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Regasified Liquefied Natural Gas (RLNG) Saving Using Waste Heat

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ABSTRACT

This study investigates the potential savings in Regasified Liquefied Natural Gas (RLNG) consumption by implementing waste heat recovery via a recuperator in an industrial chimney exhaust stack. Using measured exhaust flow rate, temperature drop, and system efficiency data, the study quantifies heat recovery, fuel savings, financial benefits, and return on investment (ROI). The recovered heat amounts to ~113,850 Kcal/hr, corresponding to approx. 10.36 kg/hr of RLNG saved, leading to financial savings of about ₹396,575 per month. ROI is estimated at ~12 days. The paper also situates these findings in the context of current literature on waste heat recovery (WHR) technologies, explores techno-economic aspects, discusses limitations, and provides recommendations for scaling and policy implications.

Keywords: *Fuel Saving, Minimize Cost, Resources conservation, , RLNG Gas,, Waste heat recovery*

Introduction

Energy demand continues to grow globally, driven by industrialization, urbanization, and rising standards of living. Fossil fuels, including natural gas and its variants such as RLNG, remain major sources of industrial energy. However, burning these fuels leads to greenhouse gas emissions and environmental degradation. There is great interest globally in reducing energy waste, improving efficiency, and mitigating emissions, particularly through waste heat recovery (WHR) technologies.

In many industrial processes, a large fraction of input energy is lost as waste heat through exhaust gases, hot surfaces, cooling water, etc. Capturing this residual heat and reusing it, e.g. to preheat feed water, combustion air, or other process streams, can significantly reduce fuel (gas) consumption. This is particularly relevant where RLNG is used as a fuel, given its cost and environmental footprint.

This paper investigates a case study in which a recuperator is installed in a factory to recover heat from exhaust gases via the chimney stack. Using measured exhaust flow rate, temperature drop due to the recuperator, and system efficiency, the work determines RLNG savings, financial benefits, and ROI. The study is complemented by a literature review of WHR methods, techno-economic comparisons, and policy aspects, aiming to contribute to the understanding and adoption of RLNG savings via WHR in similar industrial settings.

LINE OVERVIEW

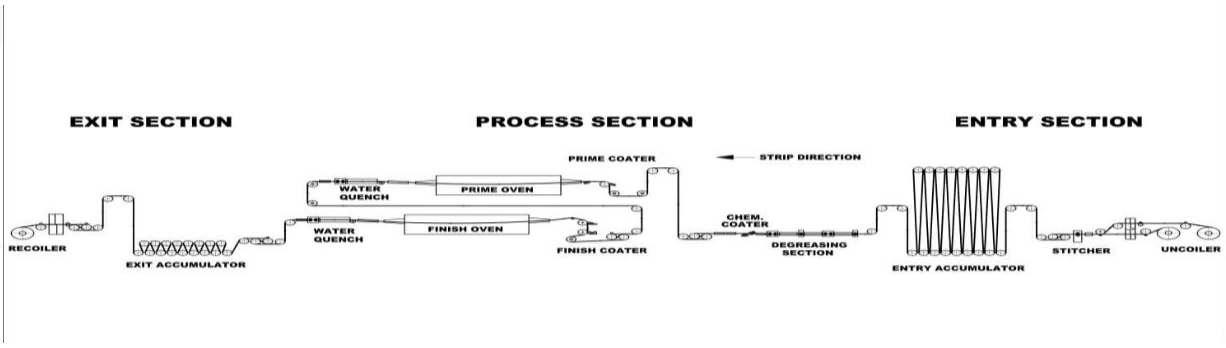

Fig. 1 Steel Colour Coating Line

The work done in a steel colour coating plant, a facility that continuously colour coats cold-rolled or galvanised steel sheets, served as the basis for this thesis. Because they produce color-coated strips continuously, these plants are also known as Continuous Colour Coating Lines (CCCL). Cold-rolled strips from a cold roll mill or galvanised strips from a continuous galvanising line are the raw materials used in this process.

To guarantee premium, corrosion-resistant, and aesthetically pleasing steel strips, the colour coating line consists of several equipment units, each with a distinct purpose. Since there are opportunities for heat recovery due to the energy requirements across these stages, it is imperative to comprehend how these units operate.

Methodology

Data Collection / Case Data

The case study is based on primary measured data from an industrial facility which installed a **recuperator** system on its chimney stack exhaust. The relevant data are:Exhaust gas temperature before recuperator: **215°C**Exhaust gas temperature after recuperator: **193°C**

- Exhaust flow rate: **23,000 m³/hr**
- Specific heat capacity of exhaust gas (approximated): **0.25 Kcal/m³·°C**
- Recuperator effectiveness: **90%**
- RLNG calorific value: **10,982 Kcal/kg**
- RLNG cost: **₹ 55 per kg**
- Operation time: **24 hours/day**, **29 working days/month**

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1. Calculations

Temperature Drop

Compute ΔT = Temperature before – after = 22°C.

