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Manual picking from flat and tilted pallet containers

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1. Introduction

Manual picking operations are common both in distribution settings and within manufacturing industry. In the context of manual assembly, previous studies have shown that the use of smaller unit loads for presenting materials at the assembly stations can improve flexibility (Wänström and Medbo, 2009), efficiency (Wänström and Medbo, 2009; Finnsgård et al., 2011; Hanson, 2011), and ergonomics (Neumann and Medbo, 2010; Finnsgård et al., 2011) for the assembly operator. In a study of strategies in manual assembly tasks, Lim and Hoffman (2015) point out the need for determining the ergonomically best layout of components for assembly, where components are arranged within the zone of convenient reach. However, in some situations, it is not feasible to use small containers for presenting materials. For example, the materials may be too large to fit into small containers. Another reason for using larger containers for supplying and presenting materials can be that the load factor in transport can often be increased by the use of large containers, such as EUR-pallets with collars. In order to present small containers at assembly stations, without compromising the load factor in transport, it is common to perform repacking within, or in association with, the assembly plant. Therefore, whether at the assembly stations or in repacking areas, manual picking from large containers is still frequently performed in association with manufacturing operations, resulting in operators having to reach, bend, stretch and load their back, neck, hands and arms. Also in order picking for distribution, it is common to apply manual picking from large containers (De Koster et al., 2007; Dallari et al., 2009; Glock and Grosse, 2012). This type of order picking has seen an increase following the increase in e-commerce.

In spite of its frequent occurrence, manual picking from large containers is problematic from a perspective both of efficiency and of ergonomics (Neumann and Medbo, 2010). Generally, work-related disorders caused by materials handling remain a health issue worldwide. Statistics from the Swedish Work Environment Authority (2016) indicate that between 2014-2016, approximately 10% of the total Swedish working population reported work-related disorders caused by heavy manual handling (which was the 3rd largest cause) and awkward work postures. The Health and Safety Executive (2014) of Great Britain reported in 2013/2014 that the manufacturing sector had the 3rd highest rate of handling injuries (with a rate of 133.5 injured per 100 000 employees).

All in all, to support efficiency as well as favourable working conditions, there is a need for studies addressing the picking of components from large containers. Efficiency is in this paper measured mainly through the picking time, which is in turn closely related to man-hour consumption and cost. The influence of worker behaviors and occupational health and safety culture further complicate the understanding of how ergonomic factors influence time consumption and performance accuracy; Grosse and Glock (2015) have found that workers learn behaviors in order picking that increase efficiency as they become more familiar with the task, but in contrast, Digiesi et al. (2009) have stated that a number of work environment factors contribute to great variability of worker behavior (particularly with regard to fatigue) over a work shift, leading to variability in flow time.

There is evidence that picking time can be reduced by having the container tilted towards the picker (Finnsgård and Wänström, 2013). In addition, when picking is performed from a flat pallet, it is difficult to reach all components from the short side of the pallet, which then means that either picking needs to be performed from the long side of the pallet, or space needs to be made available along both the short and the long side of the pallet, so that the picker can choose picking position depending on where each

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component is located. In a picking area where multiple pallets are presented, both of these approaches are associated with more space requirements than if all picking can be performed from the short end of the pallet, which is generally the case with picking from tilted pallets. Accordingly, in addition to the potential for shorter picking time, this is another motive for using tilted pallets.

However, while the tilting of pallets is relatively common within industry, no studies have been found that consider the effects on the physical workload associated with this approach. Moreover, no studies have been found that address, in any depth, the variations that arise during picking from large containers, neither of picking time nor physical workload. It seems that both the picking time and the physical workload will vary depending on the exact location of the component within the container. This location, in turn, will vary during the emptying of a container. In an environment that is controlled by a predetermined takt time, as many manufacturing plants are, time variations can often cause time losses, due to difficulties of balancing the operations. From a perspective of ergonomics, variations of workload are important to consider, so that peak load and not only average load is acceptable. This is especially important as it is often large and heavy components that are handled in large containers. The present paper has the purpose of determining how physical workload and picking time vary during picking from large containers, depending on where in the container the component is located and depending on whether the pallet is tilted or not.

