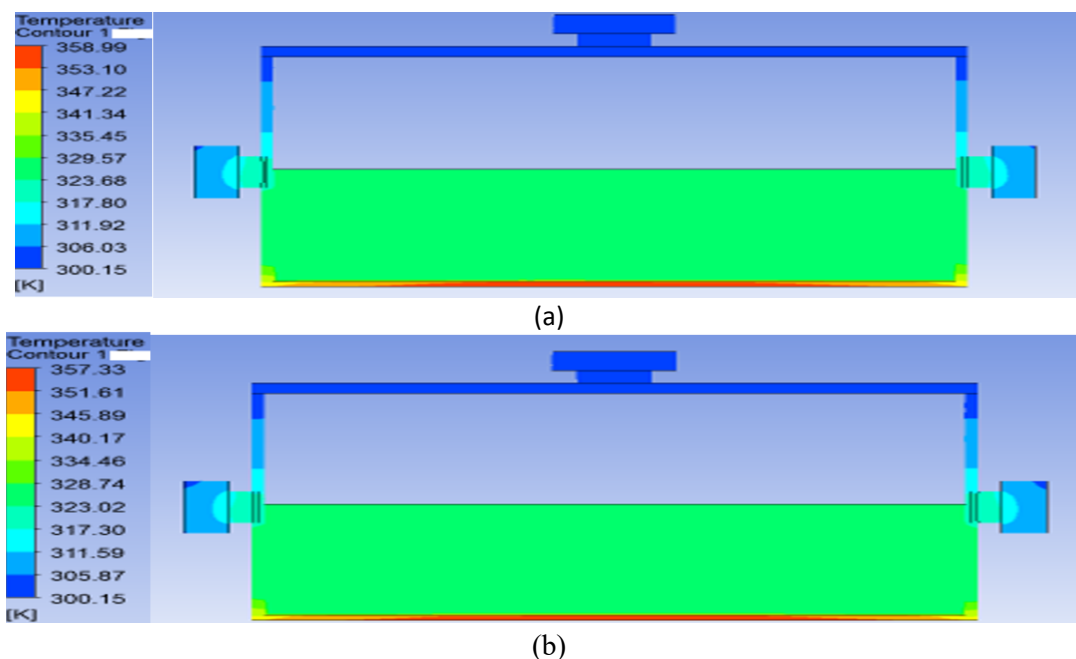
3.4 Numerical Results for the Aspect Ratio of 0.75

The pot is simulated for aspect ratio of 0.75 with only the height and diameter of the pot changed while the volume of the fluid is kept constant. Analysis is run for Bakelite and the ten selected composites.

Table-9 Numerical results for composites with aspect ratio of 0.75

Composite type	Temp-max (T_w)	Temp-max (LH)	Temp-max (RH)	T_w -LH	T_w -RH
	°C	°C	°C	°C	°C
Bakelite	59.91836	45.87792	45.80718	14.04044	14.11118
50-2E	58.60226	45.33654	45.27731	13.26572	13.32495
75-1D	60.47369	44.33856	44.27004	16.13513	16.20365
75-2B	59.57641	45.90145	45.95873	13.67496	13.61768
75-2D	59.50671	45.50268	45.49517	14.00403	14.01154
100-1B	60.99087	45.32299	45.06378	15.66788	15.92709
100-1C	61.6032	44.39529	44.36794	17.20791	17.23526
100-1D	59.28079	45.55203	45.57461	13.72876	13.70618
125-2E	58.2907	44.75698	44.72097	13.53372	13.56973
150-1D	58.71649	45.68136	45.6141	13.03513	13.10239
150-2B	60.53192	44.89184	44.8341	15.64008	15.69782

Increasing the aspect ratio to 0.75 (as shown in Table-9) resulted in a further decrease in the maximum water temperature, with Bakelite measuring at $T_w = 59.92^\circ\text{C}$. The top-performing composite at this ratio was the 100-1C composites with the LH insulation: 17.21°C and RH insulation: 17.23°C , as compared with Bakelite insulation (LH: 14.04°C and RH: 14.11°C). This translates to an impressive 22–23% improvement over Bakelite. Additionally, three other composites (75-1D, 100-1B and 150-2B) also outperformed Bakelite in this configuration. The other remaining composites either matched or fell short in performance. This indicates that as the height-to-diameter (H/D) ratio increases, the effectiveness of composite insulation tends to diminish, making performance more reliant on the specific materials used. Conversely, composite 150-1D exhibited the lowest insulation performance ($\approx 13.04^\circ\text{C}$), which is inferior to Bakelite. Figs. 7 (a) and (b) show the temperature distribution in the pot.



Figs. 7 Temperature contours in the pot for (a) 75-1D (b) Bakelite

3.5 Numerical Results for the Aspect Ratio of 1.0

The pot is optimized to an aspect ratio of 1.0 while the volume of the fluid is kept constant. Analysis is run for Bakelite and the ten selected composites. The Fig.8 below shows how the composites and Bakelite performed.

