TUGA
MAPNA GROUP

OPTIMAP™

MAPNA TURBINE ENGINEERING & MANUFACTURING Co. (TUGA)

As one of the most applicable gas turbines in Iran and around the world, MGT-70 gas turbine (V94.2 product family) is perceived as a highly valued option for investing in upgrade and optimization of power output and efficiency. As an active player in the field on an international scale, in response to ever-increasing demands of energy sector and to meet its national responsibilities, MAPNA group has put a considerable effort into research, development and innovation of its product and service portfolio. The OPTIMAP™ package is used to increase the flexibility, availability and power output of MGT-70 gas turbine. This package includes the following:

1. Increasing power by optimizing the position of the input guide vanes (IGV+)
2. Increasing power at peak load with optimal turbine gas inlet temperature management (EMS)
3. Starting a unit with fuel oil with the help of pilot flames
4. Starting unit with fuel oil by means of gas diffusion flames (Applicable for fuel oil DLN's design)
5. Hot start of MGT-70 gas turbine with both fuel gas and fuel oil
6. Fast loading of the turbine
7. Upgrading the compressor pressure ratio controller taking into account the relative humidity of the air (Possibility of increasing the available power in harsh environment)
8. Modification of the fuel gas controller to compensate for pressure and temperature fluctuations of the fuel entering the fuel gas skid
9. Ability to change lube oil pumps of MGT-70 gas turbines to increase operating maneuvers
10. Quasi-dynamic gas turbine simulator
11. Smart adjustment of control system parameters (MAPtune-70)

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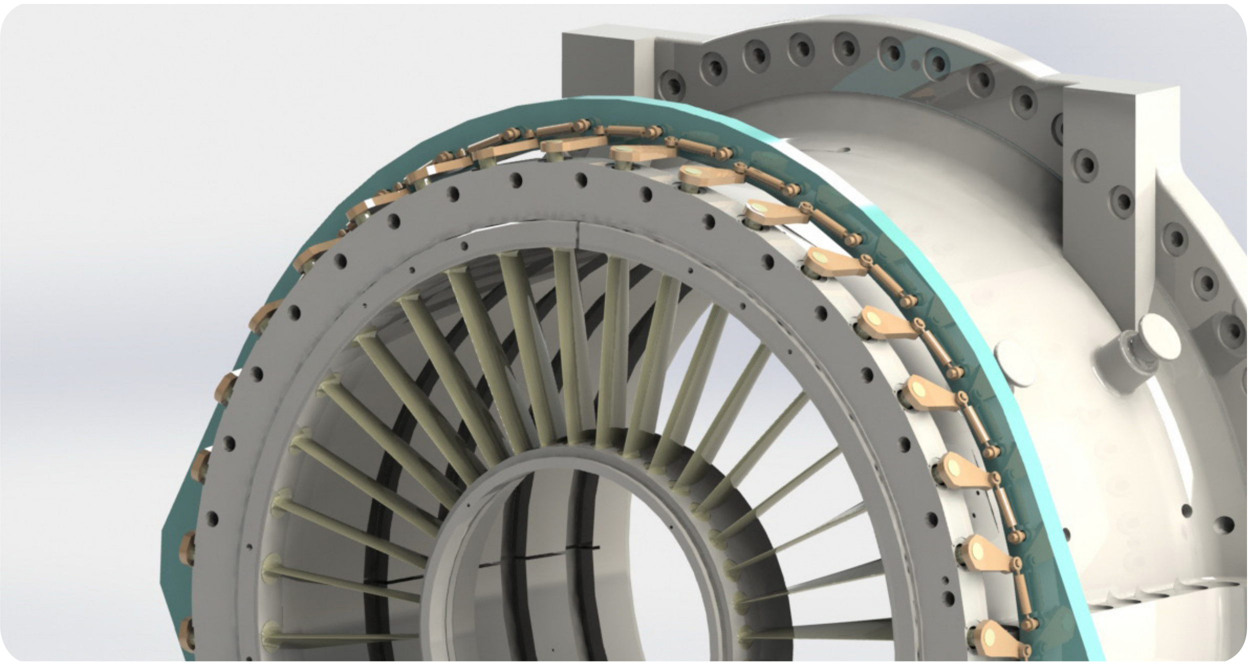
Increasing power by optimizing the position of the input guide vanes (IGV+)

Code: G70.OP.01

The basis of this design is based on optimizing the position of the compressor inlet guide vanes (IGV) in different versions of the gas turbine. By changing the IGV's angle, the mass flow through the turbine and the compressor increases and in proportion to that, the output power increases and according to the turbine model, it increases the power between 3 to 5 MW. One of the advantages of the IGV+'s plan is the increase in electricity production in the national grid of Iran in a scattered manner, while the increase in production in the case of construction of a new power plant is concentrated. The current demand for electricity in Iran is only at the peak of consumption, and the IGV+'s plan, unlike the construction of a new power plant, covers this need. Also, the time and cost of implementing this technology is very low compared to any other method. In summary, the capabilities of this plan include the following:

- Short execution time of the plan, including changes in the hardware of the guide vanes mechanism and software changes in the control system in less than one day
- No negative effects on the gas turbine performance, efficiency and life
- The possibility of exploiting the effect of increasing the mass flow rate of the gas turbine to increase the steam power of the combined cycle units (approximately half of the megawatt increase obtained in the gas turbine is also obtained in the steam turbine)



Increasing power at peak load with optimal turbine gas inlet temperature management (EMS)

Code: G70.OP.02

This design is based on a tolerance of 10 °C for the turbine inlet temperature (TIT) at the base load point that exists for all family turbines. This tolerance is due to the errors in the calculations related to the turbine inlet temperature from the turbine outlet temperature (OTC) and the other parameters affecting it. By intelligently and simultaneously using the following two factors, this tolerance can be used to increase power in peak network times without a negative impact on the machine life:

- Increasing the accuracy of OTC calculations
- Intelligent and proportional distribution of increasing and decreasing the TIT temperature, so that the average operation temperature of the turbine remains unchanged.

Before calculating the inlet temperature of the turbine based on the environmental conditions of Iran, MGT-70 gas turbines experienced inlet temperature changes of 15 degrees, but by refining these calculations in the EMS design, this number is significantly reduced and on the other hand by intelligently managing this TIT temperature tolerance within the allowable range, a power increase of about 3 MW can be achieved during peak network times (similarly, a power increase of about half this value is achieved in a combined cycle, i.e. about 9 MW in a block). At other times and after passing the peak of the network, the effect of reducing life is compensated by decreasing the TIT temperature.

There are three approaches to intelligently managing the TIT temperature distribution as follows:

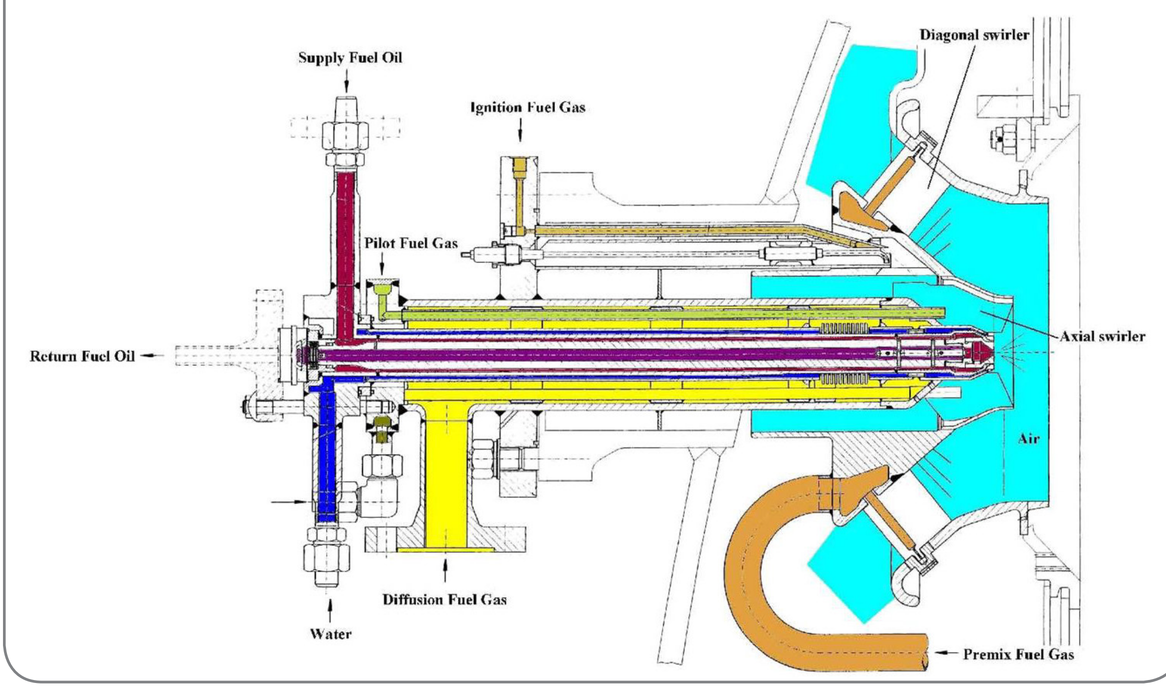
- Daily temperature distribution (DTD): Based on the peak hours of consumption in the network, the total time of increasing the inlet temperature (over-firing) and decreasing the inlet temperature (under-firing) during one day for each gas unit is balanced.
- Overall Temperature Distribution (OTD): The sum of increasing the inlet temperature (over-firing) and decreasing the inlet temperature (under-firing) over the life of a gas unit is balanced.
- Overall power distribution in the power plant or network (OPD): The implementation of such a plan requires the implementation of intelligent power control (AGC) plan by the network management, according to which the command to increase the inlet temperature (over-firing) and to decrease the inlet temperature (under-firing) remotely is sent by the national dispatching.

