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Case Study on Waste Heat Recovery from Turbine Gland Steam Drain Line for Driving a Vapor Absorption Cooling System

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Abstract: In thermal power plants, Vapour Absorption Machines (VAMs) are conventionally operated using Auxiliary Pressure Reducing and Desuperheating Station (APRDS) steam, resulting in losses of high-grade energy and condensate. Simultaneously, turbine gland steam drain during self gland-sealing operation is continuously discharged to the condenser to maintain required inlet temperatures, leading to additional waste of recoverable thermal energy. This study presents a Kaizen-based modification in which the turbine gland steam drain is utilized as the driving heat source for a 300 TR Vapour Absorption Machine, integrated with a condensate recovery system. The proposed system effectively harnesses low-grade waste steam for refrigeration, reduces dependence on APRDS steam, and enables condensate reuse. Integration of DCS-based control, protective interlocks, and real-time monitoring ensured safe and reliable operation. Implementation results demonstrate a coal saving of approximately 6 tons per day, along with reductions in CO_2 emissions, ash generation, and DM water consumption. The study confirms that turbine gland steam drain utilization offers a practical and sustainable approach for waste heat recovery in thermal power plants
Keywords: Waste heat recovery; Vapour Absorption Machine (VAM); Condensate recovery; APRDS; Energy efficiency; Thermal power plant; Sustainability

I. INTRODUCTION

In thermal power plants, Vapor absorption machines (VAMs) are commonly operated using auxiliary pressure reducing and desuperheating (APRDS) steam, leading to significant high-grade energy losses VAM units are supplied with steam from the APRDS system, where the condensate is drained in atmosphere.

Additionally, in every thermal Power plant during turbine self-gland-sealing operation, a continuously open gland steam drain is maintained to ensure a gland steam inlet temperature of approximately 300 °C, and this drain steam is directly discharged to the main condenser.

To minimize this waste, a kaizen initiative is implemented by diverting the gland steam drain to the VAM inlet as the driving heat sourcewith condensate recovery system.

This paper investigates the use of waste heat from turbine gland steam drain to operate a Vapour Absorption Machine (VAM) with condensate recovery. The proposed system reduces fossil fuel consumption, conserves condensate water, and improves overall plant efficiency, supporting sustainable waste heat utilization and water conservation.

II. EXISTING SYSTEM

1) APRDS for VAM :The plant operates a 300 TR Vapour Absorption Machine (VAM), which requires approximately 1,166 kg/h of steam for continuous operation. Steam is supplied from the LT-PRDS header, throttled from the HT-PRDS of the unit APRDS system, at a supply temperature of approximately 220 °C. After utilization in the VAM, the resulting condensate is currently discharged to the atmosphere, leading to energy and water losses.
2) Turbine gland steam drain-Steam sealing of turbine glands under vacuum conditions is essential to prevent the ingress of atmospheric air and to maintain condenser vacuum integrity. During turbine start-up, gland steam is supplied through the APRDS system. Once the turbine achieves self gland-sealing operation, external steam supply from APRDS is no longer required. However, to ensure system readiness during abnormal or emergency conditions, the gland seal inlet line drain valve is maintained in a normally open position, allowing a continuous flow of steam.

This arrangement is necessary to sustain the gland seal inlet line temperature above 300 °C. The discharged high-temperature steam is routed directly to the condenser, leading to a continuous loss of recoverable thermal energy.

Problem in Existing system-

- High-grade APRDS steam was used to operate the Vapour Absorption Machine, resulting in significant throttling losses and inefficient utilization of valuable energy.
- Condensate generated after steam utilization in the VAM was discharged to the atmosphere, causing continuous loss of treated water and thermal energy.
- Turbine gland steam drain during self gland-sealing operation was continuously routed to the condenser, leading to wastage of recoverable high-temperature steam.

