Temperature affects the pump availability and reliability

Literature Review

Water Service Systems

A water pump is required to enhance the flow rate of water in the supply systems. Factors such as the diameter of the piping system and the length of the pipe affect the flow of water as per the design requirements. For instance, as water flows through the systems, the inlet pressure is different from the outlet pressure losses due to pressure that occurs as a result of friction resistance

between the pipe surface and the liquid. In addition to that, the pressure of water in a large diameter pipe differs from that of a less-diameter pipe. The less-diameter pipe tends to have a high pressure than the large diameter pipes. Centrifugal pipes have mostly been adopted to facilitate the cooling of reactors in a nuclear pumper. Reactors are subjected to intense heating conditions where the temperature levels may affect the pump of the cooling system. The cooling systems need to be robust and effective in facilitating such applications. However, the cooling systems are prone to break down. One of the main factors that affect the cooling system of a reactor is temperature. The higher temperature in the nuclear reactors has adverse effects on the pump functionality since it makes the vapor pressure of the liquid rise far beyond the liquid pressure thus causing the cavitation effect(Hu, Yang & Cao 2020). Cavitation affects the performance of the pump in the context of its availability and reliability. In such scenarios, there is a need to project the pump performance based on its availability and reliability and determine when maintenance should be done so that the functionality of the system is not affected. The reliability and availability of the pumps can be determined using risk models such as the fault tree,go-flow method, and event tree models.

Risk Models

Water service system and pump performance can be ascertained by the risk models. The risk models are important in determining what might have caused the pump failure and the consequences of such failure to the water system. Furthermore, the risk models are important in determining the reliability of the water service system. They are necessities in determining the time when the pump will be functional well before being subjected to challenges such as cavitation due to temperature surges thus contributing to the failure mechanism. The risk models utilize knowledge of physics to determine the exact cause of failure in a pump system and establish failure

mechanisms. Associated consequences to the failure mechanism are then predicted. In addition to that, the models facilitate reliability measurement and tests in the design of wasted service systems. Nevertheless, the models stipulate approaches that can facilitate fault diagnosis and enhance maintenance of the water service systems.

Fault tree model

Nuclear plants are sophisticated hence prone to unexpected failure and breakdown. Failure of a nuclear plant has detrimental effects on the economic feasibility of the relevant plant due to impending losses that would occur during repair and maintenance. The repair can be done through three approaches. First, the defective section can be extracted and taken for external repair at a designated place. The repair can also be done on the site especially when the whole system is affected. Furthermore, the defects can be detected during the normal operation and maintenance approach and repaired. The delay caused by such repairs accounts for losses in the operation of the plant. Suitable approaches such as the fault tree diagram can be used to determine the possible causes of defects and the impending consequences to the system operation. The main cause of failure is usually circled while the consequences are placed in a symbol that looks like a house. In addition to that, conditions for the possibility of a defect to occur are stipulated. The risk model gives a visual impression of how the system can fail during operation and hence adopted by firms due to its efficiency in applicability. The use of the fault tree analysis in the water service system is important to establish effects such as temperature on the operation of the system. Associated consequences of temperature to the system include the occurrence of cavitation where air pockets are introduced to the water system thus affecting its operation. In addition to that, consequences such as the vaporization of water during a surge in temperature are noted. Possible detrimental effects include economic losses due to the amount of money used to initiate repair and losses. The

approach is effective in ascertaining the reliability of the water service system since it helps the firm to determine possible causes of the system defects thus making them alert when the system is in operation. Furthermore, the reliability of the risk model is embedded in its efficiency of stimulating effects of the defects to the system thus the first can initiate a corrective mechanism before this actual risk occurs. Fault tree analysis is thus effective in ascertaining the Easter systems' availability and reliability.