3 Starting a unit with fuel oil with the help of pilot flames

Code: G70.OP.03 (Hybrid)

This plan is used to increase the safe start capability of MGT-70 gas turbine with fuel oil and to increase the availability of units in case of lack or shortage of appropriate ignition gas. This method can be applied in hybrid diffusion / premix fuel gas burners and fuel oil diffusion burners and the pilot path of the mentioned burner is used to guide natural gas. Among the capabilities of this plan, the following can be mentioned:

- The ability to select this method for starting the unit with fuel oil in the HMI is fully automatic and without the intervention of the operator.
- All previous start modes are maintained in the same way and this feature is added to the control system.
- Due to the fact that this method uses trapped gas in the gas pipeline and the pressure will change during start-up, the ability to correct the control position of the pilot valve according to the line pressure has also been seen in the logical design.
- Ability to use the gas line pressure more than 5 times for the gas turbine start where the number of doable starts depend on the initial pressure of the pipeline and the length and diameter of the pipe. For example, for an 8-inch pipe with an initial pressure of 20 bar, the gas turbine will be able to start 30 times on fuel oil.

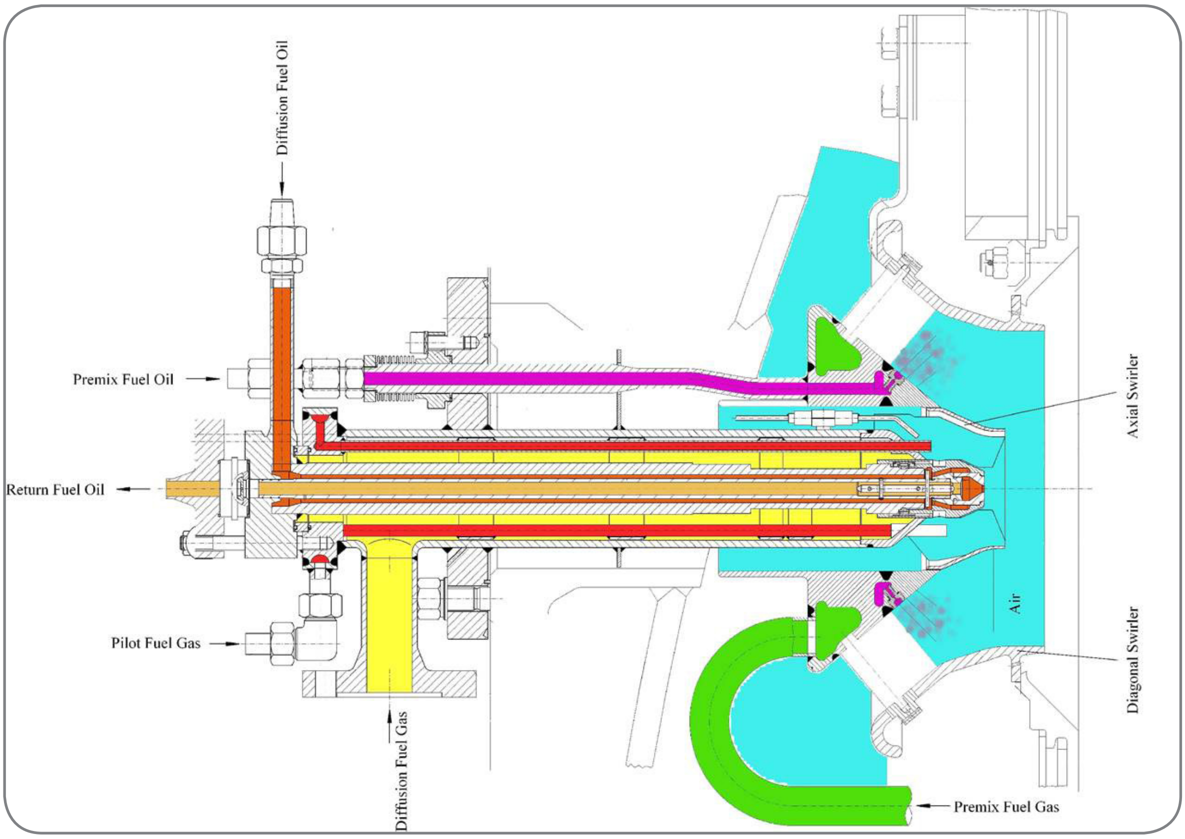


Starting unit with fuel oil by means of gas diffusion flames (Applicable for fuel oil DLN's design)

