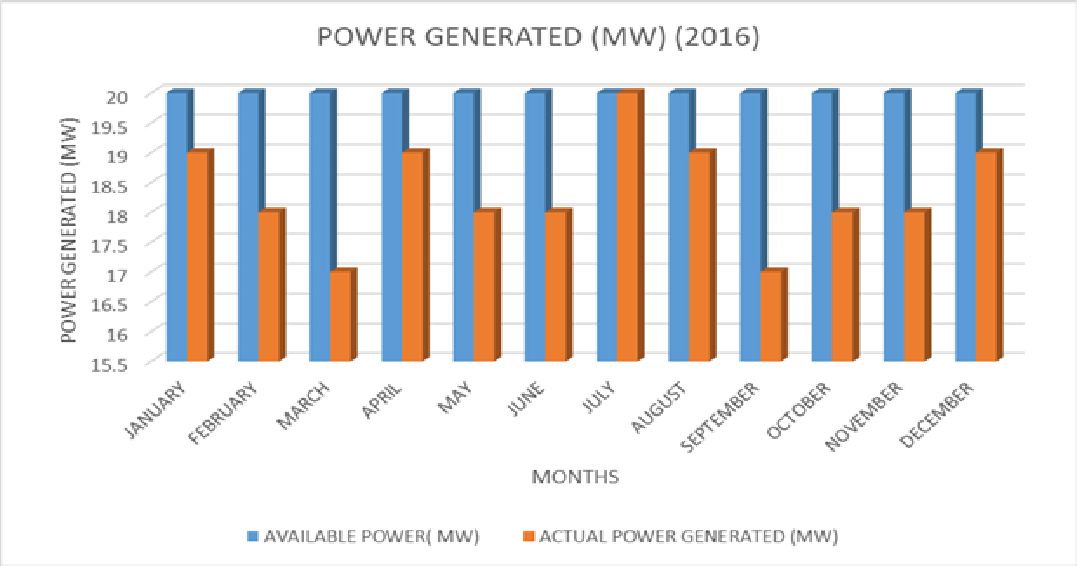

Figure 1: Power generated by Delta III GT9

The expected full load installed capacity of the plant under study is 25 MW of power for each month, then for the whole year (January to December) it is expected to generate a total of 300 MW of power. But the available capacity (the obtainable power) for each month is 20 MW (240 MW/year), and the actual generated capacity for each month ranges from 17 MW to 20 MW (Figure 1). The average actual power generated by the plant from the data obtained for the period under study is about 18 MW, and the total actual power generated is 220 MW against the 240 MW available powers. This shows that only 20 MW is lost, hence about 92% of the available power was actually available. The power lost was as a result of the plant being out of service for a period in the month of March, June and July due to gas shortage. Also, in the month of November a major inspection (MI) was carried out on the plant resulted to downtime. The plant capacity for the period under study is presented in Figure 2.

