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Inflection Analysis in Gas Turbine Operating Parameters on Co-Generation Cycle

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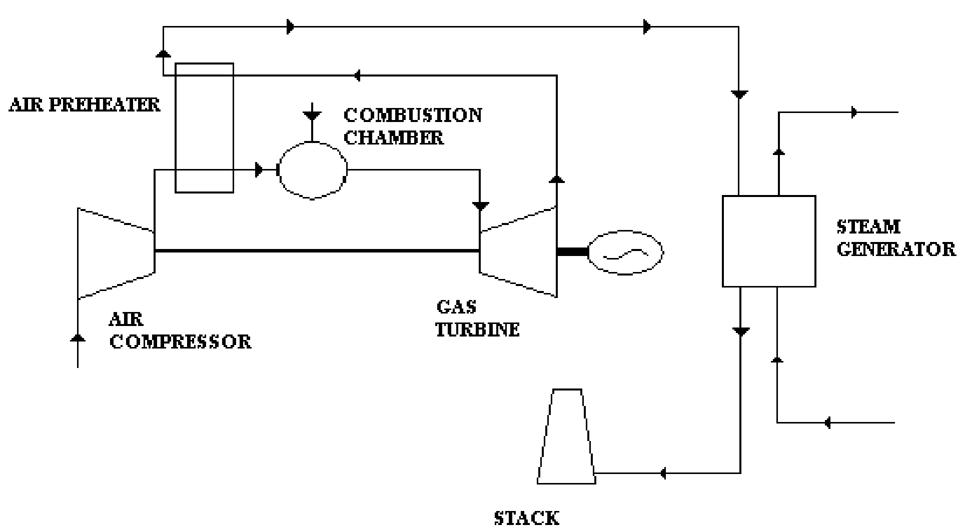
ABSTRACT

In the present analysis exergy devastation in the gas turbine in cogeneration cycle is being found that with the increase in inlet air temperature exergy devastation of the compressor is increased. it is being observed that as the compression ratio increases exergy devastation of compressor increases. With the increase in inlet air temperature exergy devastation in the combustion chamber is increased. In the combustion chamber chemical energy of fuel is converted into thermal energy and some part of Gibbs free energy is lost in the process due to which exergy devastation takes place. As the inlet air temperature increases exergy devastation in the combustion chamber increases. It is also studied, the effect of change in inlet air temperature is taken into consideration. It is being observed that as the IAT increases exergy devastation in gas turbine also increases. Further it is being found that exergy devastation in compressor is less than that of gas turbine and operating parameters are having lesser effect on the compressor than that of the turbine. It is being found that as the inlet air temperature is increased, exergy devastation in the regenerator is decreased.

INTRODUCTION

Cogeneration cycle plant is the sequential generation of two different of useful energy from a single primary energy source, typically mechanical energy and thermal energy. Mechanical energy may be used either to drive an alternator for producing electricity, or rotating equipment such as motor compressor, pump or fan for delivering various services. Thermal energy can be used either for direct process applications or for indirectly producing steam , hot water , hot air for dryer or chilled water for process cooling. Cogeneration provides a wide range of technology for application in various domains of economic activities. The overall efficiency of energy use in cogeneration mode up to 85 percent and above in some cases.
The co-generation-cycle generation system features high thermal efficiency, low installed cost, fuel flexibility with a wide range of gas and liquid fuels, low operation and maintenance costs, operating flexibility at base, mid-range and daily start, high reliability and availability, short installation times and high efficiency in small capacity increments.



Gas-steam combined cycles have the highest energy efficiency among conventional power plants, with the biggest exergy losses occurring in the combustion process and in the heat transfer process between the topping Brayton cycle and the bottoming Rankine cycle.

When steam (in the case of steam turbine) or gas (in the case of gas turbine) expands through the turbine, nearly 60 to 70% of the input energy escapes with the exhaust steam or gas. If this energy in the exhaust steam or gas is utilised for meeting the process heat requirements, the efficiency of utilisation of the fuel increases.

