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Optimal Tamping for Railway Tracks, Reducing Railway Maintenance Expenditures by the Use of Integer Programming

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Abstract : For the modern railways, maintenance is critical for ensuring safety, train punctuality and overall capacity utilization. The cost of railway maintenance in Europe is high, on average between 30,000 – 100,000 Euros per kilometer per year. In order to reduce such maintenance expenditures, this paper presents a mixed 0-1 linear mathematical model designed to optimize the predictive railway tamping activities for ballast track in the planning horizon of three to four years. The objective function is to minimize the tamping machine actual costs. The approach of the research is using the simple dynamic model for modelling condition-based tamping process and the solution method for finding optimal condition-based tamping schedule. Seven technical and practical aspects are taken into account to schedule tamping: (1) track degradation of the standard deviation of the longitudinal level over time; (2) track geometrical alignment; (3) track quality thresholds based on the train speed limits; (4) the dependency of the track quality recovery on the track quality after tamping operation; (5) Tamping machine operation practices (6) tamping budgets and (7) differentiating the open track from the station sections. A Danish railway track between Odense and Fredericia with 42.6 km of length is applied for a time period of three and four years in the proposed maintenance model. The generated tamping schedule is reasonable and robust. Based on the result from the Danish railway corridor, the total costs can be reduced significantly (50%) than the previous model which is based on optimizing the number of tamping. The different maintenance strategies have been discussed in the paper. The analysis from the results obtained from the model also shows a longer period of predictive tamping planning has more optimal scheduling of maintenance actions than continuous short term preventive maintenance, namely yearly condition-based planning.

Keywords : integer programming, railway tamping, predictive maintenance model, preventive condition-based maintenance
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