Table-10 Numerical results for composites with aspect ratio of 1.0

Composite type	Temp-max (T _w)	Temp-max (LH)	Temp-max (RH)	T _w -LH	T _w -RS
	°C	°C	°C	°C	°C
Bakelite	60.3597	43.25521	43.12911	17.10449	17.23059
50-2e	55.67883	42.59323	42.65914	13.0856	13.01969
75-1d	56.93929	41.61987	41.56945	15.31942	15.36984
75-2b	58.48611	42.07726	42.26907	16.40885	16.21704
75-2d	57.38006	42.61697	42.70834	14.76309	14.67172
100-1b	57.22802	42.82034	42.58795	14.40768	14.64007
100-1c	56.7987	41.63036	41.70574	15.16834	15.09296
100-1d	41.69171	30.3041	30.35757	11.38761	11.33414
125-2e	55.85546	42.1946	42.16085	13.66086	13.69461
150-1d	54.07299	42.73962	42.85638	11.33337	11.21661
150-2b	56.60867	42.08013	42.10488	14.52854	14.50379

At an H/D ratio of 1.0 (as shown in Table-10), where the height matches the diameter, we saw a shift in trends. Bakelite topped the charts with the highest water temperature at 60.36°C. When it comes to Bakelite insulation, the left-hand side measured 17.10°C, while the right-hand side was slightly higher at 17.23°C. The standout composite, 75-2B, managed to achieve an insulation temperature of around 16.41°C, which is notably lower than Bakelite's performance. On the other hand, the composite that struggled the most was 100-1D, with a temperature of 41.69°C and insulation around 11.38°C. This shows a significant 33% drop in insulation effectiveness compared to Bakelite. In this setup, Bakelite clearly shines as the better insulator. The decline in the composite's performance might be due to changes in heat transfer patterns and convection dynamics in the taller pot. Figure 8 shows the temperature distribution in the simulated pot.

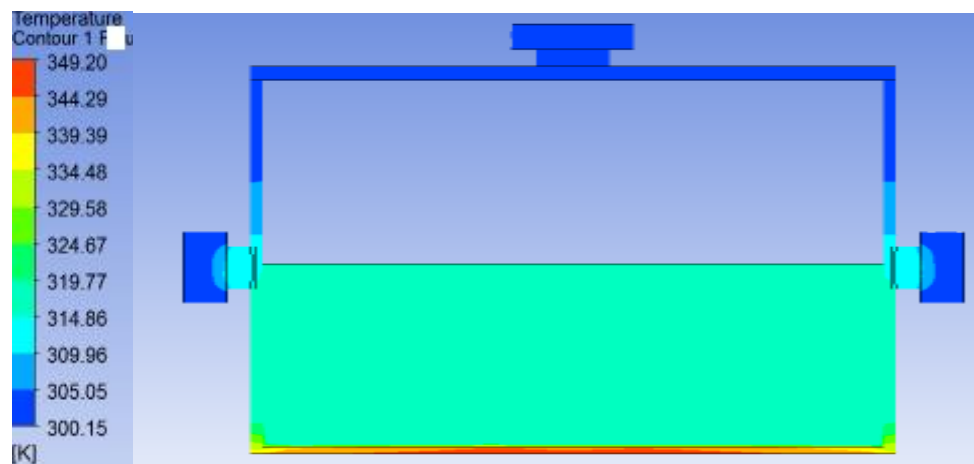


Fig. 8 Temperature contours in the pot at aspect ratio of 1.0

3.6 Observable Performance Trends

When we look at lower aspect ratios like 0.25 and 0.5, we see that the insulation benefits of the composites start to drop off at an H/D ratio of 0.75. While many of the composites still manage to outperform Bakelite, the difference in performance is not as significant. This pattern hints that as we increase the height of the pot in relation to its diameter, it changes the way natural convection works inside, resulting in stronger vertical thermal gradients and better heat transfer towards the handle areas. The standout performance of composite 100-1C likely comes from its well-balanced thermal conductivity and specific heat capacity. This balance helps control the heat flow from the fluid to the handles while keeping the bulk fluid temperature higher. In summary, the findings show that even at a moderate aspect ratio of $H/D = 0.75$, certain fiber-glass/talc epoxy composites still offer better insulation than Bakelite, although the improvement isn't as striking as it is with lower aspect ratios.

3.7 Practical Implications

For cookware design, Composites can replace Bakelite when pot diameter exceeds height ($H/D < 1$). For tall pots ($H/D \approx 1$), Bakelite remains thermally competitive. Composite 100-1C provides the most stable performance across varying geometries. These results suggest that insulation material selection should be geometry-specific rather than universal.

Table-11 Summary of Best Performing Materials

Aspect Ratio	Best Material	Approx. % Improvement Over Bakelite
0.25	100-1C	35-36%
0.5	75-1D	20-22%
0.75	100-1C	22-23%
1.0	Bakelite	Superior

CONCLUSION

This study evaluated the combined influence of geometric aspect ratio (H/D) and composite thermal properties on the insulation performance of fiberglass-talc epoxy as handles of a domestic pot, using conjugate heat transfer simulations in ANSYS Fluent. The performance of ten post-cured composite formulations was compared against conventional Bakelite across aspect ratios ranging from 0.25 to 1.0. At low aspect ratio ($H/D = 0.25$), all the composites outperformed Bakelite, with the best performing composite 100-1C achieving an insulation value of approximately 23.2°C compared to 17.1°C for Bakelite representing an insulation improvement of about 35-36%. At $H/D = 0.5$, the best-performing composite (75-1D) provided roughly 20% higher insulation than Bakelite. However, at $H/D = 1.0$, Bakelite exhibited superior performance, maintaining an insulation approximately 12-15% higher than the best composite formulation. The results demonstrate that insulation efficiency is heavily influenced by the interplay between the thermal properties of the materials and their geometric design and it also indicates that fiberglass-talc epoxy composites could be great alternatives to traditional materials for cookware, especially in situations where conductive heat transfer is a key factor. The study emphasizes the need to combine material design with geometric optimization to enhance thermal performance.

CONFLICT OF INTEREST

There is no conflict of interest for this research work.

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