

INDUSTRIAL CASE STUDY

Curing Ovens & Component Pre-heating Applications

Continuous Multi-Zone Thermal Processing for Rubber-to-Metal Bonded Components

Designed, Engineered & Validated by KERONE Engineering Solutions Limited

900 pcs/hr PLANT THROUGHPUT Continuous Rated Capacity	180°C CURE ZONE TEMP. Multi-Zone Controlled	22 min TOTAL RESIDENCE Pre-heat + Cure	98.6% CURE STATE ASTM D2084 Rheometry	~2.3 Yrs PAYBACK PERIOD On Quantified Savings
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PROJECT REFERENCE DETAIL	
Client Organisation	Apex AutoElast Components Pvt. Ltd. — Automotive rubber-to-metal bonded component manufacturer (illustrative reference profile)
KERONE Reference	KRDC/ICS/CuringOven/2026-04 Based on KRDC Lab Report 62/KRDC/LAB/09
Technology	Continuous Multi-Zone Chain-on-Edge Curing Oven with Integrated Pre-heat Tunnel
Feedstock / Input	Pre-molded EPDM/NBR rubber-to-metal bonded components — engine mounts, bushings, dampers
Product Output	Fully vulcanized components, 98.6% cure state, <1.5% reject rate
Plant Location	Client facility (Pune, Maharashtra) — replacing legacy batch box ovens
Document Date	July 2026 Validated on KRDC Lab Data — May 2026

Automotive Rubber Components | Curing & Vulcanization | Component Pre-heating | Continuous Thermal Processing | Industrial Productivity | Automotive & Rubber Processing

Executive Summary

Apex AutoElast Components Pvt. Ltd., a Pune-based manufacturer of rubber-to-metal bonded automotive parts (engine mounts, bushings, and vibration dampers), faced a persistent quality and throughput constraint: its legacy batch box curing ovens produced inconsistent temperature profiles ($\pm 15^{\circ}\text{C}$ zone-to-zone variation), resulting in a 9.5% reject rate from under-cure and over-cure defects, and a 45-minute batch cycle that capped output at roughly 300 components per hour.

KERONE Engineering Solutions Limited was engaged to design, validate, and specify a continuous multi-zone pre-heat and curing oven system capable of delivering consistent, repeatable cure quality at significantly higher throughput, without increasing the plant's shop-floor footprint.

Following a structured KRDC (Kerone Research & Development Centre) laboratory validation programme using an instrumented static test oven across multiple pre-heat and cure hold-time combinations, the optimal industrial process envelope was established. The KERONE continuous chain-on-edge oven — operating with an 8-minute, 120°C pre-heat zone followed by a 14-minute, 180°C cure zone — delivers a 98.6% cure state (ASTM D2084) with reject rates below 1.5%, at a rated throughput of 900 components per hour.

CHALLENGE	KERONE SOLUTION	OUTCOME ACHIEVED
Batch box ovens with $\pm 15^{\circ}\text{C}$ temperature non-uniformity driving 9.5% reject rate, 45-minute cycle time, and a 300 pcs/hr throughput ceiling.	Continuous 900 pcs/hr multi-zone chain-on-edge oven, 120°C pre-heat + 180°C cure, PLC-controlled — validated from KRDC lab trials.	98.6% cure state, <1.5% reject rate, ~2.3-year payback from quality, energy, and labour savings.

Key Performance Summary

KPI	Baseline (Batch Oven)	After KERONE Processing (900 pcs/hr Plant)	Improvement
Reject Rate	9.5%	< 1.5%	~85% reduction
Cure State (ASTM D2084)	~82% (variable)	98.6%	Consistent, in-spec cure
Cycle Time	45 min/batch	22 min continuous residence	51% reduction
Rated Throughput	300 pcs/hr	900 pcs/hr	3x increase
Temperature Uniformity	$\pm 15^{\circ}\text{C}$	$\pm 3^{\circ}\text{C}$	5x improvement
Energy Consumption	~0.18 kWh/pc	~0.13 kWh/pc	~28% reduction
Annual Reject/Rework Cost	INR ~38 Lakhs/yr	INR ~6 Lakhs/yr	~84% reduction

Industry Context & The Business Challenge

India's automotive component sector supplies both domestic OEMs and export markets, with rubber-to-metal bonded parts — engine mounts, suspension bushings, and vibration dampers — forming a critical, safety-relevant product category. These components require consistent vulcanization across the bonded rubber-metal interface; incomplete cure compromises bond strength and long-term fatigue life, while over-cure degrades elongation properties and increases cycle-time cost.

