Efficient use of energy in container cranes

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Introduction

Fully electric operation of cranes at container terminals is the most environmentally friendly means of operation compared to other power sources (read fossil fuels). Making that statement today is not especially provocative, and for some years now in our industry we have seen a trend for electrifying machines that have traditionally been diesel-powered, such as RTGs.

Many suppliers are now offering solutions for electrification using, for example, cable reels or conductive wires to connect machines to terminals' electrical power grids.

So far so good. But how is the electrical energy used, which can be supplied to the cranes via cables in a nearly unlimited amount?

Drive systems

If cranes are connected to a terminal's electrical grid, energy can be generated onboard the cranes and fed back to the supply grid. This energy can then be used either by the neighboring cranes or other power consumers on the grid. In this way, the amount of energy taken from the point where the local power utility supplies electrical energy to the terminal is reduced, thus further lowering energy costs compared to when electrical power is generated onboard the cranes with diesel generators.

Modern electrical drive systems are of the four-quadrant type, which means that they can feed energy back to the supplying grid.

Feedback occurs when there is a pulling load, and in crane applications this is mainly when a load is lowered. Naturally, not all energy can be recovered. This is both due to mechanical losses in gearboxes, ropes and sheaves; as well as to losses in the electrical system, such as in motors and frequency converters, even if losses in the electrical system are quite low, just a few percent. About 75-80 percent of the energy released when a load is lowered is fed back to the grid.

Ship-to-shore cranes

The majority of all ship-to-shore cranes in the world are connected to a terminal supply grid, and in principle, all new cranes are equipped for AC operation with some form of four-quadrant supply to the drive system. The conditions for saving energy are thus already fulfilled.

All that remains now is to find other potential energy consumers for which energy can be saved. To accomplish this, we utilize a number of measurements made on relatively large and modern ship-to-shore cranes.

Based on these measurements, Table 1 was prepared.

Total auxiliary power amounts to about 60kW. Note that air conditioning is not included in the summary. Depending on power dissipation in the electrical room, the size and the required temperature in the cabin, as well as the ambient temperature,

Ship-to-Shore crane with dual hoist

TABLE 1: MEASURED AUXILIARY POWER CONSUMPTION

Area	Power
AC motor cooling fans	10kW
Spreader pump	15kW
Flood lights	25kW
Walkway lights	7kW

TABLE 2: METHODS OF REDUCING AUXILIARY POWER

Area	Possible improvement
AC motor cooling fans	Temperature and/or speed controlled
Spreader pump	For new cranes specify electric spreader
Flood lights	Sectionalize and switch off when not needed
Walkway lights	Switch off automatically after certain time

energy consumption due to air conditioning can be substantial. To rectify this, the drive system configuration must be changed to, for example, water-cooled type. This, however, is beyond the scope of this article.

Energy consumption per move was measured to totally 6kWh, and with 30 moves per hour the auxiliary energy consumption is 2kWh per move.

We can now see that energy consumption attributable to auxiliary equipment amounts to approximately 25 percent of the energy consumption for work that contributes to production. Because this crane is naturally equipped with a four-quadrant drive system, energy is fed back to the grid when a load is lowered.

Table 2 shows a few examples of simple measures that reduce energy consumption.

Even a minor change to auxiliary consumption has an impact. This is due to energy being continuously consumed and not actually performing any work. Halving energy consumption for floodlights, for example, produces a 25 percent reduction of the contribution to energy consumption from auxiliary equipment.

Ship-to-shore automation also contributes to reducing energy consumption. This is primarily accomplished by cranes making more moves per hour for all operators, but also by never lifting a load higher than necessary. Although energy is recovered when the load is lowered again, it only amounts to 75-80 percent because of the degree of efficiency of the mechanical and electrical systems. There are savings to be made with automation.

Automatic stacking cranes

Automatic Stacking Cranes (ASCs) are energy-efficient by definition since they are electrified. ABB has made energy and power measurements on ASCs with cantilevers, and studied a number of conceivable alternatives for saving energy in these applications as well.

ASCs are supplied with electrical energy from terminal grids and roll on steel wheels with low friction. The cranes' drive systems feed back energy when loads are lowered. Moreover, the need for floodlights and other lighting is minimal due to work being conducted without operators. In principle, the cranes do not need any lighting at all. Under these conditions, it is important to look at how the cranes work, both independently and in interaction with one another.

