

MECHZONE

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Department of Mechanical Engineering
SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY
Karukutty, Ernakulam, Kerala

From the Editor's Desk

December 2024 marks a pivotal moment for mechanical engineers across the world. The twin forces of electrification and digitisation are reshaping every domain of our discipline — from powertrain design and manufacturing floors to energy systems and materials science. This issue of **MechZone** reflects that energy.

Our faculty contributors tackle three defining challenges of this decade: the thermal engineering demands of electric vehicles, the role of artificial intelligence in keeping our factories running smarter, and the promise of green hydrogen as the engineering community's answer to hard-to-abate emissions. Each article is grounded in current research, industry practice, and our department's ongoing work.

On the student side, the energy is equally inspiring. You will read about S6 students fabricating a Formula-style SAE car from the ground up, a creative S5 project designing a solar dryer for Kerala's agricultural sector, and an honest internship account from a student who learned what 'industry-ready' truly means inside a KINFRA manufacturing plant.

Dr. Vidya Chandran
Editor-in-Chief, MechZone 2024
Head, Dept. of Mechanical Engineering, SSET

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Vision and Mission

Vision and Mission of the Institute

Vision

To be a centre of excellence in providing technical education in harmony with the changing global order.

Mission

To offer technology related education of exceptional quality to students by developing their total personality with due emphasis on ethical values and preparing them to meet the growing challenges of the industry and human society.

Vision and Mission of the Department

Vision

To be a centre of excellence in Mechanical Engineering recognized for its quality education, innovative research and social outreach programs.

Mission

1. Provide excellent student-centric education generating high calibre graduates to face global challenges.
2. Maintain state-of-art facilities for faculty and students to learn, research and disseminate knowledge.
3. Emphasize on collaborative technology-transfer encouraging innovations for the benefit of society.