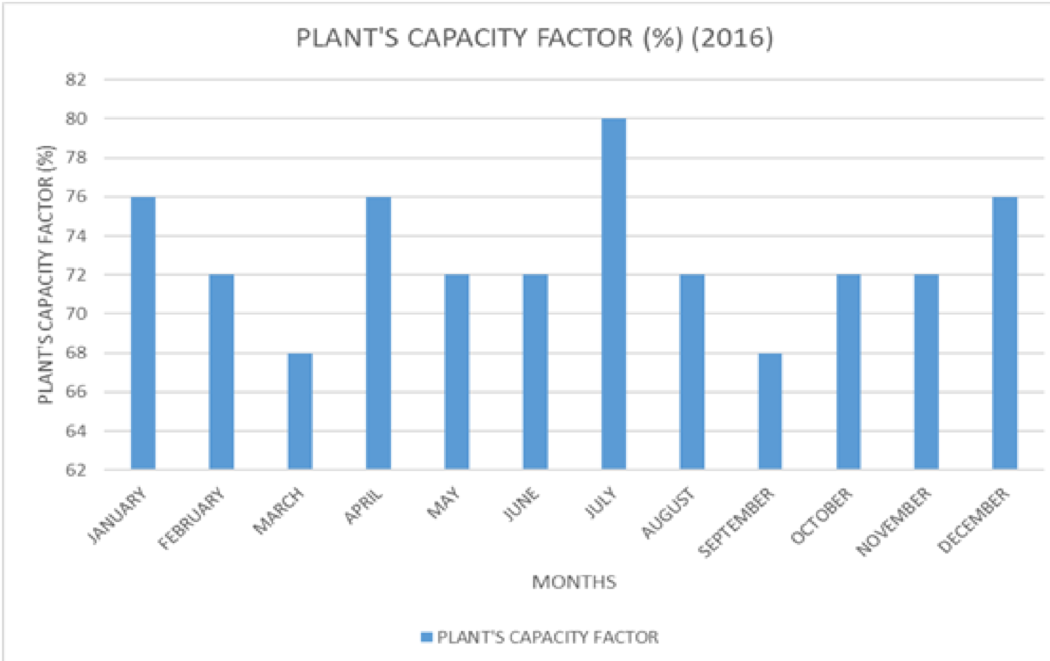

Figure 2: Plant's Capacity Factor

The average capacity factor of Delta III GT9 from the data obtained from the period under study is 73% with a minimum value of 68% in the month of March and September, and a maximum value of 80% in July against the best industrial practice (between 40% to 80%). The values of the plant's capacity factor signify that the average power generated is acceptable. The thermal efficiency of the plant for the period under study is shown in Figure 3.

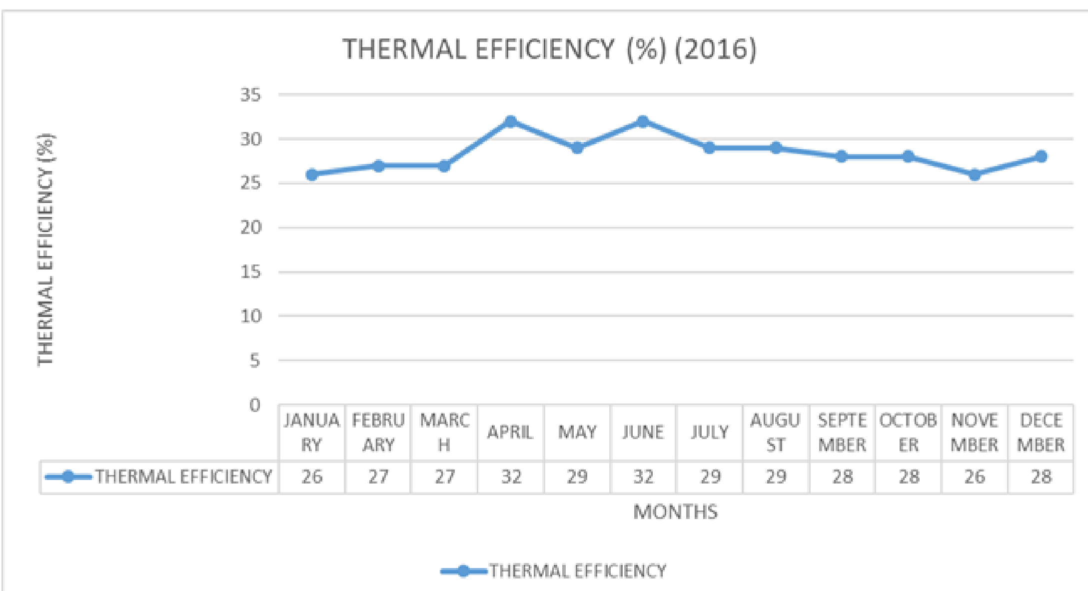

Figure 3: Thermal efficiency of Delta III GT9

The thermal efficiency of a gas turbine is about 20% to 35%. From figure 4.3, the thermal efficiency of the plant for each month is above the 20%, and the average efficiency is 28%. That is to say, the plant is quite efficient. The maximum thermal efficiency is 32% in the month of April and June, while the minimum thermal efficiency is 26% in the month of January and November. The maximum efficiency corresponds to the minimum amount of fuel consumed and the minimum efficiency corresponds to the maximum amount of fuel consumed. The plant fuel rate under the period under study is presented in Figure 4.

