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Reduction of Evaporator Running Time

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Abstract

The project titled **"A Project to Reduce Evaporator Running Time in ETP Process"** aims at minimizing the high operational hours of the evaporator unit in the Effluent Treatment Plant (ETP) at Tenneco, Hosur. The primary issue identified was the high hardness of inlet water, which caused membrane scaling and increased reject load, leading to increased evaporator utilization.

A root cause analysis and Kaizen approach led to the implementation of a chemical treatment method involving Calcium Hydroxide and Soda Ash. This treatment significantly reduced the hardness of inlet water, thus reducing the load on the evaporator and saving on diesel, electricity, and manpower costs. The result was a net annual saving of approximately INR 10.33 lakhs. This report elaborates on the step-by-step methodology, cost analysis, implementation challenges, and the sustainable benefits of the project.

Chapter 1: Introduction

1.1 Background

Effluent Treatment Plants (ETPs) play a crucial role in managing industrial wastewater. In heavy manufacturing industries like automotive component production, effluents containing heavy metals, oils, greases, and other contaminants must be treated before disposal or reuse. One of the most resource-intensive units within ETPs is the evaporator, which is used to concentrate reject water after membrane filtration.

At Tenneco's Hosur plant, the evaporator was observed to be running for an average of 325 hours per month, leading to high consumption of diesel, electricity, and human resources. This raised both operational costs and environmental concerns.

1.2 Company Profile – Tenneco

Tenneco is a global automotive components manufacturer with over 73,000 team members and 201 manufacturing plants. The Hosur plant in India specializes in shock absorber and strut manufacturing, supported by a comprehensive ETP system to manage process wastewater.

1.3 Objective of the Project

The primary objective of this project is to reduce the running time of the evaporator in the ETP process through process optimization, chemical treatment, and root cause elimination using Kaizen methodology.

1.4 Scope of the Project

• Analysis of current evaporator usage

• Identification of key contributing factors to high runtime

• Implementation of cost-effective and sustainable solutions

• Evaluation of results and potential for scalability across other units

1.5 Methodology Overview

This project followed the Kaizen continuous improvement cycle: • Define the Problem • Identify Root Cause • Generate and Evaluate Solutions • Trial and Implementation • Review and Sustain Results Through this methodology, the project aimed to achieve a measurable reduction in operating hours and associated costs, while improving the overall efficiency of the ETP system.

Chapter 2: Problem Identification

2.1 Understanding the Process

The Effluent Treatment Plant (ETP) at Tenneco Hosur is designed to treat process wastewater generated from plating, washing, and machining operations. The process consists of:

- Effluent collection tanks (Chrome and Washing)
- Chemical treatment tanks (Reduction, Neutralization)
- Filtration units (Iron removal, multi-grade, activated carbon)
- Reverse Osmosis (RO-1 and RO-2)
- Final stage evaporation for reject concentration

2.2 Observed Problem

The average evaporator running hours was found to be **325 hours/month**, far exceeding the desired benchmark of **195 hours/month**. This increased runtime leads to:

- Excessive steam and diesel consumption
- High electricity usage
- Increased operator fatigue due to overtime

2.3 4W1H Analysis (What, Where, When, Who, How Much)

- **What:** Excessive evaporator operating hours
- **Where:** ETP section at Tenneco Hosur plant
- **When:** Observed across multiple months in 2024-25
- **Who Identified:** ETP team members and intern Tamilarasan. C
- **How Much:** Average of 325 hours per month

2.4 Graphical Analysis

Evaporator operating hours were tracked over 12 months. Values ranged from **314 to 349 hours/month**, with little variance, indicating a systemic issue rather than seasonal or load-based variations.

2.5 Impact of the Problem

- **High Diesel Usage:** 29 liters/day, costing ₹72384/month
- **Steam and Energy Wastage:** Additional 0.5 to 1 hour/day of RO and evaporator run time
- **Labor Cost:** 4 hours of overtime/day costing ₹144000/year
- **Member Fatigue:** Regular overtime causing dissatisfaction among operators
- **Environmental Concerns:** Increased salt generation and fuel-based emissions

This chapter sets the stage for detailed root cause analysis in the next chapter by establishing the critical nature and scope of the problem.

Chapter 3: Root Cause Analysis

3.1 Initial Investigation

The problem of high evaporator running time was traced back to a higher-than-expected volume of reject water from the Reverse Osmosis (RO) system. Upon inspection, the RO membranes showed signs of **scaling and fouling**, leading to decreased efficiency.

