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DEPARTMENT - ELECTRICAL ENGINEERING

TITLE - OPTMIZATION OF ELECTRICAL GENERATOR OUTPUT AT VARYING INPUT CONDITIONS IN COMBINED CYCLE GAS TURBINE

ABSTRACT- Combined cycle gas turbines Electric power generation is an alternative to replace the existing Steam /Gas Electric power plants. However the combined cycle gas turbines (CCGT) operation is very complex This is because two different power generation cycles working on two fluids are connected to each other via a heat recovery steam generator (HRSG), and any change in its design directly affects variables such as Electric power, efficiency, cost, etc.

Combined cycle gas turbines Electric power generation needs to run efficiently and effectively. A large number of physical parameters of diverse nature need to be studied to understand the phenomenon of Electric power generation. There are three different regions of study with regards to Electric power generation namely Gas/ steam turbine cycle, HRSG and Electric Generator.

Researchers have studied to enhance the Electric power generation attempting one of the region in isolation. Studies pertaining to two or more regions in tandem are scant.

Generator output is a function of Turbine work and effective use of HRSG to convert the exhaust gas energy of Gas turbine to produce Steam, which further is used for extra power generation in Stem turbine Generator.

The present work is an attempt to integrate the different regions to achieve the common goal of producing Electric power generation at optimum efficiency and low cost.

To achieve this goal, Mathematical Model was adopted with the help of MATLAB and SIMULINK/MATLAB. Model was verified and validate with the data obtained from the Electric power generation CCGT plant in Delhi.

VALIDATION-The validated model was applied to study the parametric investigations. The input physical parameters such as Compressor pressure ratio(4to 20), Air Fuel ratio(50 to 100), Turbine inlet Temperature(900 to 1600K), compressor and turbine efficiencies(0.8 to 0.9) , HRSG pressure and temperature(10 bar 623K to 20 bar 813K), amount of supplementary heating(0% to 50%), amount of auxiliary power, electrical generation frequency(50,60), power factor(0.8 to 0.9) etc. were varied to determine the Electric power generation in terms of EMF generated per unit. Optimum conditions were determined with the application of optimization techniques.

CONCLUSIONS- Based upon the studies undertaken following conclusions are drawn

1. The Mathematical model adopted was in close proximity with the data obtained from the Electric power generation CCGT plant in Delhi.

2. As the Air flow for fixed amount of Fuel or Air Fuel ratio increases Exhaust temperature of the gases in the gas turbine decreases.
3. As the ambient temperature increases the power output from the Electric power generator decreases. For 25°C increase in ambient temperature there is a decrease of almost 10% of the power.
4. As the air flow increases fuel flow also increases for the same power output.
5. The generated EMF of the generator (internal EMF) is directly related to the excitation provided to the rotor. (as seen in generator at no load).
6. Effect of sudden changes in load on speed was studied and it is concluded that for system to be able to operate properly the governor system should be such that it is able to balance electrical and mechanical torque after a disturbance has occurred in the system.
7. The changes in the load angle were observed when the generator was suddenly loaded; it showed that the setup is stable for small disturbances as the load angle was able to attain a constant value after some disturbance was applied to the system.
8. The dependence of real power on the load angle delta was observed that as with the decrease in delta active power generated also decreases.
9. The temperature control in the turbine was also shown which was seen to be directly in increasing when fuel slow was increased and it was shown that air flow is used to control the temperature of the turbine.
10. A speed control loop is essential for the plant stability, as the frequency feedback in fuel flow and air flow render the plant very sensitive to turbulences
11. The plant is unsteady, without the frequency control mechanism, To achieve steady state after a disturbance, a necessary condition is for the LVS to switch back to speed control.
12. Air control helps in increasing the power output, to correct frequency errors without creating overheat.
13. For the same air fuel ratio EMF generated in the generator as a function of compressor pressure ratio increases or decreases depending upon the amount of supplementary heating in HRSG. From no supplementary heating to certain percentage of supplementary heating EMF generated increases. At certain percentage of supplementary heating it first increases and then decreases due to non formation of steam in HRSG. For further supplementary heating it decreases.
14. Certain percentage of supplementary heating at which EMF generated starts decreasing depends upon the Air Furl Ratio or Turbine Exhaust Temperature.
15. For same air fuel ratio Temperature in the HRSG goes on decreasing with increasing pressure ratio. HRSG temperature increases with the increasing air fuel ratio and marginal Drop in temperature at higher air fuel ratio goes on decreasing.
16. EMF generated per unit at no supplementary increases with increasing pressure ratio. It happens so at low supplementary heating as both gas turbine and steam turbine generator are producing Electric power. At higher supplementary heating EMF generated decreases due to less EMF generated in gas turbine Electric generator.