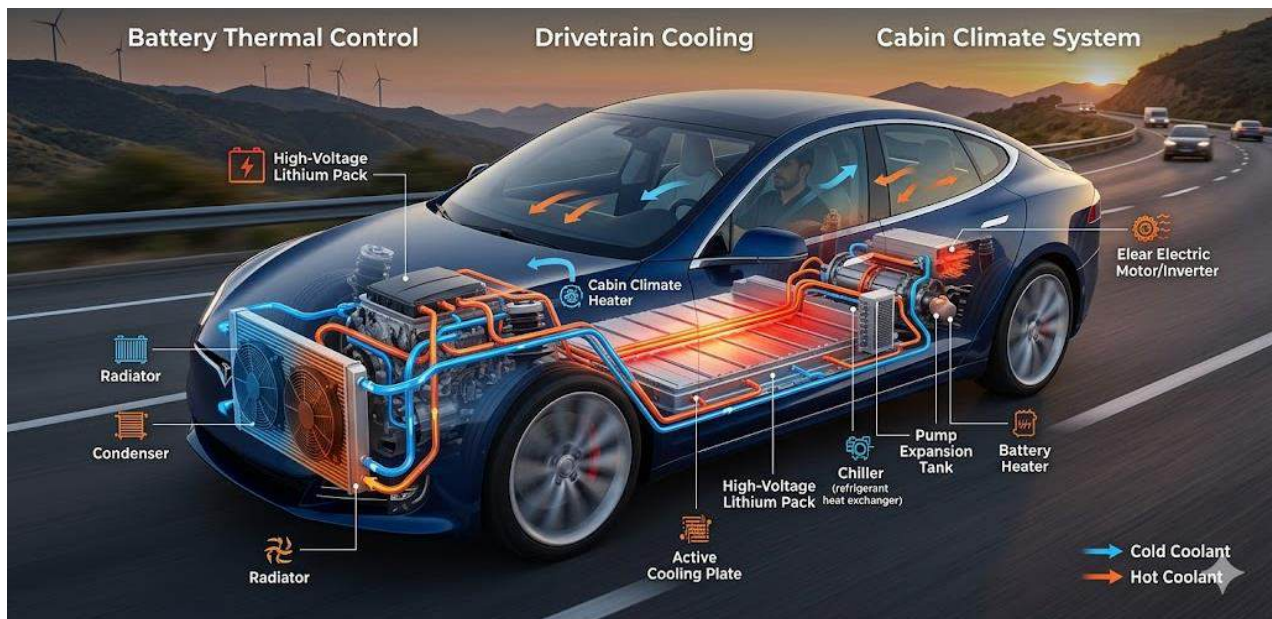


Fig. 1 — Schematic of an EV powertrain thermal management system integrating battery, motor, and power electronics cooling loops.

FACULTY ARTICLE

Electric Vehicles & Thermal Management: What Mechanical Engineers Must Know Right Now

As India's EV market accelerates past 1.5 million annual sales, the thermal engineering challenges beneath the hood demand urgent, India-specific solutions.

Mr. Noel Joseph Gomez · Assistant Professor, Department of Mechanical Engineering

India crossed a significant milestone in October 2024 when cumulative electric vehicle registrations surpassed the 5 million mark. Ola Electric, Tata Motors, and Mahindra collectively account for over 70% of this volume, and their engineering teams face a challenge that no textbook fully anticipated: how do you keep an EV's battery, motor, and power electronics within safe temperature windows when the ambient temperature regularly touch 38°C and humidity exceeds 80% in Kerala. In an ICE, waste heat is abundant and cheap — you simply route coolant through a radiator. In an EV, every joule of thermal energy mismanaged is a joule of range lost. A lithium-ion cell operating above 45°C degrades its cycle life by 20–35% per 10°C excess, while below 15°C, available capacity drops precipitously.

The Three Thermal Domains

EV thermal management must address three distinct, inter-coupled domains:

- 1

Battery Thermal Management System (BTMS)

Maintains each cell between 20–40°C during charge/discharge. Approaches include air cooling (low cost, poor for tropical climates), liquid cooling via serpentine cold plates (dominant in BEVs above 40 kWh), and immersion cooling with dielectric fluids (emerging for fast-charge applications above 150 kW).
- 2

Motor & Inverter Cooling

Permanent magnet synchronous motors (PMSM) and the associated SiC-based inverters generate localised heat fluxes exceeding 50 W/cm². Hollow shaft rotor cooling and direct winding oil injection are entering production for high-performance platforms.
- 3

Cabin HVAC Integration

Unlike ICE vehicles, EVs have no waste engine heat for cabin warming. Heat pumps — now standard on the Tata Nexon EV Max and MG ZS EV — deliver a COP of 2.5–3.5 for heating, conserving up to 20% range in winter versus simple resistive heaters.

"A 10°C rise above the optimal battery window can cut cycle life by over 25%. In Indian ambient conditions, BTMS is not optional — it is existential."

Current Research at SSET

Our thermal sciences lab is currently evaluating phase change material (PCM) enhanced cold plates for two-wheeler battery packs. Paraffin-based PCMs with graphene oxide dispersion (2% w/w) demonstrate isothermal behaviour over a 22-minute discharge cycle, maintaining cell temperatures within ±2.5°C of 35°C setpoint — a result 11°C better than the air-cooled baseline.

Cooling Strategy	Peak Temp (°C)	Uniformity (ΔT)	Mass (kg)	Cost
Passive Air	58.4	12.1°C	0.8	1×
Forced Air	51.2	8.3°C	1.4	1.4×
Liquid (Cold Plate)	38.7	3.2°C	4.1	3.2×
PCM + Graphene	36.1	2.5°C	3.6	2.8×
Immersion (Dielectric)	33.8	1.8°C	5.9	6.5×

Table 1 — Comparative performance of BTMS strategies at 2C discharge, 38°C ambient.

