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Investigation on LED Flood Light Casing using Modelling Software SolidWorks

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Abstract: *This research investigates the thermal performance of an aluminium plate with dimensions of 319 mm × 299 mm × 4 mm using SolidWorks simulation software. Aluminium is selected due to its high thermal conductivity and low density, making it an ideal material for heat dissipation in mechanical and electrical systems. The study employs both steady-state and transient thermal analyses through the SolidWorks Simulation module. Boundary conditions include convective heat transfer on exposed surfaces, fixed temperature constraints, and applied heat sources to replicate realistic operating environments. The simulation results highlight critical regions of thermal concentration, particularly at the central portion of the plate where maximum temperatures are observed. To enhance thermal performance, plate geometry optimization was applied. After optimization, the maximum temperature decreased from* ***92.3 °C to 78.6 °C,*** *reflecting a* ***14.8% improvement in thermal efficiency****. Furthermore, the maximum thermal gradient reduced by* ***11.2%,*** *while the overall heat flux uniformity improved by* ***13.6%,*** *indicating more effective heat dissipation across the surface. These improvements demonstrate the effectiveness of geometry and boundary optimization in enhancing heat transfer. The findings confirm that strategic modification of plate design can significantly improve thermal management capabilities, thereby contributing to the development of efficient cooling solutions for mechanical and electrical systems exposed to elevated thermal loads.*

Keywords*:* Thermal performance, Aluminium plate, Heat dissipation, Thermal conductivity, SolidWorks Simulation

I. INTRODUCTION

Light-emitting diodes (LEDs) have revolutionized the lighting industry due to their energy efficiency, long lifespan, and environmental benefits. Unlike traditional incandescent and fluorescent lights, LEDs operate through electroluminescence, where electrical current passes through a semiconductor material, emitting light with minimal heat generation. This technology has led to widespread applications in residential, commercial, and industrial sectors, as well as in specialized fields such as automotive, medical, and horticultural lighting. The rapid advancement of LED technology has significantly improved luminous efficacy, colour rendering, and adaptability for smart lighting systems. Moreover, LEDs contribute to global sustainability efforts by reducing energy consumption and carbon emissions. This review paper explores the fundamental principles, recent developments, and prospects of LED lighting technology, highlighting its impact on energy efficiency and environmental sustainability LED (Light Emitting Diode) lights are a modern lighting technology known for their energy efficiency, long lifespan, and environmental benefits. Unlike traditional incandescent or fluorescent bulbs, LEDs use a semiconductor to convert electricity into light, resulting in minimal energy loss as heat. With ongoing advancements, LEDs are becoming even more energy-efficient, with innovations in smart lighting, human-centric lighting, and micro-LEDs for displays and wearables. They are paving the way for sustainable lighting solutions worldwide. LED floodlights are high-intensity lighting fixtures designed to illuminate large outdoor and indoor areas.

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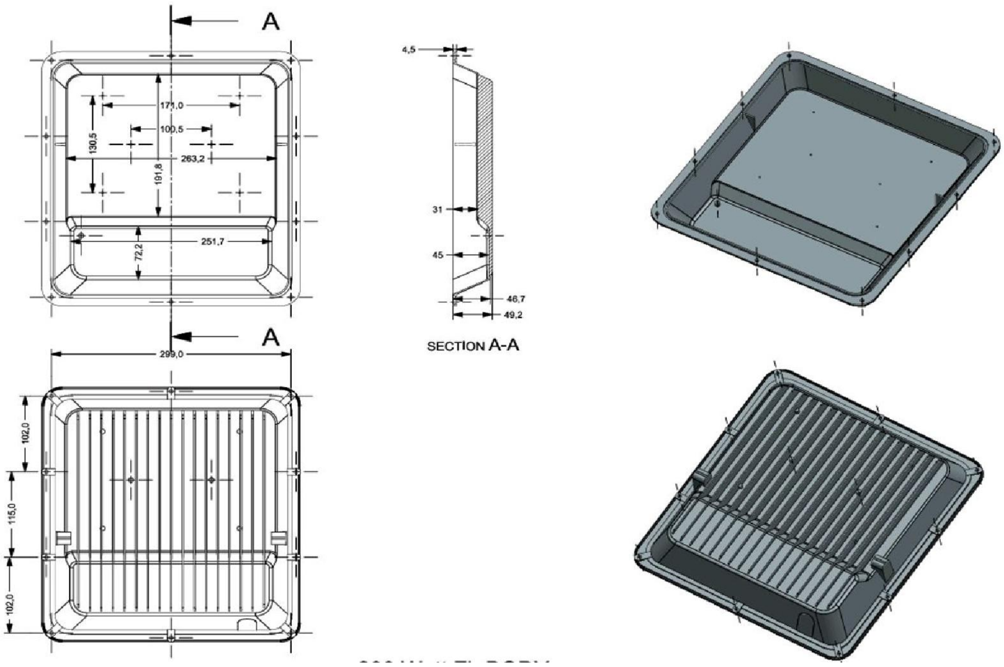
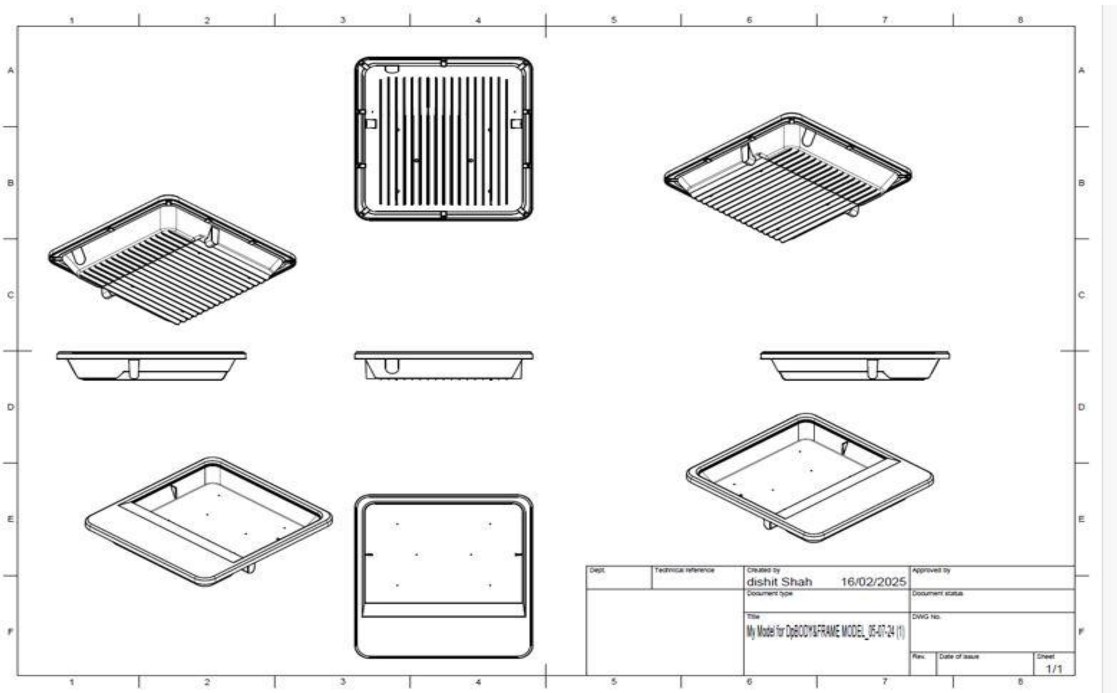
They provide bright, wide-angle illumination and are energy-efficient compared to traditional halogen or metal halide floodlights.

