AIRLIZE LNG
JGC'S Innovative Technology Package for Operating and New Air-cooled LNG Plants

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ABSTRACT

LNG plant operators often face issues in the performance of their plants that lead to a drastic reduction in the LNG production rate. The reasons for these issues can be traced back to inadequate design of installed equipment and unforeseen conditions such as changes in the weather which cause the plant to operate beyond the design limits. This is especially true for air-cooled LNG plants, which often exhibit similar patterns of problems. Operators may not be able to come up with viable solutions that can be implemented while the plant is operating and a shutdown may become unavoidable.

In order to address recurring problems that can be detrimental to these types of plants, JGC has established the highly advanced and innovative technology package, called "AIRLIZE LNG". AIRLIZE LNG encompasses innovative technologies that are specific for air-cooled LNG plant design. Solutions can be offered throughout an LNG project lifecycle to help identify the root cause(s) of issues, improve performance, and maximize the production rate for a plant. Technologies such as weather simulation and computational fluid dynamics (CFD) are effective during the planning and engineering phase, while site assessment methods for checking the performance of equipment that are common in air-cooled LNG plants including air-cooled heat exchangers (ACHE) can help improve the energy efficiency of plants without disrupting operation.

In this paper, the core technologies that form AIRLIZE LNG and the significant benefits that can be offered for both operating plants and new projects through these technologies are described.

"AIRLIZE LNG" OVERVIEW

BACKGROUND

All year long, and in all kinds of environmental conditions, minus 160 degrees centigrade LNG is being produced around the world. However, occasionally there's an unwelcome surprise—an unexpected drop in production. The culprit isn't feed gas or plant trouble — but hot air!

Yes, hot air exhausted by the various types of equipment installed in LNG plants, such as gas turbines (GT) and air-cooled heat exchangers, hinders the production of minus 160-degree LNG. Grasping the nature of this phenomenon in actual operating plants - a desire of LNG plant engineers everywhere - was long-believed to be impossible. However, by devoting long years to measuring more than 100 million data values and then analyzing and verifying the results — a breakthrough was achieved by devising a comprehensive technological innovation, and establishing a unique technology package, “AIRLIZE LNG”.

Based on the “AIRLIZE LNG”concept, solutions for technological issues that appear at each phase of the project life cycle for an air-cooled LNG plant using its proprietary technology are provided.