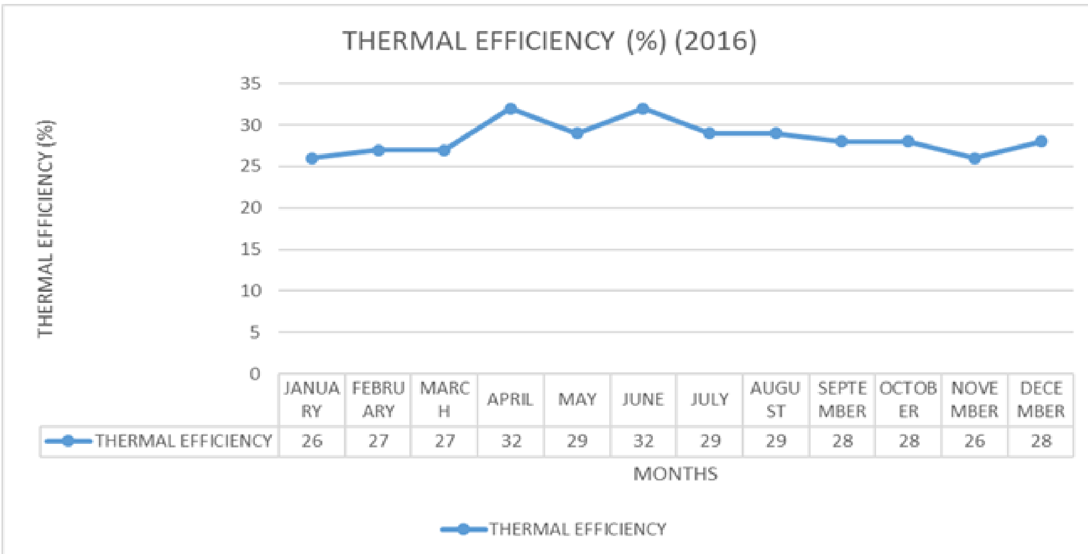

Figure 4: Plant Fuel Rate

It can be seen that the best value of the plant fuel rate is for the month of June which only took 7.3% of the total plant fuel against the other months which fall between the ranges of 7.3% to 9.0%. The maximum value (9.0%) occurs in the month of January. The plant heat rate for the period under review is shown in Figure 5.

