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Multi-principle preventive maintenance: a design-oriented scheduling study for mechanical systems

Key words:

Preventive maintenance (PM) scheduling, Multi-objective optimization, Mechanical system

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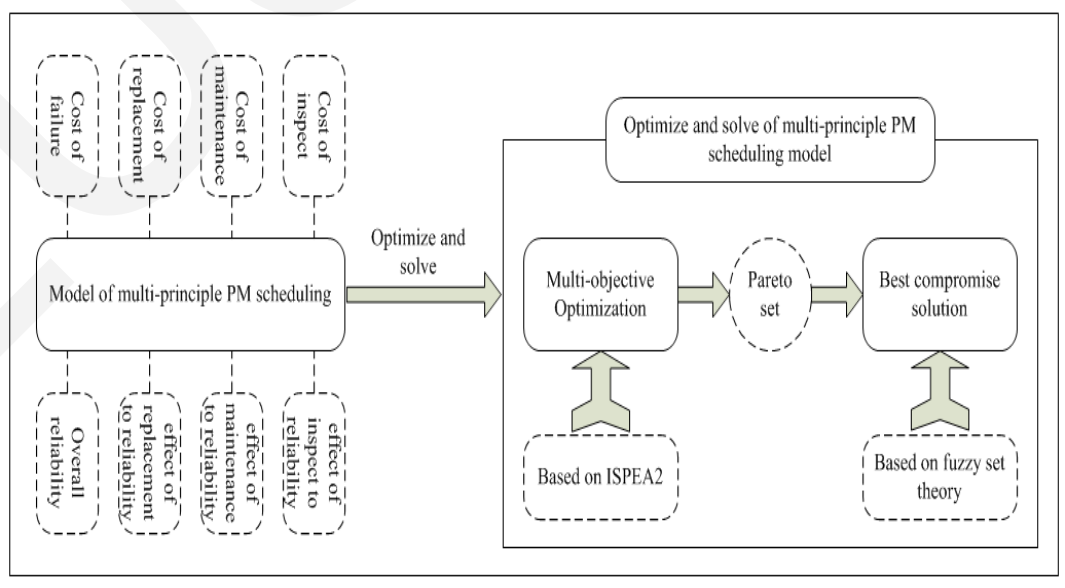
Key objective

- A multi-objective mathematical model is developed to determine a plan for different PM activities for each component of a mechanical system, such that their total cost is minimized and the overall reliability of the mechanical system is maximized simultaneously, over the planning horizon.

Key methodology

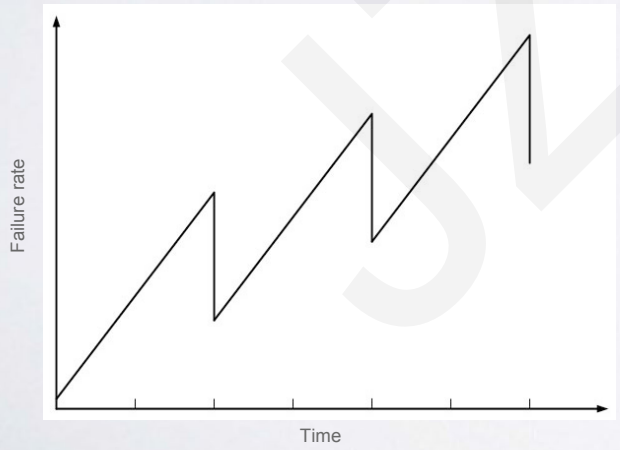
- Two basic principles are integrated to support the PM scheduling of mechanical systems: the cost principle; the reliability principle.
- The improved strength Pareto evolutionary algorithm is used to find the Pareto-optimal set within which the best compromise solution can be obtained according to fuzzy set theory.



