Research

Executive summaries of IIE Transactions and IIE Transactions on Occupational Ergonomics and Human Factors

Edited by Ronald Askin and Maury A. Nussbaum

This month we highlight two articles focusing on new travel time models that can be used in warehouse design. The first article presents models for determining the best shape for warehouses with a forward picking area considering storage, picking and replenishment activities. The second article examines warehouses with automated storage and replenishment but manual in-the-aisle case picking. These articles will appear in the September 2014 issue of IIE Transactions (Volume 46, No. 9).

What does shape have to do with it?

What is the best shape of a distribution center so that it balances labor productivity and capital investment? An industrial engineer would be correct in answering, "It depends." But on what does it depend? And exactly how does it depend?

In "Analytical Models for Warehouse Configuration," Lisa Thomas and Russ Meller of Fortna present models that can help industrial engineers design the most cost-effective distribution center with a mission to store pallets of goods from suppliers and pick cases of goods to fulfill customer orders. The models were developed through their work with companies in the Center for Excellence in Logistics and Distribution (CELDi), a multiple-university industry-university cooperative research center.

Designing distribution centers is a complex mix of science and art. It involves choosing between hundreds of possible designs that vary the shape of the facility, the number of levels, the size of the forward area, its layout, etc. Some "rules of thumb" help with isolated decisions (e.g., the width of the distribution center should be twice its depth). But no integrated, analytical models could provide direction for design considering put-away, replenishment and picking operations.

The article includes many examples of how performance can be improved using the authors' analytical models. The models can be used, as they were with one CELDi member, to evaluate specific real estate options and to develop a holistic "total cost of ownership" that includes real estate costs as well as distribution center operational costs.

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Cold engineering: The logistics of ice cream

To prevent ice crystals from melting, ice cream temperature must not fluctuate. This is a challenge for distribution centers tasked with fulfilling the orders of hungry customers. One way to avoid an ice cream headache is to implement automation in the distribution process.

The motivation for the research investigated by Ph.D. candidate Faraz Ramtin and assistant professor Jennifer Pazour in "Analytical Models for an Automated Storage and Retrieval System with Multiple in-the-Aisle Pick Positions" came from the authors' visit to a grocery distribution center. During the visit, they observed how orders for a variety of products from multiple retail grocery locations were fulfilled.

The tour included the area that filled orders for ice cream and other deep freeze items. This facility, kept at negative 30 degrees Celsius, implemented an automated storage and retrieval system with multiple in-the-aisle pick positions (MIAPP-AS/RS). Case-level order fulfillment with MIAPP-AS/RSs is a semiautomated process because the storage and replenishment of pallets to pick positions is automated using storage and retrieval (S/R) machines. However, the case-fulfillment process is conducted by human order pickers because the pallet building process is difficult to automate due to the varying sizes and weights of cases. MIAPP-AS/RSs are common in deep freeze distribution centers because they require fewer operators to work in the extreme cold temperatures. Such systems also reduce the amount of space that is required to be temperature-controlled, which is both financially and environmentally expensive.

Because of high infrastructure investment costs and the critical importance of order fulfillment on cost and customer
satisfaction, designing and assessing an MIAPP-AS/RS is an important strategic decision in distribution center design. Such systems are commonly constrained by S/R machine throughput; therefore, the authors develop models that estimate the average travel times for different design configurations and operating policies. These models can be used by engineers to aid in the design of MIAPP-AS/RSs, ensuring that the system meets the throughput requirements and has enough pick positions available to handle the large number of ice cream flavor requests.

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This month we highlight two articles in IIE Transactions on Occupational Ergonomics and Human Factors that appeared in the January issue (Volume 2, No. 1). The first article identifies patterns in the causes of fatalities during mining maintenance and repair work, subsequently developing intervention strategies. The second article examines how an individual's gait changes after experiencing a slip event and may help prevent occupational slips and falls in the future.

Fatal hazard patterns in mining maintenance and repair work

Mining is hazardous, with one of the highest fatality rates across sectors in the U.S. Maintenance and repair work is carried out at various locations. The tasks are often atypical, which can increase the risk of fatal incidents.

Researchers at the Office of Mine Safety and Health Research of the National Institute for Occupational Safety and Health investigated maintenance and repair work fatalities in the article, “Analysis of Fatalities During Maintenance and Repair Operations in the U.S. Mining Sector.” Using a 10-year span of data from the Mine Safety and Health Administration, researchers Leanna Reardon, John Heberger and Patrick Dempsey analyzed fatality reports to identify patterns in what caused the fatalities, factors that contributed to the incidents, and which tasks were being performed during the incidents.

The authors identified hazard patterns among the fatalities and developed intervention strategies to reduce their occurrence. Primary suggestions include ensuring that workers always follow proper de-energizing and lockout/tag-out procedures and proper blocking procedures. Many fatalities occurred after the victim came into contact with energized objects or machines. This is especially true in coal mines, where the proportion of electrical-related deaths is higher than in mines that extracted metals or other nonmetals. In addition, many fatalities were caused when objects fell because they were not blocked correctly. This included failing to block equipment in all directions of motion or misusing jacks as a primary support.

Many fatalities occurred after the victim fell from heights. These accidents could be prevented by ensuring that safety equipment and personal protective equipment are available and used. Specifically, many fatalities were the result of unguarded openings or missing fall protection, and a number happened in metal/nonmetal mines, where, compared to coal mines, there is a greater chance for objects or miners to fall from heights.

Mines also should ensure that workers do not work near conveyors with missing guards, as many of the fatalities resulted from entanglement in conveyor belts and pulleys. Fatalities occurred most often while the victim was performing maintenance and repair work on equipment, cleaning or removing blockages, so intervention efforts should focus on these tasks.

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Making slips and falls less slippery

High injury rates and costs associated with occupational slips and falls make them an important prevention target at the workplace. Injury prevention during slips, trips and falls is a major research area of April Chambers, Elizabeth Harchick, Rakié Cham and their team at the University of Pittsburgh Human Movement and Balance Laboratory. They achieve their goals by gaining a thorough understanding of the biomechanical and postural control principles that govern human movement, balance during standing, walking and the performance of occupational tasks.
Their study, “Shoe-Floor Frictional Requirements During Gait After Experiencing an Unexpected Slip,” provides the first description of how adults changed their gaits after a slip experience when they didn’t perceive a threat of dealing with additional slippery surfaces. After a slip experience and being told that the floor was no longer slippery, young adults initially altered their gait to reduce their biomechanical risk of slipping. However, they eventually returned to within baseline levels and walked faster with longer steps. When young adults suffered a second slip, the slips were of a similar magnitude to their first slips. After experiencing a slip, older adults continued walking more cautiously, with decreased risk of slipping based on walking style, even though they thought they faced no threat of a subsequent slip. With this cautious gait, older adults experienced more than a 40 percent decrease in slip magnitude whenever they slipped a second time.

The age-related differences found after experiencing an unexpected slip provide valuable information that should be considered when designing slip paradigms, slip-prevention measures and the workplace. The possibility of generating more than one unexpected slip would allow researchers to further investigate this unique event to prevent falls in the workplace.

It is important to understand how biomechanics, frictional requirements and other gait adaptations are impacted by experiencing a slip to ensure that ergonomic interventions, such as shoe-floor design, slip prevention training and warning systems, can be effective.

Safety warning systems also should be a focus of slip prevention in the workplace, since experiencing a slip alone may not have a long-lasting effect on gait adaptations that could minimize future slip risk, especially in young adults.

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