

INDUSTRIAL CASE STUDY

Conveyorized Curing & Infrared Pre-Heating Systems

High-Throughput Powder Coating Line Upgrade — Continuous Conveyorized System with Short-Wave IR Pre-Heat Zone

Designed, Engineered & Validated by KERONE Engineering Solutions Limited

4.2 m/min CONVEYOR LINE SPEED	180 °C IR PRE-HEAT SURFACE TEMP	14 min TOTAL CURE CYCLE TIME
34% SPECIFIC ENERGY REDUCTION	+50% THROUGHPUT INCREASE	~1.9 Yrs PAYBACK PERIOD

Project Reference Detail

Field	Detail
Client Organisation	Apex MetalFinish Industries Pvt. Ltd. — Automotive & Appliance Component Powder Coating Job-Work Provider
KERONE Reference	KRDC/ICS/IRCure/2025-02 Based on KRDC Trial Report 52/KRDC/LAB/22
Technology	Conveyorized Continuous Curing Line with 3-Zone Short-Wave Infrared Pre-Heating Module
Feedstock / Input	Powder-coated mild steel fabricated components (brackets, panels, appliance housings), 1.5–2.5 mm gauge
Product Output	Fully cured powder-coat finish meeting cross-hatch adhesion & MEK rub specification, at increased line speed
Plant Location	Client facility (powder coating line) — retrofit inline with existing convection cure oven
Document Date	July 2026 Validated on KRDC Lab Data — May 2026

Powder Coating | Infrared Pre-Heating | Conveyorized Curing | Surface Finishing | Industrial Energy Efficiency | Automotive & Appliance Components

Executive Summary

Apex MetalFinish Industries Pvt. Ltd. operates a conveyorized powder coating line finishing approximately 1,800 components per day for automotive ancillary and appliance OEM clients. Their existing single-zone convection curing oven required a 22-minute dwell at 200 °C to achieve full cure, creating a line-speed bottleneck that limited throughput to 2.8 m/min and consumed significant energy ramping cold parts entering the oven purely by hot-air convection.

KERONE Engineering Solutions Limited was engaged to design a retrofit solution: a conveyorized Short-Wave Infrared (IR) Pre-Heating Zone installed ahead of the existing convection curing tunnel, rapidly raising part surface temperature before entry into the main cure zone — thereby cutting overall cure dwell time and enabling higher conveyor speed at equal or superior cure quality.

Following KRDC bench-scale trials on Apex's actual production test panels (both flat and 3D-formed mild-steel geometries) at varying IR panel-to-part distances and exposure durations, optimal pre-heat parameters were established. The KERONE conveyorized system — a 3-zone IR pre-heat module raising part surface temperature to 180 °C within 90 seconds, followed by a reduced 14-minute convection cure zone at 200 °C — delivers full cure equal to or exceeding the 22-minute baseline, at nearly 50% higher line speed, with a 34% reduction in specific energy consumption per unit of coated area.

CHALLENGE	KERONE SOLUTION	OUTCOME ACHIEVED
Existing single-zone convection curing oven bottlenecked at 22-minute dwell / 2.8 m/min line speed, with high energy use ramping cold steel parts to cure temperature by hot-air convection alone.	Conveyorized 3-zone short-wave Infrared pre-heating module ahead of the existing convection tunnel — validated from KRDC bench trials on the client's actual production parts.	Cure dwell cut to 14 minutes, line speed raised to 4.2 m/min (+50% throughput), specific energy down 34%, full cure quality maintained (cross-hatch / MEK rub pass).

Key Performance Summary

KPI	Baseline (Convection Only)	After KERONE IR Retrofit	Improvement
Cure Dwell Time	22 min	14 min	36% reduction
Line Speed	2.8 m/min	4.2 m/min	+50% throughput
Specific Energy Consumption	1.85 kWh/m ²	1.22 kWh/m ²	34% reduction
Daily Throughput (2-shift)	1,800 parts/day	2,700 parts/day	+50% increase
Under-Cure Reject Rate	3.2%	< 0.8%	75% reduction
Annual Energy Cost	INR 38–42 L/yr	INR 25–28 L/yr	~INR 13–14 L/yr savings

Industry Context & The Business Challenge

India's powder coating industry is expanding rapidly on the back of automotive ancillary and consumer appliance demand, with job-work and OEM-captive finishing lines under growing pressure to raise throughput and lower energy intensity per part. Conventional single-zone convection ovens are limited by the thermal lag of heating a cold steel substrate purely through hot-air convection, which caps achievable line speed for a given cure specification.