3.2 Why-Why Analysis

The team conducted a Why-Why Analysis to identify the root cause of increased reject load:

- **Why 1:** Why is evaporator running time high?

→ Because the RO system is producing more reject water.

- **Why 2:** Why is RO producing more reject water?

→ Because RO membranes are clogged and inefficient.

- **Why 3:** Why are RO membranes clogged?

→ Due to hardness scaling on membrane surfaces.

- **Why 4:** Why is hardness scaling occurring?

→ Because inlet water to RO has very high hardness.

- **Why 5:** Why is inlet water hardness high?

→ No pre-treatment is done to reduce hardness before feeding water to RO.

3.2 Root Cause

The **root cause** was identified as **high inlet water hardness** due to the absence of a suitable water softening or conditioning stage before the RO membrane units.

3.3 Supporting Data

3.3.1 **Inlet Water Hardness:** ~2000 PPM
3.3.2 **Scaling Observations:** White deposits and reduced permeate flow
3.3.3 **Rejected Water Volume:** Increased by 20–25%

3.4 Impact of the Root Cause

3.4.1 Overloading of evaporator with reject
3.4.2 Premature membrane fouling and reduced life span
3.4.3 Increased consumption of chemicals in post-RO processes

This analysis led to focused idea generation in the next phase to tackle the water hardness challenge effectively.

Chapter 4: Idea Generation & Evaluation

4.1 Brainstorming Session

A cross-functional team (CFT) consisting of ETP operators, maintenance personnel, safety engineers, and the intern Tamilarasan. C convened to brainstorm potential solutions to reduce water hardness and thereby minimize evaporator running time.

4.2 Ideas Generated

The following ideas were proposed:

4.2.1 Addition of **Calcium Hydroxide + Soda Ash (Sodium Carbonate)** to reduce water hardness.
4.2.2 Addition of **Caustic Soda + Soda Ash**.
4.2.3 Installation of a **Water Softener** before the RO inlet.
4.2.4 Installation of an **HRSCC (High-Rate Solid Contact Clarifier)** system.

4.3 Solution Selection Matrix

Each solution was evaluated on:

- **Cost of Implementation** (1 = least)
- **Time to Implement** (1 = quickest)
- **Difficulty to Implement** (1 = easiest)

Solution	Cost	Time	Difficulty	Total Score	Rank
Calcium Hydroxide + Soda Ash	2	2	2	**6**	**1**
Caustic Soda + Soda Ash	4	3	5	12	2
Water Softener	8	5	7	20	3

Solution	Cost	Time	Difficulty	Total Score	Rank
HRSCC	10	8	9	27	4

The top-ranked solution was selected for implementation due to its high effectiveness and low resource requirement.

4.4 Justification for Selected Solution

- Readily available chemicals
- Easy to implement within existing ETP infrastructure
- Proven effectiveness in reducing water hardness

4.5 Preliminary Testing – Jar Test

A **jar test** was conducted using the chosen chemical mix. Initial results showed a substantial reduction in hardness levels from ~2000 PPM to below 500 PPM, making the water more suitable for RO processing.

This chapter sets the foundation for piloting the solution and transitioning into full-scale implementation, which is covered in the next chapter.

Chapter 5: Implementation Strategy

5.1 Planning and Preparation

Following the selection of the Calcium Hydroxide + Soda Ash chemical treatment, a phased implementation plan was developed. The planning involved:

- Procurement of required chemicals

- Training ETP personnel on dosage and handling
- Calibration of dosing mechanisms

Establishing monitoring parameters

5.2 Chemical Dosage Schedule

The chemical dosage was based on inlet hardness levels and jar test results:

- **Calcium Hydroxide:** 0.5 grams/liter
- **Soda Ash:** 1 gram/liter
- Dosing applied to all inlet water feeding into the RO system

5.3 Integration with Existing Process

The new dosing was introduced just before the RO inlet. No major hardware changes were required. Inline static mixers ensured proper blending of chemicals.

5.4 Monitoring and Adjustments

Performance was monitored daily over the first month:

- Inlet water hardness
- RO permeate and reject volumes
- Evaporator operating hours

Adjustments were made weekly based on lab feedback and field observation to optimize dosage without overdosing.