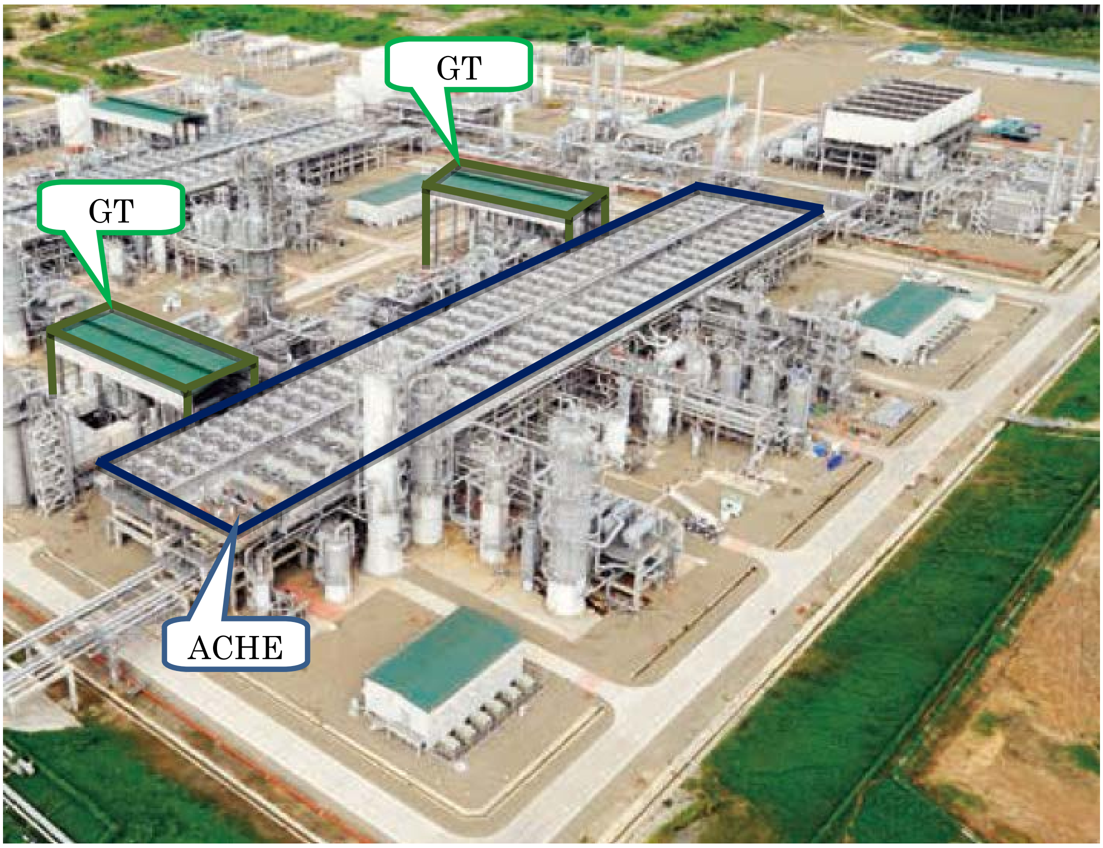

Figure 1. Air-cooled LNG Plant

EIGHT INNOVATIVE TECHNOLOGIES

“AIRLIZE LNG” is structured in the three steps of “VISUALIZE”, “UTILIZE” and “REALIZE” which in turn are materialized by eight technologies as outlined below.

“VISUALIZE” — Supported by a huge volume of measured data, the weather simulation technology makes possible the pin-point re-creation of the airflow in the plant area. “VISUALIZE” consists of the two technologies of (1) Weather Simulation and (2) Site Survey/Data Analysis.

“UTILIZE” — Based on the actually measured and/or reproduced weather data, (3) CFD simulation technology provides an accurate prediction of the hot air recirculation (HAR) flow within a model plant area and suggests (4) HAR Mitigation measures that will be most effective against the potential problems posed by local weather and HAR.

"REALIZE" — As various merits to the plant designs, we can offer (5) Compact Layout combined with optimized critical equipment and systems, such as (6) ACHE, (7) GT Intake Air Chillers and (8) Advanced Process Control (APC), that are ideal in every respect, with consideration given to every detail – including even HAR behavior.

Figure 2 shows an overview of how "AIRLIZE LNG"that consists of eight proprietary technologies supports plant operators of both operating plants and those planning new projects.