Infrared pre-heating — widely adopted on high-volume OEM finishing lines in Europe and North America — remains comparatively nascent among mid-size Indian job-work coaters. This creates a clear differentiation opportunity: Tier-1 automotive component buyers increasingly specify shorter cure-cycle capability and lower Scope-2/Scope-3 energy intensity per coated part as a condition of new sourcing volume, favouring finishers who can demonstrate both.

The Commercial Problem — Why the Existing Line Falls Short

Performance Parameter	Existing Convection-Only Line	Target OEM Requirement	Gap
Cure Dwell Time	22 min	< 15 min preferred for new capacity commitments	FAIL — too slow
Line Speed / Capacity	2.8 m/min (~1,800 parts/day)	2,500+ parts/day for new contract	FAIL — insufficient
Specific Energy Consumption	1.85 kWh/m ²	< 1.3 kWh/m ² (OEM energy target)	FAIL — 42% over target
Under-Cure Reject Rate	3.2%	< 1.0%	FAIL — quality risk

Table 1: Existing line performance vs incoming OEM sourcing requirements | Source: Apex production data & client-communicated OEM targets

Productivity Opportunity — Unlocking Existing Line Capacity

The Opportunity: at the retrofitted 4.2 m/min line speed, Apex gains approximately 900 additional finished parts per day within the existing floor footprint. At an average job-work realisation of INR 45 per part, this represents incremental revenue of roughly INR 40,500/day, or approximately INR 1.21 Cr/year across 300 operating days — alongside standalone annual energy savings of INR 13–14 Lakhs from the 34% reduction in specific energy consumption.

About Apex MetalFinish Industries Pvt. Ltd.

Apex MetalFinish Industries Pvt. Ltd. is a privately held job-work powder coating and metal finishing company with coated-area capacity exceeding 15,000 m²/month, serving automotive ancillary and consumer appliance OEM clients across western India. Their operations span pre-treatment, electrostatic powder application, and convection curing — positioning them as an ideal candidate for KERONE's conveyorized IR pre-heating retrofit. The KRDC trial was conducted on Apex's actual production test panels (mild steel, 1.5 mm and 2.5 mm gauge, dispatched to KRDC on 12 May 2026) to ensure industrial relevance of all process parameters.

Process Validation — From KRDC Bench Trials to Industrial Scale

KERONE's engineering approach mandates bench-scale validation before any industrial system specification. The KRDC (Kerone Research & Development Centre) conducted a structured experimental programme on Apex's actual powder-coated test panels over 5 days (12–16 May 2026), using a bench IR emitter rig with adjustable panel-to-part distance and exposure duration to establish the process envelope that informs the conveyorized industrial design.

KRDC Experimental Programme — Key Findings

Test Condition	Panel-to-Part Distance	Exposure Time	Surface Temp Achieved	Assessment
Control (no IR)	N/A	0 sec	Ambient (~28 °C)	Baseline — full convection reliance
Short exposure	150 mm	45 sec	95 °C	Insufficient — inconsistent downstream cure
OPTIMAL	150 mm	90 sec	180 °C	Optimal pre-heat, uniform across gauge
Extended exposure	150 mm	150 sec	210 °C	Risk of localised overheat / discolouration on thin gauge

Table 2: KRDC bench trial results — short-wave IR pre-heat on Apex mild-steel test panels | KRDC Test Report 52/KRDC/LAB/22

Scale-Up Methodology — Bench to Conveyorized Line

KERONE's scale-up process follows a structured engineering framework translating bench parameters into conveyorized industrial equipment specifications using validated radiant-heat-transfer models. The key translation factors for this project are:

Parameter	KRDC Bench Rig	Industrial Plant (Conveyorized)
IR Emitter Type	Short-wave quartz emitter	Short-wave quartz emitter
Panel-to-Part Distance	150 mm (fixed)	150 mm (motorised, adjustable 100–200 mm)
Exposure / Residence Time	90 sec (static panel)	90 sec (at 4.2 m/min over 6.3 m zone length)
Throughput	Single test panel	Continuous multi-part loading
Emitter Control	Manual on/off	Zone-wise SCR + PID temperature control
Cooling / Handling	N/A	Integrated into conveyor transfer to cure oven

Industrial Plant Design — Conveyorized IR Pre-Heat & Curing Line

Process Flow



Fig. 1: KERONE Conveyorized IR Pre-Heat & Curing Line — Continuous Industrial Process Flow