5.5 Training and Safety

All ETP staff underwent a training session covering:

- Safe handling of Calcium Hydroxide and Soda Ash
- Personal protective equipment (PPE) use
- Emergency spill response
- First aid for chemical exposure

5.6 Trial Results

During the initial trial period of 30 days:

Chapter 6: Results and Outcomes

6.1 Performance Metrics

Post-implementation data showed significant improvements across key parameters:

Parameter	Before Implementation	After Implementation
Average Evaporator Runtime	325 hours/month	186 hours/month
Diesel Consumption	29 liters/day	15 liters/day
Manpower Overtime	4 hours/day	0 hours/day
Water Hardness (Inlet to RO)	~2000 PPM	~350 PPM
RO-2 Running Time	Full cycle	Reduced by 0.5 hr/day
ETP Permeate Water Generation	Base rate	+10% increase

6.2 Graphical Representation

Evaporator Running Hours (Before vs. After)

Month	Before (hrs)	After (hrs)
Jan	328	185
Feb	338	188
Mar	340	186

Diesel Consumption (Before vs. After)

- Before: ~29 liters/day
- After: ~15 liters/day

Manpower Cost (Before vs. After)

- Before: ₹144,000/year in overtime

- After: ₹0/year (overtime eliminated)

6.3 Efficiency Gains

6.3.1 **Reduced Energy Load:** Evaporator hours down by over 40%
6.3.2 **Improved Water Recovery:** RO performance optimized
6.3.3 **Extended Equipment Life:** Less wear on RO membranes and evaporator

6.4 Employee Impact

6.4.1 Operators reported improved work-life balance
6.4.2 No extra shifts or overtime required
6.4.3 Increased engagement due to involvement in Kaizen process

6.5 Summary of Outcomes

The implementation delivered tangible savings, improved environmental performance, and enhanced operator satisfaction. The ETP system is now operating closer to its design efficiency with optimized resource usage.

The next chapter will present the detailed cost-benefit analysis that quantifies these savings.

6.5.1 RO recovery rate improved
6.5.2 Evaporator hours reduced by ~45%

This confirmed that the chemical pre-treatment was both effective and feasible for full- scale operation.

The success of this trial led to regular implementation, which is discussed in the next chapter along with performance metrics and cost benefits.

Chapter 7: Cost-Benefit Analysis

7.1 Overview of Cost Savings

The project yielded significant tangible financial benefits. These savings were tracked monthly and projected annually:

Parameter	Unit Savings (INR)	Monthly Savings (INR)	Annual Savings (INR)
ETP Permeate Water (+10%)	₹70/kl × 0.73 kl	₹1,328.60	₹15,943.20
RO-2 Running Time (-0.5 hr/day)	₹7/kw × 6 kw	₹546.00	₹6,552.00
Evaporator Energy Use (-1 hr/day)	₹7/kw × 18.6 kw	₹3,385.20	₹40,622.40
Diesel Reduction (14 L/day)	₹96/liter	₹2,784.00	₹868,608.00
Manpower OT Elimination	4 hr/day × ₹461.50	₹12,000.00	₹144,000.00
Total		**₹8G,642.80**	**₹10,75,725.60**

7.2 Implementation Cost

7.2.1 **Chemical Cost (Soda Ash):** ₹35/kg
7.2.2 **Monthly Usage:** 100 kg → ₹3,500/month → ₹42,000/year
7.2.3 Net Annual Savings: ₹10,75,725.60 - ₹42,000 = **₹10,33,725.60**

7.3 Return on Investment (ROI)

7.3.1 **Initial Investment:** Negligible (no equipment change)
7.3.2 **Payback Period:** < 1 month (due to immediate diesel and OT savings)
7.3.3 **ROI:** Over 2400% annually based on net savings

7.4 Intangible Benefits

7.4.1 **Environmental Impact:** Reduced salt rejection and fuel emissions
7.4.2 **Operator Morale:** Boosted by less fatigue and skill improvement

7.4.3 **Knowledge Gain:** Enhanced understanding of chemical treatment in ETP
7.4.4 **Process Sustainability:** Established foundation for horizontal deployment

7.5 Cost Summary Chart

Savings Breakdown (Annual):

- Diesel: ₹8.68 L
- Manpower: ₹1.44 L
- Energy (Evaporator & RO): ₹0.47 L
- Water Recovery: ₹0.16 L Total: ₹10.75 L

Net after Chemicals: ₹10.33 L

The next chapter will discuss sustainability practices and how this project can be replicated at other Tenneco facilities.