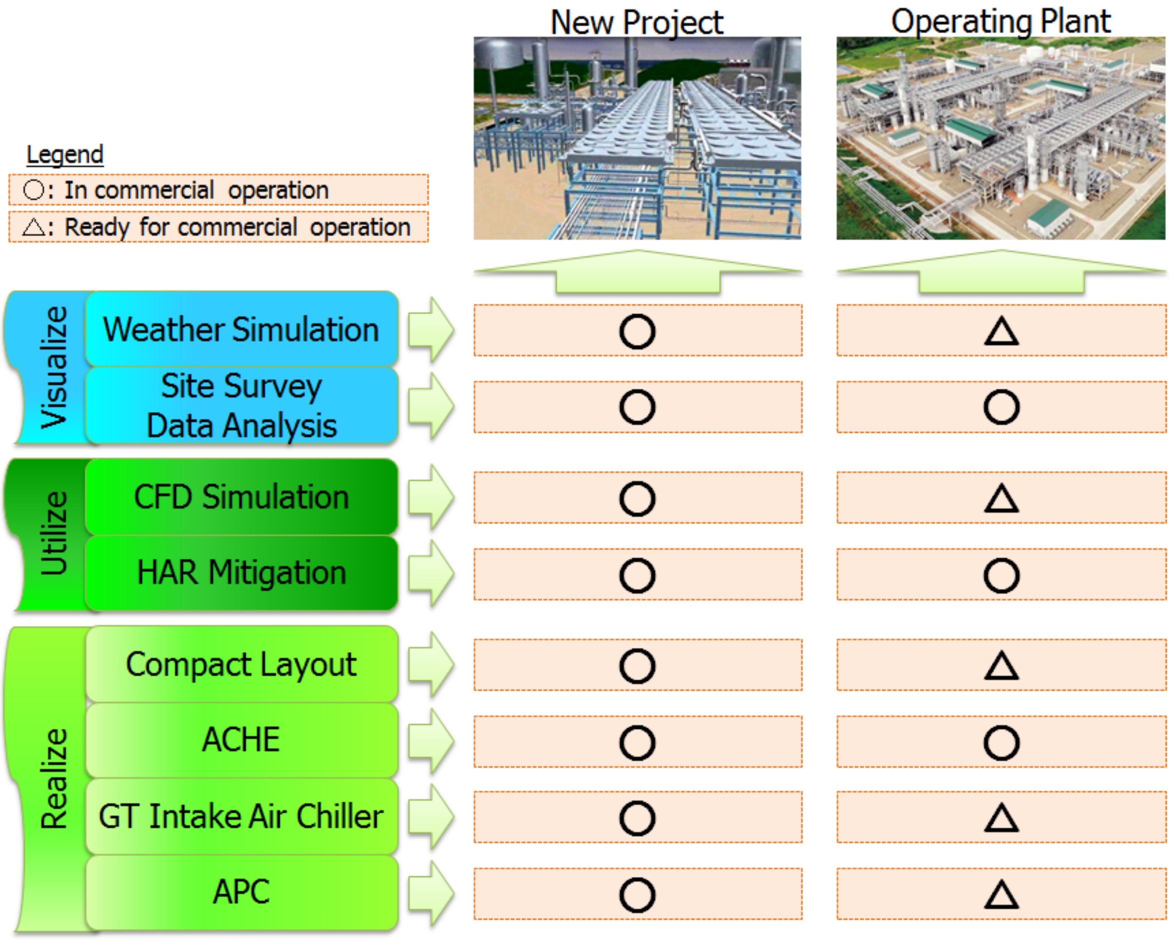

Figure 2. Overview of "AIRLIZE LNG"

WEATHER SIMULATION

Weather and atmospheric conditions such as air temperature, wind speed, wind direction, humidity, etc., have a vital and sensitive impact on process and structural engineering of plants. Since they are different from one plant to another, creating a store of data regarding changes in weather and atmospheric conditions that are specific to each plant is beneficial to plant owners and contractors. Weather simulation is able to generate this beneficial data.

This simulation service was developed by meteorological experts working with us. Though weather simulation technology development has a long history, our weather simulation method is the first in the world to be applied to plant engineering. With public data from the United States on weather patterns for the whole globe on a large-area scale (e.g. 500 km grid), our technology is able to transfer the data into a more detailed grid (e.g. 1 km grid), enabling the pinpointing of weather and climate conditions at individual plant sites.

Commenced with the first application in South-East Asia region, subsequent applications were followed to compare and verify the simulation data with the actual measured values for numerous sites, the performance of weather simulation was constantly improved and thereby applicable regions and climate conditions for weather simulation are being expanded.

LNG plant investors who desire to construct new LNG plants in a new location may enjoy a significant schedule merit. If plant engineering planning could begin without years of prior measurements of climatic conditions at the site, plant development schedules could be condensed by several years by means of weather simulation.