FACULTY ARTICLE · CONTINUED

Design Implications for Mechanical Engineers

The shift to EVs is not just a powertrain change — it is a complete rethinking of thermal architecture. Students entering the industry in 2025 and beyond must be comfortable with conjugate heat transfer simulation, refrigerant cycle modelling, and the materials science of thermal interface materials (TIMs). Silicone-based TIMs with thermal conductivities of 3–6 W/m·K are standard today; next-generation boron nitride composites push this above 12 W/m·K.

From a manufacturing perspective, the cold plate itself presents interesting challenges. Micro-channel aluminium extrusions with hydraulic diameters below 1 mm offer heat transfer coefficients exceeding 8,000 W/m²·K, but require precision joining — typically vacuum brazing — that demands tight quality control. Our students gain hands-on exposure to these processes through our thermal engineering lab and industry internship partnerships.

"The engineer who understands both the electrochemistry of a cell and the fluid mechanics of its cooling plate will be the most valuable person in any EV team."

Looking ahead: Solid-state batteries, expected to enter mass production between 2027–2030, will dramatically change the BTMS landscape. Operating at wider temperature windows with lower thermal runaway risk, they may allow simpler cooling architectures — but they will bring new challenges in manufacturing precision and separator thermal management that mechanical engineers are uniquely positioned to solve.

AI-Driven Predictive Maintenance in Modern Manufacturing Plants

How machine learning and IIoT sensors are replacing scheduled downtime with intelligent, real-time asset health monitoring.

Mr. Ajith Kumar R, Assistant Professor, Department of Mechanical Engineering

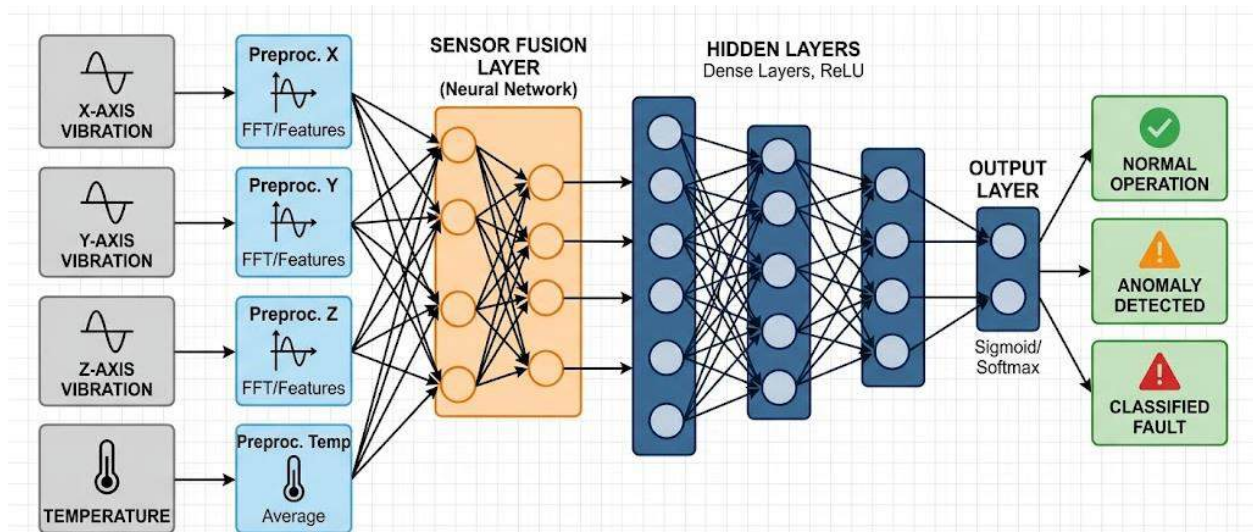


Fig. 2 — Neural network node graph representing an IIoT sensor fusion architecture for multi-axis vibration and temperature anomaly detection.