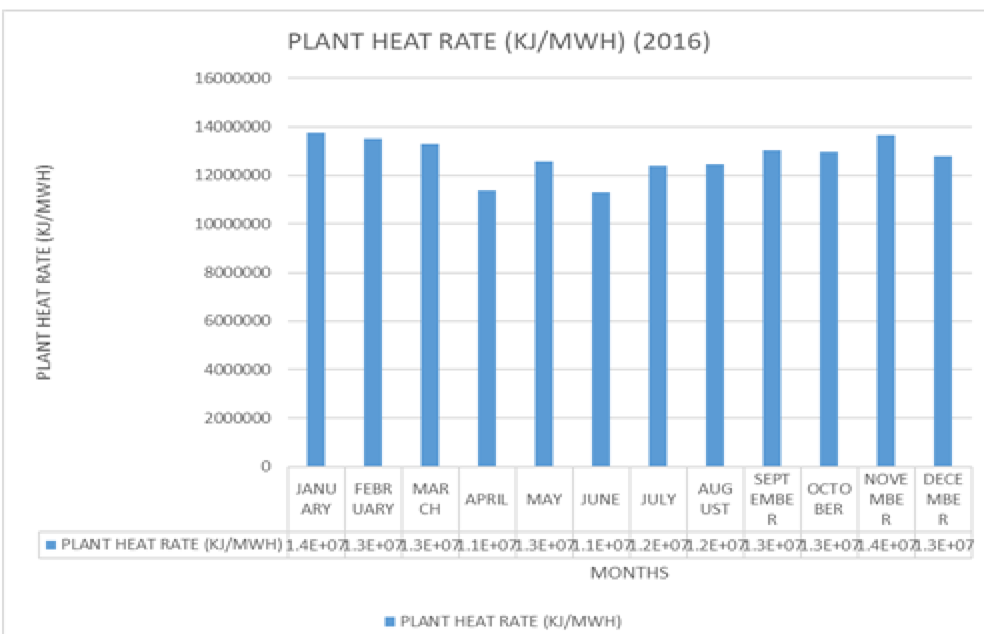

Figure 5: Plant Heat Rate

The reliability of Delta III GT9 for the period under study is presented in Figure 6.

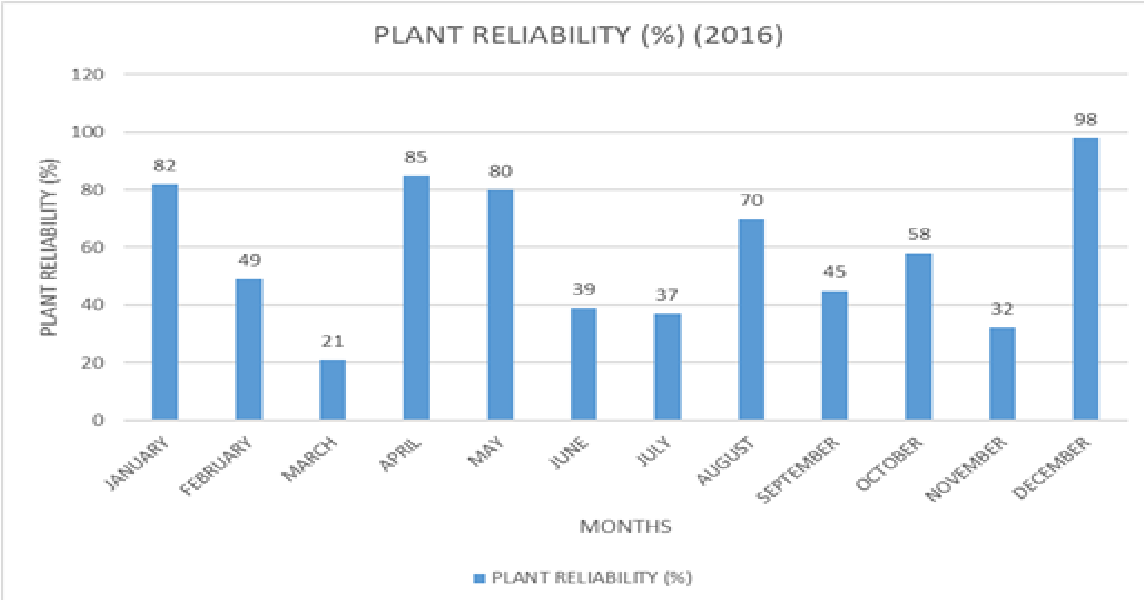

Figure 6: Reliability of Delta III GT9

The average reliability of the plant from the operational data obtained from for the period under study is 58%. The decreased in reliability of the plant in the month of March, June, July and November was as a result of major inspection (MI) that was carried out on the plant; also the plant was out of service for a period due to gas shortage. Generally, the behavior of the gas power plant depends majorly on the capacity factor. High capacity factor is desired for economic operation of the plant. Gas turbines are designed for standard air conditions. However, the operating periods at off-design conditions are much greater than that at design conditions. A difference between the actual power generated by a gas turbine and the design rated power tagged on the gas turbine is observed whenever a gas turbine operates at site ambient conditions that vary from the stipulated International Standard Organization (ISO). A detail study and extensive logging of operational data has shown the existence of a direct relationship between the ambient temperature and the de-rating of gas turbine power output. For every 1^oC rise in ambient temperature above ISO condition, the gas turbine losses 1% in terms of thermally efficiency and 1.47 MW of its gross power output.