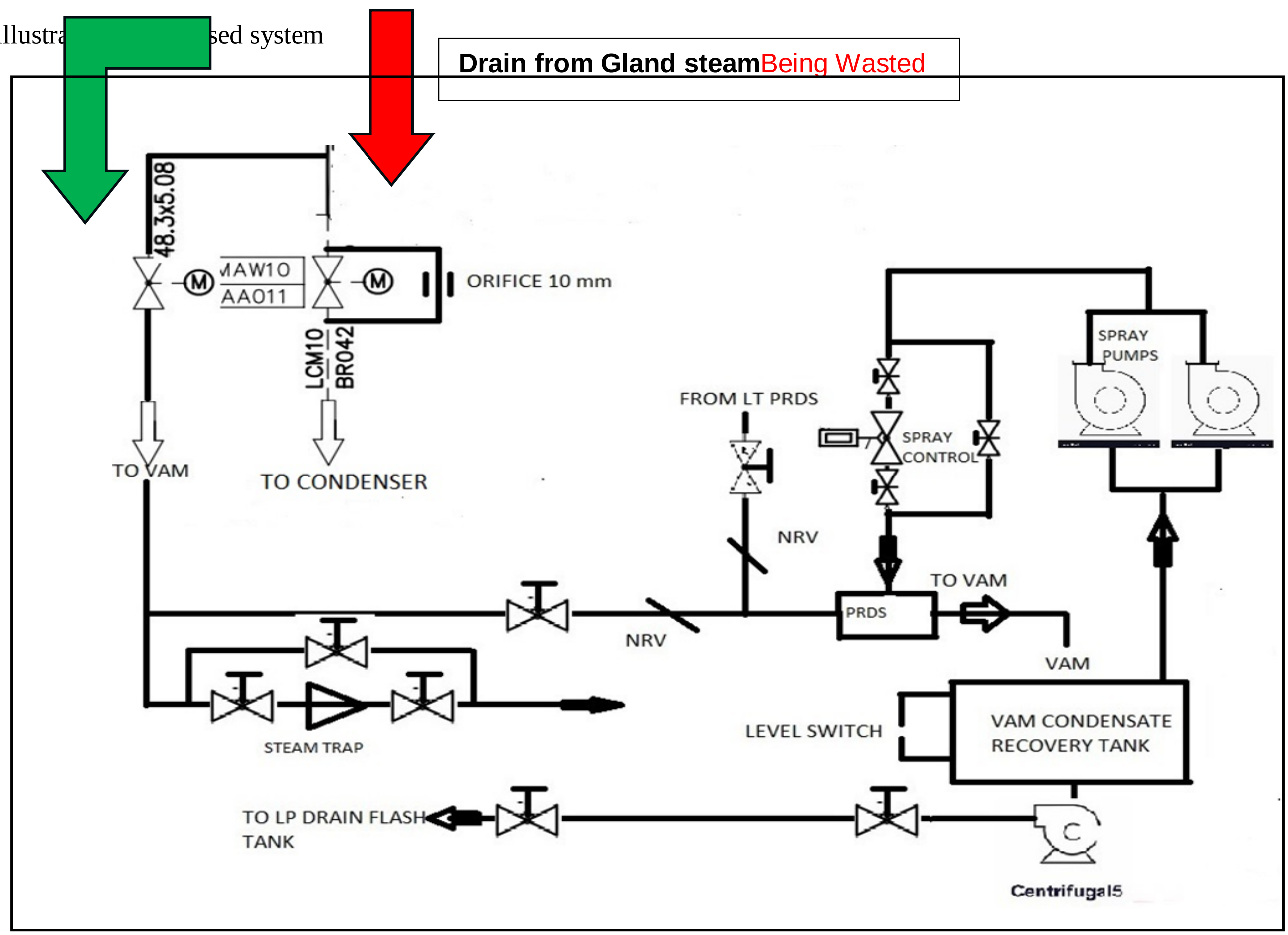
III. MODIFIED SYSTEM: UTILIZATION OF GLAND STEAM DRAIN FOR VAM OPERATION

In the proposed system, the gland steam drain, which is continuously discharged to the condenser to maintain the gland seal inlet temperature, is diverted and utilized as the driving steam source for the Vapor Absorption Machine (VAM). Instead of allowing this high-temperature drain steam to remain an energy loss, it is routed to the VAM steam inlet, where its thermal energy is effectively used for refrigeration.The steam, after transferring heat in the VAM generator, is condensed, and the resulting condensate is recovered and routed back to the plant condensate system.

