



Comparison and Selection of Twin 40 Quay Crane for Automated Terminal

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Abstract: Based on the selection of twin 40ft spreader headblock systems at automatic container terminals, we studied the dual hoist and single hoist quayside container crane (QC). We analyze the practical data of using the dual hoist QC, compare the structure and performance of three main headblock systems with twin 40ft container spreader's.

Conclusions from the data and analysis gathered, shows a preference to use a single hoist dual spreader headblock at Yangshan ports on the twin 40ft container quayside crane.

Keywords: dual hoist type of quayside container crane; single hoist type of quayside twin 40ft container crane; single hoist type of twin40ft spreader headblock system

Selection of twin 40ft spreader headblock systems in automatic container terminal

Since the 1990's following a global economic recovery, the international shipping market entered a new era of development. With these developments the container shipping market has developed the quickest. In recent years, the trends in developing and introducing larger container vessels has raised the requirement for increased port loading and unloading productivity.

Terminal's container loading and unloading efficiency mainly depends on the STS crane handling efficiency. Over the years equipment manufacturers have been increasing crane speeds to improve efficiency, but the room for improvement is not great.

Following the birth of the dual hoist ship-to-shore crane (*two sets of independent drive hoisting mechanism referred to as "dual hoist STS crane"*) and single hoisting double spreader ship-to-shore crane (*single set of hoisting mechanism with scissors type headblock or separable headblock and double spreader, referred to as "single hoist double spreader STS crane"*), it has opened a new avenue for improving the STS crane operating efficiency.

The current design for new automatic container terminals as well as those terminals under construction, the majority of which adopt the single hoist double spreader cranes, however the number of ports adopting the double spreader system and put this it into operation actually is not that many. Whereas a dual hoist STS crane has a large market share both at home (China) and abroad, especially in the Yangshan Deepwater Port Phase II, Phase III project, who already have 29 units.

This report provides a comparative analysis of the dual hoist STS crane and single hoist double spreader STS crane from an actual operational perspective. It serves as a reference for an automated terminal with dual spreader crane configuration selection.

1. Brief introduction of the dual hoist STS crane 1.1 Dual hoist STS crane application example

The first dual hoist STS crane which can handle two 40ft (12.2m) or four 20ft (6.1m) containers was successfully developed in 2004 (Figure 1). The operating efficiency can be theoretically increased by 50% - 60%. The introduction of the system has attracted widespread attention from ports all over the world.

From 2006 to 2010, the number of dual hoist STS cranes in use reached 277 at ports located in UAE Dubia, Singapore, Korea Pusan, Germany Hamburg, Malaysia PTP, Shenzheng Yantian port (YICT), Shanghai Yangshan port. Amongst these, Shanghai Yangshan port has 29 dual hoist STS cranes out of the total of 42 STS cranes installed at phase 2 and 3 terminals. At such a large scale and concentrated use of dual hoist STS cranes has a decisive effect on improvements of the overall loading and unloading efficiency and reforms the container handling process. It also positioned Yangshan deep water port container handling operation at a world class level.



Figure 1 Dual Hoist STS Crane

1.2 Dual hoist STS crane efficiency - real life example

On May 18, 2007, Phase 2 of the Yangshan port introduced 10 dual hoist STS cranes to load and unload China Shipping Lines "Ze bu Le Hv" container ship. In 7.5 hours of operation, they completed the handling of 5,182 TEU's. Hourly container handling rates overall reached 690.93 TEU's and the crane's highest hourly rate reach 97.70 TEU's. These hourly ship handling rates and crane hourly rates set new world records.

At the end of 2015, the Yangshan port dual hoist STS crane operations had rewritten the container handling world record 8 times consecutively (single crane: 135.75TEU's/hr). From these figures it can be seen that a dual hoist STS crane has a significant advantage in terms of operation efficiency.

1.3 The use of a dual hoist STS crane

Although a dual hoist STS crane can achieve a considerable level of operational efficiency for a single ship, however because the use of a dual hoist STS crane is not universal, ports are not using dual spreaders to load or unload ship's. As such, there are no opportunities for the continuous use of the dual spreader for operational purposes.

The full use of the dual hoist STS crane is restricted by various conditions such as the ship model, ship equipment, stacking plan, container trailer and system coordination, and the difficulty in alignment during operation. These contributing factors has made the use of the crane in dual spreader mode not as high as anticipated and not become the main mode of operation for a terminal. The full use of the

crane only serves as an auxiliary function or a function reserve of the crane.

