

Analysis of Electric-Rubber Tyred Gantries for a more green Durban Container Terminal

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Abstract:- The Durban Container Terminal (DCT) is currently the biggest and busiest container terminal in Africa and handles about 2.7-million TEUs a year. DCT handles approx. 70% of South Africa's containers and generates 60% of South Africa's revenue (Port of Durban, 2014).

The work-horse of the container handling industry is the Rubber Tyred Gantry (RTG) crane. For over 50 years, these heavy duty cranes have been a staple at ports worldwide. Typically powered by diesel engines, these cranes require constant maintenance and fuel management to remain operational. In addition to costs, ports have begun to feel the pressure to become more "Green" by local authorities and governments. Pier 1, at DCT is currently utilizing RTGs. High energy consumption and high pollution result from RTGs operating around the clock. This entails a high cost burden for terminal operators and causes serious environmental pollution. An investigation into solutions to lessen operating costs, strengthen business competitiveness, and alleviate environmental pollution is presented in this paper. The results were analyzed and conclusions, as well as recommendations were made.

I. INTRODUCTION

In the wake of severe energy shortages and higher energy costs around the world, some equipment (such as RTGs and straddle carriers) with large operating costs are being phased out in favour of handling facilities offering energy savings, environmental friendliness, and electric power systems. Electric Rubber Tyred Gantry (E-RTG) cranes offer maintenance and repair costs that are 30% lower than for standard diesel RTGs, and also provide additional fuel cost savings of as much as 70%. The use of E-RTGs can reduce CO₂ emissions by 60-80% compared with conventional diesel powered RTGs, which can result in overall terminal CO₂ emissions decreasing by 20% per TEU handled, and the retrofitting of the majority of the existing 400-unit APM terminal RTG fleet with electrical systems will reduce CO₂ emissions by 70,000 tons annually (APM, 2011)

II. OBJECTIVES OF THE STUDY:

The main purpose of this study was:

- To compare RTGs and E-RTGs in terms of energy saving and CO₂ reduction Performance.

Study limitations

This study is based within the vicinity of berth 101-107. Figure 1 shows a detailed layout of the area covered by this study.



Figure 1: Detailed layout of DCT

Current equipment used at DCT, Pier 1

Pier 1 operations were based on a pure Straddle Carrier(SC) system and have converted to RTG system a few years now. The Ship to Shore (STS) gantry crane places the container on a Tractor Trailer Unit (TTU) that transports the container to the storage area where the RTG crane stacks the containers in long blocks. An RTG can be used together with TTU's or road trucks. The size and structure of the RTG crane is determined according to the requirements of the terminal operator. Very heavy concrete paving is required in the wheel tracking areas to support the heavy wheel loads. There are concrete/steel pads necessary for turning purposes of the cranes to travel to adjacent storage areas (or blocks) to perform stacking operations. RTG's are generally smaller and lighter than Rail Mounted Gantrys (RMG's) Therefore, they are sometimes more favorable for terminals built on reclaimed marshland, where reinforced piling would be too costly (Brinkmann 2011: 34). DCT is built on reclaimed land so RTG's would be suitable for this terminal. The current throughput of the terminal is provided as 770,000 TEU.



