PERFORMANCE ANALYSIS OF POWER GENERATION: A GRAPH THEORETIC APPROACH

Nikhil Dev
YMCA University of Science and Technology, Faridabad.

Sandeep Kumar
UIET, MDU Rohtak.

ABSTRACT -Simple, numerically efficient model based on GTA used for CPI for thermal systems is proposed in the present work. Thermal system is divided into sub-systems and various interconnections between sub-systems. Design and development of thermal power systems and design of its components and sub-components can be evaluated by GTA. Preliminary quantification is obtained from the thermodynamic inference. During the analysis worst state of affairs, for evaluating criticality for equipment, all of the components and equipments are to be analysed for all these attributes. The index value for the best and worst is found to be 33475 and 61875 respectively. The value of index in real life situation will vary in-between these two.

Keywords -TPP, GTA, SPP, RH.

INTRODUCTION

On the earth water is the second most needed commodity after air. Water is in solid, liquid and gaseous state either in equilibrium or stable state. Water is having the expected inclination to evaporate itself even at room temperature. Water is found in the air as vapour which is called as humidity. Temperature of water is alike with air temperature. It is in gaseous state at this lower temperature due to partial water vapour pressure. Requisite amount of heat to evaporate is absorbed by water from contiguous environment. When the amount of heat supplied to water is high enough then at one point its vapour pressure converts equivalent to atmospheric pressure. At that time it is having higher energy content and known as vapour. The gaseous state of water is called steam if the vapour temperature is above the boiling point. Higher heat content inside a body is experienced by higher body temperature.

Steam is observed to be gaseous form of water. In its gaseous form water follows gas laws only up to some extent. Ideal gas model tends to fail at very low temperatures or higher pressures as inter-molecular forces turn out to be more significant. In water inter-molecular hydrogen bonding force is appreciably large and it is accountable for higher boiling point (BP) of water (100 °C). At elevated pressures, due intermolecular repulsion it is observed that volume of real gas is greater than that of an ideal gas. Due to higher in volume pressure of a real gas is substantially minus to an ideal gas at lower temperature. At higher pressure molecules of gases comes close to each other. But each and every molecule is confined to a specified space. It is energy intensive phenomena to bring one molecule to another molecule after an intermolecular distance of R_0. As the pressure is increased, molecules come closer, repulsion becomes higher and hence it is stored as internal energy. Outside to system it appears as increase in system temperature. During this phenomenon some heat is lost to environment and it is continued till the system becomes in equilibrium with surrounding. If the amount of heat lost is high then phase change of the system can also be observed.

MATHEMATICAL MODELING

In its gaseous form it follows the gas laws. At normal temperature and pressure i.e. 25°C and 60% RH, water may exist in gaseous and liquid form. Very common example to this is natural mechanism of sweating which cools our body. During summer relative humidity (RH) in air is higher than winter but it is less than rainy season. To lower body temperature water is evaporated easily from the body and heat of evaporation is taken from the body itself. Due to temperature difference heat flows from a body of higher temperature to the body of lower temperature. This heat is stored inside the body as molecular kinetic energy. Therefore, higher is the temperature of the body more is the kinetic or vibrational energy in the molecules of the body. In real time situation water molecules absorb heat from body by conduction and transfer heat by convection. Heat transfer by convection is dependent upon surface tension and the intermolecular forces. Water is a polar substance (solvent polarity index 10.2) with high surface tension (72.8×10^{-3} mN/m at 20 °C).

In case of heating when water molecules gain sufficient amount of heat from the lower most surface then they travel to the upper most surface. If the amount of heat absorbed by them is sufficient to overcome surface tension then molecules may evaporate to atmosphere. Otherwise molecules wait for there for more energy to come so that they may enter to atmosphere. At high temperature surface tension is decreased and the way to enter the atmosphere is easy. In this way over all temperature of the water is decreased in comparison to surrounding temperature.

The permanent function for the digraph represented in Figure 1 is as represented in expression (1).

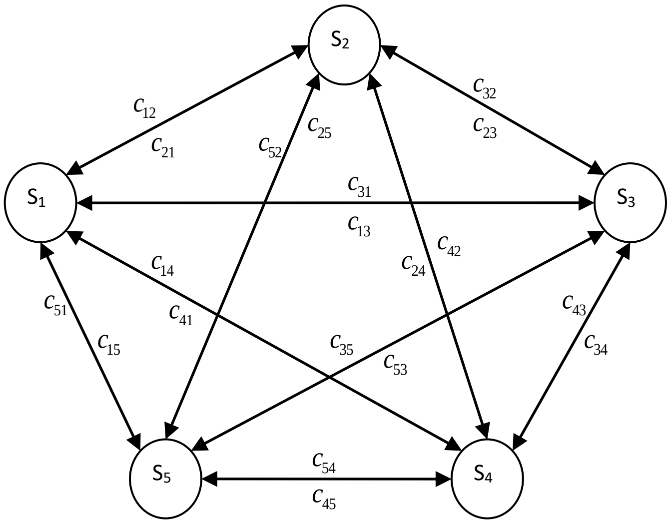

Figure 1 Digraph representing the five attributes of power generation and their interdependencies in the system

$$\begin{aligned}
Per(E) = {} & \prod S_i (Group-I) \\
& +\sum_i\sum_j\sum_k .....\sum_m\sum_n c_{ij}^2 S_k S_l S_m S_n ....(Group-III) \\
& +2\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{ki}\right) S_l S_m S_n ....(Group-IV) \\
& +2\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{kl}c_{li}\right) S_m S_n ....(Group-V) \\
& +\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c^2{}_{ij}c^2{}_{ij}\right) S_m S_n ....(Group-V) \\
& +2\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{kl}c_{lm}c_{mi}\right) S_n ....(Group-VI) \\
& +\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{ki}\right) c_{lm}^2 S_n ....(Group-VI) \\
& +\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c^2{}_{ij}\right)\left(c^2{}_{kl}\right)\left(c^2{}_{mn}\right) ....(Group-VII) \\
& +4\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{ki}\right)\left(c_{lm}c_{mn}c_{ln}\right) ...(Group-VII) \\
& +2\sum_i\sum_j\sum_k .....\sum_m\sum_n \left(c_{ij}c_{jk}c_{kl}c_{li}\right)\left(c^2{}_{mn}\right) .....(Group-VII)
\end{aligned} \tag{1}$$

RESULTS AND DISCUSSION

Combustion is the most common route to generate electric power from mechanical power which intern comes from fuel chemical energy. Adiabatic flame temperature and surrounding temperature are the upper limit and lower limit respectively for the Carnot cycle to evaluate maximum temperature limits. Rankine cycle is the improved form of thermodynamic cycle employed for power generation. At present a lot of research is going on to improve the efficiency of Rankine cycle. One of the real time solutions is the development of combined cycle power plant. Their development was started with the development of regeneration. Some part of the regenerated steam was supplied for town heating in the earlier times in European countries. Afterwards the concept of combination of gas turbine power plant and steam turbine power plant was developed. At present a lot of different combinations are tried so that better fuel utilization efficiency could be achieved.

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