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Simulation analysis of reliability on available power consumed versus lube oil quality

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A B S T R A C T

The effect of reliability on available power consumed was monitored and simulated using MATLAB program and the energy utilization was investigated in view of the variation in the physicochemical properties of the lube oil. This research revealed that the lube oil concentration decreases as the running hour increases and the efficiency in terms of performance dependents on the characteristics of the lube oil. The available power consumed decreases as the lube oil quality decreases and high performance experienced when the total running hours is less than 200 h. The result obtained shows the effect of the lube oil characteristics is significant effect as the load utilization increases and resultantly, the power utilization is affected.

Capsule Summary: The reliability on available power consumed was monitored and simulated using MATLAB program and the energy utilization was investigated in view of the variation in the physicochemical properties of the lube oil, which affected the efficiency of generator significantly.

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INTRODUCTION

This research on evaluating the performance of lube oil in the generator using reliability analysis has been developed to address the significant of available power consumed and energy utilization effect on the characteristics of the lubricating oil degradation (Ukpaka and Gift-Onyesoh, 2020, a,b,c,d). Research conducted on lube oil properties reveals that the lifecycle cost prediction of lube oil utilization, the role played by the catalyst and the blending agent used during production to help increase the quality of the end products. Other research also considered the control measure of managing the used lube oil to reduce its environmental effect on human and vegetation (Ukpaka and Umah, 2020., Essiet et al., 2020). However, research work carried out on field reliability of fresh lube oil reveals that the quality of the lube oil decreases as it is exposed into constant sunlight as well as the temperature of contact increases. Others looked at the plant characteristics and effect on the quality of lube oil as well as type of catalyst used during production (Meel, 2008, Shaeda and Bury, 2010, 2011., Dekker, 2006., Ukpaka et al., 2020, a).

In this case, there is no researcher that has considered the effect of available power consumed and energy utilization properties of lube oil in terms of the physiochemical parameters effect analysis on the hourly run of generator set and their performance. However, this dissertation has addressed the challenges faced by the generator set when the lube oil has lost its value and the aim

not well achieved, due to high level of unreliability (Ukpaka, 2018, a, b, c, d. e).

This research will address the cause of generator set failure when the operator or user neglects the importance of good lube oil to achieve optimum performance and the required time for running a generator set before changing the existing lube oil in the generator engine. The research shows constant failure or shutdown of the generator set when the lube oil quality is low and black in nature as well as loss in the physiochemical properties example, kinematic viscosity, pour point, flash point, density, pH, refractive index, viscosity index, colour, appearance, Sediment, Suphated ash examined. The output performance (in terms of load utilization) of the generator set can be attributed to the composition of the parameters analyzed (Ukpaka et al., 2019, a., Ukpaka, 2020, a, b., Ukpaka and Ekperi, 2020). Saurin et al. (2010), on the bottleneck analysis of a chemical plant using discrete event simulation revealed the debottlenecking of different products and were evaluated using the Dow Chemical Company as a case study.

Models were developed, simulated and verified and the key models indicated were revealed, constraints identified and checked for the improvement of the plants (Gano, 2003., Hauptmanns, 2004., Ukpak and Okara, 2019, a). In the simulation stage, model validation was performed using statistical analysis as a medium for the comparison of the output value of the simulation costs using the industrial values or data. The functional parameters that were validated include, the processing times for the various stages, processing rates, equipment cycle time etc (Law and Kelton, 2000., White et al., 2009). The research also demonstrates the successful validation of the developed model using the simulation model of the bottlenecks identified in the process for the production of the various products (Owen, 2006).

Work optimization is described as the best processes that can give the highest output or the processes of seeking the best. The concepts of the Genetic Algorithms Approach have recently been used in optimization problems. Hence, the simulation analysis of reliability on available power consumed versus lube oil quality was done in the present investigation.