At the same time, due to various factors such as high procurement cost, high energy consumption during single container lifting and higher breakdown rate has brought great pressure to the terminal operation. This can be seen in Table 1.

Table 1: Dual hoist STS actual operation data

Project	Dual spreader loading / unloading ratio (%)	Energy consumption per container	Maintenance cost	Breakdown rate
Yangshan Phase 2	22.2/18.1	1.13	1.08	1.67
Yangshan Phase 3	13.98/0.59	1.14	1.06	1.63

Note : the maintenance cost, energy consumption and breakdown rate for Single hoist STS crane are define as 1.0.

2. Single hoist dual spreader headblock

Due to reasons such as high price of dual hoist STS crane (higher than the single hoist STS crane by more than 1 million US dollars), not in high use due to many factors, high energy consumption and high operating cost, at present new design terminals or terminals under construction have not been selecting dual hoist STS cranes. Instead they opt for the more economic single hoist dual spreader crane to meet the daily requirement of a single hoist operation, while taking care of double spreader operations. The comparisons of the dual hoist STS crane, the single hoist double spreader crane and the standard STS crane are shown in Table 2.

Table 2: Comparisons of Dual Hoist T40 and Single Hoist T40 with a standard STS crane

QC	Crane total weight	Trolley weight	Hoist system	Electrical Room size	Boom weight	Price
Dual hoist T40	A lot heavier	15T heavier	One additional hoist system	4m longer	1m wider	A lot more expensive
Single hoist T40	Slightly heavier	5T heavier	Same	Same	Same	Slightly higher

Currently, major equipment manufacturers and spreader manufacturers that manufacture twin 40 headblock's are: the tandem headblock spreader system produced by Bromma, a split headblock developed by Stinis and Singflex which is a detachable headblock developed by RAM Spreaders.

2.1 BROMMA tandem headblock

BROMMA's tandem headblock spreader system is relatively simple in construction (Figure 2). The principle is to connect an adaptor frame under a standard headblock, and through the use of 8 chains connects to the two spreader's below. Due to its simple construction, the system is only able to fulfil the functions of spreader gap adjustment, skew and height differential. The headblock is not able to perform a side-shift function. Other than that, the chain connection between headblock and spreader is a flexible connection and hence the spreader's underneath the headblock will adopt a swinging/pendulum movement during operation. There will also be difficulties with aligning and landing onto containers. At the same time there will be potential dangers that the two containers may collide with each other. Currently, this type of spreader system is only used in a limited way in individual smaller terminals and has not been widely popularized.

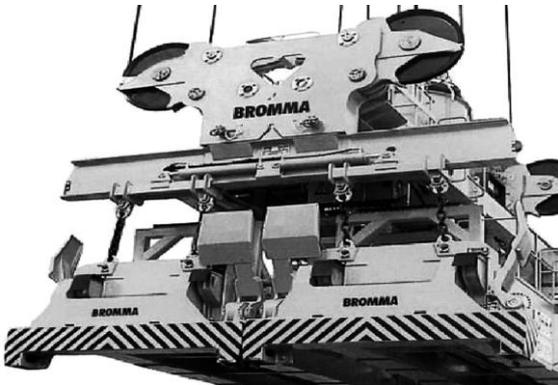


Figure 2 – Bromma tandem headblock

2.2 Stinis Split Headblock

As one of the world's largest container spreader suppliers, Stinis a Netherlands company, released the split headblock which employs full hydraulic control and through the use of 4 cylinders on the headblock, it can achieve the various functions of gap separation, side shift, height differential and skew and able to meet the actual operational conditions. Its technical parameters are ranked ahead of other similar products (Figure 3).

Due to its unique single pin connection between the headblock and the spreader's, the headblock is only suitable for use with Stinis spreader's and is not compatible for use with other brands of spreader. Also, during spreader changing, though it is a fully automated operation, the dedicated mobile trailer brings an inconvenience to spreader changing. This is especially so, for automated terminals and will affect its actual operation to a certain extent.