Manufacturing downtime costs the Indian economy an estimated Rs.96,000 crore annually, according to a 2024 FICCI report. Traditional scheduled maintenance — oil changes at fixed intervals, bearing replacements every 6,000 hours — is simultaneously too conservative (wasting good components) and too reactive (missing failures that than the schedule anticipates).

Predictive Maintenance (PdM) replaces this with continuous monitoring: sensors stream vibration, temperature, current signature, and acoustic data; machine learning models parse this stream for anomaly patterns; maintenance is triggered only when a fault signature is detected — typically 48–96 hours before failure.

The Three-Layer IoT Stack

Edge Layer: MEMS accelerometers, RTDs, and current transformers mounted directly on rotating assets. Data sampled at 5–20 kHz, pre-processed on ESP32 or Raspberry Pi compute modules.

Fog/Gateway Layer: Industrial gateways (Siemens SCALANCE, Advantech) aggregate sensor streams, perform local FFT processing, and transmit compressed feature vectors to the cloud via MQTT or OPC-UA.

Cloud Analytics Layer: AWS IoT Core or Azure IoT Hub ingests data; trained CNN-LSTM or Random Forest models classify fault state; dashboards display severity scores with maintenance work order generation.

Key 2024 Milestones in PdM

Month	Development
Jan 2024	Siemens: Industrial Copilot for MindSphere PdM
Mar 2024	NASSCOM: 40% YoY IIoT growth in Indian factories
Jun 2024	SKF India: AI bearing monitor across 18 plants
Sep 2024	Bosch Rexroth: PdM in hydraulic servo systems
Nov 2024	KINFRA: IIoT pilot across 12 SME tenants

Common Fault Signatures

Fault Type	Signature	Detection
Bearing defect	BPFI/BPFO harmoni	cEsvelope
Shaft imbalance	1× freq. dominant	FFT peak
Misalignment	2× & 3× harmonics	Cepstrum
Gear tooth wear	Gear mesh freq.	Kurtosis
Motor stator	Sidebands fs±2sf	MCSA

"The best predictive maintenance system is one that maintenance technicians actually trust enough to act on. Technology without adoption is just expensive data collection."

The most impactful finding was not technical but human: maintenance technicians initially distrusted the AI alerts, preferring to rely on their experience and scheduled checks. Achieving adoption required a three-week co-design workshop where technicians reviewed past failure data alongside model predictions. By Month 3, alert compliance reached 89%.

What Students Should Learn: MATLAB/Python for signal processing (FFT, wavelet analysis), fundamentals of machine learning classification, exposure to industrial protocols (OPC-UA, MQTT), and — critically — the soft skills to work with shop-floor technicians who will be the ultimate users of these systems.



Fig. 3 — Molecular dynamics of green hydrogen production via PEM electrolysis powered by renewable energy — the cleanest pathway to H_2 production.

FACULTY ARTICLE

Green Hydrogen: Engineering the Fuel of a Decarbonised Economy

Following COP29 in Baku and India's ramping National Green Hydrogen Mission, mechanical engineers are at the centre of a global energy transition.

Mr. Jose Sheril D'Cotha · Assistant Professor, Department of Mechanical Engineering

When world leaders gathered at COP29 in Baku, Azerbaijan in November 2024, green hydrogen occupied a prominent place in the negotiations — not as a distant promise but as a near-term industrial reality. India's National Green Hydrogen Mission, which committed Rs.19,744 crore through 2030, is already catalysing electrolyser manufacturing, hydrogen-ready pipeline infrastructure, and fuel cell vehicle development across the country.

For mechanical engineers, green hydrogen presents a rich constellation of technical challenges spanning thermodynamics, fluid mechanics, materials science, and safety engineering. This article walks through the key mechanical engineering dimensions of the hydrogen economy.

