Stochastic Modeling of Repairable Machining System with Spare Provisioning

THESIS

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by

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Chapter 7

Conclusions and Future Work

"As far as the laws of mathematics refer to reality, they are not certain; as far as they are certain, they do not refer to reality."

Albert Einstein

In this chapter, the main outcomes of the thesis are encapsulated. Further, few research directions are also provided that may be studied in the future course of research work.

7.1 Conclusions

The reliability, availability, and maintainability ratings of the machining system and units have necessitated the performance measures assessment using suitable techniques. In this thesis, various queueing models are developed for performance prediction of machining system, the provision of spare units support and prompt repair facility, which can act as crucial strategies in saving the high incurred costs due to blocking, delay, and downtime.

An interruption due to failure of a unit leads not only to deterioration in the quality of manufacturing products but also an increase in the expected total cost. Therefore, the future of the machining system subject to interruption due to failure is sensitive and challenging for the system designer's point of view. The machining system developed in the present study provides some state-of-the-art strategic suggestions about the concept of spare units, and maintenance and replacement policy, etc.

The determination of the optimal number of spare units and maintenance specialists in repair facility is the most critical issue to maintain a system performance to the mark with the minimum expected total cost. The analytical and numerical results obtained. The sensitivity and optimal analysis exhibit that the machining system

studied may be improved to the desired extent by choice of the system parameters. Optimal design and optimal allocation of active units, spare units, and maintenance specialists may be used to enhance the productivity of the machining system.

In multi-unit machining systems, the caretaker of units may balk /renege due to the long queue of the failed units. In such a real-life situation, the provision of advanced repair facilities like additional repairers, increased repair rate, etc. may be helpful to reduce the backlog of the failed units. The state-dependent queueing systems analyzed herein have their applicability in various congestion problems of the machining system. The average number of arriving jobs may be state-dependent instead of constant in many real-time systems. The proper utilization of costlier resources may be achieved by minimizing cost function and improving the repair rate of the repairmen, as shown in some models developed in the present study. Many studied models consider the degraded failures, switching failure, common cause failure, etc. which are also common in many real-life machining systems. The optimal design is suggested to improve the reliability of the machining systems by incorporating spare units as well as a queue- dependent repair provision.

The study of policy of vacation, working vacation, server breakdown, etc. which are the crucial strategic ingredient for the optimal design of many queueing problems, is also done. The working condition of units and repair facilities in the machining system affect production, cost, and growth directly. The state can be made favorable by taking a proper combination of redundant units support and the prompt repair facility.

7.2 Specific Contributions

The main contributions of the present study in the thesis are as follows:

- various queueing models for performance prediction of fault-tolerant redundant repairable machining systems involved in real-time scenarios are developed;
- various machining failures and delays variants such as unpredictable failures, switching failures, common cause failure, switchover delay, reboot delay, recovery delay, imperfect coverage, abandon policy, etc are considered;
- besides optimal design, modified policy such as working vacation, vacation interruption, provisioning of spares of different types etc. are investigated;
- the transient, steady-state, fuzzy analysis of fault-tolerant redundant repairable machining system with different failure variants and prompt repair facilities

has been done. The sensitivity and optimal analysis also enrich the content of the thesis; and

- distinguished types of repair time distributions are assumed from different families to explore services in more realistic manner

7.3 Future Work

The investigations, which have presented in the present thesis, is applicable in the machining system having different arrangements. The queueing techniques suggested for modeling and analyzing the machining system have demonstrated the potential for altering the system parameters to improve the grade of service (GoS) to the desired extent subjected to techno-economic constraints. Hopefully, the outcomes of our investigations on machining system with spare units provisioning will be helpful to uncover the underlying principles of queueing theory, to view the applicability in manufacturing and production system, computer and communication system, security and safety system, and to control related issues in future also.

The present study can be further extended in the future involving many real-time machining variants, for example, imperfect service, types of abandonment, state-dependent vacation, working breakdown, retention, restoration, and many more. There is no end of extension and future research since the investigation is continuous thought as complexities increase with the advancement of the machining system and technology.