OEM quality systems (IATF 16949-aligned) increasingly mandate tightened reject-rate ceilings and traceable cure-state verification per batch. Legacy static or batch box ovens — common across India's tier-2/tier-3 component supply base — struggle to meet these requirements because of inherent zone-to-zone temperature drift, operator-dependent load patterns, and long, energy-inefficient heat-up/cool-down cycles.

The Commercial Problem — Why the Legacy Process Falls Short

Quality Parameter	Legacy Batch Oven (Apex AutoElast)	OEM / Quality Requirement	Gap
Reject Rate	9.5%	< 2%	FAIL — 4.8x over limit
Temperature Uniformity	±15°C zone-to-zone	±5°C or better	FAIL — inconsistent cure
Cycle Time	45 min/batch	< 20 min equivalent	FAIL — throughput bottleneck
Bond/Peel Strength Pass Rate	60–95% (variable)	> 98% consistent pass	FAIL — inconsistent adhesion

Table 1: Legacy batch oven performance vs OEM quality requirement | Source: KRDC Analysis & ASTM D2084 / D429 reference limits

Opportunity — Retrofitting an Existing Line for Quality & Throughput

The Opportunity: At a baseline annual demand of approximately 1,000,000 components per year, the existing 9.5% reject rate represents an estimated INR 32–38 Lakhs/year in scrapped material, rework labour, and re-inspection cost, before accounting for the throughput ceiling that limits the client's ability to onboard additional OEM programmes. A continuous, PLC-controlled oven system directly addresses both constraints from the same capital investment.

Process Validation — From KRDC Lab to Industrial Scale

KERONE's engineering approach mandates laboratory-scale validation before any industrial system specification. KRDC (Kerone Research & Development Centre) conducted a structured experimental programme on representative production components over a multi-day trial period, using an instrumented static test oven to establish the pre-heat and cure envelope that informs the 900 pcs/hr industrial plant design.

KRDC Experimental Programme — Key Findings

Test Condition	Pre-heat / Cure Hold	Cure State (ASTM D2084)	Shore A Hardness	Assessment
Control (no pre-heat)	0 min pre-heat + 10 min cure	68%	62	Under-cured — rejects
Short cycle	6 min pre-heat + 8 min cure	82%	68	Marginal — inconsistent bond
OPTIMAL	8 min pre-heat + 14 min cure	98.6%	74	Standard production grade
Extended	8 min pre-heat + 18 min cure	99.1%	75	Premium / critical-application grade

Table 2: KRDC laboratory results — 120°C pre-heat / 180°C cure trials on representative bonded components | KRDC Test Report 62/KRDC/LAB/09 | Cure state per ASTM D2084 oscillating disc rheometry

Scale-Up Methodology — Lab to 900 pcs/hr

KERONE's scale-up process follows a structured engineering framework where laboratory-validated parameters are translated directly to industrial equipment specifications. The key translation factors for this project are:

Parameter	KRDC Lab (Static Test Oven)	Industrial Plant (Continuous Oven)	Scale-Up Factor
Pre-heat Temperature	120°C	120°C	1:1 (direct)
Cure Temperature	180°C	180°C	1:1 (direct)
Pre-heat Hold Time	8 min	8 min residence (Zones 1–2)	1:1 (direct)
Cure Hold Time	14 min	14 min residence (Zones 3–5)	1:1 (direct)
Throughput	1 component/test	900 pcs/hr	Batch → Continuous
Heating Mode	Static IR panel	Multi-zone IR + forced convection, chain conveyor	Configuration change
Atmosphere	Ambient air	Forced ventilation with VOC extraction	Enhanced

Industrial Plant Design — Continuous Processing System

Process Flow: Component Loading → Pre-heat Tunnel (Zones 1–2) → Cure Tunnel (Zones 3–5) → Controlled Cooling Zone → Unloading & In-line QC → Product Handling.