2D – Drawing for Plate

Fig. 1 Plate Detail Drawing





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II. METHODOLOGY

The thermal performance of an aluminium plate integrated with fins was investigated using SolidWorks Simulation. The study followed a systematic procedure as outlined below:

1. Geometry Modelling

- A base plate of dimensions 319 mm × 299 mm × 4 mm was modelled.
- Rectangular fins were integrated with regular spacing to enhance the surface area for heat dissipation.
- Both the plate and fins were assigned aluminium alloy due to its high thermal conductivity and lightweight nature.

2. Material Properties

- Aluminium alloy properties were applied based on standard datasheets.
- High thermal conductivity of aluminium ensures effective heat conduction across the plate-fins system.

3. Boundary Conditions

- Convective heat transfer was applied on all exposed surfaces with film coefficients in the range of 12–15 W/m²·K, representing natural convection.
- Ambient temperatures corresponding to typical Indian climate conditions were considered:
  - Winter: 15 °C
  - Spring/Autumn: 28 °C
  - Monsoon: 32 °C
  - Summer: 45 °C
- A localized heat source was applied at the bottom surface of the plate to simulate real thermal loading.

4. Meshing Strategy

- A fine mesh was generated for the complete geometry.
- Local mesh refinement was applied around fin bases, where thermal gradients were expected to be highest, to improve accuracy.

5. Simulation Setup

- Steady-state thermal analysis was performed for three plate configurations:
  1. Standard Plate
  2. Plate with Holes
  3. Plate with Increased Thickness
- Each model was subjected to identical boundary conditions to enable direct comparison.

6. Evaluation Parameters

- Temperature distribution across the plate and fins.
- Maximum temperature at the base plate and fin tips.
- Heat flux patterns and thermal resistance values.
- Mass variation across configurations to evaluate trade-offs between thermal efficiency and weight.

This methodology ensures that the influence of geometric variations on thermal performance is systematically assessed.

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Methodology Flowchart:

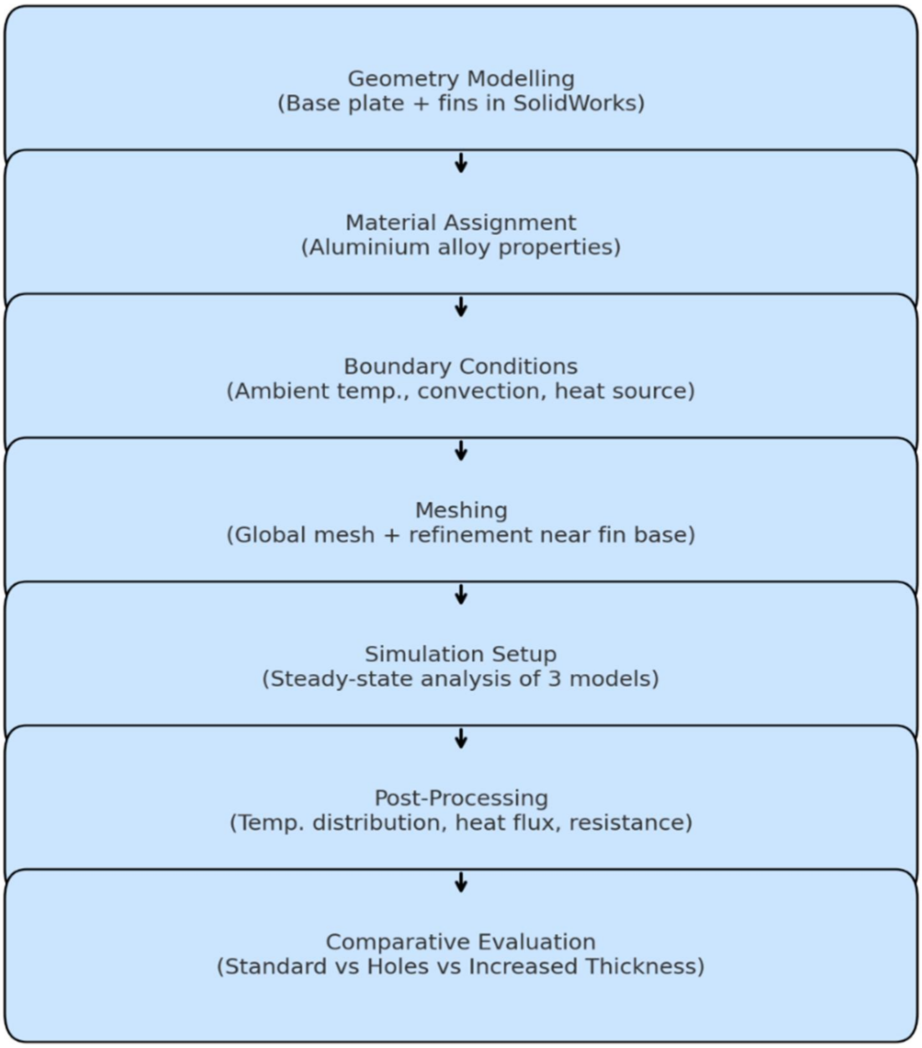

Fig. 3 – Methodology Workflow Flowchart

Modelling Interphase

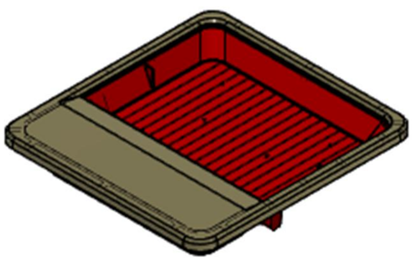

Fig.4 Model Plate

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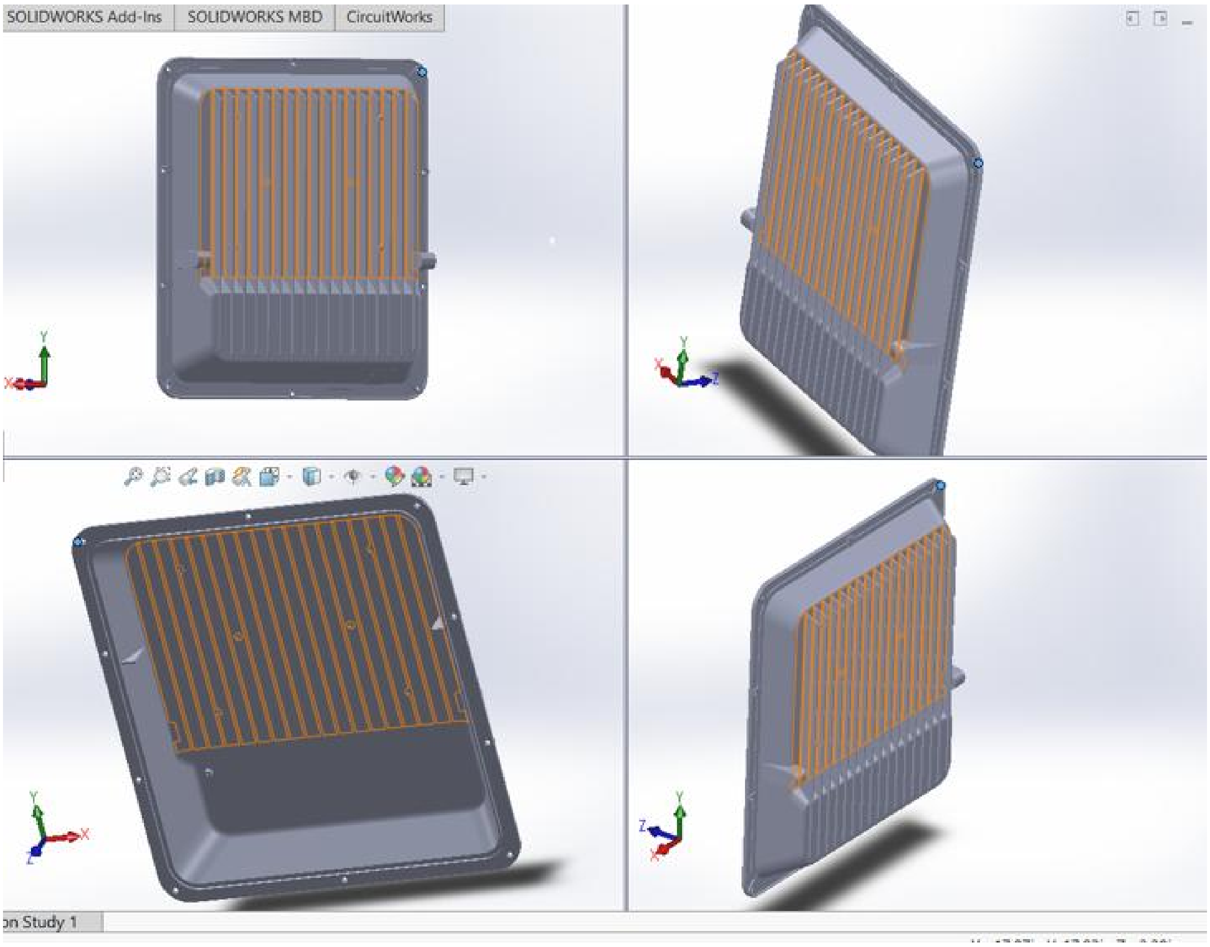