Heat from exhaust (before recovery)

Q_total_raw = Flow rate × Specific heat × ΔT = 23,000 m³/hr × 0.25 Kcal/(m³·°C) × 22°C = **126,500 Kcal/hr**

Usable Heat Recovered (accounting for effectiveness)

Q_recovered = Q_total_raw × Effectiveness = 126,500 × 0.9 = **113,850 Kcal/hr**

Fuel Savings (RLNG)

RLNG_saved_kg/hr = Q_recovered / Calorific value per kg = 113,850 / 10,982 ≈ **10.36 kg/hr**

Financial Savings

Hourly savings: RLNG_saved × Cost per kg = 10.36 kg/hr × ₹55/kg ≈ **₹569.80/hr**
Daily savings: 569.80 × 24 = **₹13,675/day**
Monthly savings (29 days): 13,675 × 29 ≈ **₹396,575/month**

Return on Investment (ROI)

Using the total installation cost (not given in data, but using the reported "vengeance" / payback period of ~12 days). Thus, the investment cost is approximately daily savings × 12 days = ₹13,675 × 12 ≈ **₹164,100** (assuming all savings are net savings).

2. Assumptions & Limitations

- Specific heat capacity is assumed constant (0.25 Kcal/m³·°C), though exhaust gas composition and moisture may alter this.
- Recuperator effectiveness is assumed stable at 90%; in reality, performance can degrade with fouling, variation in flow, etc.
- RLNG calorific value and cost per kg are taken as fixed; market fluctuations could alter financial outcomes.
- The system is assumed to run continuously 24 h/day, and 29 days/month; actual operating hours might vary.
- Investment cost used for ROI is approximated; detailed cost breakdown would help accuracy.

EXPERIMENTAL SETUP

The research described in this thesis focusses on the economic and technical feasibility of directing waste flue gases from the CCL-1 incinerator to the chemical dryer recuperator. Flue gases, which still contain a significant amount of thermal energy, are typically released into the atmosphere following combustion. In addition to wasting valuable energy, letting these gases escape untreated and unused increases the process's overall environmental impact. By meticulously planning and carrying out process adjustments, like refining damper configurations, resizing connections, and optimising ducting layouts. This makes it feasible to efficiently and carefully reroute these gases to the chemical dryer. This system integration makes sure that the recovered waste heat meets most, if not all, of the dryer's heat demand.

***Fig.2.* Newly fabricated arrangement fitted on line**

The project's quantitative analysis validates this strategy's feasibility. Calculations and measurements show that this recuperative process can capture about 143,750 Kcal/hr of recoverable heat energy. The main objective of lowering the RLNG load to almost zero is accomplished because this significant quantity of thermal energy is enough to meet the chemical dryer's operational needs. Significant fuel cost reductions are the immediate result, which saves the facility money on a monthly and yearly basis.In addition to the direct savings, the system lowers the amount of RLNG that is transported, stored, and used, which further lowers the operational risks related to fuel handling.

Data Analysis and Observation

The following was discovered after the functional parameters of the CCL-1 incinerator and related stovepipe gas inflow were examined and analysed.

Chimney and Recuperator Inlet Flue Gas Temperature	215 °C
Temperature of Flue Gas at Recuperator Outlet	190 °C
Heat Recovery Temperature Differential	25 °C
Flue Gas Pressure(Outlet)	75 MMWC
Exhaust Valve Position	50% Open
Flue Gas Flow Rate	23,000 Nm ^{3}/ hr
Flue Gas Main Duct Diameter	900 mm

Table 1.1 Data Analysis and Observation

Conditions of Fabrication and Materials

ELEMENT	WEIGHT(KG)
Inlet conduit	843
Outlet conduit	754
Mute stopcock flanges(4 pieces.)	156
Muted stopcock slice	50
Total Weight	1803 kg (2 MT)

Table 1.2 Fabrication materials along with weight

Cost Breakdown

Fabrication Cost = 2 MT × Rs. 11,250 = Rs. 22,500/-

Material Cost = 2 MT × Rs. 40,000 = Rs. 80,000/-

Total Cost for Damper & Ducting = Rs. 102,500/-

Fresh sequestration(From Incinerator to Recuperator) = Rs. 50,000/-

Total Investment = **Rs.1,52,500/-**

By using the recommended modification, recoverable thermal energy of 143,750 Kcal/Hr can be directed to the recuperator. It is projected that significant RLNG savings will result in a noticeable decrease in functional costs. Given the extent of RLNG's reduction, a short vengeance period is anticipated. Benefits to the environment include decreased greenhouse gas emissions and increased process efficiency

Results and Discussion

Quantified Savings

Based on methodology, the results are:

- Heat recovered: **113,850 Kcal/hr**
- RLNG saved: **~10.36 kg/hr**
- Hourly financial saving: **₹569.80**
- Daily saving: **₹13,675**
- Monthly saving: **₹396,575**