System Architecture — Major Process Units

Unit / Section	Equipment	Design Parameters	Function
U-01: Component Loading	Vibratory feeder / pick-place station	900 pcs/hr rated Orientation jigs	Load components onto chain-on-edge conveyor in consistent orientation
U-02: Pre-heat Tunnel (Zones 1–2)	IR + forced convection panels	120°C 8 min residence	Primer activation and surface moisture drive-off ahead of cure
U-03: Cure Tunnel — Zones 3–5 (Primary Process Unit)	Multi-zone convection curing oven	180°C 14 min residence 3-zone independent control	Core thermal processing — full vulcanization of bonded rubber compound
U-04: Chain-on-Edge Conveyor	VFD-driven indexing conveyor	Variable speed 900 pcs/hr rated	Continuous, repeatable component transport through all zones
U-05: VOC Extraction & Scrubber	Forced exhaust + carbon/scrubber module	800 Nm3/hr <15 mg/Nm3 VOC outlet	Capture primer and rubber off-gas; meet emission norms (CPCB)
U-06: Controlled Cooling Zone	Forced ambient-air cooling tunnel	Inlet 180°C Outlet < 60°C	Cool cured components before handling; prevent thermal distortion
U-07: Unloading & In-line QC	Automated unload + hardness/visual check	Load-cell & optical inspection	Divert non-conforming parts; log cure-state traceability per batch
U-08: Emission Control	Bag filter + exhaust fan	PM < 10 mg/Nm3 CPCB compliant	Capture particulate from handling and exhaust streams
U-09: Process Control	PLC/SCADA control panel	Siemens S7 / Allen Bradley Remote monitoring	Automated zone temperature, residence time, and data logging

Table 3: Process unit descriptions — KERONE continuous curing & pre-heat oven system | U-03 (Cure Tunnel) is the primary process unit; all others are ancillary

Core Equipment Specification — KERONE Continuous Curing Oven

The KERONE Continuous Multi-Zone Curing Oven is the heart of the component pre-heating and cure system. Designed and manufactured in-house at KERONE's Ambarnath facility, it directly scales the validated laboratory parameters from KRDC trial 62/KRDC/LAB/09 to industrial throughput while preserving the identical thermal profile and residence time that produced the 98.6% cure-state result.

ROTARY / TUNNEL OVEN — CORE SPECIFICATIONS	
Design Throughput	900 pcs/hr (≈450 kg/hr component-equivalent)
Pre-heat Zone Temperature	120°C (Zones 1–2)
Cure Zone Temperature	180°C (max design: 250°C, Zones 3–5)
Total Residence Time	22 min (8 min pre-heat + 14 min cure), adjustable 15–30 min via conveyor speed
Tunnel Dimensions	L 24,000 mm x W 900 mm (5 independently controlled zones)
Heating Mode	Electric IR panels + forced convection recirculation
Atmosphere	Ambient air with forced ventilation and VOC extraction
Drive System	VFD-controlled chain conveyor, 3.7 kW
Installed Power	~165 kW (total connected load)
Shell Material	MS with SS 304 inner lining
Insulation	Mineral wool — 100 mm
Zone Sealing	Curtain-sealed entry/exit per zone to minimise heat loss

Utilities & Ancillary Requirements

Utility	Specification	Consumption (at 900 pcs/hr)	Source
Electrical Power	415V, 3-phase, 50Hz	~165 kW connected ~115 kW avg demand	Site utility
Compressed Air	6 bar dry, instrument grade	10 Nm3/hr	Air compressor (site)
Ventilation / Exhaust	Forced exhaust with VOC extraction	800 Nm3/hr	Dedicated exhaust fan + scrubber
Cooling	Ducted ambient air	Natural + forced draft	Site ventilation
Space Requirement	Building / covered area	L 28m x W 4m x H 4m	Existing bay (line replacement)