Unsynchronized movements

The greatest saving is in being able to operate several cranes simultaneously and in doing so, evening out their consumption of

ASCs in operation.

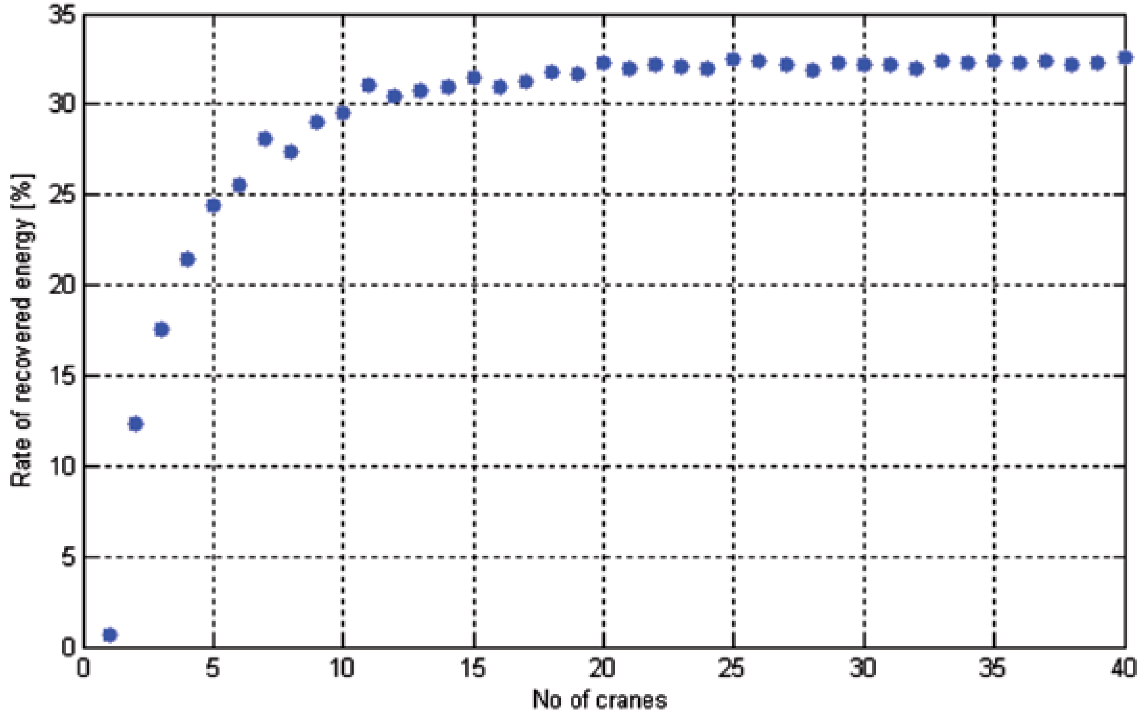

Figure 1. Rate of recovered energy depending on the number of independently connected cranes.

energy. In other words, when energy is generated at one location, it can be used by another crane in the same supply grid.

Our studies shows that even with just ten cranes operating at the same time, an optimum situation is attained in which energy is being simultaneously generated and consumed with savings of about 30 percent.

Once the ASCs are installed, this should work on its own with little interaction from users or operators. Moreover, neither planning from the Terminal Operating System (TOS) nor the movements or operations of any cranes are affected. At a busy terminal, it should almost always be possible to utilize recovered energy.

Synchronized movements

With synchronized movements, additional energy can be saved amounting to approximately 5 percent with the same amount of cranes as in the example above. Depending on the debiting principles of the local power utility, it may be necessary to immediately utilize the recovered energy. If the movements are coordinated between the cranes, recovered energy can usually be used while at the same time, reducing peak power demand.

A reduction of peak power demand saves money in installed power because smaller transformers, substations and lighter cables can be used to supply the cranes with electrical energy. Less installed power means lower CAPEX and subsequently lower OPEX as well. The rationale concerning synchronized movements for saving energy and power can also be applied to automated ship-to-shore cranes.

Although there is no “one-size-fits-all” solution, it is obvious that automation has potential and that automation will be utilized even more in the future. Saving energy and using it responsibly must be considered regardless of the type of industry or operation.

ABOUT THE COMPANY

ABB is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. The ABB Group of companies operates in more than 100 countries and employs about 117,000 people.

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