Analysing electric yard cranes with simulation

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Introduction

Electric yard cranes, such as RTGs and RMGCs, are becoming increasingly common in terminals today. Although RTGs have traditionally been diesel powered, there is a major trend in the container handling industry to shift towards electronically powered RTGs. Electric RTGs can be powered from a cable reel, but the most common electrical solution is an above ground bus bar power system. RMGCs are electrically powered, usually via cable reels, similar to the kind used for dock cranes.

Compared to diesel machines, electric yard cranes reduce emissions and noise, as well as power consumption and maintenance costs, while sustaining operational performance. With no oil being involved for fuel, there are no spills or emissions to consider. Several major terminal operators, such as Modern Terminals Ltd in Hong Kong and APM Terminals, are retrofitting their current RTGs with electric power systems.

Many port authorities are becoming increasingly aware of, and concerned by, the looming increase in demand for electric power on marine terminals. A detailed analysis of peak electrical demand is difficult to quantify because machines are constantly shifting on a second by second basis and these electric machines are also able to regenerate power. With electric yard cranes, the energy that would have been lost through crane braking and decelerating can be captured and reused. Electric motors acquire and store energy generated by deceleration and lowering of containers; this later provides for acceleration and therefore reduces the overall energy needed.

Tracking this change in energy manually or with estimations and spreadsheets can be tedious and lead to broad and potentially inaccurate results. This is where having a simulation that is capable of tracking the energy expended and used by all machines would be useful.

Simulation models for electric power

A good simulation model can help quantify the power used. It does this by tracking and graphing electrical power use and generation of the machines. AECOM's simulation software, General Marine Terminal Simulation (GMTS), models container yard operations in detail. It is used to size terminal equipment fleets and to compare different terminal layouts. As an output, it produces extensive statistics summarizing the course and pattern of simulated container operations. This can be analyzed to determine details between layouts.

The tracked movements of a yard crane are described below. Figure 1 is a screen shot of the three-dimensional AECOM simulation model; showing the back and forth trolley motion and the up and down hoist motion of a spreader. Trolley motion refers to the back and forth movement of the spreader within the frame of the RMGCs and takes a user-defined amount of energy. Hoist refers to the up and down motion of a spreader and uses energy hoisting up, but produces energy in the downward motion. Gantry is the whole machine moving up and down the rows and draws energy to accelerate.

Figure 2 shows a sample energy output chart from a container yard crane generated from a simulation run. In the sample snapshot of time, the yard cranes are moving along the rails and hoisting containers up and down with the spreader. The machine consumes power while moving along the rail or while hoisting up the spreader with a container and generates power to be used when decelerating and lowering a container.

Traditional methods of calculating the overall electrical demand may result in radical overestimation of the true demand. For example, if a single machine can draw a maximum of 700 kilowatts. A straight multiplication of this by 36 machines yields a theoretical maximum of 25,200 kilowatts for the entire fleet of machines. Even after applying some correction factor to account

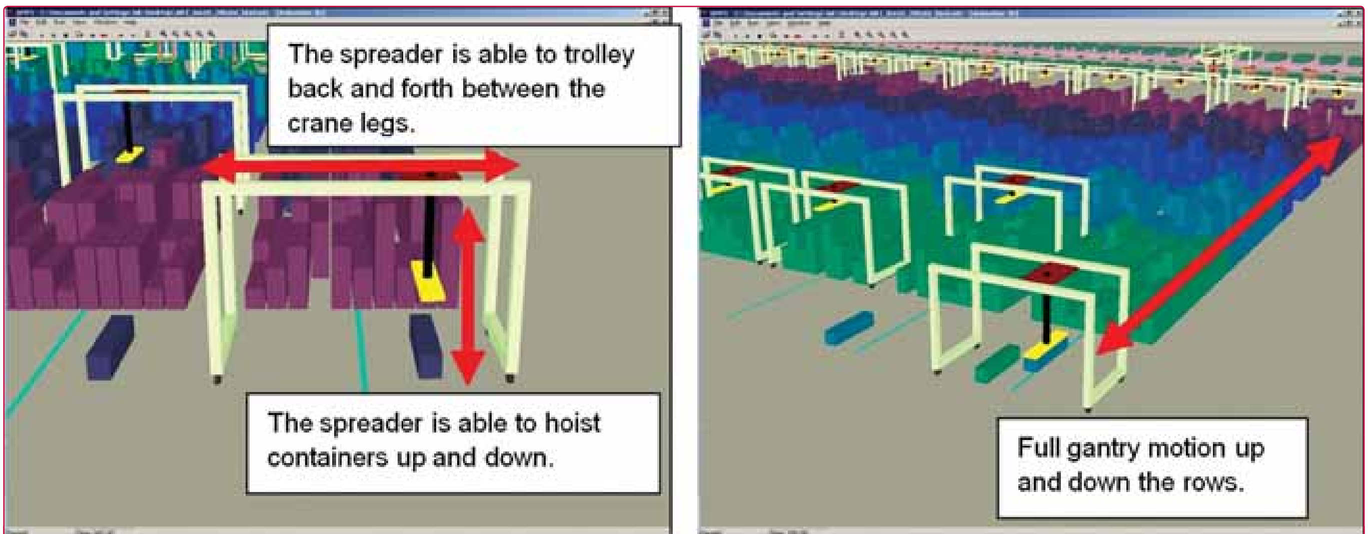
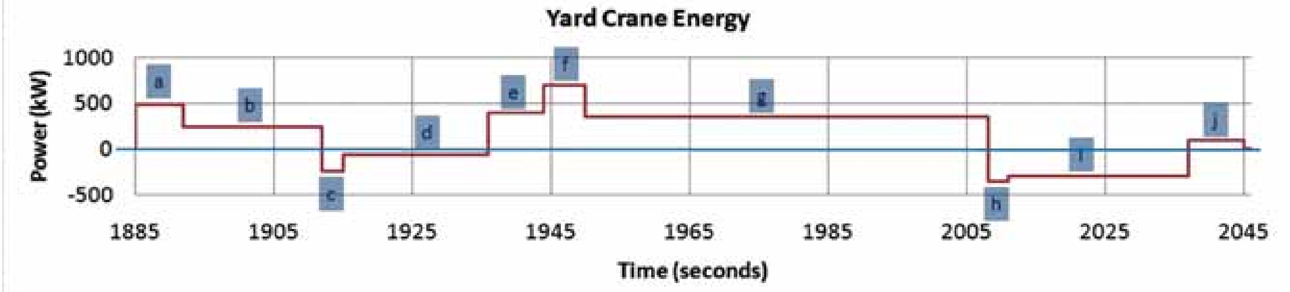