Code: G70.OP.03 (DLN)

This plan is used to increase the safe start capability of MGT-70 gas turbine with fuel oil and to increase the availability of units in case of lack or shortage of appropriate ignition gas. This method can be applied in DLN's design burners (hybrid diffusion / premix fuel gas burners and diffusion/premix fuel oil burners) and the pilot path of the mentioned burner is used to guide natural gas. Among the capabilities of this plan, the following can be mentioned:

- The ability to select this method for starting the unit with fuel oil in the HMI is fully automatic and without the intervention of the operator.
- All previous start modes are maintained in the same way and this feature is added to the control system.
- Due to the fact that this method uses trapped gas in the gas pipeline and the pressure will change during start-up, the ability to correct the control position of the pilot valve according to the line pressure has also been seen in the logical design.
- Ability to use the gas line pressure more than 5 times for the gas turbine start where the number of doable starts depend on the initial pressure of the pipeline and the length and diameter of the pipe. For example, for an 8-inch pipe with an initial pressure of 20 bar, the gas turbine will be able to start 10 times on fuel oil.



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Hot start of MGT-70 gas turbine with both fuel gas and fuel oil

Code: G70.OP.04

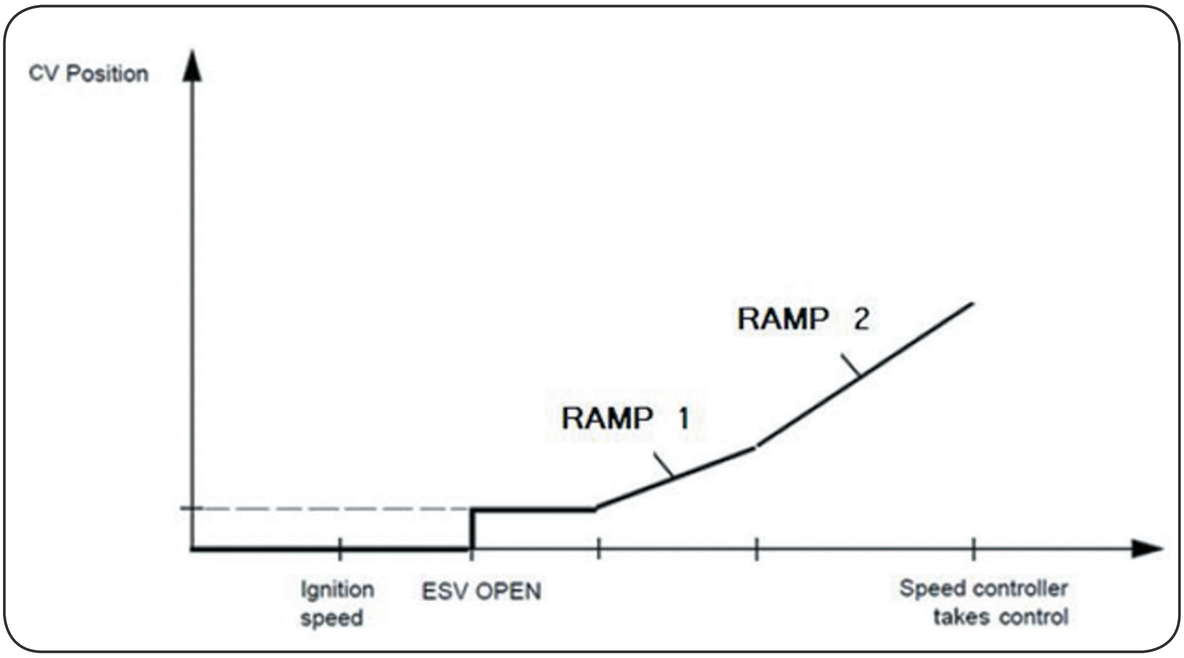
In order to increase the availability of MGT-70 turbines, this plan allows the users to accelerate the restart of the turbine.

Normally, to start MGT-70 gas units, the turbine outlet temperature must be reduced to below 150 °C, and this process takes two hours. By implementing this plan, it is possible to restart the gas unit without interruption.

In this method, when the turbine is started, the position of the gas and fuel control valves is dynamically adjusted according to the outlet temperature in such a way that the least temperature changes occur on the hot part of the turbine.