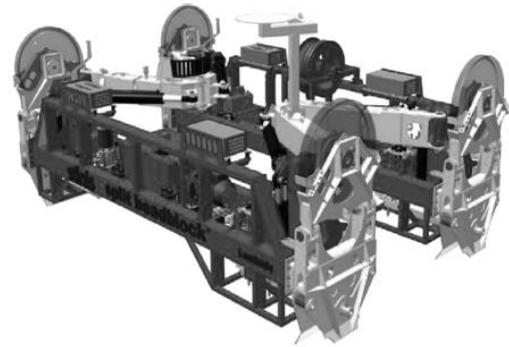


Figure 3 – Stinis split headblock

2.3 RAM Spreaders SingFlex detachable headblock

RAM's newly developed "SingFlex" Twin40 detachable headblock (Figure 4) is able to easily meet the twin spreader operating conditions of gap separation, height differential, side shift etc. The two independent headblock design does resolve compatibility issues of spreader interchangeability with other brands of spreader (although not compatible with Stinis spreader single pin connection method).

Due to its horizontal separation design, the headblock construction is light, simple and more compact. The overall height is only 3metres. In twin spreader operation mode, the headblock weight is 12.7T, in single spreader operation mode the headblock weight is 9.8T. This is an advantage in design of the crane lifting height and lifting capacity. RAM's SingFlex detachable headblock uses a dedicated docking station installed on the crane's seaside sill beam for single spreader to twin spreader mode change. The entire mode change process is completed within 90 seconds, completely without manual intervention.



Figure 4 – RAM Spreaders SingFlex detachable headblock

2.4 Dual spreader headblock comparison

The 3 types of dual spreader headblock, due to their difference in design philosophy, the structural characteristics and actual operation performance also differs. (see Table 3).

From 2012, the single hoist double spreader system has gradually been replacing the dual hoist spreader system and has become the mainstream configurations for a dual spreader crane system.

Table 3 - Main technical parameter of 3 types of headblock

Headblock	Spreader/HB height	Operation method	Difference in container loads	Gap between spreader	Spreader height difference	Spreader side shift	Spreader/compatibility with other spreader
Bromma	4.0m	Manual	HB slanted, uneven loading on chain	1.0m	0.7m	0	Non standard/Not compatible
RAM	3.0m	Auto(dedicated docking station)	HB remain leveled	1.5m	1.0m	0.25m	Standard/ compatible
Stinnis	3.6m	Auto (dedicated trailer)	HB remain leveled	1.8m	1.4m	0.9m	Non standard/Not compatible

3. Dual hoist STS crane and single hoist STS crane comparisons and selection

In the theoretical calculation, under lifting condition of 130T and above, the dual hoist STS crane performs better than the single hoist STS crane in terms of energy consumption. For lifting conditions of 65T and when the twin 40 ratio reaches a certain number, the single hoist dual spreader crane has a very obvious advantage in energy consumption. When dual spreader's are in operation at the terminal, for the majority of the time they are lifting empty containers. This may be the consideration and the reason why majority of terminals that are currently under construction have opted for the single hoist double spreader crane.

The Yangshan phase 4 automated terminal is currently the world's largest automated terminal and has during the early stage of construction already set the target for high efficiency and reliable operation container handling. The terminal has installed a large number of trolley target detection systems (TDS), spreader detection systems (SDS) on their automated STS cranes. They also use various technologies such as spreader anti-sway, anti-skew and self-positioning systems. These provide technical assurance for dual spreader operation.

After considering all references from Shanghai Port Group for dual hoist crane operations, Yangshan's Phase 4 Project have abandoned the selection of dual hoist cranes for their STS cranes along the berth and instead opted for the single hoist cranes with the double spreader headblock system.

After overall assessment, Yangshan Phase 4 automated twin40 cranes will use the SingFlex headblock manufactured by RAM. The main characteristics in terms of choice are:

1. **Lower price** – compared with dual hoist STS cranes, there is **saving of 1 million USD on the cost of acquisition**.
2. **Construction is simple and clean** – has the lowest height (at only 3.0m). For the same STS crane height it can achieve a higher lifting height.
3. **Lower weight** (50% lighter than a dual hoist crane under twin 40 operation mode) which is a big advantage on energy consumption.
4. **Dedicated fixed docking station** for twin spreader changing – **fulfilling a highly efficient automated change over**.
5. Equipped with a compatible headblock design which can fulfil the interchangeability requirements with a multi-brand of spreader.

4. Conclusions

1. The contradiction amongst high operational costs, actual utilization rates and the operating efficiency of the dual hoist STS crane has been well known by the respective parties. The two independent hoist systems lower the risk of crane stoppage caused by the breakdown of one of the hoist systems.
2. The single hoist double spreader for STS cranes, due to a lower capital cost, simple in construction, flexible and quick change over process has been accepted by more and more newly constructed container terminals. At the same time, it has also provided the existing terminals with a feasible option for single hoist STS cranes to fulfill twin spreader operation.