Emission Compliance

Emission Point	Pollutant	Expected Level	CPCB / MoEF Limit	Status
Cure tunnel exhaust	VOC / TOC	< 15 mg/Nm3	20 mg/Nm3	COMPLIANT
Cure tunnel exhaust	PM	< 10 mg/Nm3	50 mg/Nm3	COMPLIANT
Pre-heat exhaust	VOC	< 8 mg/Nm3	20 mg/Nm3	COMPLIANT

Throughput & Energy Analysis — 900 pcs/hr Operation

Detailed Process Balance — Per Hour at Full Load

Stream	Description	Rate	Notes
Component Input	Pre-molded rubber-to-metal bonded parts (uncured/semi-cured)	900 pcs/hr	Avg. 0.5 kg/pc, Apex AutoElast production quality
Pre-heat Output	Primer-activated, surface-conditioned components	900 pcs/hr	Core temperature raised to 120°C
Cured Output	Fully vulcanized, in-spec components	~887 pcs/hr	98.6% cure state; bagged/racked for dispatch
QC Rejects	Under-cure / visual defect	~13 pcs/hr	< 1.5% of throughput; routed to rework or scrap

Table 4: Process balance — continuous curing & pre-heat plant | Based on validated KRDC lab data scaled to industrial throughput

Energy Consumption Estimate

Energy Category	Equipment / Unit	Power (kW)	Load Factor	Est. Consumption
Pre-heat Zones	IR + convection heaters (Zones 1–2)	55	75%	~41 kWh/hr
Cure Zones	IR + convection heaters (Zones 3–5)	80	75%	~60 kWh/hr
Conveyor & Drive Systems	Chain conveyor + zone dampers	10	80%	~8 kWh/hr
VOC Extraction & Cooling	Exhaust fan, scrubber pump, cooling blowers	14	85%	~12 kWh/hr
Utilities & Controls	PLC/SCADA, lighting, misc.	6	60%	~4 kWh/hr
TOTAL		~165 kW		~125 kWh/hr (~0.13 kWh/pc)

Table 5: Energy consumption estimate — continuous curing & pre-heat plant | Based on KERONE engineering estimates; actual values to be confirmed during detailed engineering

At the legacy batch box oven's estimated ~0.18 kWh/pc consumption (driven by idle heat-up/cool-down losses inherent to batch operation), the continuous multi-zone system's ~0.13 kWh/pc represents a like-for-like energy reduction of approximately 28% per component processed.

Product Quality Specification & Market Applications

Expected Product Specification — KERONE Processed Components

Parameter	Test Method	Legacy Batch Oven (Baseline)	Continuous Oven — 14 min (Standard)	Continuous Oven — 18 min (Premium)	OEM Spec (Reference)
Cure State	ASTM D2084	~82% (variable)	98.6%	99.1%	> 97%
Shore A Hardness	ASTM D2240	68 (±6)	74 (±2)	75 (±1)	73 ± 3
Bond / Peel Strength Pass Rate	ASTM D429	~65%	99.2%	99.4%	> 98%
Compression Set (22h/100°C)	ASTM D395	28%	18%	17%	< 20%
Dimensional Stability	Internal gauge check	± 0.8 mm	± 0.2 mm	± 0.15 mm	± 0.3 mm
Reject Classification	Visual + in-line QC	9.5%	1.4%	1.2%	< 2%

Table 6: Product quality specification — legacy batch oven vs continuous oven (14-min standard and 18-min premium cure) vs OEM reference spec | 14-min column highlighted = recommended standard production setting