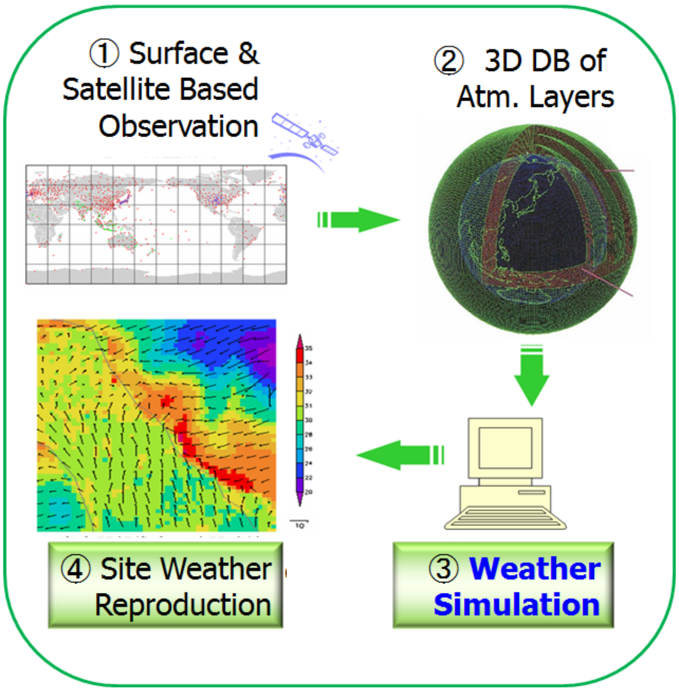

Figure 3. Weather Simulation

SITE SURVEY/DATA ANALYSIS

Conducting a site survey and making actual data measurements is easier said than done, in particular, in a broad area like that covered by an LNG plant. Yet actual data collected is often used for setting project basic design data to be used by all engineering disciplines, and the utmost care must be paid to the accuracy of the data.

In order to overcome these issues, integrated technology services are provided by joining the work of meteorological experts together with that of the plant engineering team. After integrated consideration of various conditions, including the specific characteristics of the environment around the plant site, human resources, and budget constraints, a site survey program addressing measurement items, locations, precision levels, measurement frequency, measurement devices and power supply is established. In choosing data collection methods, planning measurement frequency, etc., rich experience in recording over 100 million actual data values is drawn upon to prevent the collection of incorrect data, and provide waste-free, hassle-free prompt service.

Specialized know-how is accumulated not only through site survey and actual data measurement but also through creating a database of the measured data. The points where measurements are actually made differ depending on the LNG site, but the database is advanced in standardization so that its data can be readily and rapidly applied to any site. The database has two standard analytical functions for design condition setting and for HAR visualization. The former function is frequency distribution analyses such as wind roses and atmospheric temperature distribution. The latter function enables visual verification through comparison with CFD simulations described in the following section.

CFD SIMULATION

The CFD simulation is unique in that it has been verified using a total of more than 100 million HAR data values actually measured at operating LNG plant sites. Figure 4 shows a comparison between the actual measured data and CFD simulation data of air temperatures at the intakes of ACHEs and GTs at MLNG Tiga.

The CFD simulation is being further improved through a synergistic effect produced by integrating the four elements: CFD simulation, weather simulation (mentioned above), actually measured data (mentioned above), and HAR mitigation strategies (mentioned below). In this way, a level of accuracy sufficiently high to support plant design is ensured.

Typically, as shown in Figure 4, the HAR phenomenon between adjacent trains (Figure 5) is one of the most serious problems that disturb LNG plant stable operation. The capability to foresee this phenomenon has been greatly improved, and has enabled the calculation of the minimum required distance between adjacent trains combined with HAR mitigation measures.

Determining the amount of data that will enable the formation of a sufficiently detailed CFD model can only come from long experience of dealing with actual, real-life data. An unnecessarily detailed CFD model greatly increases calculation time. Drawing on experts' know-how and extensive experience in CFD simulation is essential to carry out a simulation with a good balance between the calculation time and accuracy within the allowed time frame of the individual project.