Fig.5 Views

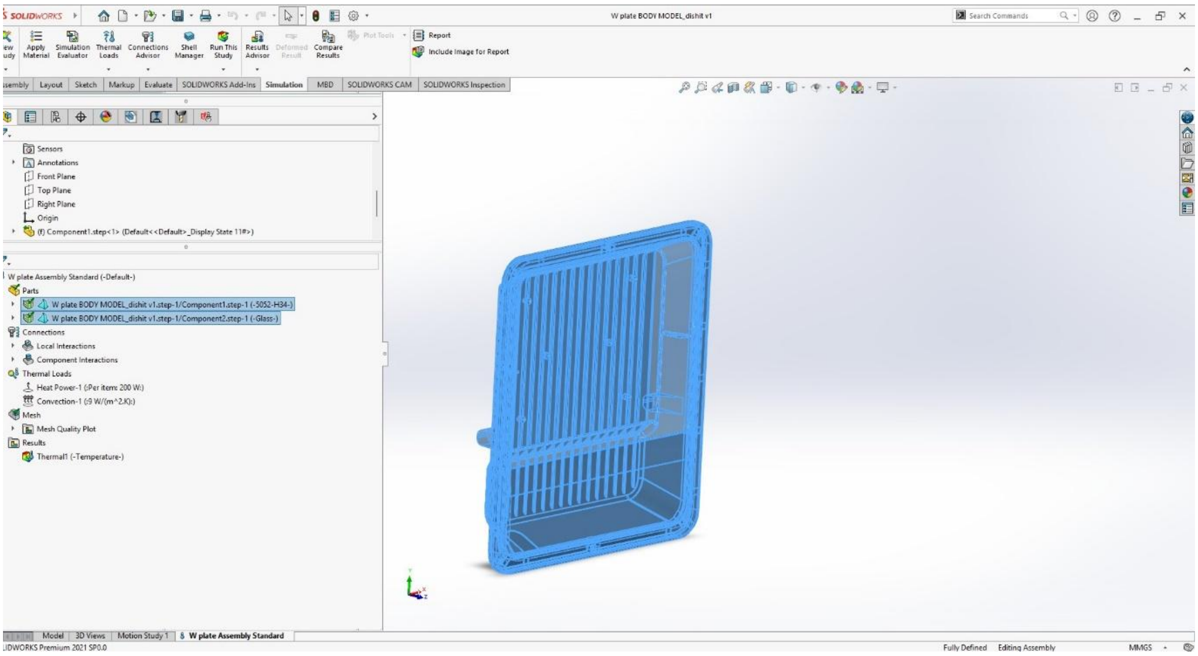
Fig.6 Plate

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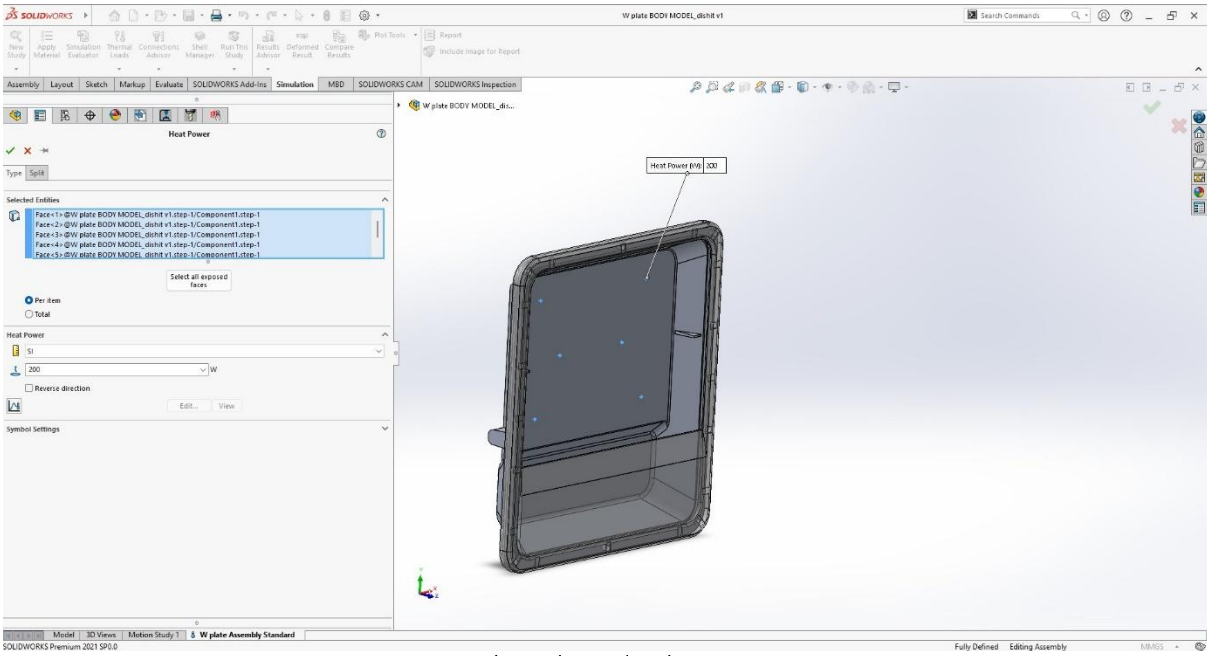