MATERIAL AND METHODS

Modelling

The model development of unreliability, reliability, and availability for the various operational conditions of 11KVA, 20KVA and 40KVA was examined upon the influence of time and their impact on the characteristics of the lube oil performance output in load utilization.

Power unreliability analysis

The model development for unreliability in terms of load utilization and their impact on the generator set was studied. The mathematical expression for the evaluation of unreliability of the process plant can be expressed as:

$$U_N = 1 - e^{-\left(\frac{1}{OSLI/ALF}\right)t} \quad (1)$$

$$U_N = 1 - e^{-\left(\frac{1}{y/x}\right)t} \quad (2)$$

$$U_N = 1 - e^{-\left(\frac{1}{MTBT}\right)t} \quad (3)$$

$$U_N = 1 - e^{-\left(\frac{1}{\lambda}\right)t} \quad (4)$$

Power reliability analysis

The reliability model of the operational system can be expressed mathematically as:

$$R_m = e^{-\left(\frac{1}{OSLI/ALF}\right)t} \quad (5)$$

$$R_m = e^{-\left(\frac{1}{y/x}\right)t} \quad (6)$$

$$R_m = e^{-\left(\frac{1}{MTBF}\right)t} \quad (7)$$

$$R_m = e^{-\left(\frac{1}{\lambda}\right)t} \quad (8)$$

The reliability of the process can be grouped in terms of the lube oil characteristic upon the influence of number of Times (Hours) and their load utilization. The reliability of process from 0 h to 400 h can be summed to represent them through the scenario of the process for each generator product capacity, thus, we obtained:

$$^{20KVA}R_m = e^{-\left(\frac{1}{\lambda}\right)_{50rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{100rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{150rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{200rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{250rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{300rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{350rpm}} + e^{-\left(\frac{1}{\lambda}\right)_{400rpm}} \quad (9)$$

Power availability analysis

The model for availability can be developed by considering the mean time between failures with the lost time per year. Therefore, the mathematical expression for availability can be expressed as shown in Eq. 10.