PRODUCTION <i>PEM Electrolysis</i> Proton exchange membrane electrolyzers split water using renewable electricity. Stack efficiencies of 65–70% (LHV basis) are achievable today; 80% is the 2030 target. Mechanical engineers design the bipolar plates, membrane electrode assemblies, and balance-of-plant piping systems.	STORAGE <i>Type IV Vessels</i> Compressed hydrogen at 700 bar requires Type IV composite overwrapped pressure vessels (COPV) — carbon fibre reinforced polymer over a polymer liner. Burst pressure must exceed 1.5× working pressure; fracture mechanics and fatigue life analysis are critical mechanical engineering competencies here.	UTILISATION <i>H₂ Combustion & Fuel Cells</i> Hydrogen burns 6× faster than methane with a wide flammability range (4–75% in air). Retrofitting existing gas turbines and industrial burners for H ₂ blends up to 30% is the 2030 target. Volume fraction requires careful NOx management through lean premixed combustion design.

Material Challenges: Hydrogen Embrittlement

One of the most insidious mechanical threats in hydrogen service is hydrogen embrittlement (HE) — the diffusion of atomic hydrogen into metallic lattices, reducing fracture toughness and fatigue resistance by up to 90% in susceptible steels. Pipeline steels must meet ASME B31.12 hydrogen service requirements; high-strength steels (yield strength > 550 MPa) are typically excluded from hydrogen service unless rigorously qualified.

Austenitic stainless steels (316L, 304L) and aluminium alloys show excellent HE resistance and are preferred for electrolyser and fuel cell balance-of-plant components. In our materials lab, we are currently conducting hydrogen exposure tests on candidate alloys for a proposed hydrogen refuelling station at KINFRA Ernakulam — a project that gives our M.Tech students extraordinary hands-on research exposure.

Kerala's Hydrogen Opportunity

Kerala's high renewable energy penetration — over 65% of power generation from hydro, solar, and wind — creates a natural competitive advantage for green hydrogen production. KSEB's 10 MW electrolyser feasibility study, announced in August 2024, could position Kochi as South India's first hydrogen hub. For our graduates, this is not a distant career opportunity — it is a present one.

"Hydrogen will not replace every energy carrier — but for industrial heat, long-haul shipping, and green steel, it is the only credible decarbonisation pathway that mechanical engineers are uniquely equipped to deliver."