The advantages of this plan can be summarized as follows:

- Increasing the ability to restart the unit without interruption
- Reduction of thermal stresses of the restart time with turbine outlet temperature above 150 °C due to the reduction of temperature changes



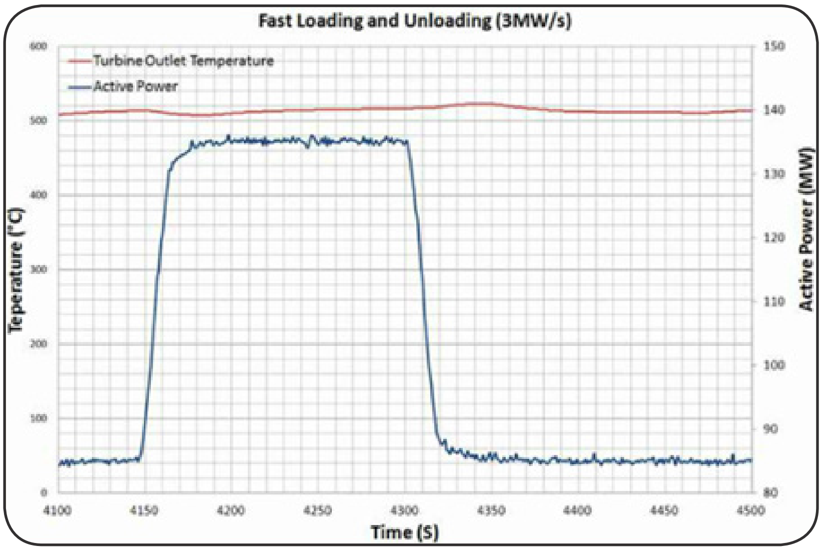
Fast loading of the turbine

Code: G70.OP.05

This design can be used for better frequency response or operation in the case of MGT-70 turbine islands. In gas turbines, due to the control of thermal stresses on hot parts, the maximum turbine loading rate is directly related to the IGV's operating speed. The MGT-70 gas turbine does not currently use the maximum engine drive capacity of the input guide vanes (IGV), and the turbine loading speed in the IGV's operating range is exactly the same as in the case where the IGV is closed (30 MW/min), while for frequency response and island operation in the IGV's operating range, it is possible to increase the loading rate to respond to changes in network frequency. In this design, by using the maximum IGV's engine drive speed and without any hardware changes, the machine loading rate in the IGV's operating range can be significantly increased up to 180MW/min (6 times the current maximum loading rate of these turbines).

The advantages of this plan include the following:

- No negative effects on turbine life
- Executing the plan in a short time without the need for major hardware changes
- Ability to respond quickly to frequency changes and providing island operation (without connection to the network) for MGT-70 turbines



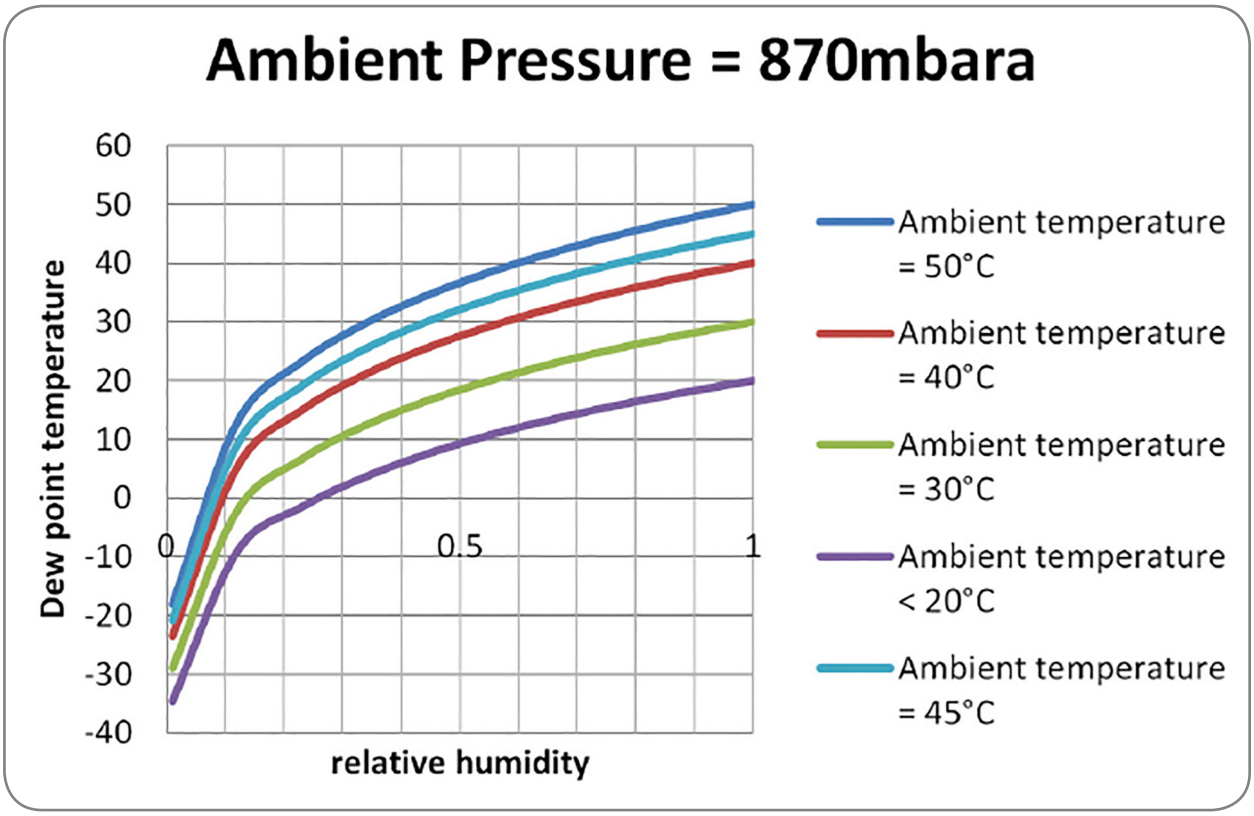
7 Upgrading the compressor pressure ratio controller taking into account the relative humidity of the air