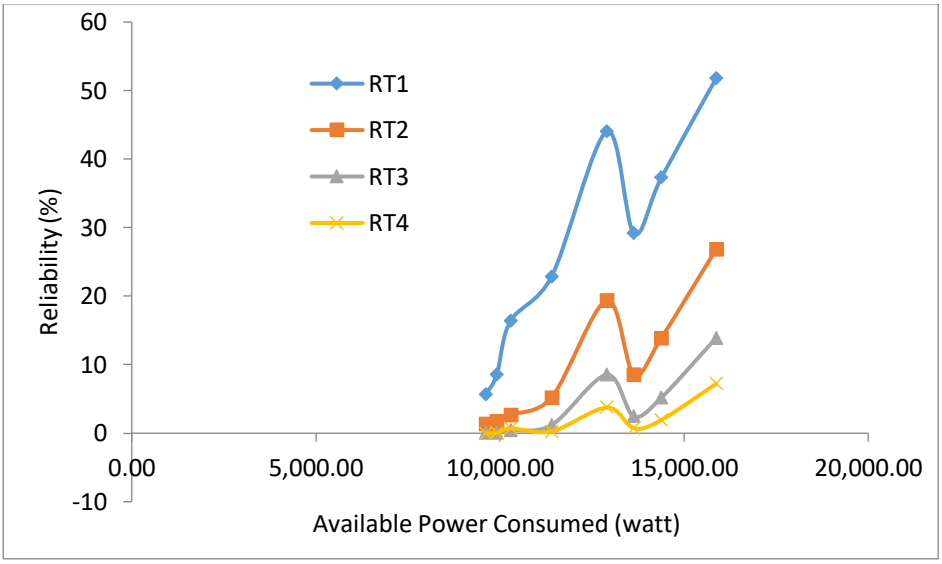

Fig. 1: Plot of reliability versus available power consumed

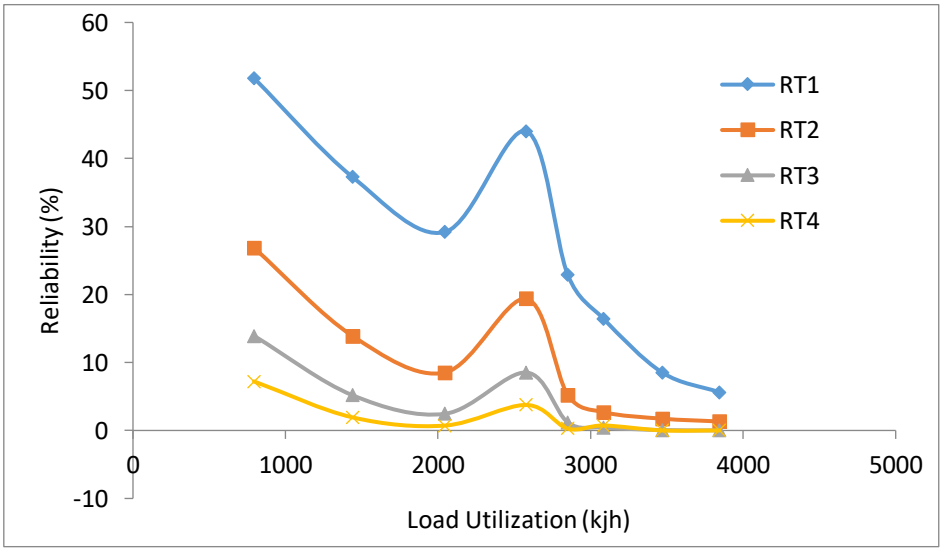

Fig. 2: Plot of reliability versus load utilization

$$Av = \frac{Mean\ time\ between\ failure - lost\ time\ per\ year}{Mean\ time\ between\ failure} \quad (10)$$

Also, the model development of availability can be written as;

$$Av = \frac{MTBF - LTPY}{MTBF} \quad (11)$$

$$Av = \frac{\left(OSLI/ALF\right) - LTPY}{OSLI/ALF} \quad (12)$$

$$Av = \frac{\left(y/x\right) - LTPY}{y/x} \quad (13)$$

$$Av = \frac{\lambda - LTPY}{\lambda} \quad (14)$$

Load utilization identification analysis

Sample analysis was carried out on the load utilization by the generator sets while in operation as well as a function of lube oil concentration on the effect of load to utilization.

Data conversion analysis

In this case, mathematical language was used in the conversion of the data into a mathematical value. The mathematical value was used in the computation of the process, which gives an in-depth knowledge of the process or system in terms of cost, risk, and productions.

Failure Rate Data

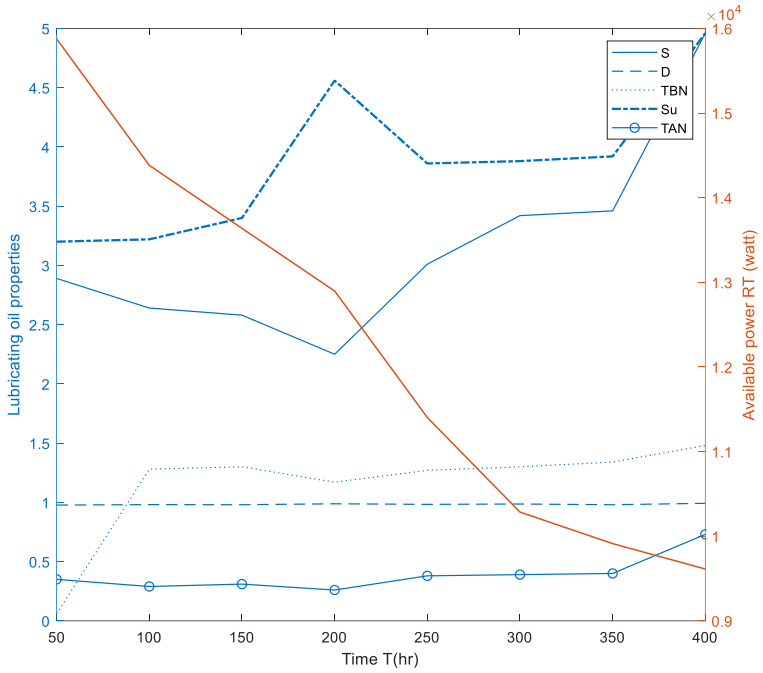

Fig. 3: Comparison of lubricating oil properties and available power consumed versus operating time