LITERATURE SURVEY

Najjar & Akyurt [(1994) According to this study: 1). Combined cycles boost power output and efficiency to levels that are considerably above those of steam power plants 2). Repowering, when converting an existing steam plant to combined cycle, offers savings in capital cost as compared to new construction 3). Combined cycle, when integrated with coal gasification, holds promise in converting coal into electric power in an efficient, economical and environmentally acceptable manner 4). The air-bottoming cycle (ABC), chemically recuperated gas turbine, compressed air energy storage (CAES) and compressed air storage humidification (CASH) are among advanced concepts with promise for combined cycle applications.

Horlock [(1995) based on thermodynamic considerations, outlined developments of 1970s and 1980s and future prospects of co-generation-cycle power plants. The main focus was on (i) raising the mean temperature of heat supply; (ii) minimizing the irreversibility within the heat recovery steam generator; (iii) keeping the heat loss between the two plants as low as possible.

K.ito, R. yokoyama, Y. matsumoto (1995), The effect of introducing steam-injected gas turbine into cogeneration plant is investigated from economical and energy-saving aspect on the basis of mathematical programming approach. An optimal planning method is first presented by which the operational strategy is assessed so as to minimize the hourly running cost. Then, a case study is carried out on a plant used for district heating and cooling. Through the study, it is ascertained that the proposed method is a useful tool for the operational planning of steam-injected gas turbine plants, and that these plants can be attractive from economical and energy-saving viewpoints.

T. Heppenstall(1998), Described and compared several power generation cycles which have been developed to take advantage of the gas turbine's thermodynamic characteristics. Emphasis has been given to systems involving heat recovery from the gas turbine's exhaust and these include the combined, Kalina, gas/gas recuperation, steam injection, evaporation and chemical recuperation cycles. Thermodynamic and economic characteristics of the various cycles are considered in order to establish their relative importance to future power generation markets. The present dominance of the combined cycle as the preferred option for a new plant is thought likely to continue.

P.A. Pilavachi(2000), gave an overview of power generation with gas turbine and combined heat and power (CHP) systems and discussed various methods to improve the performance of the several types of gas turbine cycles

RESULT AND DISCUSSION

Exergy devastation in compressor with change in inlet air temperature

It is being observed that as the compression ratio increases exergy devastation of compressor increases. For the present system compression ratio beyond 26 is not beneficial. Compression ratio for the gas turbine is varied from 5 to 26. It is being observed that at higher compression ratio exergy devastation is less than at lower compression ratio. The exergy devastation in compressor is increased by 38.16% by changing the compression ratio from 5 to 26.

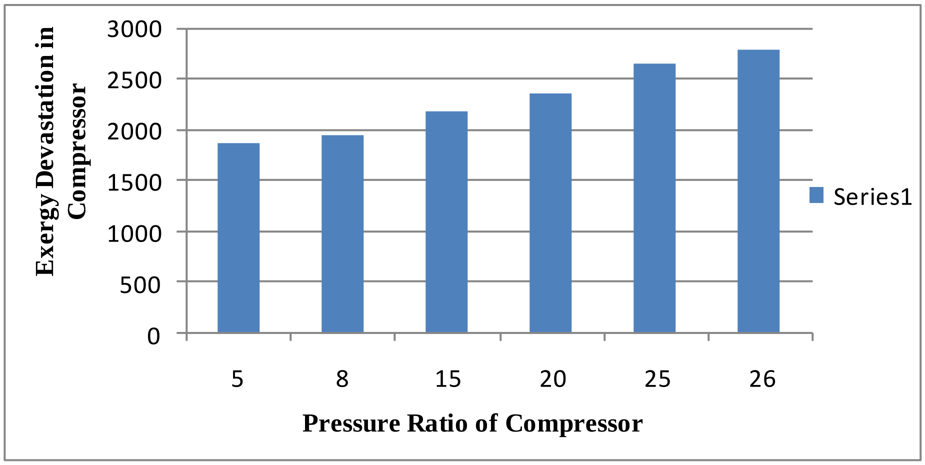


Figure: Exergy devastation in compressor with change in inlet air temperature

Table 1: Exergy devastation Readings in compressor with change in inlet air temperature