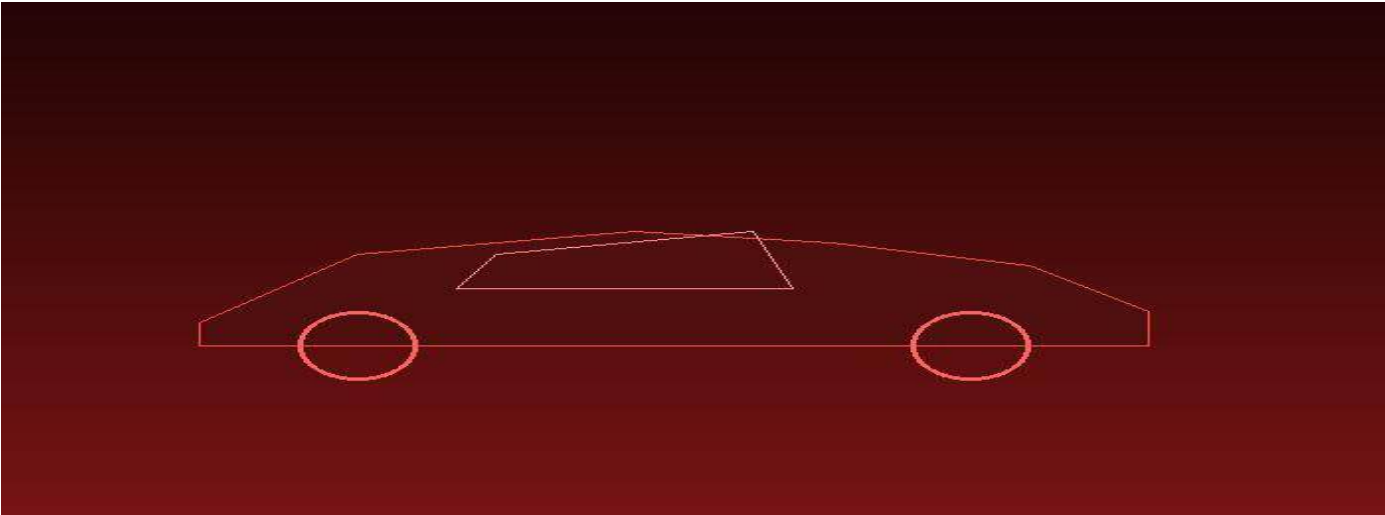


Fig. 4 — CAD render of the SCMS SET SAE car (Team MechRacer): carbon fibre body panels, tubular space frame, and 600cc single-cylinder engine.

STUDENT ARTICLE

Inside Our SAE Formula-Style Car Build — A Semester 6 Project Diary

How twelve S6 students designed, debated, fabricated, and (almost) gave up before building the most ambitious student project in our department's history.

Pranav George Abraham · S7 Mechanical Engineering

We signed the project registration form on a Tuesday afternoon in January 2024, fully confident and completely naive. Twelve students, one unused workshop corner, a team WhatsApp group called 'MechRacer', and an ambition to build a Formula-style open-wheel car from scratch. Nine months later, we have something that moves under its own power, stops when we ask it to, and turns corners without killing anyone. This is that story.

Phase 1: Requirements & Concept Design (Jan–Feb 2024)

SAE India Formula Bharat rules cap engine displacement at 610cc, mandate roll hoop protection, and specify minimum track widths, suspension travel, and braking performance. We spent six weeks purely on requirements before touching CAD — a discipline that Mr. Nikhil Asok N insisted on and that we are immensely grateful for.

TECHNICAL SPECIFICATIONS — MechRacer Mk.1	
Chassis	AISI 4130 chromoly steel space frame; 22 nodes, 48 members; MIG welded
Engine	Honda CBR600RR (599cc, 118 hp, adapted for Formula rules)
Transmission	Chain drive, 6-speed sequential; custom sprocket ratio 14:43
Suspension	Double wishbone F&R; pushrod-actuated coilovers; 60mm travel
Brakes	Hydraulic disc, 4-pot callipers front & rear; bias bar adjusted

Steering	Rack & pinion; 2.5 turns lock-to-lock; Ackermann geometry
Bodywork	Hand-laid fibreglass nose cone & side pods; GFRP undertray
Dry Weight	298 kg (target: 290 kg; 8 kg over — our biggest regret)
0–60 kph	3.9 seconds (measured, KMM Ernakulam test track, Nov 2024)

Phase 2: The Hardest Part — Fabrication (Mar–Aug 2024)

Nobody told us that MIG welding chromoly steel to aerospace-quality standards would require 200 hours of practice runs before touching actual chassis tubes. Our first weld bead looked like a caterpillar having a crisis. By month three, our two best welders — Ajo and Govind — were producing joints that passed dye-penetrant inspection.

The suspension geometry was our most intellectually demanding challenge. Getting Ackermann steering geometry correct in SolidWorks was straightforward; fabricating the steering rack mount to ±0.5mm tolerance on our department's conventional lathe was not. We learned that the gap between simulation and reality is bridged by patience, measurement, and rework.

"The day the engine fired for the first time — oil leaking from three different gaskets, half the team screaming, the other half filming — is a memory none of us will ever lose."

What We Learned (Beyond Engineering)

- 1

Budget management is engineering

We had Rs.3.8L. We spent Rs.4.1L. Every decision — local supplier vs. imported bearing, fibreglass vs. carbon fibre — was a financial trade-off.
- 2

Documentation saves projects

We nearly repeated a suspension geometry error because we hadn't documented our first iteration's failure analysis. Now we write everything down.
- 3

Team dynamics are as complex as any mechanism

Four of our twelve team members considered quitting at various points. Regular retrospectives and honest conversations kept us together.

