ABSTRACT

Million of workers are everyday at risk of occupational injuries and illnesses due to the job-related hazards. Workforce scheduling, also known as job rotation, is frequently recommended to help decrease the exposure of hazards. Very few workforce scheduling problems in the literature focus on the safety of worker. This dissertation introduces three new safety-based workforce scheduling problems (WSPs) and their algorithms. The objectives of all WSPs are to minimize the number of workers performing the required hazardous tasks, while the hazardous exposure to all workers must not exceed the permissible limits. Two hazards, noise exposure and energy expenditure, are considered in this study due to their statistically high rates of injuries and illnesses.

The Workforce Scheduling Problem with Noise Criterion (WSP-N) considers only the noise exposure associated with the tasks. None of worker receives the daily noise exposure that exceeds 90 dB*A* in each 8-hour workday. WSP-N is a variant of the One-Dimensional Bin Packing Problem where bins are viewed as identical workers of the same noise limit.

The Workforce Scheduling Problem with Energy Criterion (WSP-E) concerns only the energy expenditure of the tasks. It is recommended not to assign any worker to expend more than 33% of his/her maximum energy capacity in each 8-hour workday. WSP-E is a variant of the Variable-Sized Bin Packing Problem where the bins of different sizes are the non-identical workers of different energy capacities.

The Two-Criterion Workforce Scheduling Problem (2WSP) considers both noise and energy criteria. 2WSP is a variation of the Two-Dimensional Vector Packing Problem.

The lower bounds and algorithms for solving the proposed WSPs are developed and computationally tested through extensive experiments. Techniques in the lower bounds are such as (1) assuming that the hazard weights associated with each task can be divided into small parts, and (2) grouping all tasks into three sets according to its weights and then apply the first technique.

Different ideas in developing heuristics are used. List algorithms, which generate the list of tasks and assign each task to workers according to its order in the list, are developed. Heuristics with dual strategy are also developed so that they can generate the dual solutions satisfied the WSP assignment and safety constraints. Solutions can be made feasible or improved by the swap procedures and random search. A heuristic for WSP-N using the branch-and-bound scheme is also developed.

For exact algorithms, the branch-and-bound methods specially designed for solving WSPs are developed. Techniques for improving the branch-and-bound process are developed such as eliminating nodes by the dominance rule and eliminating the unexplored branches that are similar to the already explored branches.

The hybrid procedures for all proposed WSPs are developed. Based from the computational experiments, the hybrid procedures are most recommended when considering both the solution quality and computational time.