2.1. INTRODUCTION

We are aware that the population of the world is increasing dramatically, and the demand for energy is greater than ever before. Fossil fuels are the main source of our energy, and are not renewable resources meaning that once used they cannot be replaced or recreated. They also pose environmental problems during their extraction, transportation and utilization. However all the forecasts suggest that more fuels will be burned in the future and 85% of it will be fossil fuel, and almost every step of the process of supplying energy damages the environment? All these factors have forced us to go for extensive designing and manufacturing of highly efficient energy conversion devices which produces minimum damage to environment. Mixed gas-steam cycle based power plants have been chosen for this purpose as they are efficient systems and continuous extensive researches are in progress in the direction of increasing its efficiency. It is significant to have a systematic review of literature from the point of view to find the useful information for engineering design, performance prediction, application and scope of the future research work in the field of mixed gas-steam cycle. This very chapter is an attempt in this direction.

2.2 VARIOUS CONFIGURATIONS OF GAS TURBINE BASED THERMAL POWER

A large number of configurations of gas turbine based thermal power plants arepossible. A vast quantity of literature is available on this topic however; here it is restricted mainly to those power plants which are associated with recovery and utilizations of waste heat as a modus operandi to enhance the power plant performance.

Ahmed M. Bagabir (2011)the present study investigates two techniques of gas turbine performance augmentation which arecooling intake air and applying of intercooler between two compressors. Power augmentationfrom a 4 kW-micro gas turbine test unit using evaporative and coil cooling systems has beenexperimentally investigated. The parametric study examines the effect of ambient air conditions(temperature, humidity and pressure) on evaporative and coil cooling gas turbine cycles. Theexperimental results reveal that the performance of gas turbine cycles is successfully improved bydecreasing the temperature of inlet air. The cooling coil cycle is capable of enhancing theefficiency of the studied gas turbine unit by 2% at low ambient temperature and 6% at highambient temperature, whereas the evaporative cycle merely increases the efficiency by about 1%.

Reducing the temperature from ambient condition to ISO standard condition could boost gasturbine efficiency by 3%. The effect of ambient relative humidity indicates that coil coolingoutperforms evaporative cooling by 3%. In general, the efficiency of turbine cycles deteriorates ata relative humidity level greater than 20%. Another method of gas turbine power augmentation,which is applying intercooler between two compressors, is also investigated theoretically. It isfound that this method can enhance turbine performance especially at high expansion ratios.

Thamerk.ibrahim (2012)in this paper it is known the performance of a gas turbine (GT) has strong dependence of climate conditions. A suitable solution to minimize this negative effect is to raise inlet turbine temperature and reduce temperature of inlet air to GT compressor. Combined cycles gas turbines (CCGT) are a lot used to acquire a high-efficiency power plant. Increases the peak compression ratio has been proposed to improve the combined-cycle gas-turbine performance. The code of the performance model for CCGT power plant was developed utilizing the MATLAB software. The simulating results show that the overall efficiency increases with the increase of the peak compression ratio. The total power output increases with the increase of the peak compression ratio. The peak overall efficiency occurs at the higher compression ratio with low ambient temperature and higher turbine inlet temperature. The overall thermal efficiencies for CCGT are higher compared to gas-turbine plants.

Roumeliotis I. and Mathioudakis K. (2007) have presented experimental work concerning the effect of water injection on a compressor stage. The effect on compressor stage performance and stability is examined for water injection up to 2%. The behavior of the airflow in the blade rows is examined through aerodynamic measurements. The results indicate that although the water injection appears to not have any significant effect on the flow pattern and to stage pressure rise and stall margin, there is a measurable effect on compression efficiency, which seems to result mainly from losses of a mechanical nature and water acceleration. The efficiency degradation is found proportional to the water ratio entering the engine.

Poullikkas (2005) has presented in this work an overview of current and future sustainable gas turbine technologies. In particular, various gas turbine technologies are described and compared. Emphasis has been given to the various advance cycles involving heat recovery from the gas turbine exhaust, such as, the gas to gas recuperation cycle, the combined cycle, the chemical recuperation cycle, the Cheng cycle, the humid air turbine cycle, etc. The thermodynamic characteristics of various cycles are considered in order to establish their relative importance to future power generation markets. The combined cycle technology is now well established and offers superior to any of the competing gas turbine based systems, which are likely to be available in the medium term for large-scale power generation applications. In small-scale generation, less than 50 MW,it is more cost effective to install and a less complex power plant due to the adverse effect of the economics of scale. Combined cycle plants in this power output range normally have higher specific investment costs and lower electrical efficiencies but also offer robust and reliable performance. Mixed air steam turbines (MAST) technologies are among the possible ways to improve the performance of gas turbine based power plants at feasible costs (e.g. peak load gas turbine plants).

Lingen Chen *et al*(2004) have done a performance analysis and optimization of an open-cycle regenerator gas-turbine power plant. The analytical formulae about the relation between power output and cycle overall pressure-ratio are derived taking into account the eight pressure-drop losses in the intake, compression, regeneration, combustion, expansion and discharge processes, flow process in the piping, the heat transfer loss to the ambient environment, the irreversible compression and expansion losses in the compressor and the turbine, and the irreversible combustion loss in the combustion chamber. The power output is optimized by adjusting the mass flow rate and the distribution of pressure losses along the flow path. Also, it is shown that the power output is a maximum with respect to the fuel-flow rate or any of the overall pressure-drops and the maximized power output has an additional maximum with respect to the overall pressure-ratio. The numerical example shows the effects of design parameters on the power output and heat-conversion efficiency.