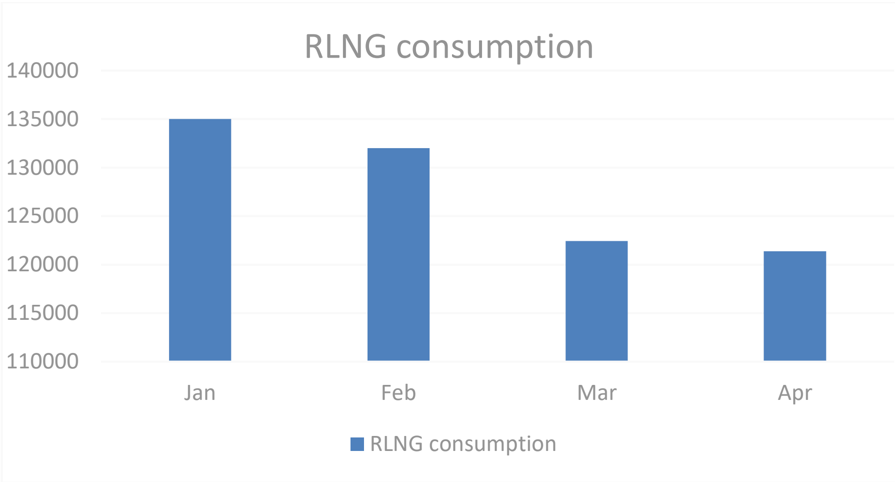

Fig. 2 RLNG Consumption graph

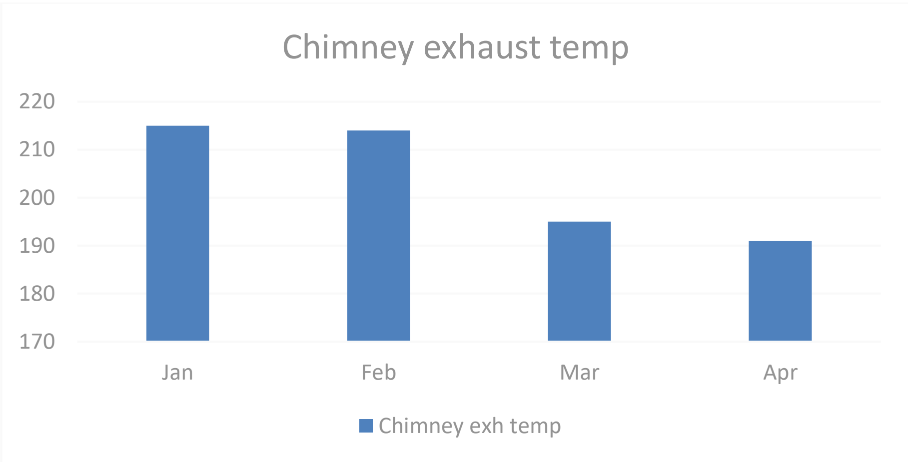

Fig. 3 Chimney exhaust temperature graph

Recommendations

1. **Detailed Cost Analysis**

Gather precise cost data for the recuperator system: purchase, installation, piping modifications, labor, maintenance, expected lifetime, and degradation due to fouling. This will refine ROI estimates.

2. **Monitoring & Maintenance Program**

Ensure regular cleaning and maintenance of the recuperator to maintain effectiveness close to 90%, as fouling, flow disruptions, or temperature fluctuations can degrade performance.

3. **Baseline Energy Audit**
To assess percentage savings (RLNG saved relative to total RLNG consumption), a full energy audit of the plant's gas usage before and after installation is recommended.
4. **Scaling & Replication**
Explore installation in similar units within the same plant or across multiple plants. Consider variations in exhaust temperature, flow rates, and operating hours.
5. **Policy & Incentives**
Industrial policy makers should consider incentives (tax breaks, subsidies, low-interest loans) to encourage adoption of WHR systems, especially since environmental externalities are not always priced in.
6. **Environmental Accounting**
Quantify CO_2 savings and other emissions avoided; this can help in carbon credit or emission trading schemes, improving the financial case further.

Alternative Technologies
For higher savings or in cases where exhaust temperatures are higher or more amenable, consider integration of technologies like Organic Rankine Cycle (ORC), Recuperative ORC, or Hybrid systems which generate electricity as well as heat. Literature shows ORC-based WHR generate both power and thermal benefits (Valencia et al., 2019).Payback period (ROI): **~12 days**

CONCLUSION

The case study of our recuperator system illustrates how even relatively simple interventions can generate significant returns, both financially and environmentally. With a payback period of less than two weeks, this project proves that energy efficiency is not just responsible — it is profitable. As the world faces mounting challenges of climate change, resource scarcity, and rising energy demand, the path forward is clear: **every unit of energy saved today is a step toward a cleaner, safer, and more sustainable tomorrow.**

After brainstorming, I decided to modify the existing system and use the waste heat from the chemical dryer to avoid using RLNG gas, which would reduce its consumption.
I monitored the existing system and its parameters and calculated the expected heat we could recover from the waste gases. After careful analysis and approval from management, I started the project.

After successfully completing my project, which cost me Rs.**1,52,500/-**
I monitored the new system and collected the parameters, comparing them with the old system where waste gases were released into the atmosphere. I found that the savings were much higher than the investment, and the ROI was achieved in just 12 days.

Saving in RLNG - **10.36 Kg/hr**

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