Abstract

This thesis is concerned with development of some preventive replacement planning and scheduling models for process industries. Process industries such as integrated steel plants, power plants, fertilizer and chemical plants etc. are not only capital intensive complex systems but also they consist of several subsystems and large number of components with functional, structural and economic dependences. Available preventive replacement models normally do not explicitly consider such dependences and assume availability of the plant for preventive replacement shutdowns. While production compulsions do not permit frequent shutdown of the plants for the preventive replacements in such industries, limited resources and shutdown durations, call for coordinated planning and preventive replacement of several components. The preventive replacement planning and scheduling models of the thesis address some of these issues of the process industries.

For process industries, we develop models for replacing a component or a number of components that show signs of fault or malfunctioning before their actual failure after a random period of functioning with degraded performance. The period of degraded performance from the point of occurrence of the fault to the final failure of the component is commonly referred to as delay time. The replacement on failure or preventive replacement after a specified period from the occurrence of a fault is named as Age Replacement during Delay Time Policy (ARDTP). Such a replacement policy for single component has many advantages over the classical Age Replacement Policy (ARP).

Process plants normally do not permit frequent shut down for the purpose of preventive replacements due to production compulsions and high cost of production loss. Replacement of components/subsystems/systems at periodic (weekly, fortnightly, monthly) shutdowns and randomly occurring opportunities (common cause failures that forces a plant shutdown) are used to carry out preventive replacements. Considering this aspect, the thesis extends Age Replacement during Delay Time at randomly occurring opportunities (OARDTP model)or at periodic shut downs (PARDTP model).

Depending on the expected time required for a replacement, we classify the replacements into two classes: major replacements and minor replacements. The later types of replacements require lesser time compared to the former. For preventive replacement of multiple major jobs within the specified duration of periodically available shutdowns or its extensions at cost, the thesis considers scheduling of multiple replacement jobs that minimizes the relevant cost. Similarly, we develop models for scheduling many minor replacement jobs during randomly occurring opportunities. We particularly address the problems of packaging/prioritizing (i) the minor replacement jobs for execution in random opportunities, (ii) the major replacement jobs at periodically available shutdowns. The scheduling models are presented in form of Integer Linear Programme (ILP).

The modeling exercise is further extended to consider feasibility of doing both minor and major replacement jobs during periodic shut downs and only minor jobs during randomly occurring opportunities. For all these otherwise complex (from computational consideration) combinational optimization problems, we develop easy to use implicit enumeration algorithms. The thesis also addresses the problem of scheduling multiple jobs with economic dependence amongst jobs and restrictions on the resources like manpower and shutdown times.

Different systems of a process plant need complete overhauling periodically that require major shutdowns. Sometimes, to replace a large component, one also needs a major shutdown. The thesis attempts to coordinate and combine such major shutdowns that optimize the cost of operation.

The thesis illustrates each model and its solution algorithm with examples taken from an integrated steel plant. It also compares the results of the proposed policies and models with the ones normally used in practice.

Key words: *Maintenance Models, Optimization Models, Multi-unit replacement models, Scheduling, Integer Linear Programming.*