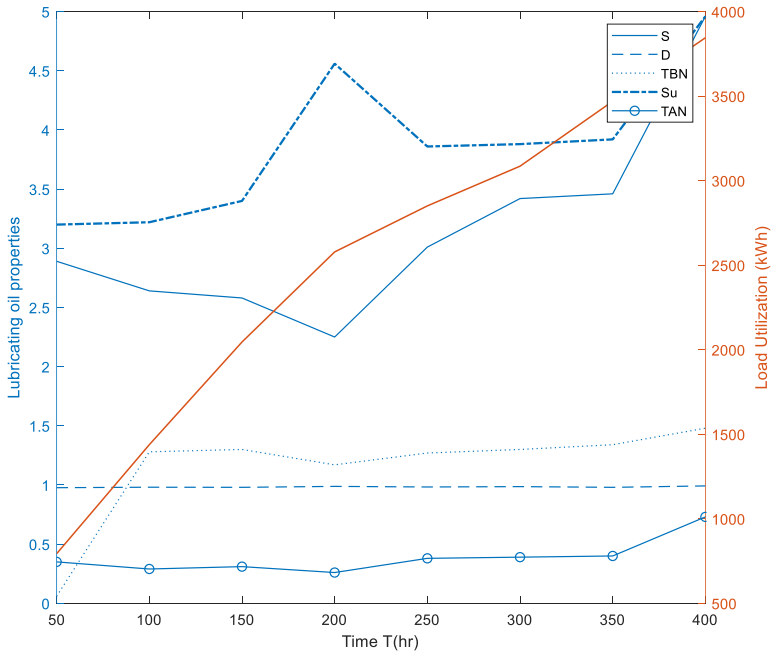

Fig. 4: Comparison of lubricating oil properties and load utilization versus operating time

The main obstacle in terms of risk assessment using the best techniques for effective plant output performance is the un-availability of reliability data that makes the procedure time consuming and error prone. On this note, generic ranges for probability data were used in the research work which accounts for functional parameters such as temperature, pressure, velocity, and other influencing parameters subjected to different operating conditions. The procedure adopted by Hauptmanns (2004) reveals a better understanding of the maintenance condition which will improve maintenance culture into less time consumption, reduce human error, increase the effectiveness in performance, reduces operational conditions errors and problems.