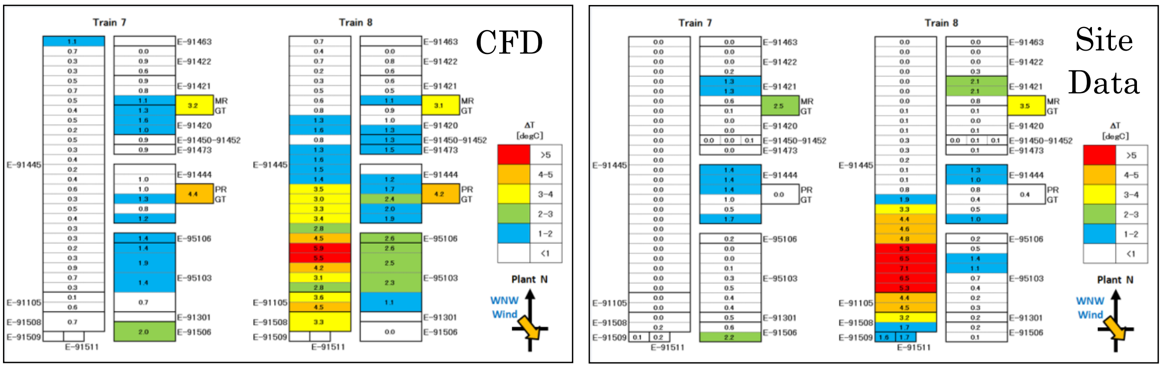

Figure 4. Temperature Rise above Ambient, site measured data vs. CFD (WNW Wind)

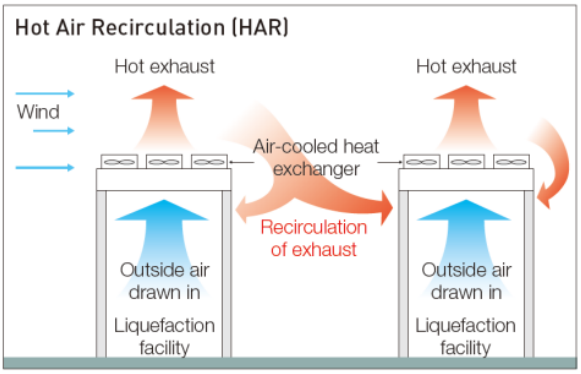

Figure 5. Hot Air Recirculation (HAR)

HAR MITIGATION

In determining HAR margins and mitigation strategies to be applied for plant layout and critical equipment, a systematic approach is ideal, which is in sharp contrast with an easy approach such as copying previous projects.

HAR mitigation strategies against HAR risks proposed for LNG plants are superior in that the best combination of HAR margins and HAR mitigation strategies is determined at the initial stage of design engineering. ACHE design margins and HAR mitigation strategies such as adding chimneys have positive or negative effects on each other from the standpoint of plant performance and plant layout. Using the established design guide covering an analysis of such effects, a basic policy for adopting an optimal HAR mitigation strategy reflecting the cost data of each specific project is determined.

For example, with regard to ACHE, we can look at HAR design margins and mitigation as described below. For the design margin, the intake air temperature and heat transfer surface area are considered. For the HAR mitigation strategy, the distance between trains or facilities, and the installation HAR mitigation measures, such as skirts, winglets, and chimneys, etc., are considered. Among a number of possible combinations of these elements, the optimal one is systematically identified by using our HAR design guide and CFD simulation technique.

The distance between trains and/or facilities is a core element to be finalized with HAR mitigation strategies. Increasing the distance is not easily adoptable because it involves layout area expansion, taller facilities, and significant effects in terms of project delivery date and cost. ACHE design assumes that the ACHE units will be installed in a space free from high-temperature exhaust air, but in reality plant designers who determine plant layout have to cope with the risk of ACHE intake air temperature increasing due to facilities installed close to each other. This risk has been increased as a result of the recent trend for compact plant layout and facility modularization. An HAR design guide is required to address how to manage this risk.