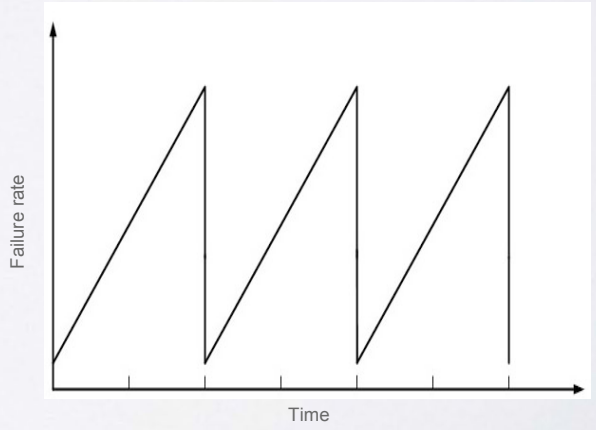
Conceptual modeling of the multi-principle PM scheduling method

Key conclusions

- **PM activities are classified into inspection, maintenance, and replacement. By combining the effects of PM activities on these components, the enhancement in performance of the mechanical system is calculated.**
  - **Inspection is to be carried out on component in period *j*, leaving component in a state of "bad-as-old".**
  - **Component is maintained in period *j*, which places it into a state somewhere between "good-as-new" and "bad-as-old".**
  - **Component is to be replaced at the end of period *j*, immediately placing it in a state of "good-as-new".**



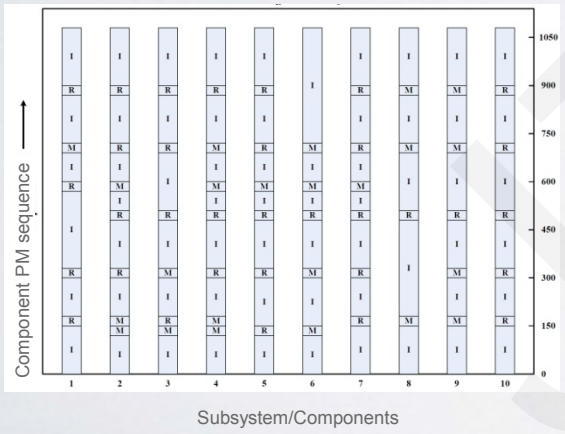
Effect of period *j* maintenance for failure rate of SC_i



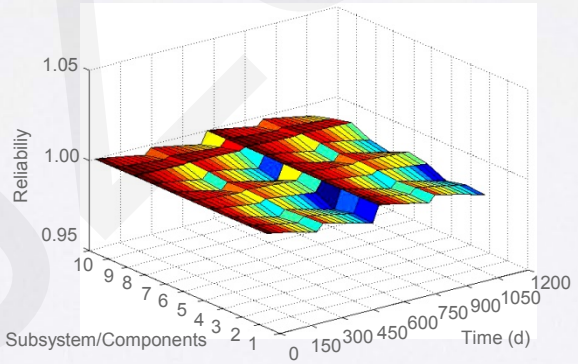
Effect of period *j* replacement for failure rate of SC_i

Key conclusions

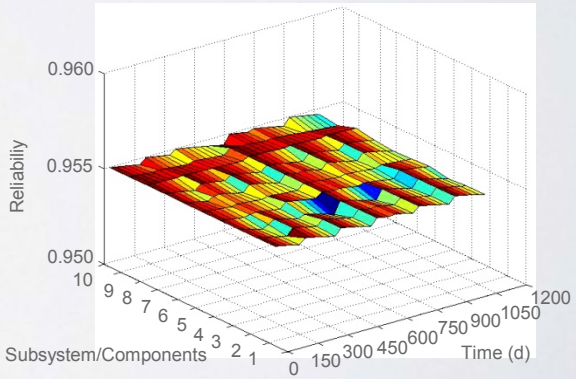
- **When a Component is maintained, the effective age of that component drops, based on the value of improvement factors η and β.**
- **The reliability curve of the optimal PM schedule is smoother and the reliability of each component is almost the same at each stage. The system under the proposed PM policy is safer than the non-optimal PM schedule considered.**



PM schedule for the Pareto solution
I: inspection; M:maintenance; R: replacement



The reliability of SCs of DMCM under the non-optimal PM schedule



The reliability of SCs of DMCM under the optimal PM schedule