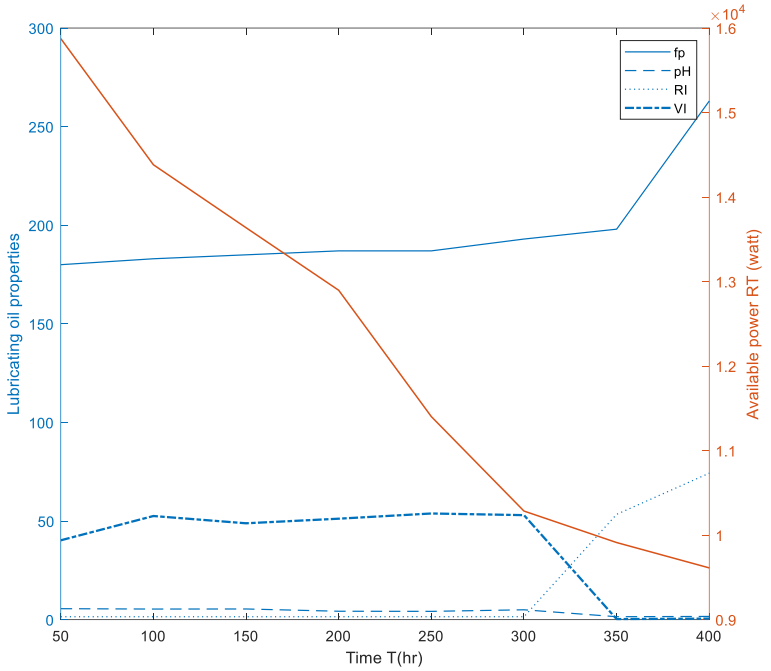

Fig. 5: Comparison of lubricating oil properties and availability of power consumed versus time

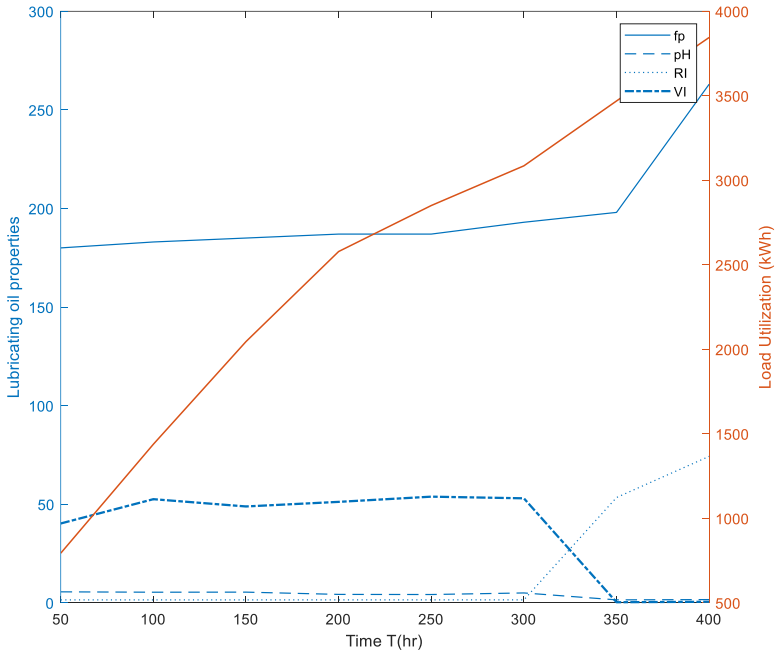

Fig. 6: Comparison of lubricating oil properties and load utilization versus time

RESULTS AND DISCUSSION

Figure 1 demonstrates the relationship between reliability of the generator set with the variable power consumed. The result obtained revealed that the generator set reliability was high when it runs within $t > 50$ h > 250 h. Increase in reliability was observed with increase in available power consumed before a sudden decrease and increase. The reliability order of magnitude is RT1 > RT2 > RT3> RT4. The variation in the reliability of the generator set can be attributed to variation in available power consumed. Figure 2 illustrates the plot of reliability of the generator set with load utilization was observed with increase in load utilization before sudden increase and increase before indicating decline. The variation in the reliability of the generator set can be attributed to variation in load utilization.

