iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: XI Month of publication: November 2025

DOI: https://doi.org/10.22214/ijraset.2025.75962

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

Design and Development of Eye Mould for Netra Tarpana Therapy

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Abstract: Netra Tarpana, a classical Ayurvedic ocular therapy, requires medicated ghee to be maintained within a therapeutic range of 35–40 °C, yet traditional dough dams lack reproducibility and temperature control. To address this limitation, a temperature-controlled silicone mould was developed using a nichrome wire heating element with a diameter of 0.19 mm and a length of 65 cm. Heating was applied at fixed voltages of 6V, 8V, and 9V, with ghee temperatures measured manually using a calibrated thermometer at an ambient room temperature of 28 °C. The initial ghee temperatures were 38 °C (6V), 36.5 °C (8V), and 35.5 °C (9V). Results showed that at 6V, ghee rose gradually to 40 °C over 30 minutes, providing stable heating suitable for long-duration therapy at 8V, ghee reached 42 °C in ~11 minutes, balancing heating speed and stability for shorter sessions; and at 9V, ghee overshot to 45 °C within 15 minutes, demonstrating uncontrolled heating without feedback and posing clinical risk. Electrical calculations confirmed a wire resistance of 25.2 Ω, with power dissipation values of 1.43 W (6V), 2.54 W (8V), and 3.21 W (9V). These findings highlight that voltage selection directly influences heating rate and stability, and that silicone-insulated nichrome moulds can reproducibly maintain ghee within therapeutic limits, supporting modernisation of Netra Tarpana therapy.

Keywords: Netra Tarpana, Ayurvedic therapy, Eye mould, Temperature control, Silicone, Biomedical Device, Thermal stability.

I. INTRODUCTION

Netra Tarpana, also known as Akshi Tarpana, is a prominent procedure in Ayurvedic ophthalmology designed to nourish, rejuvenate, and protect the eyes. In this therapy, medicated ghee is retained around the eyes using a specially prepared boundary for a prescribed duration. Patients are encouraged to blink, allowing the therapeutic medium to lubricate and penetrate ocular tissues [1]. Clinically, it is indicated for conditions such as ocular dryness, burning sensation, myopia, and early stages of degenerative eye disorders.

The core principle of this therapy is rejuvenation—restoring the vitality and functional integrity of ocular tissues [3]. However, modern implementation faces significant challenges. Medicated ghee solidifies below 35 °C, interrupting treatment continuity and reducing patient comfort. Traditional methods involve manual reheating or refilling, which introduces variability and contamination risks [2].

To address these issues, there is a need to integrate biomedical engineering principles with traditional practices [8], [13]. Recent studies have highlighted the importance of uniform cavity surface temperature in mould heating structures [5] and the role of thermal insulation in energy conservation for biomedical devices [6]. Furthermore, advancements in neonatal temperature control using Pulse Width Modulation (PWM) circuits [7] suggest that precise thermal regulation is achievable in small-scale medical devices.

This work focuses on the design and development of a temperature-controlled eye mould. By employing food-grade silicone as a biocompatible insulating medium and nichrome wire as a heating element, this system aims to maintain ghee within the optimal range of 35–40 °C, ensuring treatment reproducibility and patient safety.

II. METHODOLGY

The mould was fabricated using food-grade silicone. This material was selected based on the properties outlined by Nair [11], which emphasise its biocompatibility, flexibility, and thermal stability for biomedical applications. Silicone serves a dual purpose: it ensures patient safety during direct ocular contact and acts as an effective thermal insulator, minimising heat loss to the external environment [12].

The heating element was constructed using a nichrome wire of 0.19 mm diameter and 65 cm length embedded within the silicone wall. Nichrome was chosen for its high resistivity and durability under repeated heating cycles. The wire was coiled uniformly around the mould cavity to ensure even heat distribution, a critical factor in compact heating systems for wearable devices [14].

The heating performance was evaluated by applying fixed Direct current voltages of 6V, 8V, and 9V. The system operated without integrated feedback sensors for this prototype phase to validate the baseline thermal behaviour. The experimental setup is depicted in the figures below.

