Peak shaving port of spain

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An important development that facilitates the growing container market is the increasing capacities of containerships. Whereas the largest containership in 1980 had a capacity of 3000 TEU, the largest containerships operating in 2015 have a capacity of almost 20,000 TEU (Lloyd"s List 2015).

The growing size of containerships influences container terminal operations, as the number of containers per containership has also increased as a result of this development. Container carriers demand that container terminals handle their ships as fast as possible to continue their journey to the next port. This higher productivity is achieved by more automated terminal processes (Grunow et al. 2005) and by deploying more terminal equipment simultaneously. However, with more and more simultaneously operating ship-to-shore (STS) cranes, the energy demand (kW/s) increases. This also increases the highest observed peak demand, leading to a higher energy bill and therefore higher handling costs.

Container terminals" peak demand is responsible for about 25-30% of the monthly energy bill (Personal communication, ABB, a worldwide provider of electrotechnical solutions for the shipping, offshore, and harbour industries (ABB 2014; Stedin 2014). The main reason is that the highest observed peak demand is charged for the next 12 months. To illustrate this: if the highest peak in January is 12,000 kW, the terminal is charged for 12,000 kW for the rest of the year. However, if the highest peak in March is 14,000 kW, the terminal is charged for 14,000 kW until March the year after. A lower peak demand could result in large annual savings for container terminals. It is consequently very important to investigate the possibilities of reducing this peak demand.

This paper presents the results of this research by discussing STS cranes" terminal operations and the volatility of their energy demand in section 2. Both the methodology applied and the study"s relevance are presented in this section as well. Section 3 presents the energy consumption model, which forms the basis for the simulation model developed. The simulation model is presented in section 4, and the results of the simulation study are discussed in section 5. Finally, the implications of these results and the conclusions of the study are discussed in sections 6 and 7.

After a containership has berthed at the seaside of a terminal, the STS cranes start unloading the incoming containers according to the unloading plan. STS cranes can use a normal spreader, enabling them to handle one container at a time, or more advanced spreaders (e.g. the twin-lift and tandem-lift) to handle multiple containers at the same time (Stahlbock and Voss 2008). The Super Post Panamax STS cranes, the current standard for unloading the largest containerships, are able to make approximately 32 lifts per crane per hour (APM Terminals 2014). This allows an STS crane to handle 32-64 TEUs per hour with a normal spreader and up to 128 TEUs per hour with a tandem-lift spreader.

During the (un)loading of a containership, two criteria are important: the ship"s stability and the number of unproductive moves (Imai et al. 2006). During (un)loading, the ship"s stability changes as a result of the continuously changing container load. Because containerships visit several container terminals, each time unloading containers from and loading containers onto the ship, not all containers that have to be unloaded are positioned on top of the ship"s stacks. Ships therefore have to be loaded in an efficient way, allowing the next container terminal to unload the containership with a minimum of unproductive moves.

These two criteria are often in conflict, because the most efficient loading (regarding the minimization of unproductive moves) might not be in line with the most efficient loading regarding the ship"s stability. This makes stowage very complex (Bortfeldt and Gehring 2001; Steenken et al. 2004; Dekker et al. 2006), especially because the stowage plans have to be aligned over all the different ports that have to (un)load the ship (Wilson and Roach 2000).

The STS cranes are connected to the electricity network. For all quay crane processes (moving of crane and spreader, crane lighting, and auxiliary processes), electricity is supplied by the network. Vertical movements have the most volatile energy demand, showing high peaks for hoisting the crane spreader and low falls for lowering the spreader, as can be seen in Fig. 1 (MSC Terminal Valencia 2009, field data). The gantry (horizontal) movements and auxiliary energy consumption are less volatile in character.

Detailed energy consumption of quay crane (MSC Terminal Valencia 2009, field data)

In Fig. 2, the total energy consumption for one STS crane is visualized. In total, two peaks can be identified for handling a container: the first for lifting a spreader and container above the ship and the second for lifting the spreader after the container is positioned in the terminal. When all STS cranes in a terminal are lifting at the same moment, the potential peak demand is very high. It is therefore important to visualize the peak demand of a terminal while it is handling a containership and to investigate the opportunities to reduce the peak demand.

Detailed energy consumption for handling one container (ABB 2014)

The growing need for container terminals to handle containerships as fast as possible leads to more automation and more simultaneously operating STS cranes, leading to high peaks in electricity demand. As discussed in section 1.1, because an observed peak demand is charged for the next 12 months, the highest peak is responsible for nearly 25-30% of the total electricity costs. This implies that higher handling speeds of containerships result in more peak-related energy costs, leading to higher handling costs. Because container carriers require both higher handling speeds and lower handling costs, terminals are confronted with a dilemma. The challenge is therefore to find opportunities to reduce the peak-related costs without reducing the handling speed too much.

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