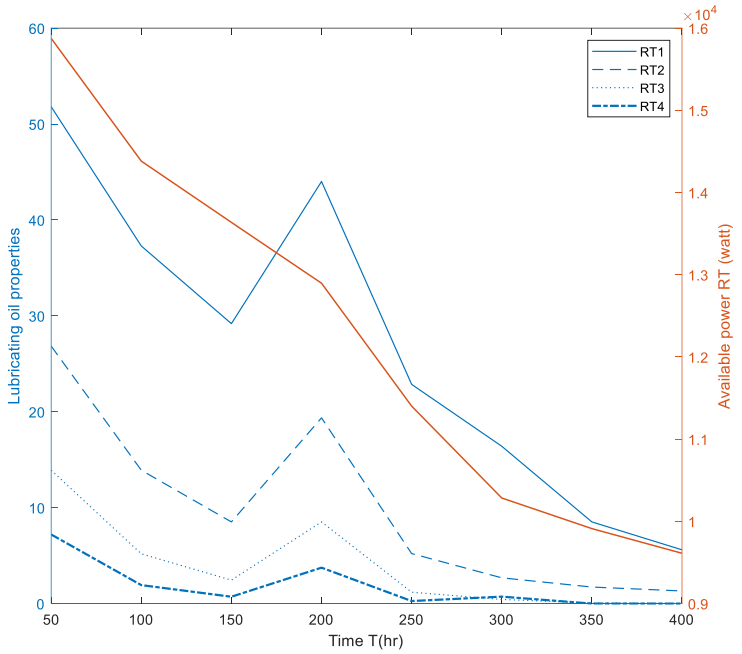

Fig. 7: Comparison of reliability and available power consumed versus time

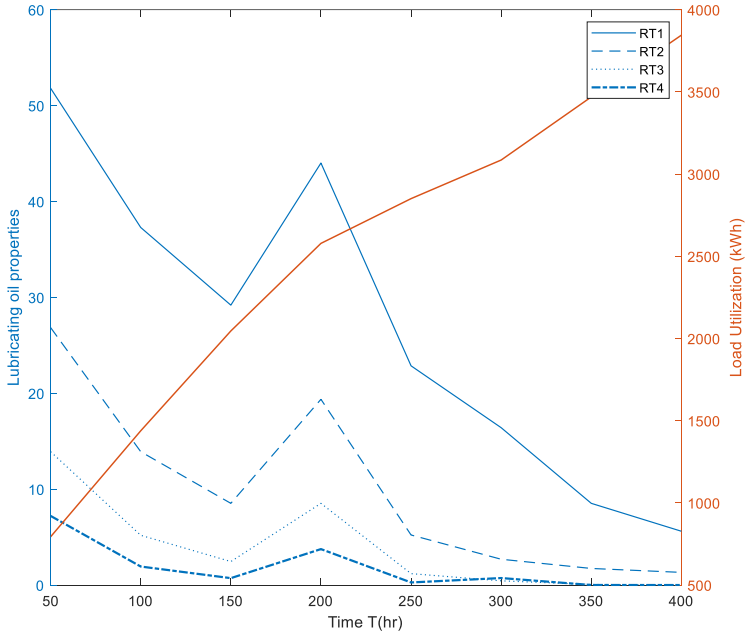

Fig. 8: Comparison of reliability value and load utilization versus time

Figure 3 demonstrates the correlation relationship between lubricating oil properties and available power utilization with the operating time of the generator set. The result obtained reveals that lubricating oil properties are influenced with increase in available power consumed as well as increase in operating time. Figure 4 illustrates the correlation of the lubricating oil properties and load utilization with the operating time. The result obtained demonstrates variation in the characteristics of lubricating oil properties in correlation with the load utilization with variation in operating time. The result also revealed that the load utilization influences the lubricating oil properties of the generator set. Figure 5 showcases the relationship among the variation in the available power consumed, lubricating oil properties of some functional parameters with variation in contact or operational time. Decrease and increase was observed in functional parameters on the lubricating oil and available power consumed with increase in time.

