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HOT AIR RECIRCULATION (HAR) DIGITAL 1.0 – IMPROVING EFFICIENCY OF LNG PLANTS USING AI AND IOT

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ABSTRACT

PETRONAS (PETRONAS Research, Group Technical Solution and LNG Plant), in collaboration with JGC Corporation (Japan), developed a predictive algorithm-based application named HAR Digital 1.0 that utilises Artificial Intelligence (AI) and Internet of Things (IoT) technologies. The system provides real-time weather data prediction to forecast power margin setting for gas turbine and allow the plant to maintain stable operation with the opportunity to increase LNG production. Hot air recirculation (HAR) is a phenomenon that affects air-cooled LNG plants due to its geographical location, in which the hot air from air-cooled heat exchangers (ACHE) flows back into the ACHE intake or the intake of other equipment such as the gas turbine (GT). This reduces the turbine helper motor power margin availability, hence forces higher power requirements to the gas turbines, making the operation energy inefficient, exposes them to instability, and subsequently may cause plant trip. To date, there is no accurate method to predict the occurrence of HAR that could allow the plant's advanced process control (APC) to adjust the power margin setting to optimise GT operation. This innovation uses Real-Time Qualified Plant Data and Predictive Data Analytics to provide Forecasted Temperature and Power Margin Set Limit to allow for early ACHE/GT temperature prediction. This will assist APC in power margin setting, which allows the plant to use any available power margin to boost LNG production safely and reduces process fluctuation. A solid and compelling economic case is confirmed from the economic evaluation conducted based on the new power margin value. The production increase is estimated to translate to more than MYR 12 million per annum for two LNG trains.

Keywords: *Hot air recirculation, LNG Production*

INTRODUCTION

Natural gas and LNG have been highly mentioned in the oil and gas fraternity as the cleaner alternative to oil products and coal. Substitution to gas as the premier fuel source will help to reduce the impact of greenhouse gases on the environment. The improvement in GT efficiency with the help of the HAR Digital 1.0 System will boost LNG production and availability to the market. Higher efficiency means the lower unit cost of production, which translates to lower LNG price to the market, which certainly benefits the masses.

In terms of technology advancement, the hybrid digital solution of weather prediction and process control will pave the way for how plants can solve daily inefficiency problems related to weather in the future. Data analytics application has proven to bear many benefits to modern society. Thus, data analytics in chemical processes such as HAR Digital 1.0 will undoubtedly benefit the future generation.

MATERIALS AND METHODS

A detailed study covering multi-disciplines engineering identified the opportunity loss due to the HAR incidences via exhaustive investigation of historical plant data and HAR occurrences effect to GT power margin. Several process simulations were conducted to reduce risks associated with elevated temperatures and gas compositions. This immediately reduced the risks associated with unplanned shutdown during the pilot phase. Considering the unique means

of simulating hot air recirculation using rigorous CFD studies, the development of early temperature prediction model logic and power margin model logic were also completed.

RESULTS AND DISCUSSION

Phase 1: Feasibility Study and Front End Engineering

In Phase 1 of the project, the objective is to create a weather data prediction application to anticipate the HAR phenomenon in PETRONAS LNG plants. In this phase, the feasibility study was conducted to identify the potential opportunity & efficiency increase from the HAR prediction model. A thorough study involving a multi-discipline team looked into the pain points of opportunity loss due to the HAR incidences via exhaustive investigation of historical plant data. A link between HAR occurrences and their effect on GT power margin was established. From this evidence, a new, lower power margin value was proposed for the GT operation.

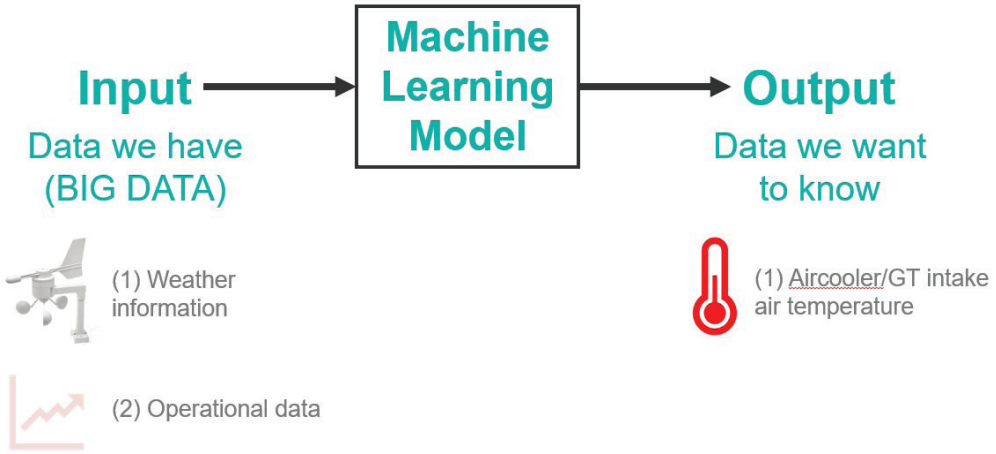

Figure 1 Machine learning model to predict the air cooler/GT air intake temperature