Mustapha Chaker*et al*(2004) have emphasized that the inlet fogging of gas turbine engines for power augmentation has seen increasing application over the past decade yet not a single technical paper treating the physics and engineering of the fogging process, droplet size measurement, droplet kinetics, or the duct behavior of droplets, froma gas turbine perspective, is available. This paper along with Parts I and II provides the results of extensive experimental and theoretical studies conducted over several years coupled with practical aspects learned in the implementation of nearly 500 inlet fogging systems on gas turbines ranging in power from 5 to 250 MW. In Part III of this paper, the complex behavior of fog droplets in the inlet duct is addressed and experimental results from several wind tunnel studies are shown.

Bhargava R. *et al*(2004) have presented a comprehensive and simple in application design methodology to obtain a gas turbine working on recuperated, intercooled, and reheat cycle utilizing existing gas turbines. Applications of the proposed design steps have been implemented on the three existing gas turbines with wide ranging design complexities. The results of evaluated aerothermodynamics performance for these existing gas turbines with the proposed modifications are presented and compared in this paper. Sample calculations of the analysis procedures discussed, including stage-by-stage analysis of the compressor and turbine sections of the modified gas turbines have been also included. All the three modified gas turbines are found to have higher performance, with cycle efficiency increase of 9% to 26%, in comparison to their original values.

Torbidoni L. and Massardo A.F. (2004) have presented with the objective of performing reliable innovative gas turbine cycle calculations, a new procedure aimed at evaluating blade cooling performance. This complete analytical (convective and film)39blade cooling modeling provides the coolant mass flow and pressure loss estimation, and isa useful tool in the field of innovative gas turbine cycle analysis, mainly when alternative fluids are considered. In this case, in fact, the conventional semi-empirical data based onthe use of air as traditional coolant and working media are no longer suitable. So the analytical approach represents a way of properly investigating alternative cooling methods andfluids. In the presented analysis the effects of internal blade geometry on cooling performance are summarized by the Z parameter which also highly affects the coolant flow pressure losses. Since existing technology represents a natural starting point for the assessment of Z, the model is able to automatically estimate a proper value relying only on available semi-empirical data which were established for air-cooled gas turbine blades. When alternative fluids are considered, the same estimated value of Z is still maintained for the calculation, with the result of investigating the performance of existing blade technology for novel operational conditions. This represents an example of how the analytical approach, supported by conventional air-cooled blade semi empirical data appears as an innovative tool in the analysis of novel gas turbine cycles.

Horlock J. H. (1998) has proposed the flow through a gas turbine in a variety of forms. The STIG plant involves the generation of steam by the gas turbine exhaust in a heat recovery steam generator (HRSG), and its injection into or downstream of the combustion chamber. This increases the mass flow through the turbine and the power output from the plant, with a small increase in efficiency. In the Evaporative gas turbine (or EGT) cycle, water is injected in the compressor discharge in a regenerative gas turbine cycle (a so-called CBTX plant- compressor[C], burner [B], turbine[T], heat exchanger [X]);the air is evaporative cooled before it enters the heat exchanger. While the addition of water increases the turbine mass flow and power output, there is also apparent benefit introducing the temperature drop in the exhaust stack. In one variation of the basic EGT40cycle, water is also added downstream of the evaporative after cooler, even continuously in theheat exchanger. The present paper analyzes the performance of the EGT cycle. The optimum pressure ratio in the EGT cycle for given constraints (e.g. fixed maximum to minimum temperature) were also calculated. It is argued that this optimum has a relatively low value.

Dechamps P. J. (1998) has looked at some of the heat recovery possibilities with the newly available gas turbine engines, characterized by a high exhaust temperature, high specific work, and the integration of some gas turbine cooling with the boiler in this paper. The schemes range from classical dual pressure systems, to triple pressure systems with reheat in supercritical steam conditions. For each system, an optimum set of variables (steam pressures, etc.) is proposed. The effect of some changes on the steam cycle parameters, like increasing the steam temperatures above 570°C are also considered. Emphasis is also put on the influence of some special features or arrangements of the heat recovery steam generators, not only from a thermodynamic point of view.

Yousef M. Abdel-Rahim (2013) A general mathematical model is developed to specify the performance of an irreversible gas turbine Braytoncycleincorporating two-stage compressor, two-stage gas turbine, intercooler, reheated, and regenerator withirreversibility's due to finite heat transfer rates and pressure drops. Ranges of operating parameters resulting inoptimum performance (i.e., $\eta I \geq 38 \geq \eta II \geq 60\%$, ECOP ≥ 1.65, xloss$\leq$ 0.150 MJ/kg, BWR $\leq$0.525, wnet$\geq$ 0.300 MJ/kg,andqadd$\leq$ 0.470 MJ/kg) are determined and discussed using the Monte Carlo method. These operating ranges areminimum cycle temperature ranges between 302 and 315 K, maximum cycle temperature ranges between 1,320and 1,360 K, maximum cycle pressure ranges between 1.449 and 2.830 MPa, and conductance of the heatexchanger ranges between 20.7 and 29.6 kW/K. Exclusive effect of each of the operating parameters on each of theperformance parameters is mathematically given in a general formulation that is applicable regardless of the valuesof the rest of the operating parameters and under any condition of operation of the cycle.