Designing a Solar Dryer for Post-Harvest Loss Reduction in Kerala

Devanarayanan A R · S3 Mechanical Engineering

Kerala loses an estimated 25–35% of its perishable agricultural produce annually to inadequate post-harvest processing — a statistic that translates to significant income loss for small-hold farmers, particularly in banana, coconut, turmeric, and fish segments. Open-air sun drying, while cost-free, is slow (3–5 days), weather-dependent, and susceptible to contamination.

My S5 minor project set out to design, fabricate, and field-test an indirect solar dryer optimised for Kerala's climatic conditions — high humidity (75–90% RH), moderate solar irradiation (4.2–5.8 kWh/m²/day), and a primary crop of banana chips, the region's most economically significant dried product.

Thermal Design Methodology

The dryer uses an indirect design: air is heated in a flat-plate solar collector and directed into a separate drying chamber, avoiding direct UV exposure on the product (which degrades colour and vitamin content). The flat-plate collector uses a selective absorber surface (copper sheet, black chrome coating, $\alpha=0.95$,

$\varepsilon=0.08$) under 4mm tempered glass glazing with a 60mm air gap.

Using the Hottel-Whillier-Bliss (HWB) equation for collector efficiency and psychrometric analysis for the drying chamber, I determined an airflow requirement of 0.08 m³/s, delivered by a 25W DC fan powered directly by a 40W solar panel — making the system fully off-grid.

Design Targets

Parameter	Specification
Drying capacity	8 kg/batch
Drying time (banana chips)	< 6 hours (vs 3 days open-air)
Collector area	2.4 m ²
Collector efficiency	> 55%
Max. drying temperature	55–65°C
Fabrication cost	< Rs.15,000
Material	MS frame + polycarbonate glazing

Field Test Results

Metric	Open-Air Drying	Solar Dryer (This Project)	Improvement
Drying time (8 kg banana)	68 hours	5.4 hours	92.1% reduction
Final moisture content	14.2%	10.8%	Meets FSSAI standard
Product colour (L* value)	61.3	72.8	Brighter, market-preferred
Microbial count (CFU/g)	1,240	< 50	Well within safe limits
Energy input	0 (solar)	40W fan × 5.4h = 0.22 kWh	Off-grid capable

STUDENT ARTICLE

CNC Automation on a Budget: What My Internship at KINFRA Taught Me About Real Engineering

Six weeks inside a KINFRA Ernakulam precision components plant — where theory meets coolant, chips, and the quiet satisfaction of a part that fits.

Gokulakrishnan P R · S7 Mechanical Engineering

The morning I walked onto the shop floor at KINFRA's precision components unit in Kalamassery, the first thing I noticed was the smell. Not the clinical smell of a university lab — something more honest: cutting oil, hot metal, and the particular ozone tang of three-phase electrical equipment working hard. It was, I realised, the smell of manufacturing. I immediately felt both excited and profoundly out of my depth.

My internship supervisor, Mr. Pradeep K., a tool room manager with 24 years of experience, summed up my first week memorably: 'You know GD&T; from your textbook. Now I will show you what happens when a machinist interprets the same drawing differently from the designer.' That week, I saw three rejected batches and learned more about tolerancing than in two semesters of Manufacturing Engineering.

My Primary Project: CNC Cycle Time Optimisation

The plant runs 14 CNC turning centres (Fanuc 0i-TD controller) producing aluminium aerospace brackets for a Tier-1 supplier. I was tasked with reducing cycle time on their most-produced part — a 6061-T6 wing rib bracket — from the current 8.2 minutes to below 7.0 minutes without compromising surface finish ($Ra \leq 1.6 \mu m$) or dimensional tolerance ($\pm 0.02 mm$ on critical features).