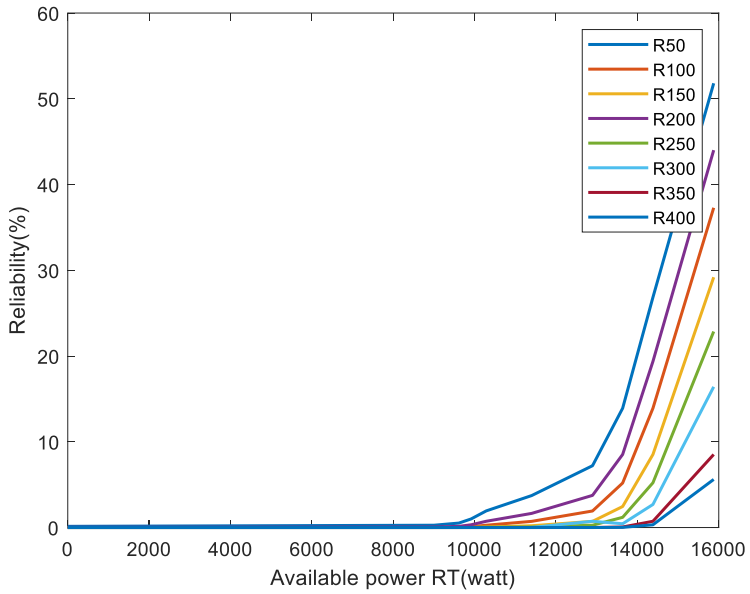

Fig. 9: Plot of reliability versus available power consumed

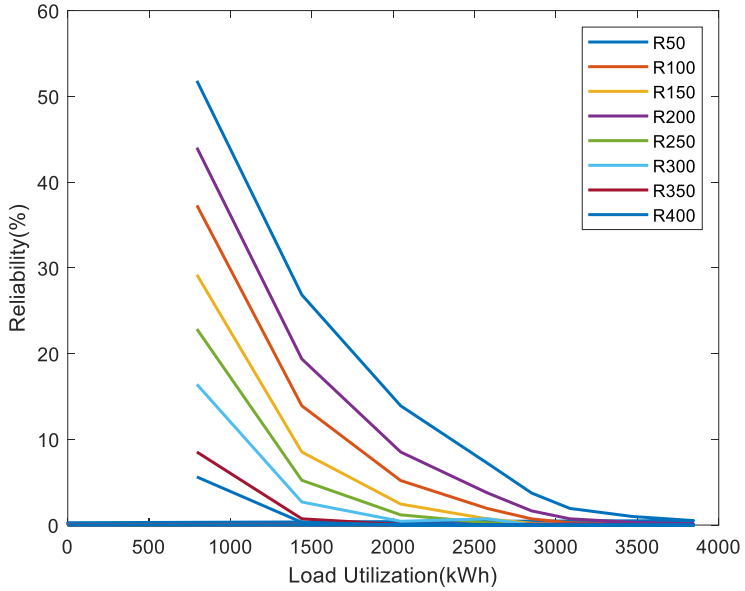

Fig. 10: Plot of reliability versus load utilization

Figure 6 illustrates the variation in the lubricating oil functional parameters examined in correlation with the load utilization with variation in operational periods. Increase and decrease was experienced in lubricating oil properties load utilization with increase in operating time. The variation in lubricating oil properties and utilization can be attributed to variation in time.

Figure 7 demonstrates the variation of reliability and available power consumed with variation in the operating time. Decrease and increase was observed at different time as the reliability value and available power consumed decreases with increase in time. The variation in reliability value and available power consumed can be attributed to the variation in the time. Figure 8 demonstrates the variation on the reliability value and load utilization with variation time. Increase and decrease was experienced in the reliability and load utilization with increase in time.

Figure 9 Illustrates the relationship between reliability and available power consumed for the variation in the operation hour and available power consumed. Decrease in reliability was experienced with increase in allowable running hour and available power consumed. Figure 10 demonstrates the relationship between the

reliability and load utilization for different hours covered. The result obtained revealed decrease in reliability with increase in allowable load utilization for different operational time.

CONCLUSIONS

In this research work, the performance of the lube oil in generator set was monitored, predicted and simulated using MATLAB in the correlation of the power consumption with allowable load. The reliability analysis was conducted in relationship with the lube oil quality and for the period of utilization with the shutdown occurrence monitored. However, the research work showcases the effect of reliability and unreliability with time. The result obtained shows the effect of the lube oil characteristics as the load utilization increases.

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