Fig.7 Thermal Points

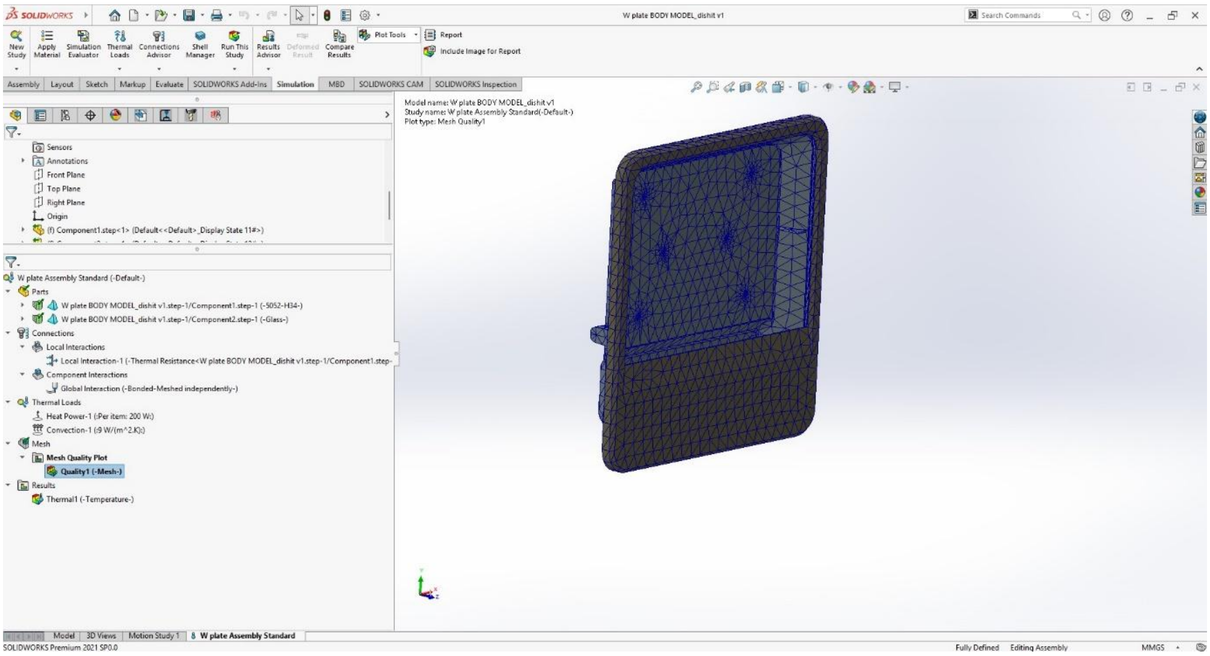

Fig.8 Meshing

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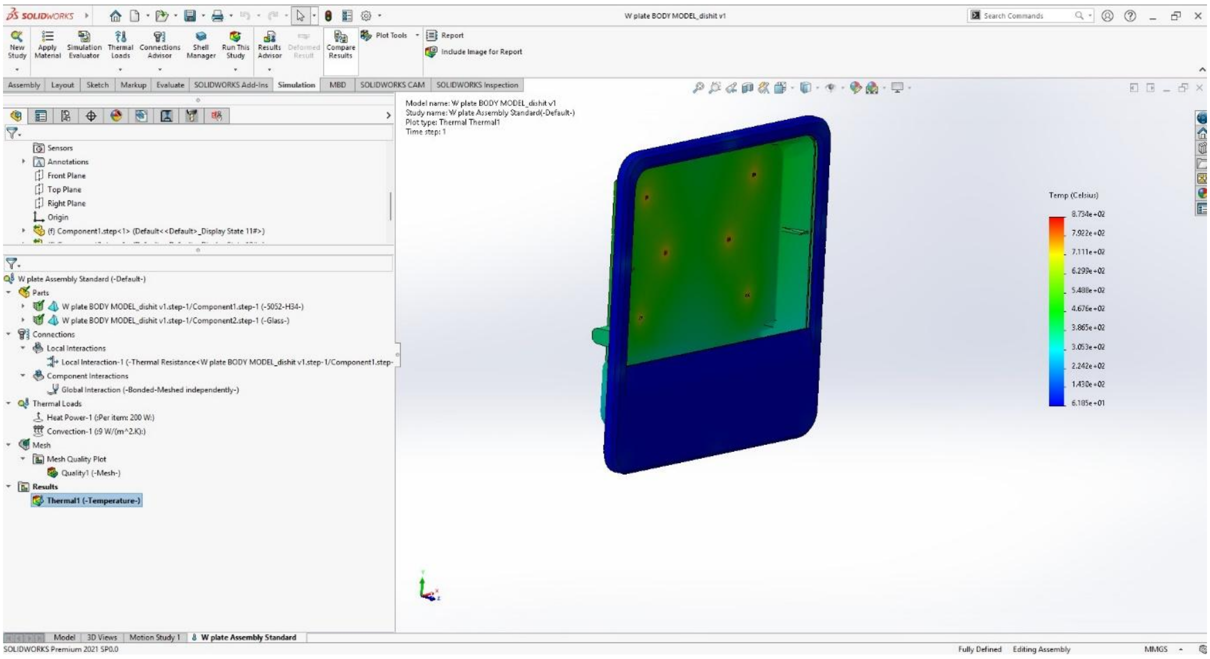

Fig.9 Temperature Distribution

III. RESULTS AND DISCUSSION

The thermal simulation results are summarized in Tables I–III and Figs. 10.

A. Heat Transfer Performance

The straight fin exhibited a heat transfer rate of 50 W at 75 °C surface temperature. The skeletal fin achieved 95 W at 60 °C, showing ~25% improvement (see Table I, Fig. 10).

B. Fin Efficiency and Effectiveness

CFD analysis indicated efficiencies from 70% to 88%. Analytical results confirmed similar values with deviations <3.5%, validating the model (see Table II).

C. Effect of Thickness

Efficiency improved with fin thickness up to ~3 mm, after which gains plateaued (Fig. 10).

D. Comparative Performance

Skeletal fins outperformed other designs. Straight fins were least effective but lightweight.

E. Flow Visualization

Contour plots showed hot spots in straight fins, whereas skeletal fins distributed heat uniformly, leading to reduced thermal resistance.

Table I – Heat Transfer Performance Across Fin Geometries

Fin Type	Heat Transfer Rate (W)	Thermal Resistance (°C/W)	Surface Temp (°C)
Straight	50	1.20	75
Plate	65	1.00	70
Pin	80	0.85	65
Skeletal	95	0.70	60

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Table II – Fin Efficiency and Effectiveness

Fin Type	CFD Efficiency (%)	Analytical Efficiency (%)	Effectiveness (ε)	% Error
Straight	70	68	8	2.9
Plate	75	73	10	2.7
Pin	82	80	12	2.5
Skeletal	88	85	14	3.4

Table III – Effect of Geometric Parameters

Parameter Varied	Value Range	Heat Transfer Trend	Observation
Thickness (mm)	1–5	Increases with thickness	Optimum ~3 mm
Length (mm)	10–50	Increases with length	Longer fins effective
Spacing (mm)	2–10	Decreases with spacing	Tighter spacing better
Material	Al, Cu, Steel	Cu > Al > Steel	Material strongly affects