System Architecture — Major Process Units

Unit / Section	Equipment	Design Parameters	Function
U-01: Part Loading & Conveyor Infeed	Motorised overhead/floor conveyor + part carriers	4.2 m/min rated, adjustable 2–6 m/min	Uniform part spacing and orientation into IR zone
U-02: IR Pre-Heat Zone	KERONE 3-Zone short-wave IR emitter bank	150 mm working distance, 180 °C surface target, 6.3 m zone length	Rapid non-contact surface heating of powder film prior to convection cure
U-03: Transition / Buffer Zone	Insulated tunnel section	1.2 m length, minimal heat loss	Prevent thermal shock; equalise part surface temperature before oven entry
U-04: Convection Cure Oven (retrofit)	Recirculating hot-air tunnel oven, controls upgraded	200 °C, 14 min residence (down from 22 min)	Final cure / cross-link of powder coating film
U-05: Cooling Zone	Ambient air tunnel + optional forced-air blowers	Outlet <45 °C	Cool parts before handling and packing
U-06: Emitter Control System	Zone-wise SCR power controllers + PID	±3 °C control accuracy per zone	Precise IR intensity control per part geometry / gauge
U-07: Conveyor Drive & Controls	VFD-controlled chain/belt drive	Line speed 2–6 m/min, variable	Synchronise conveyor speed with pre-heat and cure kinetics
U-08: Process Control Panel	PLC/HMI (Siemens / Allen Bradley)	Recipe-based, selectable by part type/gauge	Automated zone temperature & speed control; data logging

Table 3: Process unit descriptions — KERONE conveyorized IR pre-heat & curing retrofit | U-02 is the primary added process unit; U-04 is retrofitted, all others are ancillary

Core Equipment Specification — KERONE IR Emitter Bank

The KERONE 3-Zone Short-Wave IR Emitter Bank is the heart of the pre-heating retrofit. Designed and manufactured in-house at KERONE's Ambernath facility, it directly scales the validated bench parameters from KRDC trial 52/KRDC/LAB/22 to conveyorized industrial throughput while maintaining the identical working distance, exposure profile, and zone control that produced the 180 °C uniform pre-heat result.

IR EMITTER BANK — CORE SPECIFICATIONS	
Design Throughput	85–95 m² coated surface area/hr
Emitter Type	Short-wave quartz IR lamps, gold-coated reflector
Peak Wavelength	1.2–1.4 microns
Panel-to-Part Distance	Adjustable 100–200 mm (motorised)
Number of Zones	3 independent zones
Installed Power per Zone	24 kW
Total Installed IR Power	72 kW
Zone Control	SCR-based zone PID, ±3 °C accuracy
Mounting	Motorised height/angle adjustment
Housing	Aluminium reflector housing, IP54 rated
Emitter Cooling	Integrated forced-air cooling

KERONE IR Emitter Bank (KRDC bench-scale rig used for trials) — industrial unit scaled to 6.3 m zone length across 3 zones

Utilities & Ancillary Requirements

Utility	Specification	Consumption (at Full Load)	Source
Electrical Power	415V, 3-phase, 50Hz	~95 kW connected (IR + drives)	Site utility
Compressed Air	6 bar dry, instrument grade	8 Nm³/hr	Air compressor (site)
Ventilation / Exhaust	Ambient extraction, roof/wall	2,000 m³/hr	Existing shop ventilation
Space Requirement	Retrofit extension of existing line	L 8m x W 2.2m x H 2.5m	Existing bay extension

Emission & Safety Compliance

Point	Parameter	Expected Level	Status
IR zone enclosure	External panel surface temp	< 45 °C (worker safety, limit 60 °C)	COMPLIANT
Oven exhaust	Particulate (powder overspray carryover)	< 15 mg/Nm³ (CPCB limit 50 mg/Nm³)	COMPLIANT

Powder coating is a solvent-free, essentially VOC-free process; the primary environmental and safety consideration for the IR retrofit is radiant-heat containment at the enclosure surface and standard CPCB particulate norms at the existing oven exhaust, both of which are met by the proposed design.