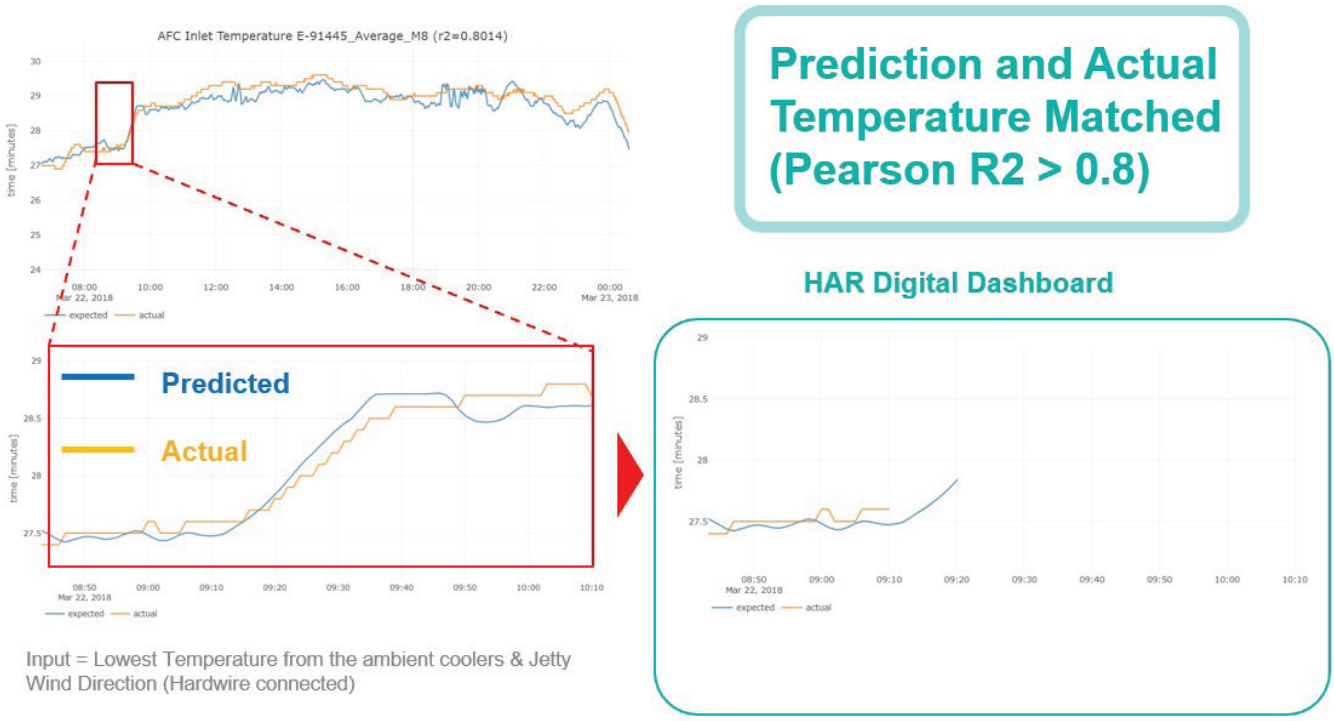

Figure 2 Pearson R2 > 0.8 for prediction vs. actual temperature

Next was the development of early temperature prediction model logic and power margin model logic. Rigorous Computational Fluid Dynamics (CFD) studies, weather data analysis, machine learning, statistical analysis, process simulation, predictive model validation, and advanced process control integration were carried out to establish this comprehensive and autonomous prediction-to-control solution. The economic evaluation showed a robust and compelling case for this innovation development. Next was the development of early temperature prediction and power margin model logic. A detailed cost estimation study for the implementation stage was also carried out in this phase.

Phase 2: Implementation

In Phase 2, a project execution plan was developed, including contracting strategy, risk analysis, EPCC, factory acceptance test (FAT), installation at site, site acceptance test (SAT), and performance test run. The HAR Digital 1.0 system, consisting of software and hardware, together with the linkage to the plant's Distributed Control System (DCS) and APC, were built, tested, assembled, and installed. The whole exercise was a big success due to excellent teamwork by interdisciplinary industry partner collaboration, continuous drive, and good project management.

Focus on Process Safety

Thorough process risk assessment was conducted before the implementation phase of this project, servicing all possible scenarios in a well-formed What-If Analysis covering analytics algorithm, input sensors failure, out-of-range input values, erroneous input transmission, failure of computational equipment, and communication infrastructure, including human error intervention. These were compounded with the potential of out-of-norm production and weather condition surges studies to realise a robust fail-safe control algorithm which was then tested through a series of functional and operational offline input to test the algorithm at an offsite facility rigorously.

The application was then commissioned onsite but was placed under probationary offline monitoring to the satisfaction of the plant custodian until it achieved the intended stability and predictability before the system went online for a performance test run. The plant custodian scrutinised the system to ensure all safety and operational compliance are met before a long performance test review was carried out to secure final acceptance before the actual production run. The complete software application is placed under strict Network Level 3 as a security barrier, where communication is confined to the Local Area Network, negating external communication.

All activities undergo an incremental stage of qualification concerning PETRONAS Technology Readiness Level and Technical Review Committee comprising Petronas wide SME of Custodian level

The fundamental premise of this innovation was to ensure the stable and efficient operation of the gas turbine through accurate prediction of HAR occurrence. This was crucial to the LNG plant operation and process/equipment safety.

CONCLUSION

Hot Air Recirculation Digital 1.0 (HAR Digital 1.0) is the brainchild of a collaborative effort featuring PETRONAS (PETRONAS Research, Group Technical Solution and LNG Plant Custodian) and partner JGC Corporation (Japan); to address, evaluate and realise increased in LNG production, leveraging internal expertise and existing LNG facilities with minimal modification; to predict and mitigate the effect of unavoidable Hot Air Recirculation, detrimental to plant production. HAR Digital 1.0 is an autonomous and self-correcting algorithm that utilises real-time forward weather data prediction to provide operational settings for plant equipment and maintain stable operation with realisable opportunities to increase LNG production.

ACKNOWLEDGEMENT

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REFERENCES

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