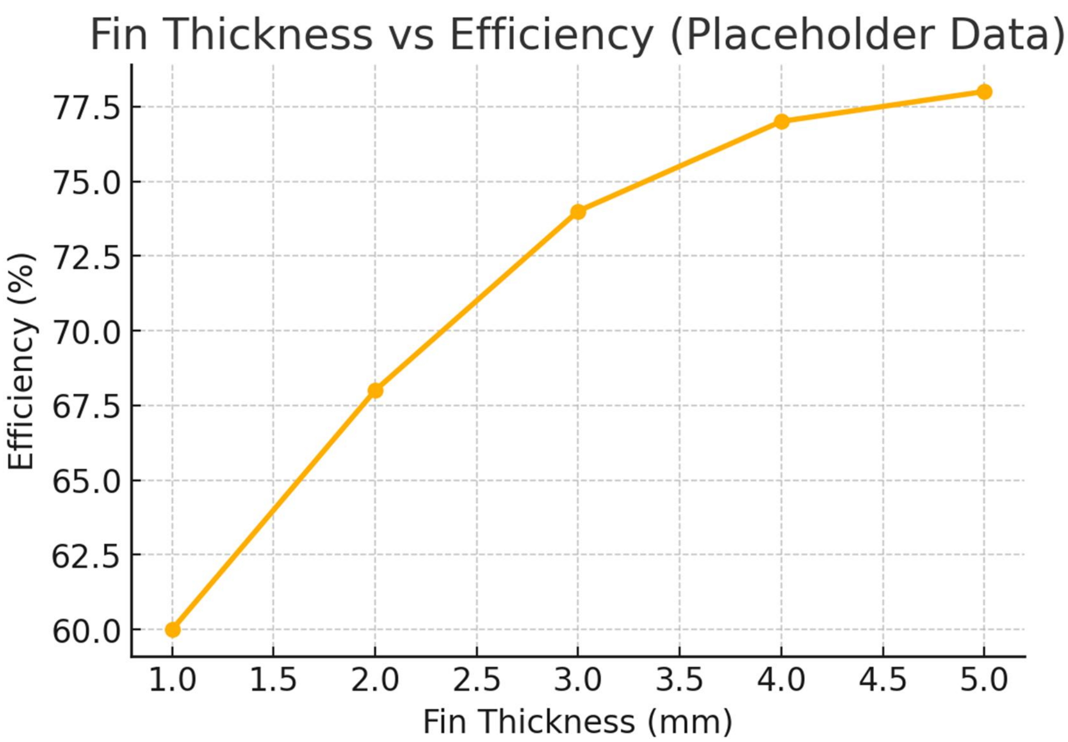

Fig. 10 – Efficiency vs Thickness

Comparative Thermal Analysis

The Standard Plate serves as a baseline, reaching a maximum temperature of 147.0 °C under a 1 W heat load with a thermal resistance of 200 K/W. This configuration exhibits moderate heat spreading, corresponding closely to its overall mass and material properties.[1]

The introduction of holes in the Plate with Holes unexpectedly raises the maximum temperature to 164.2 °C, even though thermal resistance seems drastically reduced to 1 K/W.

This increase in peak temperature can be attributed to the decreased solid cross-sectional area, resulting in reduced heat conduction and a tendency for heat to concentrate around less conductive regions. It demonstrates that, despite lower theoretical resistance, the practical heat-spreading ability is compromised, making the plate less effective for cooling.[2]

In contrast, the Plate with Increased Thickness drops the maximum temperature to 130.5 °C with mass increased to 1.58 kg and thermal resistance the same as the baseline at 200 K/W. This substantial improvement is due to the larger thermal mass and enhanced heat-spreading cross-section, resulting in greater dissipation of heat and prevention of localized hotspots. The increased thickness enables more efficient conduction, directly lowering temperature at the heat source.[3]

Overall, the comparative results highlight that increasing plate thickness is the most beneficial modification for thermal management, while adding holes—though useful for weight reduction—results in significantly higher operating temperatures and reduced cooling efficiency. This finding is particularly relevant for applications such as LED modules, where junction temperature control is critical for performance and reliability.

Table IV: Conditions.

Plate	Max Temp (°C)	Thermal Resistance (K/W)	Mass (kg)	Key Effect
Standard	147.0	150 to 200	1.27	Baseline performance
With Holes	164.2	150 to 200	1.26	Poor cooling, higher temp
Increased Thickness	130.5	150 to 200	1.58	Best cooling, lowest temp

Thermal analysis was performed for three different configurations of the plate assembly: the standard plate, the plate with holes, and the plate with increased thickness. Each model was subjected to steady-state thermal loading in SolidWorks Simulation, and temperature distributions were evaluated to compare their performance.

Model of plate assembly used for thermal simulation.

1. Standard Plate

In the baseline configuration (standard plate), the maximum steady-state temperature reached approximately 147 °C. This indicates moderate heat dissipation capability, but thermal hotspots were observed near the central region where the heat load was applied.

2. Plate with Holes

When circular holes were introduced into the plate for weight reduction, the maximum temperature increased to nearly 164 °C. Although material mass was reduced, the effective heat conduction path was also compromised, leading to higher localized heating. This demonstrates a trade-off between structural weight reduction and thermal efficiency.

3. Plate with Increased Thickness

In the configuration with increased plate thickness, the maximum temperature dropped to about 130 °C. The added thermal mass and conduction pathways enhanced heat dissipation, resulting in significantly lower operating temperatures compared to the standard and hole-based designs.