Market Applications for Continuous Curing & Pre-heating

- **Automotive Rubber-to-Metal Bonded Components** — Rubber tyre and non-tyre manufacturers can specify component-specific cure cycles validated against ASTM D2084 and D429 for consistent, traceable bond quality across production lots.
- **Industrial Rubber Moldings, Gaskets & Seals** — Conveyor rollers, anti-vibration pads, buffers, and industrial gaskets/seals benefit from the same uniform cure profile, extending the platform beyond automotive OEM supply.
- **Pre-heating for Compression / Transfer Molding** — Pre-heating components ahead of compression or transfer molding reduces in-mould dwell time and improves flow consistency, directly cutting press cycle time.
- **Pre-heating for Powder Coating / E-Coating Lines** — Uniform substrate pre-heat ahead of powder coating or e-coating lines improves film build consistency and reduces coating defects on metal components.
- **Adhesive & Composite Bonding Pre-heat** — Controlled pre-heat activates structural and rubber-to-metal adhesives/primers prior to assembly, improving bond consistency in multi-material assemblies.

Financial Analysis & Return on Investment

CAPEX Estimate — Continuous Curing & Pre-heat Oven System

Cost Head	Scope	Estimated Cost (INR Lakhs)	Notes
Curing Oven & Pre-heat Tunnel (Primary Equipment)	KERONE supply, factory tested	32-38	FOT Ambarnath; includes zone heaters, insulation, controls
Chain-on-Edge Conveyor System	Conveyor, drive, jigs/carriers	10-13	VFD-controlled, 900 pcs/hr rated
VOC Extraction & Scrubber	Exhaust system, scrubber/carbon module	6-8	800 Nm ³ /hr, CPCB-compliant outlet
Cooling Zone	Forced-air cooling tunnel	3-4	Ambient air, ducted
Emission Control (Bag filter)	Particulate capture system	3-4	PM < 10 mg/Nm ³
Component Loading & QC Station	Feeder, orientation jigs, in-line inspection	5-6	Load-cell + optical inspection
Electrical & Instrumentation	MCC panel, SCADA, cabling	8-9	PLC/SCADA by KERONE; site electrical by client
Civil & Structural	Foundation, utilities connections	4-5	Client scope; KERONE to provide layout drawing
Commissioning, Training & Startup	KERONE commissioning team, 10-day site support	3-4	Includes operator training and performance test
TOTAL CAPEX		82-98 (~INR 90 Lakhs indicative)	Approx. range; detailed quote on enquiry

Table 7: CAPEX estimate — continuous curing & pre-heat oven system | All figures indicative; formal quotation on receipt of detailed enquiry

Annual Value Generated — Basis 4,800 hr/yr Operation

Item	Basis	INR Lakhs/Year	Remarks
Reject Reduction Savings	8.1 pp reduction (9.5% → 1.4%) x ~1,000,000 pcs/yr x INR 40/rejected pc	32.4	Material, labour & rework cost avoided
Energy Cost Reduction	~0.05 kWh/pc saved x ~1,000,000 pcs/yr x INR 8/kWh	4.0	Continuous vs batch oven consumption
Labour & Inspection Efficiency	Reduced manual handling, sorting, and re-inspection	8.0	Automated loading/unloading and in-line QC
TOTAL QUANTIFIED SAVINGS		44.4	
Less: Incremental O&M (new system)	Maintenance & spares, net of legacy oven upkeep	(6.0)	Higher-automation system upkeep

Item	Basis	INR Lakhs/Year	Remarks
NET ANNUAL BENEFIT		~38.4 Lakhs/yr	Payback ~2.3 years on INR 90L indicative CAPEX

Table 8: Annual value generated — continuous curing & pre-heat oven, based on baseline ~1,000,000 pcs/yr demand | Indicative figures; throughput headroom (900 pcs/hr vs 300 pcs/hr baseline) provides additional un-monetised capacity for future OEM programme growth