COMPACT LAYOUT

In accordance with recommendations derived from the HAR mitigation strategies, the plot plan of the LNG plant is designed. Cultivated know-how through nearly half a century of experience in the construction of LNG plants is exercised in a professional manner, as is evident from the following two representative layouts.

One is that refrigerant compressors and heat exchanger units are installed on one side of the pipe rack. It eliminates extra-large bore pipe runs of refrigerants in the pipe rack to the maximum extent. The other is an aero derivative gas turbine-based layout in which a compressor and a heat exchanger unit for propane refrigerant are installed on one side of the pipe rack and those for MR refrigerant are installed on the other side. Both layouts lead to lowering of the pipe rack, and contribute not only to earlier plant delivery date and cost saving but also the safety of construction work.

As evidenced in these layouts, we can flexibly study all detailed limitations and requirements that are applied to each individual plant and create an optimum compact layout.

ACHE

ACHE are critical equipment for air-cooled LNG plants.　They discharge heat extracted from the feed gas finally to the atmosphere and contribute to producing minus 160 degrees centigrade LNG from feed gas. In this way, the performance of the ACHE has a direct impact on LNG production rate. Communication with various plant operators reports that not a few operators experience lower performance of the ACHE than the design value in actual operating plants. The root causes of lower ACHE performance range widely. Cleaning issues – dust, pollen, etc., in the atmosphere are trapped between the fins of the ACHE tube bundles during several years of operation, and cause decrease in performance of heat exchange.　In the worst case, a numbers of ACHE tube fins are too corroded to be usable any longer.

Seasonal issues – water is sprayed over the ACHE tube bundles in mid-summer in some of the operating plants to compensate for a shortfall in the cooling capacity, while no design consideration is given to such occasional water spray operation.　A risk of scale formation between the ACHE tube fins due to poor quality water is not ignorable, that may cause the same troubles as the cleaning issues.

Local weather issues – strong cross winds beyond specified speed limits cause ACHE cavitation that should be avoided in view of the risk of mechanical trouble.

HAR issues - as described above.

None of these issues can be solved easily in actual operation and they require to be managed as a crucial part of plant operation and maintenance activities.

In collaboration with a specialist ACHE O&M company (Elflow BV), we have completed several projects in which we focused on the above issues. Through the application of our experience and know-how of specifying design requirements, supervising detailed engineering and manufacturing, erecting, commissioning and operation support, we have assembled the technologies which are most effective in the diagnosis and improvement of ACHE performance.

ACHE DIAGNOSIS

The measurement of the air flow rate, an essential element for the diagnosis, can be made without scaffolding so that diagnosis is possible at any time while the plant is in operation. ACHE diagnosis compares the design data and actual measurement data on the air-related performance of ACHEs in operation. It gives reliable information as it represents a diagnosis made by a third party unrelated to ACHE suppliers.

Figure 6. ACHE Air Flow Measurement

ACHE PERFORMANCE IMPROVEMENT PACKAGE

Based on the ACHE diagnosis result, a No Cure – No Pay step-wise package is offered with guaranteed improvement (in figures) in the performance of the air side. It eventually brings benefits, both in the form of the economic benefits of cooling efficiency as well as in terms of environmental protection (noise and vibration). The package includes the revamping of ACHEs as well as the external cleaning of the ACHE finned tube bundles. A choice of cleaning between wet process (water spray) and dry process (powder spray) is possible in accordance with the prevailing conditions, and can be carried out while the plant (including the ACHEs being cleaned) is in operation.

GT INTAKE AIR CHILLER

GT Intake Air Chillers are becoming essential equipment for LNG plants that adopt aero derivative GT as an effective means for improving LNG production efficiency.