The power output of gas turbine is a function of the inlet temperature of the turbine. The turbine inlet temperature plays a vital role on the performance of the single cycle plant. The gas turbine performance is affected by the component efficiencies and the turbine working temperature. The effect of temperature is very predominant; for every 56^oC increase in temperature, the work output increases approximately 10% and gives about 1.5% increase in efficiency. The overall efficiency of the gas turbine cycle depends primarily upon the pressure ratio of the compressor. A summary of all the key performance parameters are shown in the Table 8.

Table 8: Summary of the Values of the Key Performance Parameters

Month	Power Generated (MW)	Capacity Factor (%)	Plant Fuel Rate		Plant Heat Rate		Efficiency (%)
			Kg/KWH	% Total	KJ/MWH	% Total	
Jan.	19	76	0.262	9.0	13,761,973	9.0	26
Feb.	18	72	0.256	8.8	13,498,100	8.8	27
March	17	68	0.253	8.6	13,286,909	8.7	27
April	19	76	0.217	7.4	11,392,655	7.4	32
May	18	72	0.239	8.2	12,566,088	8.2	29
June	18	72	0.215	7.3	11,315,615	7.4	32
July	20	80	0.236	8.1	12,392,834	8.1	29
August	19	76	0.237	8.1	12,463,830	8.1	29
Sept.	18	72	0.248	8.5	13,057,846	8.5	28
Oct.	17	68	0.247	8.5	12,989,730	8.5	28
Nov.	18	72	0.260	8.9	13,661,713	9.0	26
Dec.	18	72	0.243	8.3	12,773,834	8.3	28
Total	19	76	2.913	100	153,161,127	100	

Conclusion

In this study, the performance of Delta III GT9 gas turbine power plant was evaluated and analyzed. Emphasis has been on the key performance parameters (such as power generated, capacity factor, plant fuel rate, plant heat rate and the thermal efficiency of the plant). The study shows that 92% of the expected capacity was available in the period. The thermal efficiencies of the plant in the period ranged from 26% to 32% as against the standard value of 20% to 35%. The plant's capacity factor ranged from 68% to 80% against best industrial practice of 40% to 80%. The plant fuel rate ranged from 7.3% to 9.0%, and also the plant heat rate ranged from 7.4% to 9.0%. The average reliability of the plant for the period is 58%. Only 20 MW of energy (power) was lost out of the expected power of 240 MW for the period under study. The study revealed that the above performance parameters analyzed for Delta III GT9 plant are within the range of best industrial practice. Besides, the efficiencies achieved for the period under study are within the best international value for a single cycle gas turbine plant.

Recommendation

The performance and reliability of Delta III GT9 power plant can be greatly improved. The few ways in which the performance of the plant can be improved are as follow:

i. Increase the turbine inlet temperature, provided the turbine materials can withstand the high temperature or the parts can be replaced with those that can withstand the temperature. For every 56 ^{o}C increase in temperature, the work output increases approximately 10% and gives about 1.5% increase in efficiency.

ii. Install of a heat recovery steam generator (HRSG) to recover energy from the turbine's exhaust. A heat recovery steam generator helps in generating steam by capturing the heat from the exhaust system. High pressure steam from the HRSG can be used to generate additional power with steam turbines, a configuration called combined cycle.

iii. Proper maintenance and cleaning of compressor inlet filters. Dirty and poorly maintained filters would cause monumental loss of efficiency due to damage and clogging of the compressor blades. Pressure drop is a consequence of dirty filters. Regular checkup and cleaning of the components can improve the performance and reliability of the plant.

iv. Planned maintenance such as Preventive, Running, Condition Monitoring should be carried out on the plant to keep it running smoothly and thus improve the reliability of the plant.

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