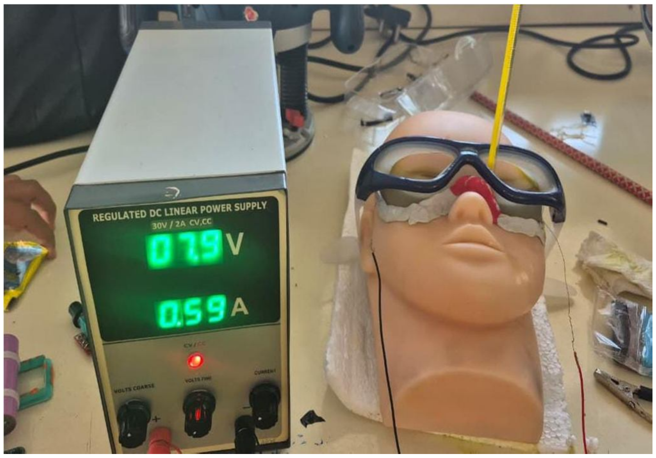

Fig. 1. Experimental Setup For Temperature-Controlled Eye Mould System.

This figure illustrates the complete laboratory arrangement, including the silicone mould, heating circuit, sensors, insulation, and power supply. It provides a clear view of how the engineering components were integrated to simulate clinical conditions.

Fig. 2. Eye mould filled with medicated ghee during Netra Tarpana simulation.

This figure demonstrates the mould in operation, filled with ghee, maintained in a liquid state. It highlights the clinical relevance of the device, showing how the therapy would be performed in practice.

Fig. 3. Eye Mould With Integrated Heating Wire And Sensor System.

This figure highlights the embedded heating wire and sensor placement for uniform heating and precise monitoring. It shows the engineering design that ensures thermal stability and patient safety.

III. RESULTS

The Nichrome wire of 0.19 mm diameter and 65 cm length demonstrated effective heating characteristics under different voltage inputs. At 6V, the wire produced gradual heating, stabilising the ghee temperature around 40 °C over 30 minutes. This slow rise was ideal for long-duration therapy, as it prevented overheating while maintaining ghee in liquid form.

All experiments were conducted at 28 °C ambient room temperature, with initial ghee temperatures of 38 °C (6V), 36.5 °C (8V), and 35.5 °C (9V). The heating curves obtained are presented in Figs. 4–7.

As shown in Fig. 5, the ghee began at 38 °C and rose gradually to ~40 °C over 30 minutes under 6V input. The slow heating rate reflects the low power dissipation of the nichrome wire, with silicone insulation minimising losses. Clinically, this profile is ideal for long-duration Netra Tarpana sessions, as it maintains comfort without overshoot. The limitation is the slow attainment of therapeutic temperature, which may be unsuitable when rapid heating is required.

In Fig. 6, the ghee started at 36.5 °C and reached 42 °C in 11.3 minutes under 8V input. The curve demonstrates a steady rise, entering the therapeutic range within 7–9 minutes. This profile balances heating speed and stability, making it suitable for shorter therapy sessions. However, without feedback control, prolonged exposure risks exceeding the therapeutic band.

As shown in Fig. 7, the ghee began at 35.5 °C and rose sharply, crossing 40 °C within 7 minutes and overshooting to 45 °C by 15 minutes under 9V input. This rapid heating reflects higher power dissipation, which, without sensor feedback, results in uncontrolled overshoot. Clinically, this profile is unsafe for direct use, as prolonged exposure above 40 °C risks patient discomfort and tissue damage. It demonstrates the need for advanced control mechanisms such as PWM regulation or sensor-based feedback.

The combined analysis in Fig. 4 underscores the importance of voltage selection in determining heating rate and stability. The 6V profile offers the safest and most stable heating for long-duration therapy, the 8V profile provides a practical balance between speed and stability for shorter sessions, and the 9V profile, though technically feasible, requires advanced control systems to ensure clinical safety. These results confirm that the integration of silicone insulation and nichrome wire heating can effectively maintain medicated ghee within the therapeutic range, provided that voltage and control mechanisms are carefully optimised.

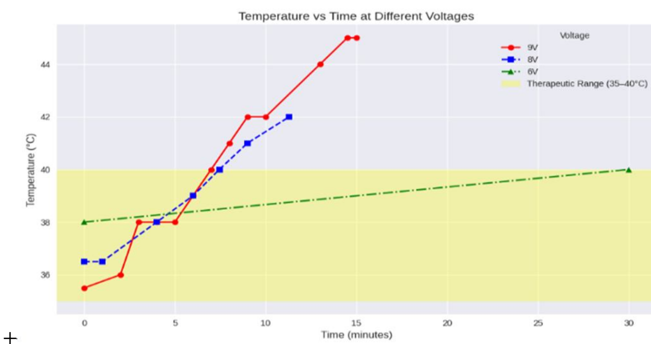

Fig. 4. Temperature vs. Time for Eye Mould at Different Voltages (6V, 8V, 9V). Curves begin at the actual initial ghee temperatures (38 °C, 36.5 °C, and 35.5 °C, respectively). The 6V profile remains most consistently within the therapeutic range, while the 9V overshoots.