2. Literature review

The use of different types and sizes of unit loads for materials supply has received considerable attention in the research literature (e.g. Ram, 1992; Castillo and Peters, 2002; Finnsgård et al., 2011; Hanson and Finnsgård, 2014). Moreover, in relation to picking, research has been performed on design of order picking (e.g. Petersen, 1999; Roodbergen and De Koster, 2001; De Koster et al., 2007; Chan and Chan, 2011; Glock and Grosse, 2012) and kit preparation processes (Brynzér and Johansson, 1995; Caputo et al., 2015; Hanson et al., 2015). However, these studies of picking processes have focused mainly on issues like planning, routing, storage policies, and batching policies. Studies that provide detailed insight into the physical activities of picking are scarcer. In a content analysis of existing literature on order picking, Grosse et al. (2017) find that there has been a lack of attention to human factors and ergonomic, and that issues of e.g. routing, batching, and zoning have received considerably more attention.

In general, poor workplace ergonomics (usually entailing high physical workload) is connected to both incurred health-related costs as well as quality/performance deterioration in industrial operations – this connection is well-established (e.g. Leigh, 2011; Fan et al., 2014; Falck and Rosenqvist, 2014; Falck et al., 2010, 2014; Winkel and Westgaard, 1996). The design of picking operations can affect both physical workload (Neumann and Medbo, 2010) and picking time (Finnsgård et al., 2011; Finnsgård and Wänström, 2013). Factors affecting this may have to do with either the circumstance of the picking task (such as presentation, task order, positioning etc.) or the nature of actual objects being picked themselves, e.g. weight, dimensions, graspability, etc. For example, Ciriello (2003, 2007) finds that the maximum acceptable weight for an item being picked is dramatically reduced the further away from the picker the object is, i.e. the horizontal reach matters. On a related note, Petersen et al. (2005) state that the size and weight of the object picked can affect picking time; they further propose that picking time and worker fatigue can be reduced if stock keeping units are presented in a “golden zone”, between the waist and shoulders of the picker. A similar concept called the “sweet-spot” (Backman, 2008) has been developed for Volvo, to organize frequently picked articles into vertical placements that have the lowest ergonomic impact.

In a study set in an assembly context, Neumann and Medbo (2010) find that picking time during manual picking from an EUR-pallet with collars varies considerably depending on where in the pallet the component is picked from, and that the picking time can triple in duration when picking from the lower rear zone of the pallet compared to from the upper front zone. They also find that picking time as well as physical workload of the operator, in terms of both peak load and cumulative load, is reduced when small containers are used. This is echoed by a result by Grosse et al. (2015) who state that the well-being of the picker and the picking time are both affected by the depth and height of the item to be picked. Similarly, Finnsgård and Wänström (2013), who present results from a full factorial experiment focusing on manual picking, find that picking time is shorter from a small container than from a pallet with collars. Finnsgård and Wänström (2013) further find that picking time is shorter from a container that is tilted with a 30° angle towards the picker and, when it comes to sideways position, that picking time is shorter when the component is located straight in front of the picker. Kothiyal and Kayis (1995), instead, who study seated assembly, find that picking time in this context is shorter if the components are presented in a 30° angle sideways from the picker, due to more favourable arm movements.

Regarding studies of physical loading aspects of manual picking, the subject has been approached from a number of assessment perspectives. For example, a case study about kitting and physical loading in the automotive industry by Christmansson et al. (2002) used “ambulatory equipment” that measured muscle activity, posture and movements (using accelerometers), wrist positions (using electrogoniometers) and worker assessments of video. Materials picking was assessed as stressful and highly repetitive for kitting. A study by Battini et al. (2016) evaluates the tradeoff between order picking and energy expenditure (which allows for a quantitative approach); results are used to estimate rest allowance and to influence the design of the picking environment and picking tasks. This study also indicates a need for more integrated approaches to evaluating ergonomics alongside economic effects. Also using energy expenditure as a measure of ergonomics, Calzavara et al. (2016) present a model for evaluating how the layout of storage racks and the way products are stored on racks in the warehouse impact both economic performance and energy expenditure. One of the options for storage considered in the model is the use of a pull-out system, where a pallet can be pulled out of the storage rack to facilitate picking. Grosse et al.'s (2015) framework for incorporating human factors into order picking takes a broader ergonomics approach, incorporating not only physical but also perceptual, mental and psychosocial aspects.

3. Methodology

The study was carried out as an observation in a controlled experimental setup, at the Volvo Trucks assembly plant in Göteborg, Sweden. The experiment was planned together with logistics engineers from the company and was intentionally controlled for certain variables to examine particular correlations and cause-and-effect relationships. Carrying out the experiment at the Volvo plant provided proximity to real operator participants, real assembly components and an industrial environment to contextualize the studied tasks.

3.1. Sample of studied operators and components

In order to explore which operator statures would be most