Throughput & Energy Analysis — Full Load Operation

Throughput / Capacity Balance

Stream	Parameter	Value	Notes
Parts In	Rate	2,700 parts/day (2-shift, 16 hr)	At 4.2 m/min line speed, avg. part area 0.35 m²
Coated Area Processed	Rate	~85 m²/hr	Basis for energy and throughput specification
Fully Cured Output	Rate	2,700 parts/day (>99.2% pass)	Cross-hatch adhesion & MEK rub compliant
Rejects (rework)	Rate	< 22 parts/day (< 0.8%)	Down from 58 parts/day (3.2%) at baseline

Table 4: Throughput and quality-yield balance | Based on validated KRDC bench data scaled to conveyorized line throughput

Specific Energy Consumption — Baseline vs KERONE Retrofit

Energy Category	Equipment / Unit	Baseline (kWh/m²)	After Retrofit (kWh/m²)
Curing / Pre-heat	Convection oven ramp-up + IR pre-heat	0.95 (ramp-up phase)	0.42 (IR pre-heat)
Curing (hold phase)	Convection oven hold at 200 °C	0.90	0.68 (reduced 22→14 min)
Conveyor / Auxiliary	Drive, ventilation, controls	included above	0.12
TOTAL		1.85 kWh/m²	1.22 kWh/m²

Table 5: Specific energy consumption per m² coated area — baseline convection-only line vs KERONE IR pre-heat retrofit | 34% net reduction

Product Quality Specification & Market Applications

Expected Cure Quality — KERONE Retrofit vs Baseline

Parameter	Test Method	Baseline (22 min Convection)	IR Pre-Heat + 14 min Cure	OEM Spec
Cross-Hatch Adhesion	ASTM D3359	4B–5B	5B	5B, no flaking
MEK Double Rub Resistance	ASTM D5402	80–90 rubs	>100 rubs	>100 rubs
Gloss (60°)	ASTM D523	82–85 GU	83–86 GU	80–90 GU
Film Cure (Tg confirmation)	DSC	Full cure	Full cure, equivalent Tg	Full cure req.
Impact Resistance	ASTM D2794	Pass 160 in-lb	Pass 160 in-lb	Pass 160 in-lb

Table 6: Product quality specification — baseline vs KERONE IR pre-heat + reduced cure vs OEM requirement | All parameters met or exceeded

Market Applications for the Conveyorized IR Pre-Heat Retrofit

- **Automotive Ancillary Components** — Rubber and gasket-free metal brackets, chassis parts, and wheel rims requiring high-throughput, consistent-quality powder cure for Tier-1 automotive supply contracts.
- **Appliance Housings & Panels** — Washing machine, refrigerator, and other white-goods body panels where surface finish consistency and cycle-time reduction directly affect OEM delivery schedules.
- **Furniture & Architectural Metal** — Metal railings, shelving, and racking systems where line-speed gains translate directly into job-work capacity for growing order volumes.
- **Electrical Enclosures & Panel Boards** — Panel boards and switchgear enclosures requiring documented cure verification (cross-hatch, MEK rub) for electrical safety compliance.
- **General Engineering / Fabrication Job-Work** — Any general engineering or fabrication job-work coater seeking to retrofit an existing convection line for higher throughput without a full oven replacement.

Financial Analysis & Return on Investment

CAPEX Estimate — Conveyorized IR Pre-Heat Retrofit

Cost Head	Scope	Est. Cost (INR Lakhs)	Notes
IR Pre-Heat Emitter Bank (3-zone)	KERONE supply, factory tested	14–17	FOT Ambernath; includes reflectors, mounting frame
Zone Control System (SCR + PID)	Per-zone temperature control	3–4	Integrated with main line PLC
Conveyor Extension / Modification	Additional 8m tunnel section, drive integration	4–5	Client civil interface
Insulated Tunnel Enclosure	Transition + IR zone housing	3–4	Steel / insulated panel construction
Electrical & Instrumentation	MCC panel upgrade, cabling	3–4	Site electrical by client
Ventilation / Exhaust	Extraction fans, ducting	1.5–2	Tied into existing shop ventilation
Commissioning, Training & Startup	KERONE commissioning team, 10-day site support	1.5–2	Includes operator training and performance test
TOTAL CAPEX		INR 30–38 Lakhs	Approx. range; formal quotation on enquiry

Table 7: CAPEX estimate — conveyorized IR pre-heat retrofit | All figures indicative; formal quotation on receipt of detailed enquiry

Incremental Revenue & OPEX Model — Annual Basis (300 days, 2-shift)

Item	Basis	INR/Year (Lakhs)	Remarks
REVENUE (Incremental)			
Additional Job-Work Revenue	900 additional parts/day x 300 days x INR 45/part	121.5	At current job-work realisation rate
OPERATING COST CHANGES			
Electricity (net change)	0.63 kWh/m ² saved despite higher throughput	-13 to -14 (savings)	Reduced specific consumption
Additional Labour	Minimal — largely automated retrofit	~2	Zone monitoring only
Maintenance (IR emitters/reflectors)	Lamp replacement provision	1.5–2	~5% of IR CAPEX/yr
NET INCREMENTAL PROFIT BEFORE TAX		INR ~131 Lakhs/yr	Payback ~1.9 yrs on INR ~34L avg CAPEX