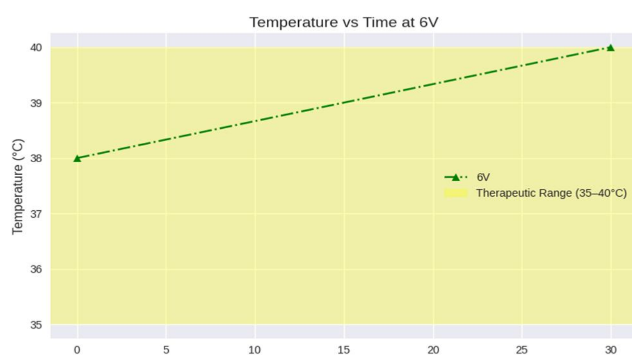

Fig. 5. Temperature vs. Time at 6V Output. Heating curve from 38 °C to ~40 °C over 30 minutes, showing slow, stable heating suitable for long-duration therapy.

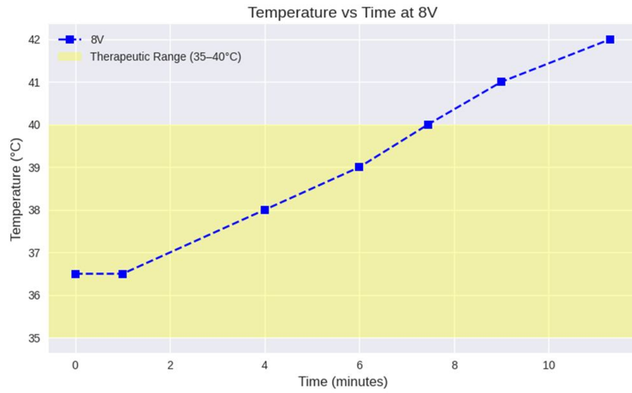

Fig. 6. Temperature vs. Time at 8V Output. Heating curve from 36.5 °C to ~42 °C in ~11 minutes, balancing heating speed with stability.

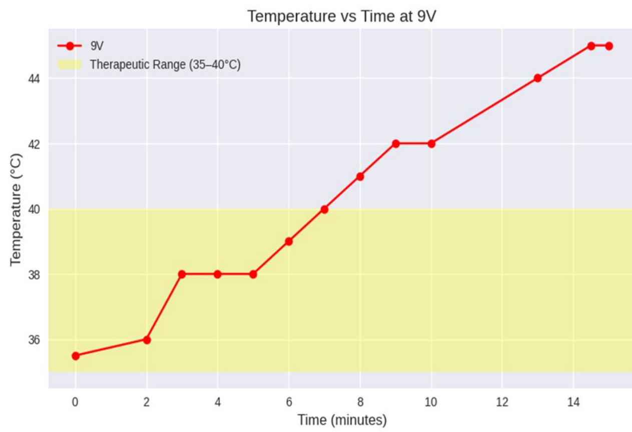

Fig. 7. Temperature vs. Time at 9V Output. Heating curve from 35.5 °C to ~45 °C in ~15 minutes, highlighting the risk of exceeding the therapeutic range.

IV. DISCUSSION

The study successfully demonstrates the feasibility of a silicone-insulated Nichrome mould for Netra Tarpana. The results align with Duan et al. [5] regarding the necessity of uniform heating structures. The 6V profile provided the safest operation, while the 9V profile highlighted the dangers of open-loop control systems.

While manual measurement was sufficient for this proof-of-concept, clinical deployment requires enhanced safety. As noted by Patel et al. [9], PWM controllers are essential for precise biomedical heating applications. Furthermore, the integration of sensors, such as thermistors or RTDs, as discussed by Rao and Nair [10], is critical for real-time feedback.

Future iterations will focus on "iterative refinement" [15] of the device, incorporating closed-loop control systems to regulate voltage based on real-time temperature data automatically. This will ensure the ghee remains strictly within the 35–40 °C range, regardless of ambient fluctuations.

