A New Tool for the Evaluation and Optimization of the Scheduling of Preventive Maintenance in for Chemical Process Plants

Authors
Miguel Bagajewicz(+), Kehinde Adesoye, Christopher Brammer, Mike Mills, and DuyQuang Nguyen

Institution
School of Chemical, Biological and Materials Engineering, The University of Oklahoma, 100 E. Boyd St., T335, Norman, OK 73019

Abstract

A new methodology designed to optimize both the scheduling of preventive maintenance and the amount of resources needed to perform maintenance on a chemical process plant is presented. The methodology is based on the use of genetic algorithms to determine what schedule is most appropriate, while evaluating each of these using a Monte Carlo simulation. The overall goal of this method is to facilitate improvements in plant safety, reduce equipment replacement costs, and reduce economic losses due to downtime or reduced production.

The simulation will accurately describe the equipment in a process plant by including several factors, such as equipment failure types, mean time between failures, maintenance cost, resources limitations, labor cost, repair downtime, failed but un-repaired equipment performance due to lack of resources, and other maintenance rules. This method is expected to alleviate the problems encountered with other methods, which include the over simplification of analytical techniques and the large computation time needed for the Markov method. Optimization of the well-known Tennessee Eastman Plant Problem is used to illustrate the method. The results of which include the optimization of both preventive maintenance intervals and resource limitations.

A Fortran model was constructed that sampled a failure list using a reliability function. The model divided the time horizon given into weeks due to the maintenance schedule being created on a weekly basis. The model identified all preventative and corrective maintenance requests and categorized them based on their priority. The program then would schedule the maintenance work to be performed each week based on the priority of the repair. A workforce resource limitation was added to determine the amount of maintenance work that could be performed each week. If all maintenance could not be performed in a given week, all corrective maintenance will be scheduled for the next week and any preventative maintenance would be seven days later.

From the models results, it was shown that the preventative maintenance makes a large impact on the total cost. In the model that considered corrective maintenance only, cost soared to around $33 million for a one year horizon and $99 million for the three year horizon. This is related to the high economic loss associated with performing only corrective maintenance. Whereas, when applying the model that included preventative and corrective maintenance with no resource limitations, the best results where obtained arriving at a total cost of around $5 million for the one year and $18 million for the three year horizon. Finally applying the resource limitation of the number of laborers and adding the labor cost incurred with them the model arrives at a solution including not only protective and corrective maintenance costs and their associated economic losses but includes also the labor cost. This gives a model that accounts for almost all maintenance costs. For this model, the total cost of around $6.5 million for the one year and around $23 million for the three year model.

So, from the results the model shows that applying the right work force and performing preventative maintenance in accordance with corrective maintenance can save approximately $26.5 million over a one year horizon and around $75.6 million over a three year horizon.