(Possibility of increasing the available power in harsh environment)

Code: G70.OP.06

MGT-70 turbines have a compressor outlet pressure limiting controller that protects the turbine against surge in harsh environmental conditions (high temperature and humidity) and low rotational speed. The set point of the controller varies depending on the environmental conditions and depends on the temperature and humidity of the environment as well as the IGV's angle. To consider the effect of air humidity on logic, an air dew point sensor is required, which is not available in current turbines. In such conditions, the control system takes into account the worst conditions (100% humidity) which in some power plant units that are operated in harsh environmental conditions will activate this controller and reduce the power available with this turbine.

Due to the fact that in existing turbines, the relative humidity sensor is available, the possibility of optimal use of the maximum achievable power with the help of this design is provided by the development of the logic based on using this sensor to calculate the air dew point, which avoids unnecessary reduction of the achievable power in harsh environmental conditions.

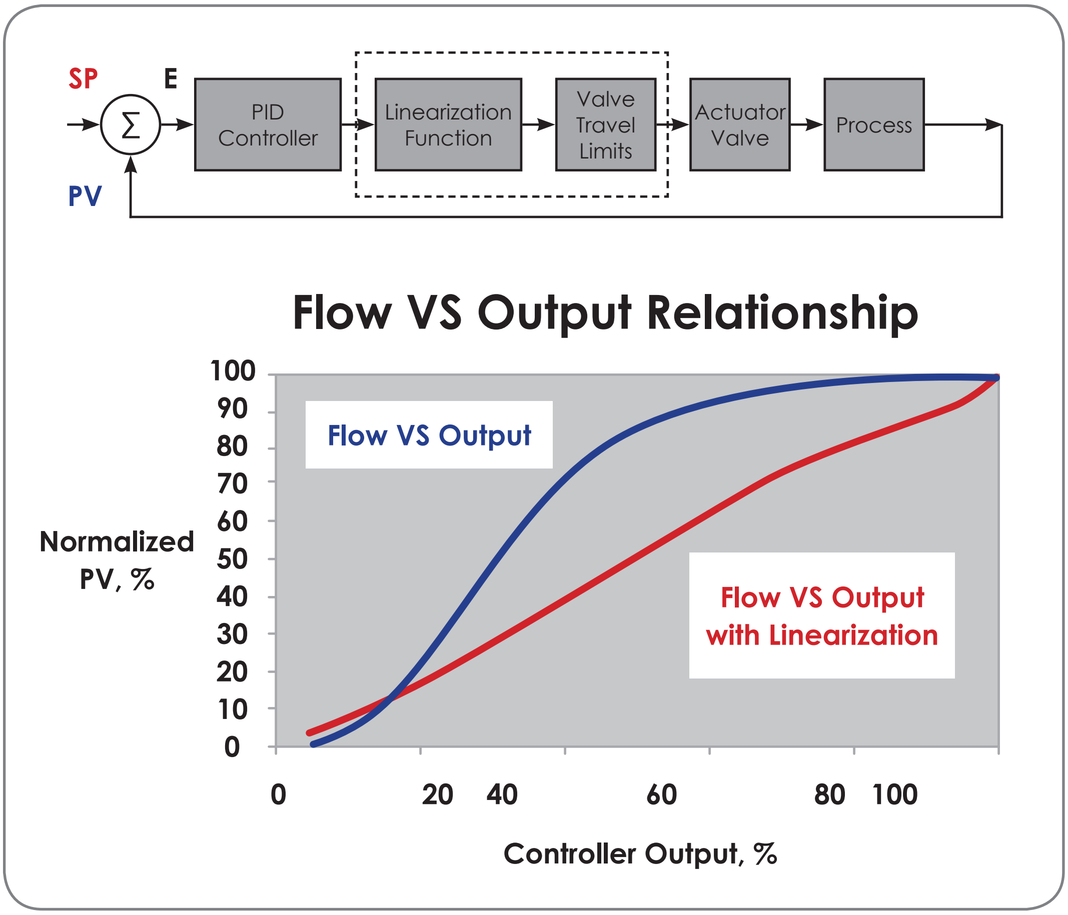


Modification of the fuel gas controller to compensate for pressure and temperature fluctuations of the fuel entering the fuel gas skid