1) Project Modification Details

- Steam line drain extension including motorised operated valve with NRV
- Condensate recovery system installation
- Conductivity meter installation
- Interlock and Protection as per new modified system

2) Below illustra sed system

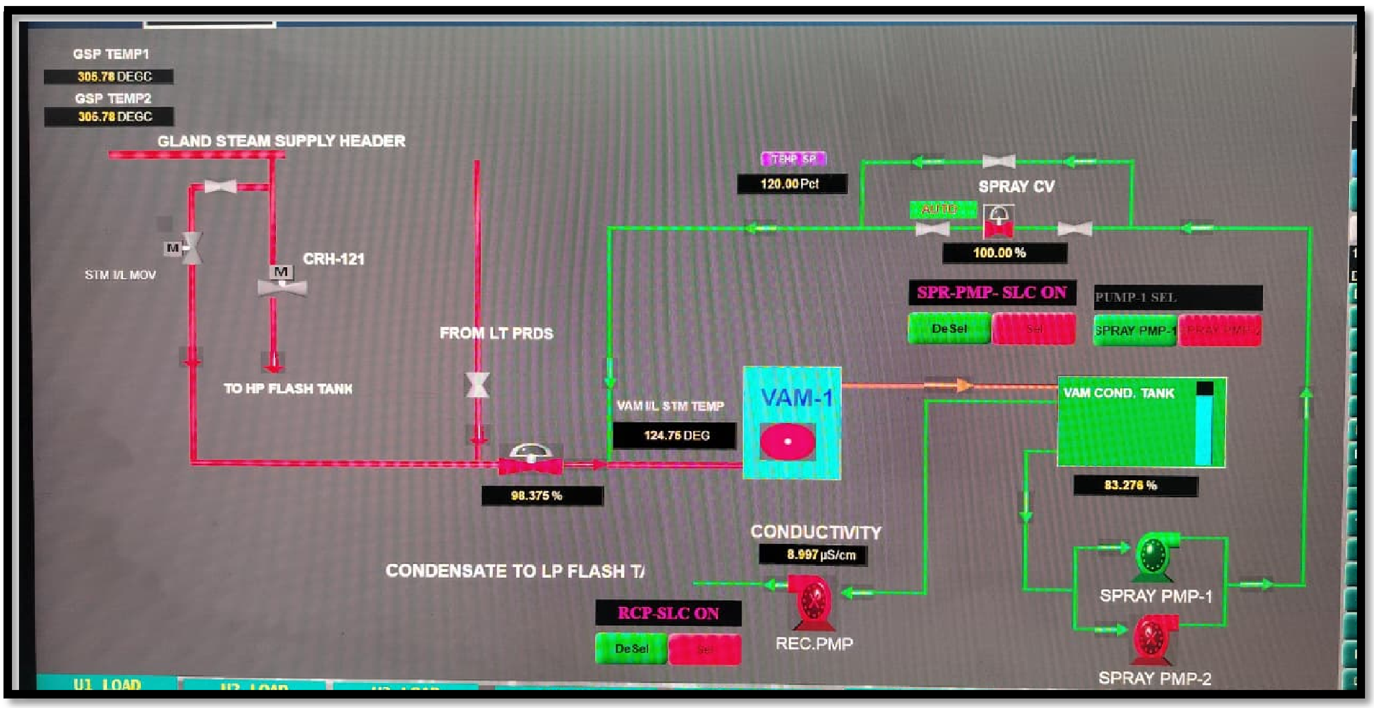


3) DCS hardware and Control system

Although the VAM is operated through a dedicated PLC-based control system, the proposed modification integrates DCS-based remote operation for the turbine gland steam drain control valve, condensate recovery pumps, and spray pump, enabling centralized monitoring and control.

To protect the condenser vacuum, an automatic trip of the condensate recovery pump has been implemented. In addition, a conductivity meter is installed to continuously monitor condensate water quality, and the recovery pump is tripped when conductivity exceeds 10 µS/cm

4) DCS page of VAM with condensate recovery system



IV. IMPLEMENTED RESULTS

After system modification, stable and reliable operation has been achieved. Enhanced monitoring and annunciation have been incorporated into the control room DCS, along with automatic start–stop logic for the pumps to ensure safe and efficient operation.

By installing a dedicated line for waste heat recovery, the plant achieves an estimated coal saving of approximately 6 tons per day, corresponding to a reduction of about 260 kg/h in coal consumption for steam generation.

BENIFITS

- Reduction in Coal consumption
- Reduction in CO_2 Emissions.
- Reduction in Ash generation.
- Reduction in DM water consumption

V. CONCLUSION

The implementation of waste heat recovery from the turbine gland steam drain for operating the Vapour Absorption Machine, along with an integrated condensate recovery system, has demonstrated significant improvements in energy efficiency and resource conservation. The modified system enables effective utilization of low-grade steam, resulting in measurable reductions in coal consumption, CO_2 emissions, ash generation, and DM water usage. Integration of DCS-based control, enhanced monitoring, and protective interlocks has ensured safe, reliable, and stable operation. Overall, the proposed approach presents a practical and sustainable solution for waste heat and water recovery in thermal power plants, with potential for replication in similar installations.