Figure 2: RTG operation- DCT Pier 1

III. GREEN CONTAINER TERMINALS

Control of logistics operations at container terminals is an extremely complex task (Grunow et al. 2006). Effective deployment of material handling equipment at container terminals is crucial in enhancing overall container handling efficiency and performance during the import, export, and transshipment of containers (Lau and Zhao, 2008). In designing a container terminal, one must weigh the value of certain types of storage and retrieval equipment by performing feasibility and economic analysis. Sisson (2006) suggested that the features of a state-of-the-art green terminal comprise cold ironing of vessels with rapid automated berthing, automated transport vehicles with low emission technology, electric end-loaded yard cranes, and electric cranes serving the on-terminal rail yard. Pedrick (2006) proposed that the features of green terminals include beneficial site planning, lower water usage, greater energy efficiency, better materials and systems, and improved environmental quality. Clarke (2006) argued that the requirements of green container terminals include minimum impact on the local environment (for instance, via air pollution mitigation, noise pollution reduction, and lower utilization of lighting), minimum impact on the macro environment (for instance, via lower energy consumption and lower land and water resource utilization). Automated container terminal equipment meets the chief requirements of green container terminals, which comprise lower greenhouse emissions, lower energy consumption, container damage reduction, air emission control, noise pollution mitigation, operating efficiency control, and lower climate impact. Pedrick (2006) proposed that green terminals should be designed in harmony with their locations, promote high efficiency, improve economics, enhance overall infrastructure, and provide a link to the community. Sisson (2006) asserted that the features of green terminals should include electricity for vessels at berth, automated mooring to reduce vessel idling, electric dock cranes, automated low emission transport vehicles, end-loaded electric yard cranes, the requirement that street trucks turn off their engines while awaiting service, and gate appointments to minimize waiting time for street trucks. Watanabe (2004) believes that competition between mega container ports is gradually intensifying, and this trend is likely to intensify further. To ease the resulting situation, international agreements should require container terminal operators to make reasonable payments proportional to their CO₂ emissions volume. Geerlings and Duin (2010) used the port of Rotterdam as an example to illustrate the optimal layout of a container terminal, which can, in the case of

Rotterdam, reduce CO2 emission volume by approximately 70%. These researchers further proposed two alternatives for CO2 reduction: The former is for the government to implement a policy requiring terminal operators to replace old equipment; this approach can reduce CO2 emissions by 20% and increase working efficiency by 20% if diesel cargo stevedoring equipment is replaced by electric equipment. The latter is to mix diesel fuel with biofuel, which can reduce CO2 emissions at a container terminal by 13%~26% and reduce CO2 emissions per container by 21%. In addition, the use of diesel fuel blended with biofuel can reduce energy consumption by 30%. Storage yards at container terminals serve as temporary buffers for inbound and outbound containers, and RTGs are the most frequently used container handling equipment in yards (Zhang, et. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9, 2013 al, 2002).

Advantages and disadvantages of RTGs

The primary advantages of RTGs are as follows:

- (1) Due to their high efficiency, RTGs can handle successive lifting, lowering, and stacking operations for a larger number of containers.
- (2) There is a high container space utilization ratio in cross-block operations.
- (3) Thanks to the good mobility of RTGs, storage blocks can be used in a complementary fashion to promote operating efficiency.

However, RTGs also have some disadvantages, which include:

- (1) Diesel generator operation can lead to a high mechanical breakdown rate and high maintenance costs;
- (2) Heavy fuel consumption can increase operating costs, and
- (3) Exhaust emissions and noise can cause environmental pollution

Performance of different type of handling equipment

Today’s modern ports require equipment that can withstand constant demand while operating in demanding environments. Mechanical failures or breakdowns lead to down time which is both unacceptable and extremely costly.

Item	RTG	E-RTG	RMG
Mobility	Average	Average	Poor
Safety	Average	Average	Good
Operating system integration method	Wireless transmission system	Wireless transmission system	Fiber transmission system
Stability of Signal	Unstable	Unstable	Stable
Breakdown frequency	Average	Average	Low
Mechanical method	Hydraulic	Hydraulic	Electric control
Repair and maintenance time	Average	Average	Short
Energy source	Diesel	Diesel/Electric	Electric
Maintenance cost	High	High	Low
Air pollution	Severe	Zero	Zero

It could be argued that RTGs are the workhorses of the industry, since they are one of the most prevalent pieces of equipment used for container handling at Ports. The existing challenges for RTGs have revolved around how they interface with a number of yard terminal tractors in the transference of containers. The average number of gross container moves per hour currently is eight, and with the increasing demands for faster productivity, efficiency and safe operations, many terminals are seeking ways to improve. In recent years, due to the high costs of fuel, attempts have been made to reduce the utilization of RTGs. For many container terminals, RTGs constitute one of the largest users of diesel fuel, which can represent as much as 50% of total energy costs. One of the major attempts practiced by terminals aimed at negating this outlay has been to introduce hybrid motors and electrification.