By making a comprehensive analysis of the necessary data for GT Air Chillers to suit each individual LNG site, the specifications for the GT Air Chillers to be issued to the vendors can be decided upon. Of course, this analysis encompasses the process heat and material balance as well as creating a plant layout that includes the supporting facilities (power source, refrigerant storage facility, etc.) for the GT Air

Chillers on which will be based judgment of the economic aspects of the CAPEX (initial investment), OPEX (cost of operation), and NPV (net present value) that will enable the recommendations for the most suitable GT Intake Air Chillers. Economic study of different balances among these three is carried out in line with the objective of each individual project.

Depending on the desired temperature of the intake air, the most suitable solution will vary. The solutions include a choice of the system among the evaporation cooler (cooling tower) method, water spray method, direct chiller method through condensing the compressor refrigerant with air, indirect chiller method through condensing the compressor refrigerant with cold water, a choice of refrigerant among propane that is mostly used but also freon refrigerant that obviates the need for explosion proofing measures as well as a number of other alternatives.

APC (ADVANCED PROCESS CONTROL)

APC that is designed to cope with fluctuation of composition and/or flow rate of the feed gas is able to expand its application as follows. In order to avoid shutdown of the plant as a result of the effect of air temperature changes or HAR, it has been the practice for operators to reduce the throughput of LNG in anticipation of such changes. Because it is difficult for the operators to anticipate the fluctuations in the ACHE intake air temperature, the operation of the plant cannot be maintained at the maximal level, resulting in an annual production that is less than the optimal (Figure 7). However, with the input from CFD simulation together with the prediction of wind speed and direction and changes in temperature, it becomes possible to maintain the level of production at the optimal level. With the installation of a relatively simple APC, it becomes possible to increase the production rate by several percent. In this way, the APC is designed in harmonization with weather simulation, site survey/data analysis and CFD simulation.

The APC makes possible plant operation without depending on the technical skill of an operator and relieves the stress on the operators should an emergency shutdown occur as a result of external factors.

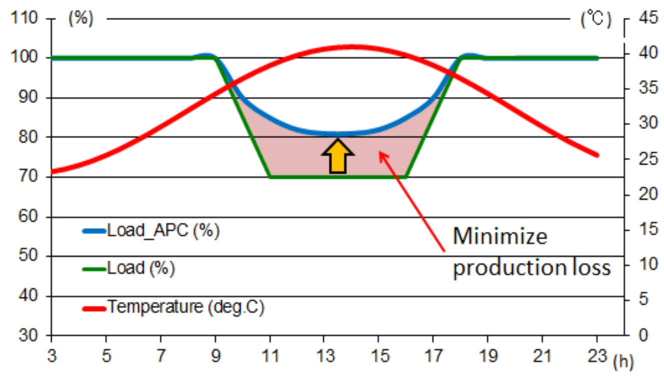

Figure 7. APC (Advanced Process Control)

CONCLUSION

The voices of society are increasingly calling for a balance between energy supply and environmental protection. Unlike the water-cooled LNG plants commonly used in the past, air-cooled LNG plants produce LNG without causing changes in the surrounding marine environment, providing one effective solution to meet global expectations.

JGC has established the "AIRLIZE LNG" technology package by focusing on the "AIR" of the air-cooled LNG plants and streamlining innovative technologies achieved till today to provide comprehensive solutions for all kinds of issues that plant operators encounter in daily plant operations. While significant advances have already been made through the application of "AIRLIZE LNG" technology package, we recognize that none of the eight technologies is perfect and each has room for further improvement. However, there is no doubt that we are now in a position to carry out further innovation that will enable us to respond positively to the pleas of plant owners and operators calling for plants that maximize production efficiency and plant availability while minimizing costs and swift completion and start of operations for both operating plants and new projects.

In closing, we should add that the AIRLIZE LNG approach is applicable for not only air-cooled LNG plants but also the whole range of plants that use ACHE, GT, etc., employing air as an energy source.

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