Author Profile

Sunil Kumar Chaubey received his Bachelor of Engineering (B.E.) degree in Mechanical Engineering from Chouksey Engineering College, Bilaspur, Chhattisgarh, in 2008. He also holds a Boiler Operation Engineer (BOE) certification, an MBA in Supply Chain Management, and a Diploma in Industrial Safety Management.

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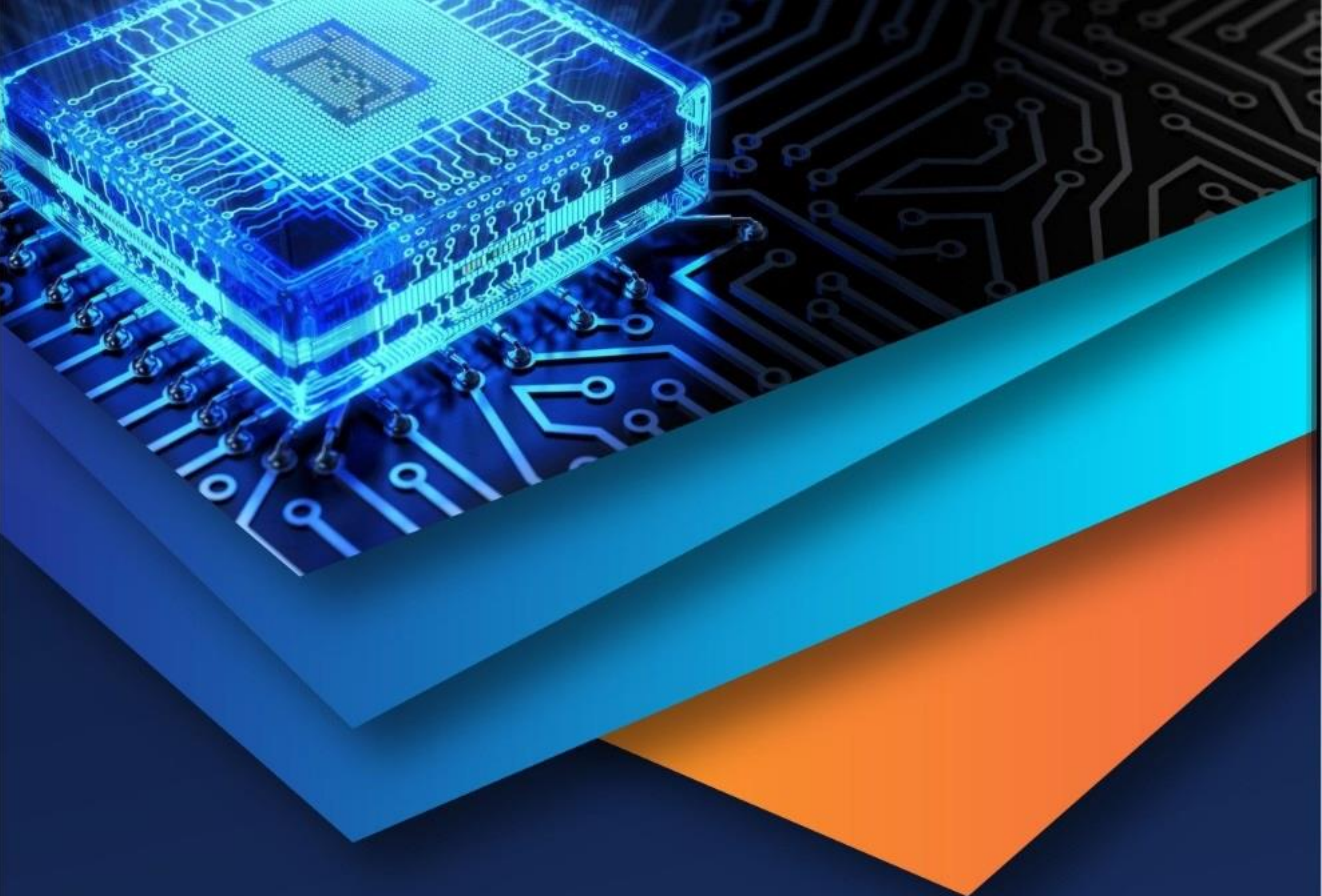

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