IV. CONVERTING TO E-RTG SYSTEMS

E-RTGs combine several advantages of RTGs and RMGs; not only does electric drive reduce fuel costs, but the E-RTGs light diesel generators allow travel across different blocks to meet terminal operating needs. At present, E-RTG conversion methods consist of the bus bar, touch wire, and cablereel systems.

(1) Bus Bar System

In a bus bar system, power supply lines in the form of rigid slide rails are installed in the container yard. When E-RTGs are operating in the storage area, their diesel generators are switched off, and power is transmitted from the slide rails to the RTGs via current collecting devices. In contrast, when an RTG must move to another working area, it will switch off electric power and turn on its diesel generator to supply the power; after returning from the other blocks, it will switch off its diesel generator and resume use of electric power. Bus bar-powered RTGs equipped with online braking can reduce energy consumption by up to 60% and reduce local emissions by up to 95%. RTGs chiefly run on electricity drawn from the local grid, not from a diesel generator. The installation of bus bar-powered RTGs offers the advantages of a small project scale, low investment cost, and simple configuration (Duan, 2009).

(2) Overhead conductor system

RTGs can also access city power through an overhead conductor system, which is a concept adopted from electric trains. This type of system enables RTGs to obtain electric power from an overhead cable instead of a diesel engine, but an RTG can also start up its diesel engine so that it can operate while electric power is off. The advantages of this system include convenient inter-block operation, high mobility, and flexibility, while disadvantages include large investment costs during the conversion period and the need to consider the threat of lightning.

(3) Cable Reel System

Cable reel RTGs employ cable reels, control systems, cable brackets, electric supply cables, cable plugs, ground switch boxes, and other components. When an RTG travels along a traffic lane, the cable reel control system coordinates the speed of the cable reel with the speed of the RTG through frequency conversion control based on tension in the cable, and this tension control model also maintains the safety of the cable reel. When an RTG must travel to another block, the operator must first turn off the electric junction box safety switch, cutting the RTG's connection with city power, and then carefully pull out the plug connecting the equipment with city power. After the RTG has returned from the other block, the operator must plug in the electric junction box and resume operation in the city power mode.

RTG power cables can be installed through cable guides in underground trenches or aboveground cement trenches. An RTG can be moved from one container route to another by disconnecting the cable plug after switching off the power source, and the cable reel can be retracted using a small crane-mounted auxiliary engine.

The advantages of a cable reel approach include a high degree of flexibility, a logical, user-friendly interface, minimal infrastructure investment, low maintenance costs, manual connection and disconnection, ability to use an MV power supply, cost effectiveness, and unrivalled electrical connection safety (CAVO tec, 2011).

RTG power supply systems can be converted via overhead conductor, cable reel, and bus bar system approaches. The advantage of conversion via these three types of systems is that they do not require changes to existing equipment functions and characteristics.

Advantages of E-RTG systems:

- 95% savings of diesel consumption
- Reduction of operation costs up to 70%
- Reduction of maintenance costs (diesel generators) up to 70%
- Significant reduction of greenhouse emissions, noise pollution
- Automated aisle entry/exit for increased productivity

V. CONCLUSIONS AND RECOMMENDATIONS

Owing to the effect of the global financial crisis and high oil prices, every shipping company is endeavoring to explore and seek optimal solutions that will minimize operating costs and improve port pollution.

When assessing cost savings and environmental protection measures, shipping companies and terminal operators should consider the possibility of converting RTGs from diesel to electric power in order to achieve the goals of energy saving, noise abatement, and CO₂ reduction.

Now that the "green port" concept has prevailed at the international level over the past decade, the government of South Africa should act promptly to lessen carbon emissions in keeping with international

standards. Motivated by the need to lower container terminal operating costs, improve air quality in the port area, decrease pollutant emissions, and protect the physical health of personnel, converting diesel RTGs to electric power has become a vitally important issue.

The green terminal concept aims to ensure that ports embody the characteristics of environmental health, ecological protection, rational use of various resources, low energy consumption, and low pollution. Another aim is to ensure harmony between container terminal operations and human health, while fostering sustainable development of the port.

This paper believes that the green container terminal concept will guide future port development.

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