Code: G70.OP.07

The basis of this plan is based on eliminating the effect of pressure and temperature of the natural fuel gas input to the fuel gas skid on the mass flow of the natural gas and also further linearization of the control behavior of the gas turbine. If the pressure and temperature of the natural gas entering the turbine fuel gas skid (which is supplied by the power plant pressure reduction station) change, this will cause a change in the mass flow of the natural gas into the combustion chamber and changes in the output power and other turbine parameters. Of course, the governor of the turbine will try to compensate for the disturbances after experiencing them. However, this can lead to turbine trips in transient conditions (such as load rejection, fuel changes, sudden drop in gas pressure etc.). In this design, if the pressure or temperature of the natural gas changes, the new position of the control valve is calculated as an open loop and prevents the occurrence of the mentioned disturbances.

By implementing this plan, in addition to the above advantages, the parameters of the turbine start will be dynamically corrected with the pressure and temperature of the natural gas, and will ensure the correct start and prevent the occurrence of impermissible thermal stresses.



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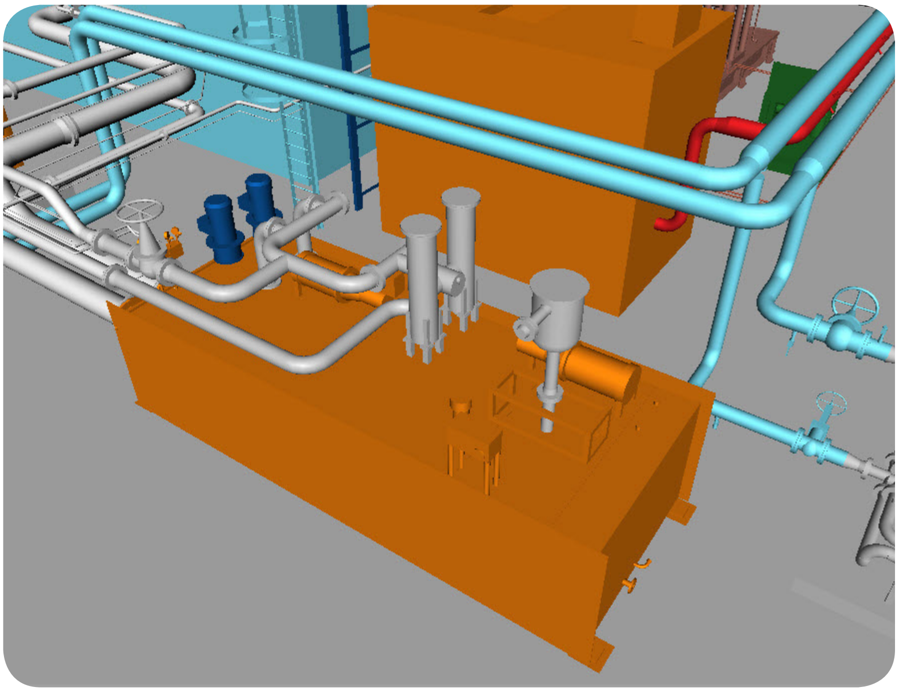
Ability to change lube oil pumps of MGT-70 gas turbines to increase operating maneuvers

Code: G70.OP.08

This design has been developed based on the feedback of MGT-70 turbine users that it is not possible to replace the main and auxiliary oil pumps in these units. In power plants, the main pump is generally worn out more than the auxiliary pump due to longer operating hours and the impossibility of placing the auxiliary pump in the circuit in an emergency. In this plan, considering all the limitations and the design structure of the lubrication system and the turbine, permission to replace the pumps while the turbine is in operation is issued safely and all changes related to this process are applied in DCS.

In summary, the advantages of this plan include the following:

- Possibility of operating maneuvers on changing oil pumps in case of problems during unit operation (for example, abnormal noise from the working pump)
- Possibility of using lube oil pumps more uniformly in order to depreciate them evenly and to plan for repairs and spare parts
- Execution of the plan in a short time and without the need for hardware equipment