V. COUNCLUSION

This research presents a novel engineering solution to the limitations of traditional Netra Tarpana therapy. The developed silicone mould, powered by a nichrome heating element, demonstrated that voltage selection directly dictates heating outcomes. The 6V input ($1.43\, W$) offered the most stable therapeutic heating, while higher voltages required active regulation to prevent overshoot. By validating the use of biocompatible silicone and resistive heating, this work lays the foundation for a reproducible, hygienic, and patient-friendly ocular therapy device. Future work will integrate sensor-based feedback and safety cut-offs to fully modernise this Ayurvedic practice.

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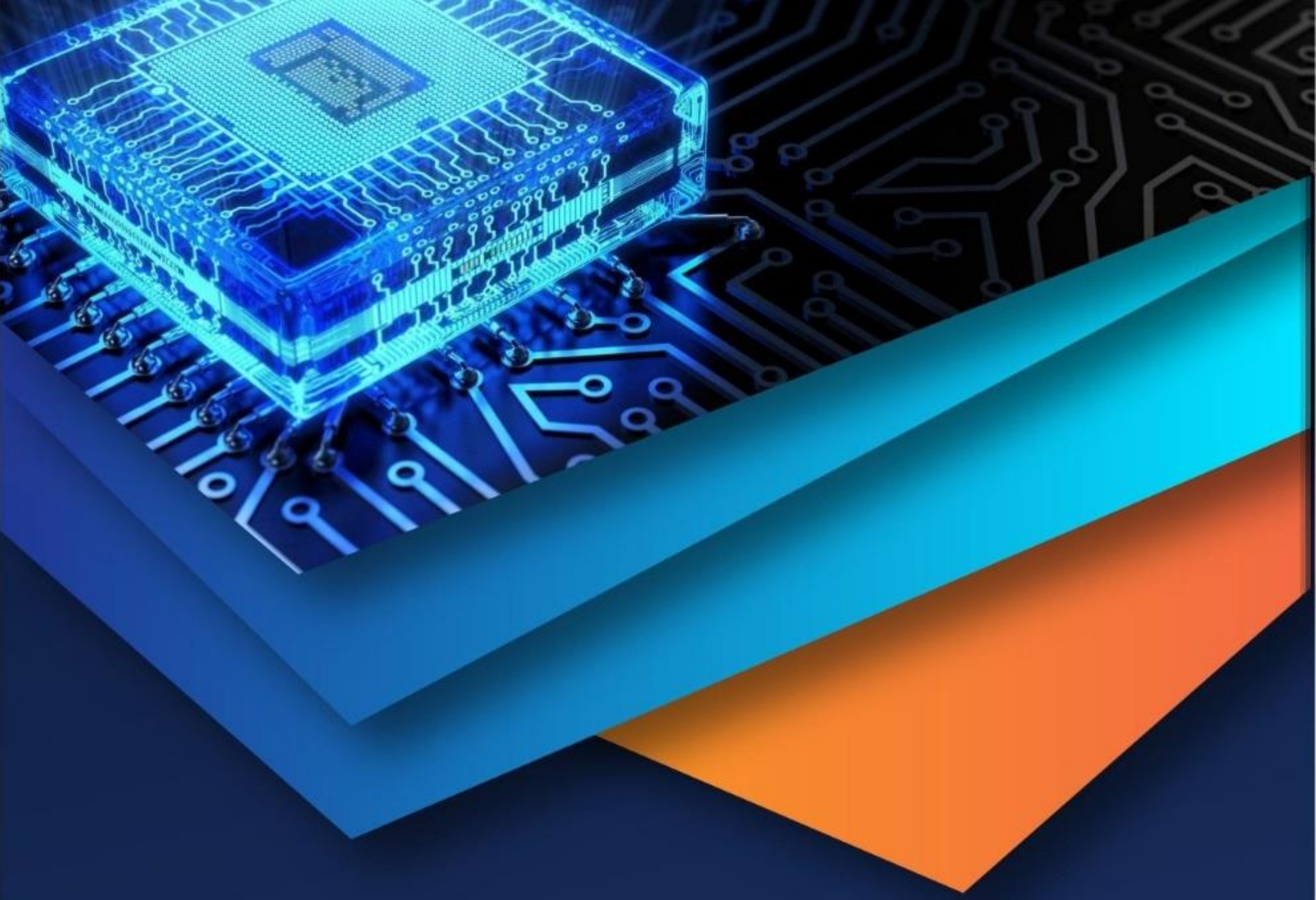

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