Table 8: Incremental revenue & OPEX model | Indicative figures; actual results depend on job-work volume and pricing achieved

Project Execution & KERONE Scope of Supply

Implementation Timeline

Phase	Activity	Duration	KERONE Deliverable
Phase 0 Pre-Order	Technical consultation, site trial validation, process design freeze, commercial negotiation	3–4 Weeks	Process Design Basis (PDB), GA drawing, utility list, commercial offer
Phase 1 Engineering	Detailed engineering: IR zone layout, electrical, controls integration	4–5 Weeks	Complete engineering package, P&ID/GA drawings
Phase 2 Procurement	IR emitters, reflectors, SCR controllers, conveyor components	6–8 Weeks	Material test certificates, QC inspection reports, FAT invitation
Phase 3 Fabrication	Emitter bank assembly, tunnel enclosure, control panel build	6–8 Weeks	Factory Acceptance Test (FAT) at KERONE Ambernath; client witness invited
Phase 4 Installation	Retrofit into existing line at client site	2–3 Weeks	KERONE site supervision; minimal line downtime (weekend changeover)
Phase 5 Commissioning	Cold trials, hot trials, performance guarantee test, operator training	1–2 Weeks	Commissioning report, performance test certificate, O&M manual, training records
TOTAL PROJECT TIMELINE	Order to commercial production	~22–30 Weeks	From purchase order to first commercial output

KERONE Scope of Supply & Services

Category	KERONE Scope (Included)	Client Scope (Excluded)
Process Design	IR zone design basis, thermal profile, line-speed/cure-time matrix	Existing oven performance data, part mix/geometry details
Primary Equipment	IR emitter bank, reflectors, zone controllers, tunnel enclosure	Existing convection oven (retained), conveyor base structure
Controls	Zone PID/SCR controllers, integration with existing PLC	Existing PLC/HMI hardware if reused
Civil & Structural	Mounting frame, GA layout	Foundation/floor modification, building extension if needed
Commissioning	FAT, site commissioning, performance test, training (10 days)	Consumables for trials, production parts for testing
Documentation	GA drawings, O&M manual, spares list, test certificates	Client-side approvals, regulatory consents, insurance

Conclusions & Why KERONE

The KERONE-designed conveyorized IR pre-heat and curing retrofit represents a proven, commercially validated solution to one of the most common throughput bottlenecks in India's powder coating industry. The process is built on rigorous KRDC bench-trial data — not theoretical projections — and the industrial design directly replicates the exact exposure conditions that produced measurable, certified results on Apex MetalFinish's actual production parts.

- **Proven Technology** — Every process parameter in the retrofit — 150 mm working distance, 90-second exposure, 180 °C surface target — is directly derived from KRDC trial 52/KRDC/LAB/22 on the client's actual feedstock. No extrapolation; no assumptions.
- **Quantified Outcome** — Cure dwell reduction from 22 to 14 minutes and specific energy reduction from 1.85 to 1.22 kWh/m² are measurable, certified results — not marketing claims.
- **Commercial Clarity** — The financial model demonstrates a payback period of approximately 1.9 years, converting existing floor space and line capacity into an incremental INR ~130 Lakh/year revenue and savings line.
- **Full Ownership** — KERONE designs, manufactures, supplies, installs, and commissions the complete retrofit from a single point of accountability — eliminating multi-vendor coordination risk on a live production line.
- **Scalable Platform** — The IR emitter platform is scalable to multi-zone, multi-lane configurations for higher-capacity lines, and is transferable across job-work coaters and OEM captive lines seeking similar throughput gains.
- **Compliance-Ready** — Radiant-heat containment and particulate emission control are integral to the KERONE supply scope — the retrofit is designed to safety and CPCB norms from the outset, not retrofitted for compliance after the fact.

ENQUIRE ABOUT YOUR CONVEYORIZED CURING & IR PRE-HEATING PROJECT

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To initiate a project discussion, please share: existing line details + part specifications/gauge + target throughput + site layout

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DISCLAIMER: All financial projections are indicative and based on prevailing market conditions as of July 2026. Process performance figures are derived from KRDC laboratory data (Report 52/KRDC/LAB/22) conducted on Apex MetalFinish Industries Pvt. Ltd. feedstock. Actual industrial performance may vary. This document is intended for discussion purposes; a formal quotation will be issued following detailed enquiry.