	5	10	15	20	25	30	35	40	45	50
Ed combustion chamber	21310	21977	22661	23359	24083	24815	25575	26348	27152	27980
Ed compress	1840	1806	1872	1940	2010	2083	2158	2235	2317	2399
Ed HRSG	3564	4027	4467	4882	5286	5662	6031	6378	6720	7049
Ed Regenerator	2543	2513	2483	2453	2425	2395	2367	2339	2312	2286
Ed turbine	2529	2618	2711	2806	2904	3006	3111	3220	3332	3449
H1 H2O	-242484	-242316	-242148							
N2	-581.4	-436	-290.7							
O2	-583.4	-437.8	-292							
CO2	-394217	-394036	-393854							
h1	-5296	-5150	-5004	-4858	-4712	-4566	-4420	-4274	-4128	-3982
h2 H2O	-232346	-231993	-231640							
N2	8050	8345	8639							
O2	8371	8685	8998							
CO2	-381889	-381429	-380968							
h2	3431	3731	4031	4331	4630	4930	5229	5528	5827	6126
h3 H2O	-221071	-220952	-220833							
N2	17280	17375	17471							
O2	18235	18337	18439							
CO2	-367012	-366855	-366697							
h3	12833	12930	13027	13128	13222	13326	13424	13528	13626	13724
h4	9678	9786	9894	10005	10110	10225	10334	10449	10558	10666
h5	-8525	-8417	-8308	-8196	-8091	-7975	-7866	-7749	-7640	-7531
h6 H2O	-226225	-226000	-225776							
N2	13109	13292	13476							
O2	13773	13696	14166							

CO2	-373834	-373536	-373238							
h6	-17640	-17337	-17033	-16729	-16426	-16122	-15818	-15514	-15211	-14907
h7 H2O	-240712	-240167	-239626							
N2	947.7	1416	1881							
O2	957.6	1435	1910							
CO2	-392254	-391628	-390996							
h7	-30269	-29675	-29085	-284.98	-27915	-27333	-26756	-26180	-25609	-25041
Ma	85.55	86.91	88.31	89.76	91.25	92.8	94.39	96.04	97.74	99.51
Mf	1.502	1.52	1.537	1.555	1.574	1.593	1.613	1.634	1.655	1.677
Q Process	38893	38600	38307	380.14	37722	37429	37136	36843	36551	36258
T1	5	10	15	20	25	30	35	40	45	50
T2	298.6	308.4	318.2	327.9	337.7	347.4	357.1	366.7	776.4	386
T3	596.8	599.9	603	606.1	609	612.2	615.3	618.4	621.4	624.4
T4	1247	1247	1247	1247	1247	1247	1247	1247	1247	1247
T5	737.1	737	737	736.9	736.9	736.8	736.8	736.7	736.6	736.6
T6	464.3	470.2	476.1	481.9	487.9	493.6	499.4	505.1	510.9	516.8
T7	57.59	73.7	89.65	105.4	21.1	136.4	151.8	166.8	181.8	196.7
Wcomp.	26061	26943	27853	28791	29759	30759	31792	32860	33964	35107
X2H2O	7.923	7.898	7.872	7.846	7.821	7.793	7.768	7.74	7.714	7.689
N2	75.12	75.13	75.14	75.15	75.16	75.18	75.19	75.2	75.21	75.22
O2	13.88	13.91	13.94	13.97	14	14.03	14.06	14.09	14.12	14.14
CO2	3.07	3.057	3.044	3.03	3.018	3.004	2.991	2.977	2.964	2.951
Cycle Eff.										

CONCLUSION

From the results it is being found that with increase in inlet air temperature, maximum increase of exergy devastation is in the heat recovery steam generator. Secondly combustion chamber is the biggest source of exergy devastation in the cycle. After combustion chamber, heat recovery steam generator, gas turbine, air preheater and compressor are the source of exergy devastation in the descending order. Thirdly it is observed that after 35°C, exergy devastation of compressor becomes more than that of air preheater. In the air preheater exergy devastation decreases with IAT while for the compressor it increases with IAT. At 35°C exergy devastation of compressor becomes more than that of air preheater.

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