G-code Modification	Before	After	Saving (per part)
Rapid traverse (G00) speed	F5000	F8000	12 seconds
Roughing depth of cut	2.0 mm	2.8 mm	38 seconds
Tool path (CYCLE97 threading)	4 passes	3 passes (optimised)	22 seconds
Spindle warm-up sequence	Manual, 90s	Macro-automated	65 seconds (amortised)
TOTAL SAVING	—	—	1 min 57 sec (23.8%)

Table 3 — CNC cycle time optimisation results, KINFRA Precision Unit, July 2024.

At 14 machines running two shifts, that 1 minute 57 second saving per part translated to an additional 34 parts per shift across the plant — a throughput improvement that Mr. Pradeep quietly informed me was 'worth more than your entire internship stipend every single day.' He said it kindly. I chose to take it as a compliment.

"University teaches you to solve problems that have solutions. Industry teaches you to solve problems that have constraints — and the constraints are never in the textbook."

Activities at the department

30 May – 05 Jun 2024	Dr. Rag R L completed the Malayalam translation of the textbook "Engineering Graphics and Design" and submitted it to AICTE after editing by the Digital University of Kerala.
20–26 Jun 2024	Mr. Noel Joseph Gomez and Mr. Sivaprasad N, PhD scholars of the department, successfully completed their comprehensive viva voce on 20th June 2024. Supervisor: Dr. Rag R L.
27 Jun – 03 Jul 2024	Dr. Mahesa Rengaraj published an article titled "Design and analysis of a novel prosthetic limb for lower knee amputee" in the journal Research on Biomedical Engineering, Springer Publications, June 2024.
18–24 Jul 2024	Dr. Raghav G R published a book titled "Mechatronics and IoT" as per Anna University syllabus, Charulatha Publications, Chennai, ISBN: 978-93-6260-200-8, July 2024.
25 Jul 2025	Mr. Ajith Kumar R & Dr. Raghav G R were granted a patent for an 'Adjustable neck-mounted phone holding device for scooters' (with student co-inventors).
08–09 Aug 2024	Mr. Nikhil Asok N, Mr. Dhanesh S, and Mr. Dinil Babu C attended the Training of Trainers (TOT) workshop by GIZ on Women E-Auto Driving, organized by SIRST.
08–14 Aug 2024	Mr. Rakesh A, Mr. Nikhil Ashok N, Mr. Dhanesh S, and Mr. Dinil Babu C attended the Training of Trainers program by GIZ on Passenger Management and Gender Sensitivity at SiRST, Thiruvananthapuram on 8th August 2024. Mr. Nikhil Asok N also served as jury member for the Road Safety Idea Pitching Competition organized by YI Ernakulam Zone on 9th August 2024.
22–28 Aug 2024	Dr. Raghav G R was granted a Design Patent titled "Protective Footwear Shield for Metatarsal Bone Fractures".
27 Aug 2024	Dr. Vidya Chandran was invited to serve as a board member of the Council on Women in Energy & Environmental Leadership (CWEEL), Kolkata Chapter, and attended the interim board meeting.
12–25 Sep 2024	Dr. Gibin George and Dr. Raghav G R submitted a book titled "Nanotechnology for Mechanical Engineers – A Comprehensive Perspective" to CRC Press for publication (accepted; publication date 11 June 2025).
26 Sep – 02 Oct 2024	Dr. Mahesa Rengaraj submitted a project proposal to the Economic Research Institute for ASEAN and East Asia (ERIA) titled "Migrant Workers in India's Construction Industry". Co-investigators: Dr. Gibin George, Dr. Raghav G R.
03–09 Oct 2024	Dr. Gibin George submitted a research project proposal to DST on sustainable and eco-friendly green material composites. Mr. Dinil Babu C attended a Teachers' Workshop on Space and Climate Change at LPSC, Valiamala, Thiruvananthapuram on 7th October 2024.



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