Chapter 8: Sustainability & Deployment

8.1 Sustaining the Results

To ensure that the reduction in evaporator running time is maintained over the long term, the following actions were taken:

- **Standard Operating Procedures (SOPs):** Developed for chemical dosing
- **Routine Monitoring:** Daily checks on water hardness and evaporator hours
- **Monthly Reviews:** Performance audits by ETP and safety team
- **Corrective Actions:** Triggered automatically if running hours exceed 200/month

8.2 Preventing Recurrence

A control mechanism was implemented using the **Plan-Do-Check-Act (PDCA)** cycle:

- **Plan:** Hardness control strategy
- **Do:** Chemical dosing implemented
- **Check:** Analyze results monthly
- **Act:** Adjust dosage as needed

This cycle ensures continuous improvement and error detection before performance decline occurs.

8.3 Horizontal Deployment

The success of this project makes it a strong candidate for rollout at other Tenneco locations:

- **Similar Plants:** Plants using RO and evaporators for effluent management
- **Training Materials:** Created for ETP teams across locations
- **Site Visits:** Arranged for peer plants to observe the implementation
- **Digital Reporting:** Online dashboard created to compare water treatment metrics across sites

8.4 Management Commitment

Senior leadership endorsed the strategy and allocated resources for:

- Bulk procurement of chemicals at lower costs
- Inclusion of results in annual sustainability reports
- Integration into Kaizen and TPM best practice libraries

8.5 Environmental Sustainability

- Reduced energy and diesel usage contributed to lower CO_2 emissions
- Less salt disposal reduced the environmental load on solar ponds and landfills
- Promoted circular water economy through increased permeate reuse

8.6 Employee Engagement

- Operators took ownership of monitoring results
- Kaizen participation recognized through appreciation letters
- Skill development led to higher confidence in process ownership

This chapter demonstrates the project's alignment with long-term environmental goals and corporate sustainability strategy.

The final chapter will summarize conclusions and recommendations.

Chapter 9: Conclusion

9.1 Summary of Project

This project focused on reducing the evaporator running time in the Effluent Treatment Plant (ETP) at Tenneco's Hosur facility. By identifying high water hardness as the root cause and implementing a cost-effective chemical treatment method using Calcium Hydroxide and Soda Ash, the project delivered significant operational improvements and cost savings.

9.2 Achievements

- **Evaporator Running Time Reduced:** From 325 hours/month to 186 hours/month
- **Diesel Consumption Lowered:** From 29 to 15 liters/day
- **Hardness Reduction:** From ~2000 PPM to <400 PPM
- **Cost Savings:** Over ₹10.33 lakhs per annum
- **Environmental Benefits:** Reduced CO_2 emissions and salt disposal
- **Employee Engagement:** Improved work satisfaction and participation

9.3 Lessons Learned

- Small chemical modifications can drive large-scale operational efficiency
- Kaizen methodology is effective for industrial problem-solving
- Data monitoring and PDCA cycles are essential for sustaining improvements

9.4 Recommendations

- Implement similar hardness reduction strategies in other Tenneco ETPs
- Periodically review water quality and scaling trends in RO systems
- Invest in training ETP teams for proactive process management

10.2 Appendices

Appendix A – Monthly Evaporator Running Hours (Before Implementation)

Month	Hours
Jan	328
Feb	338
Mar	340
Apr	317
May	321
Jun	314

Appendix B – Monthly Evaporator Running Hours (After Implementation)

Month	Hours
Jul	185
Aug	188
Sep	186

Appendix C – Cost Calculation Sheet (Sample)

Parameter	Unit Price (INR)	Daily Savings	Monthly	Yearly
Diesel (14 L @ ₹96)	₹96/liter	₹1,344	₹40,320	₹483,840
Manpower OT (4 hrs @ ₹461.50)	₹461.50/hour	₹1,846	₹55,380	₹664,560
RO + Evaporator Power Reduction	₹7/kw	₹130.20	₹3,906	₹46,872

Appendix D – Jar Test Observations

Trial	Inlet Hardness (PPM)	Final Hardness (PPM)	Remarks
1	1980	420	Acceptable
2	2050	350	Excellent Result
Trial	**Inlet Hardness (PPM)**	**Final Hardness (PPM)**	**Remarks**
3	2025	385	Acceptable

Appendix E – Safety Data Sheets (SDS)

- Calcium Hydroxide SDS (manufacturer copy)
- Soda Ash SDS

Appendix F – Photographs

- ETP Layout
- Jar Test Samples
- Operator Training Sessions

ted process improvements can result in both environmental and economic benefits. The success at Tenneco Hosur serves as a model for integrating sustainable practices within industrial wastewater treatment systems.

Chapter 10: References & Appendices

10.1 References

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