Proceedings of the 2022 Winter Simulation Conference
B. Feng, G. Pedrielli, Y. Peng, S. Shashaani, E. Song, C.G. Corlu, L.H. Lee, E.P. Chew, T. Roeder, and P. Lendermann, eds.

DETERMINING THE OPTIMAL WORK-BREAK SCHEDULE OF TEMPORARY ORDER PICKERS IN WAREHOUSES CONSIDERING THE EFFECTS OF PHYSICAL FATIGUE

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ABSTRACT

Motivated by a real-world order picking operation of an e-commerce retailer in South Korea, this paper studies a work-break scheduling problem of temporary order pickers in the warehouse, with a particular emphasis on the effects of physical fatigue. There are many temporary workers; furthermore, the proportion of elderly is increasing in e-commerce warehouses' order picking operations. Therefore, we first divide temporary order pickers into several groups based on their ages and experiences. We integrate fatigue-recovery equations to calculate each group's fatigue level under an industry's order picking schedule. We find that the current work-break schedule makes some groups work beyond their maximum fatigue level. A mixed integer linear programming model is formulated to determine the optimal work-break schedules satisfying the upper bound of the fatigue level. With our novel model, the order pickers' fatigue levels would be diminished if customized work-break schedules are implemented rather than providing an identical schedule.

1 INTRODUCTION

The picker-to-part system, where operators walk or drive along the aisles of the warehouse to pick items from storage locations, is still dominant in the industry (Sgarbossa et al., 2020). Especially in e-commerce warehouses, order picking operations need a plethora of temporary workers to handle enormous and irregular demand. Furthermore, due to the increase in average life expectancy, older people are forced to work during their retirement. Therefore, this demographic has increasingly adopted part-time work.
In this circumstance, as workers' physical and cognitive characteristics have diversified, operation policies that can identify each worker's differences and requirements are needed to ensure their safety and well-being.

Although they are an integral part of warehousing operations, workers are usually neglected or oversimplified in the models of previous studies. Little attention has been paid to the kind of fatigue that operators feel during the execution of their daily work (Grosse et al., 2015).
Since psychological fatigue is difficult to quantify, we focus on physical fatigue in this research. We posit the following research question (RQ):

- Is it correct to perceive workers with differences in stamina and experience as one homogeneous group and, therefore, give them an identical work-break schedule?

To solve the RQ, we first divide temporary order pickers into several groups based on their ages and experiences. Then the fatigue-recovery equations (Jaber et al., 2013) are integrated to calculate each group's fatigue level under a real-life order picking schedule in the industry. Then, a mixed integer linear programming model is constructed to determine the optimal work-break schedules for each worker group that correspond with the upper bound of the estimated total (accumulated) fatigue level.

2 MODEL CONSIDERATIONS AND ASSUMPTIONS

Much of the existing research considering the human factors in the order picking operations use the learning-forgetting-fatigue-recovery model developed by Jaber, Givi, and Neumann in 2013.
We only used the fatigue-recovery equations because the learning-forgetting process was not applicable to temporary workers. They assumed fatigue accumulates exponentially with time (fatigue index: λ), and a recovery break alleviates some of the accumulated fatigue over time (recovery index: μ).
The simulations were carried out using equations with computer-generated parameter in a real setting, inspired by relevant literature and by the operations of our case company. The assumptions of the proposed model are described in Figure 1 and Table 1.

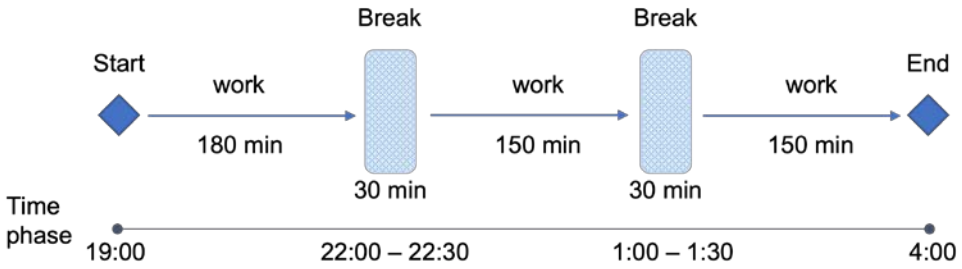

Figure 1. Current work-break schedule.

Table 1. Description of worker groups.

	Worker Groups			
	A	B	C	D
Characteristics	Young, experienced	Young, not experienced	Old, experienced	Old, not experienced
Fatigue index (λ)	0.0069	0.0077	0.0085	0.0096
Recovery index (μ)	0.0096	0.0085	0.0077	0.0069

3 CONCLUSIONS

The results demonstrate that 'worker groups C and D' surpass their maximum fatigue level (i.e., 0.906 in this research) in the current work-break schedule. In that sense, the mathematical model can alleviate the fatigue level by determining the optimal work-break schedules for each specific worker group.
We are now conducting extensive experiments to validate our results using various scenarios. Furthermore, the optimal workforce size will be computed considering the deterioration of the order picking times which is also related to physical fatigue. It could prevent order pickers from overtime work. These issues will be addressed, and the related results will be reported shortly.

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