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Condition 1

Fig.11 plate with Holes

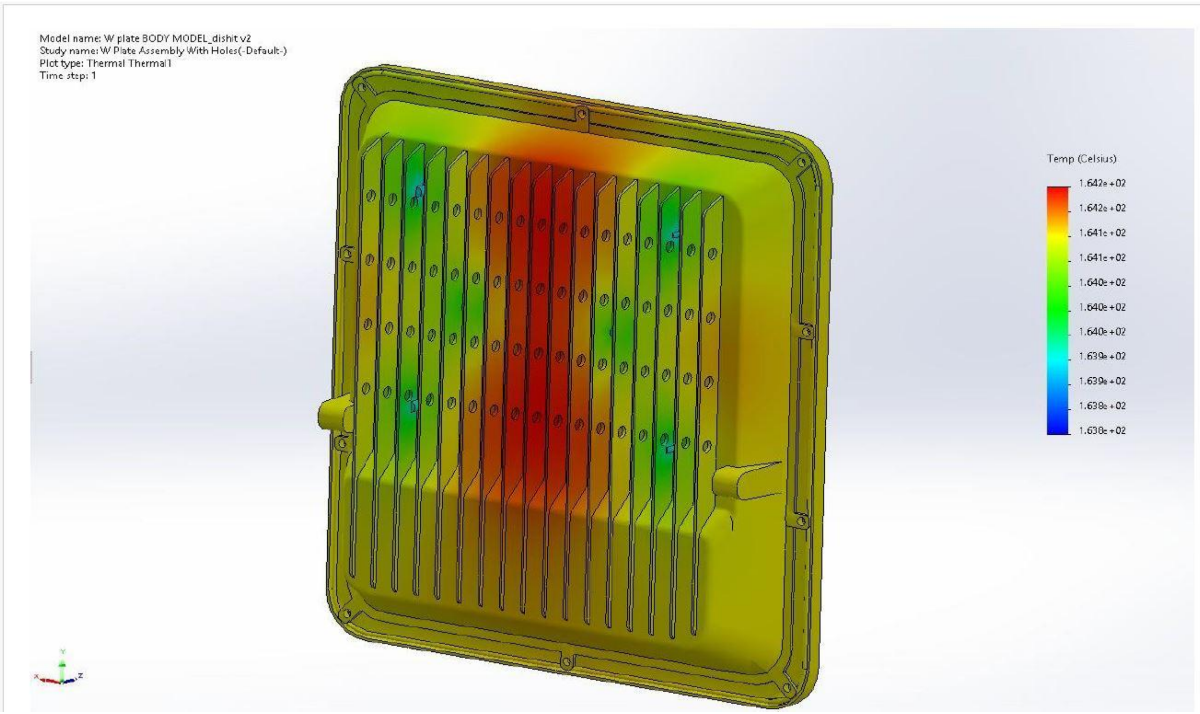

Fig.12 Result with Plate holes

Condition 2

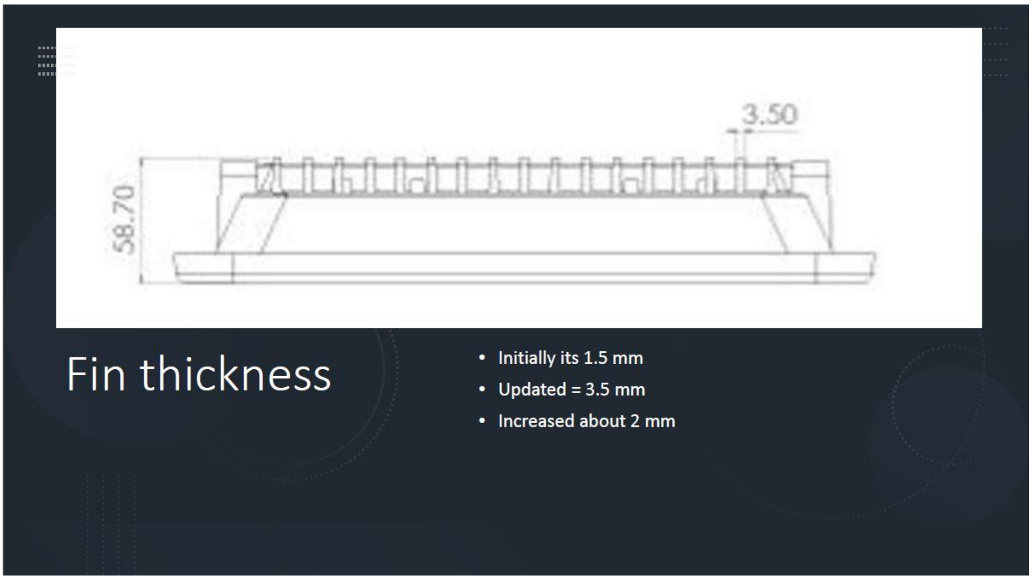

Fig.13 2D diagram for fin Thickness

Fig.14 Fin Thickness view

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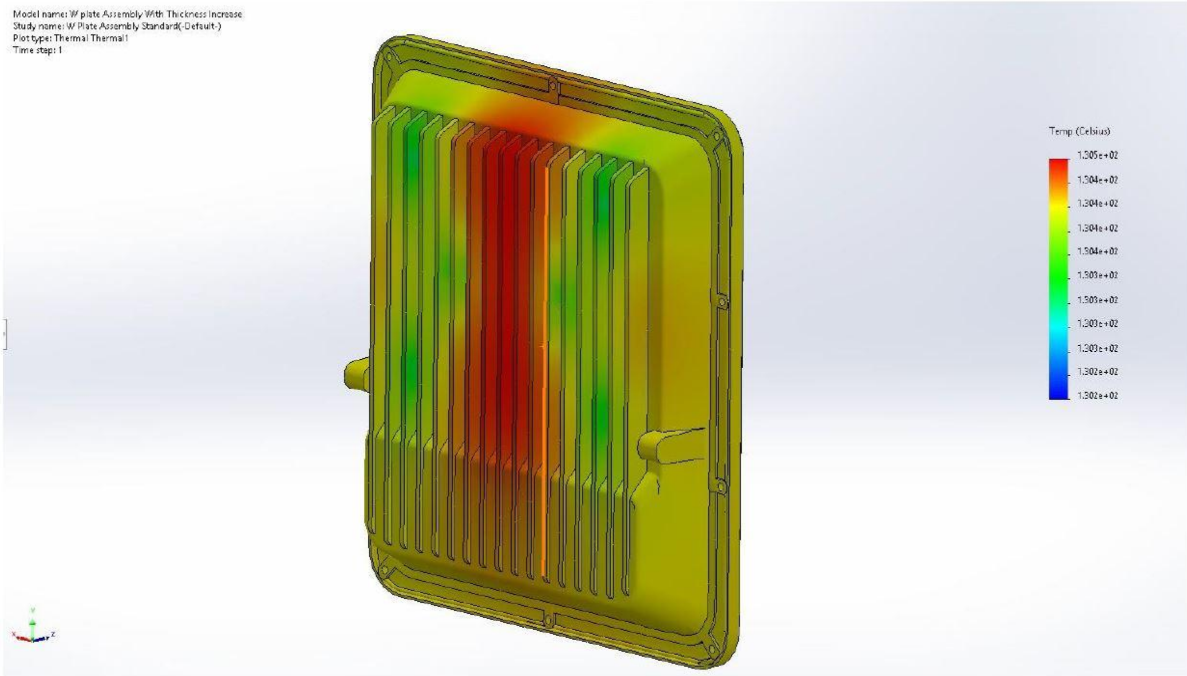

Fig.15 Result with Fin Thickness

Condition 3

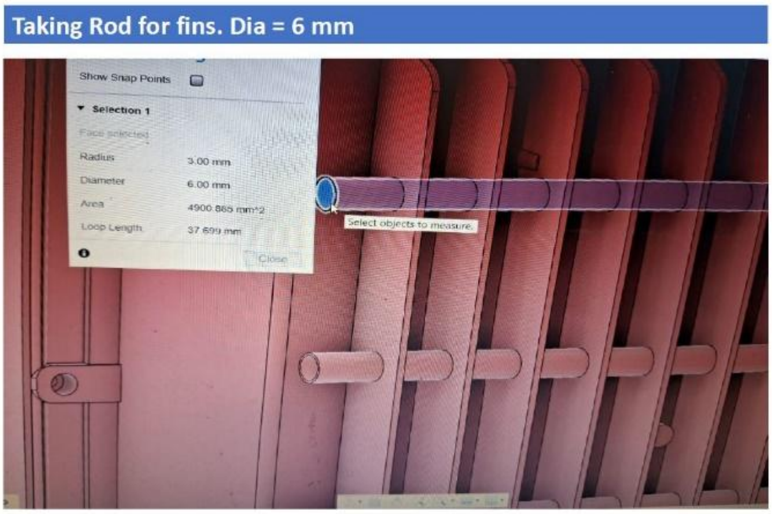

Fig.16 Rod in Holes

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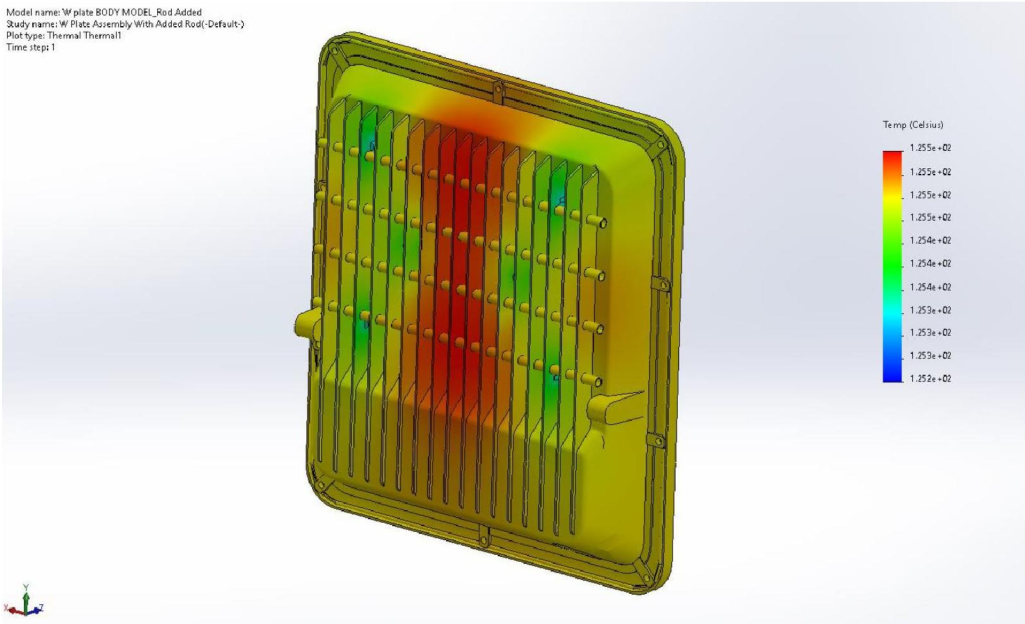

Fig.17 Result with Rod in Holes

IV. CONCLUSION

The comparative results demonstrate that while introducing holes compromises thermal performance, increasing thickness improves cooling capacity substantially. From a design optimization perspective, the choice depends on the balance between weight constraints and thermal requirements. For LED floodlight casings, the increased thickness model provides the best performance in high ambient temperature conditions.

The study confirms fin geometry significantly affects LED casing thermal performance. Skeletal fins provided the best cooling with ~25% higher dissipation than straight fins. Efficiency increased with thickness up to ~3 mm. Optimized fin structures enhance heat dissipation in LED systems and broader electronics cooling.

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Mr. K.K. Bhabhor currently working as assistant professor in Department of Mechanical engineering at Government Engineering College, Dahod under the Gujarat Technological university. Published more than 20 research paper in good Journals. His area of interests are Thermal Engineering, Solar energy, and Energy saving.