Event tree method

Event tree analysis was developed to facilitate the quality and risk management of the nuclear systems. The model was adopted after a series of events affected the plants thus leading to detrimental effects. The model encompasses a combination of events that pose high risks to the operation of the plant. In addition to that, the model stipulates the responses to the failure events as recommendations. Event tree analysis can be feasible in determining the reliability of the water service system by establishing a series of events that can lead to failure. For instance, a surge in temperature can result in vaporization of the water thus introducing air bubbles to the systems. A combination of such events contributes to the cavitation effect thus downgrading the pump performance. Furthermore, the risk analysis models stipulate responses to the events such as initiating a repair mechanism where the defective sections are replaced or taken out for repair. The risk analysis model gives the firm a visual impression of how a combination of events can cause a serious threat to the operation of the water service system. The management is thus informed on possible responses when such events occur thus ascertaining the water service system availability and reliability.

Go-flow method

Initially, probabilistic safety assessment of the nuclear plants was determined based on the fault tree and event tree analysis. However, modification of the nuclear plants has resulted in a more complex structure that requires more advanced approaches to determine its reliability and availability. The go-flow method is adopted in most cases where a chart showing individual components of the nuclear plants is developed. The functional mechanism of each of the components is also determined in terms of signals. The signals are determined hierarchically where the top signals are determined first then the down signals are established. The reliability of the model is based on how the system operates over a specific duration. Before the system is subjected to any defects, the reliability is always one. The reliability reduces as time progresses. The technique is feasible in establishing the availability and reliability of the water service systems where the structure of the system is established in a go-flow chart and the performance of individual components determined. The performance of the components is then monitored after a certain period to determine the system's reliability. Such a mechanism enables the management to determine when the system requires maintenance thus maintaining its availability and reliability.

Maintenance Intervention Strategy

Pump performance can be adversely affected by heating conditions. The increase in temperature when the pump pressure is low causes a substantial increase in the vapor pressure. When vapor pressure is above the liquid pressure, air pockets are created which causes damage to the impeller. Mechanical damage of the sections of the pump systems may affect the overall pump performance and fail the pumps. There is a need to initiate suitable maintenance strategies so that the pump system can meet its scope and objectives. The main intervention strategy is to check whether the pump meets the net positive suction head required. The strategy is design-oriented and should mostly be done by an expert. The net positive suction head required is calculated by

accounting for the pump inlet losses, friction losses, vapor pressure, and losses due to the flow velocity(Busick et al. 2018). The remaining pressure is what will make the pump to be efficient in its operation. The design requirements stipulate that the liquid pressure in the pump should surpass the vapor pressure to facilitate efficiency. However, when the vapor pressure is higher after the liquid pressure after inspection, there is a need to introduce alternative approaches to minimize the impact of the vapor pressure on the pump performance. Cavitation due to increased vapor pressure can be reduced by raising the level of liquid in the suction vessel. Pressure is directly proportional to the change in the head in the liquid vessels where a small head results in less liquid pressure. Increasing the level of the liquid head will increase the pressure of the suction head thus making liquid pressure surpass the vapor pressure hence increasing the performance of the pump system. In addition to that, vapor pressure can be reduced by reducing the number of motor revolutions per minute. Increased revolutions of the motor to an increase in temperature of the pump system due to friction.Increased temperature results in increased vapor pressure hence a cavitation effect. Reduction in motor revolutions per minute results in a reduction in temperature thus the pump system increases in efficiency.

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The availability and reliability of the pump depend on its net positive suction head available. The parameter is determined after accounting for losses in the pump system. The pump system is negatively affected by an increase in temperature. The temperature increase may result from increased motor revolutions or when the liquid flows at low pressure. The pump availability and reliability are ascertained when the liquid pressure is more than the vapor pressure thus minimizing the occurrence of cavitation in the pump system.

Economic feasibility of maintenance task

Pump maintenance has associated cost implications. As noted earlier, surging temperature results in a cavitation effect due to increased vapor pressure when compared to liquid pressure. The proposed maintenance strategy encompasses is a reduction in the number of motor revolutions per minute. However, the challenge can also be mitigated by increasing the head of the liquid in the suction head. Analysis of such approaches in terms of cost implications shows that increasing the suction head of the liquid in the vessel requires approximately $112.On the contrary, a maintenance strategy to reduce the number of motor revolutions per minute requires $200 to implement since it is a highly technical task. Based on the cost implication of each approach, there is a need to increase the suction head of the liquid in the vessel since it incurs less cost and reduces the cavitation effect by increasing the liquid pressure above the vapor pressure.

References

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