Project Execution & KERONE Scope of Supply

Implementation Timeline

Phase	Activity	Duration	KERONE Deliverable
Phase 0 — Pre-Order	Technical consultation, site visit, process design freeze, commercial negotiation	3-4 Weeks	Process Design Basis (PDB), GA drawing, utility list, commercial offer
Phase 1 — Engineering	Detailed engineering: mechanical, electrical, layout, P&ID finalisation	5-6 Weeks	Complete engineering package, vendor drawings, DFM approval
Phase 2 — Procurement	Long-lead items: heating elements, conveyor drive, VOC extraction system	6-8 Weeks	Material test certificates, QC inspection reports, FAT invitation
Phase 3 — Fabrication	Oven tunnel fabrication, conveyor assembly, control panel build	8-10 Weeks	Factory Acceptance Test (FAT) at KERONE Ambarnath; client witness invited
Phase 4 — Installation	Equipment erection at client site; electrical, instrument hook-up	3-4 Weeks	KERONE site supervision; civil and electrical by client as per KERONE drawings
Phase 5 — Commissioning	Cold trials, hot trials with production components, performance test, operator training	2 Weeks	Commissioning report, performance test certificate, O&M manual, training records
TOTAL PROJECT TIMELINE	Order to commercial production	~27-34 Weeks	From purchase order to first commercial output

KERONE Scope of Supply & Services

Category	KERONE Scope (INCLUDED)	Client Scope (EXCLUDED from KERONE supply)
Process Design	Process design basis, residence-time/temperature envelope, P&ID	Component quality guarantee; production schedule
Primary Equipment	Curing oven tunnel (complete), pre-heat zones, chain conveyor, cooling zone	Component fixtures/jigs specific to non-standard geometries
Emission Control	VOC extraction, scrubber, bag filter (CPCB compliant)	Stack height design and consent-to-operate from CPCB/SPCB
Controls	PLC/SCADA, MCC panel, all instruments and field wiring	DG set, main power supply connection, transformer
Civil & Structural	Foundation load drawings, GA layout, anchor bolt drawings	All civil work, platforms, ladders, drains
Commissioning	FAT, site commissioning, performance test, operator training (10 days)	Consumables for commissioning; components for trials
Documentation	P&ID, GA drawings, O&M manual, spares list, test certificates	Client-side approvals, regulatory consents, insurance

Conclusions & Why KERONE

The KERONE-designed continuous curing and pre-heating oven system represents a proven, commercially validated solution to a recurring quality and throughput constraint faced by India's automotive rubber-to-metal component supply base. The process is built on rigorous KRDC laboratory data — not theoretical projections — and the industrial design directly replicates the exact process conditions that produced measurable, repeatable cure-state results.

- **Proven Technology** — Every process parameter in the industrial oven — 120°C pre-heat, 180°C cure, 8 + 14-minute residence — is directly derived from KRDC lab trial 62/KRDC/LAB/09 on representative production components. No extrapolation; no assumptions.
- **Quantified Outcome** — Cure state improvement from ~82% to 98.6%, and reject rate reduction from 9.5% to below 1.5%, are measurable, repeatable results — not marketing claims.
- **Commercial Clarity** — The financial model demonstrates a payback period of approximately 2.3 years at conservative savings assumptions, converting a chronic quality/rework cost into a recurring annual benefit.
- **Full Ownership** — KERONE designs, manufactures, supplies, installs, and commissions the complete system from a single point of accountability — eliminating multi-vendor coordination risk.
- **Scalable Platform** — The continuous chain-on-edge oven platform is scalable to higher throughputs and adaptable to other components, gaskets, seals, and pre-heat applications across a client's product range.
- **Compliance-Ready** — Emission control is integral to the KERONE supply scope — the system is designed to CPCB stack norms, not retrofitted for compliance after the fact.

ENQUIRE ABOUT YOUR CURING OVEN / COMPONENT PRE-HEATING PROJECT

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To initiate a project discussion, please share: component drawing/geometry + cure specification (compound, temp, time) + daily/annual volume + site location

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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 62/KRDC/LAB/09) on representative production components. The client profile in this document is illustrative; actual industrial performance may vary and this document is intended for discussion purposes — a formal quotation will be issued following detailed enquiry.