Quasi-dynamic gas turbine simulator

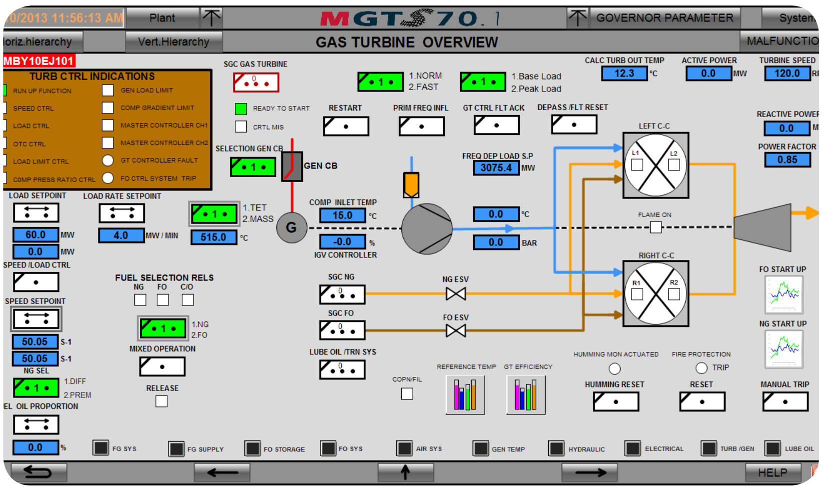
Code: G70.OP.09

The MGTS 70.1 simulator is used to simulate gas cycle power plants with the MGT-70 turbine gas. In this simulator, a graphic system is used for monitoring, data collection and data storage, and the turbine and auxiliaries are modeled with high accuracy. DCS and governor logic are also implemented in another environment that allows the user to follow the logic simultaneously during the startup process. Applications of this simulator include the following:

- Ability to make changes to the logic and to observe and verify it before running on the real unit to prevent possible damage
- Training of experts and operators of power plant sites, for better understanding of the logic, troubleshooting and correct decision-making at the time of accidents and other related matters
- Ability to test and view the results of various risky maneuvers to train people related to power plant processes with the help of a simulator

CAPABILITIES:

- Observation of the logic in the format of power plant control systems
- Observation of the turbine optimal performance Curves (Online)
- Ability to change, download and test the logic
- Viewing Logic Online in the format of the Siemens governor
- Ability to slow down and speed up the startup process
- Changing governor parameters (engineering capability)
- Events recording system
- Alarm registration system
- Possibility of errors in the system
- Drawing, recording, viewing and printing all analog values
- Simultaneous use of 16 users by one server
- Viewing the performance curve of the pumps etc. online
- Ability to record all data in the desired state and use them without quantity limitation
- Possibility of connecting several servers to each other (in combined cycle application)
- Development and customization of the simulator based on customers' needs
- Possibility to adjust the initial conditions



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Smart adjustment of control system parameters (MAPtune-70)

Code: G70.OP.10

As one of the latest MAPNA group's service packages on offer, MAPtune-70 package would increase gas turbine power output considerably with the least amount of changes and within the shortest possible time. This package has been implemented based on upgrading of control system settings in different versions of this machine. By using this package, power reduction due to incorrect adjustment of control parameters in aged turbines will be prevented.

To date, the MGT-70 gas turbine settings at base load have been implemented solely on the basis of environmental conditions, and the impacts of ageing and pollution emission have only been applied manually during periodic inspections. Even in some older versions the environmental factors were not taken into account precisely. With this scheme, an innovative solution has been provided which allows for continuous performance monitoring of main gas turbine components within the control system to provide reasonably accurate estimates of their performance so as their impacts are taken into account intelligently in the control system settings.

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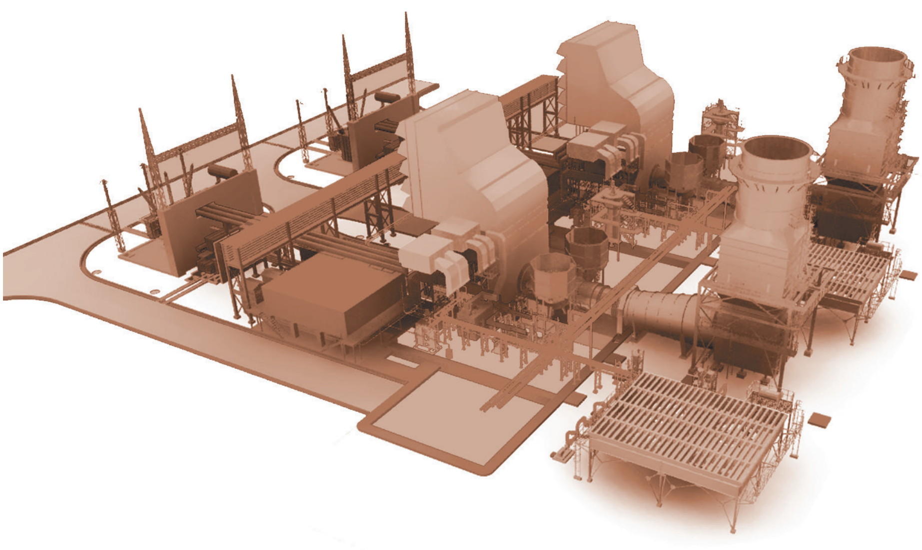

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