Figure 1. Simulation example of a yard crane spreader and gantry motion.



a	Acceleration to maximum gantry without container	Consuming about 500 kW
b	Gantry without container	Consuming about 250 kW
c	Deceleration without container	Generating about 200 kW
d	Lower spreader down without container	Generating about 50 kW
e	Hoist spreader up with container	Consuming about 400 kW
f	Acceleration to maximum gantry with container	Consuming about 700 kW
g	Gantry with container	Consuming about 300 kW
h	Deceleration with container	Generating about 350 kW
i	Lower spreader down with container	Generating about 300 kW
j	Hoist spreader up without container	Consuming about 100 kW

Figure 2. Sample yard crane energy output chart with annotation.

Source: AECOM

for the non-simultaneity of peak demand, of say 50 percent, this still yields a peak power demand of 12,600 kilowatts.

Compare this to the simulation output that computes the second by second power demand for the overall fleet of machines shown in Table 1. Taking the 99th percentile, the total power draw is about 3,240 kilowatts – a much smaller number than is likely to be computed by traditional methods.

Figure 3, below, is an overall peak shift run for a sample simulation model of 36 yard cranes. The x-axis is the kilowatts usage and the y-axis shows the frequency. On average, the amount of power used is about 1,000 kilowatts.

Conclusion

Traditional electrical analysis methods are likely to be too conservative and may waste money with overdesigned facilities.

TABLE 1: PERCENTILE OF POWER USAGE

Percentile (%)	Total kW
100	5,808
99.9	4,187
99.5	3,553
99	3,239
95	2,474
90	2,102
80	1,643
50	874

The capabilities of simulation would be useful to terminal designers who are investigating the proper sizing for electrical power supply to marine terminals. If cranes are equipped with electrical regenerating capability, the mean overall use can be surprisingly low, and designs with conventional safety factors may lead to dramatically oversized facilities. One of the benefits is the ability to conduct sensitivity analysis with different yard equipment manufacturer specifications to figure out ones that are the best fit in order to gauge what capacity the terminal is able to handle. A simulation-based design can potentially save a lot of money by optimizing the size of electrical infrastructure.

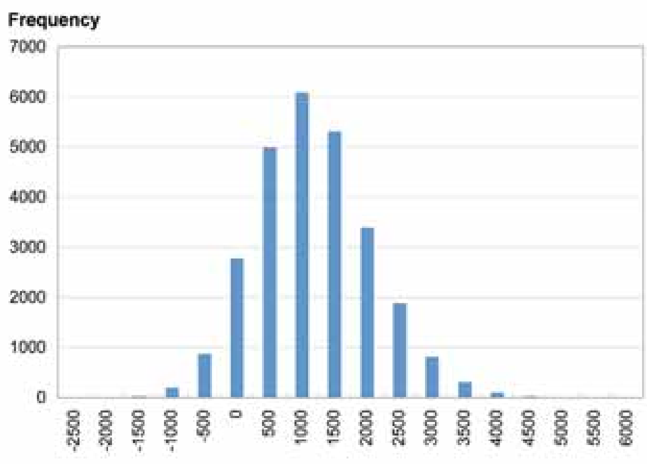


Figure 3. Overall peak shift run for a simulation model.

Source: AECOM

ABOUT THE AUTHOR

Kim Le has experience in developing simulation modeling software. She has experience with discrete event simulation projects for the marine and oil sectors. At AECOM, she works on developing and maintaining the proprietary simulation modeling tools for marine and intermodal container terminal projects to assist in the planning and analysis of marine terminal layouts and operations.

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