DUAL-HOIST, TANDEM 40 CRANE CONSIDERATIONS

By: Michael A. Jordan, S.E., Liftech Consultants Inc.
Feroze R. Vazifdar, S.E., Liftech Consultants Inc.
Patrick W. McCarthy, P.E., Liftech Consultants Inc
Larry Wright, P.E., McKay International Engineers

February 6, 2007

BACKGROUND

An increasing number of terminals are considering tandem 40 cranes. This report provides Owners with information on the status of the dual hoist, tandem 40 (DHT40) cranes, how they operate, and the available options.

CURRENT DESIGNS AND CHARACTERISTICS

Conventional Single-Hoist, Twin Lift Cranes

The conventional dockside container crane has a single hoist and a single spreader with a rated load of up to 65 LT. The hoist may be in a fixed machinery house supported on the trolley girders with the main hoist ropes running to the trolley (rope trolley crane), or the hoist may be on the trolley (machinery on trolley crane or MOT).

The single-hoist crane picks a single 20', 40', or 45' container, or two end-to-end 20' containers (twin-20s), under a single spreader.

Two Styles of Tandem Lift Cranes

"Tandem" means side by side, rather than end to end, in this case. End-to-end lifts are called "twin" lifts. Tandem lift cranes are designed to lift two 20', 40', or 45' containers as well as a single 40' or 45' container on one hoist with twin-20' containers on the other hoist, or four 20' containers (tandem twin-20s).

Single-hoist, tandem lift cranes have a single hoist with one set of falls and a single headblock. The headblock may connect to a special spreader system capable of attaching to two containers in tandem, as shown in Figure 1. Alternatively, the headblock may be separated and be connected to two spreaders, as shown in Figure 2.

Dual-hoist, tandem lift cranes have two main hoists, two sets of falls, and two headblocks. Each headblock connects to a conventional spreader.

A California Corporation 344 - 20th Street, Suite 360, Oakland, CA 94612-3593 1-510-832-5606 Fax: 1-510-832-2436 www.liftech.net

Single-Hoist, Tandem Lift Cranes

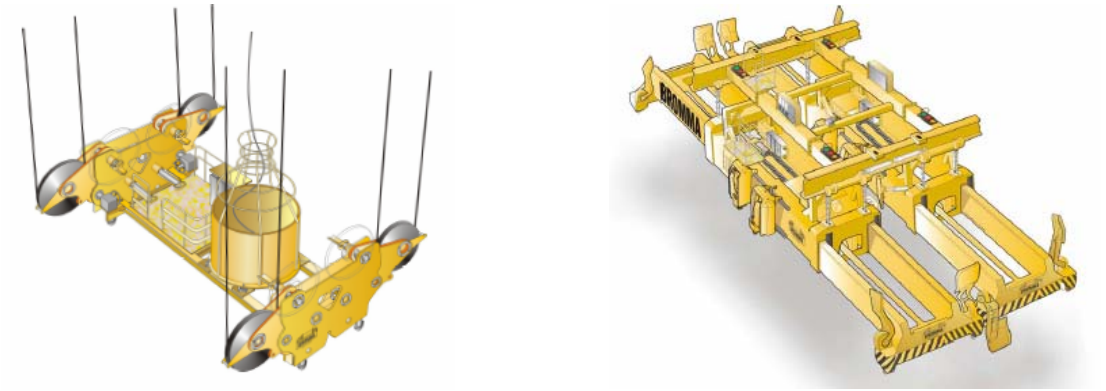
The following discussion regarding single-hoist, tandem lift cranes is presented for information only. We do not recommend using single-hoist, tandem lift cranes.

At some terminals, a special spreader is attached to a single headblock, so the crane can pick two containers in tandem simultaneously. This approach may be considered for retrofitting existing cranes, especially if the terminal handles a large number of empty 40' containers. There are significant limitations, however:

The two lift systems are inseparable. The combined lift system must be used for every lift. This will present problems within certain ships' cells. Also, the energy usage will increase, and if there is a headblock or spreader problem, the entire crane needs to be taken out of service, whereas a tandem-hoist crane could still be operated, but in a single-hoist mode.

The single main hoist system is large. To accommodate the increased lifted load, larger motors, brakes, ropes, sheaves, etc. are needed. For retrofits of existing 65 LT capacity cranes, the single main hoist system will likely be insufficient except for empty or lightly-loaded tandem lifts.

If the container weights are not balanced, the spreader needs to be side-shifted under the headblock.



See www.bromma.com

Figure 1: Bromma single-hoist, tandem headblock and spreader

See www.stinis.com

Figure 2: Stinnis single-hoist, tandem lift system with specialized headblock

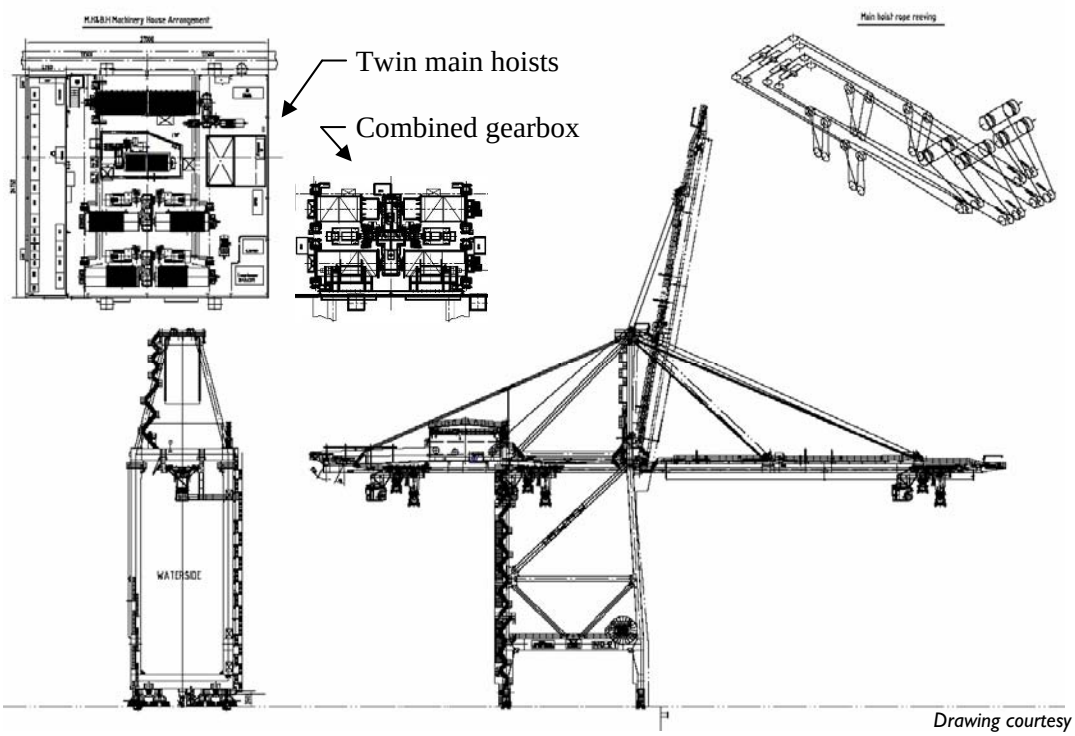
Dual-Hoist, Tandem Lift Cranes—DHT40 Cranes

To our knowledge, ZPMC is the only crane manufacturer to have built dual-hoist, tandem lift cranes. Figures 3–7 are from ZPMC projects. ZPMC has provided tandem lift cranes for Dubai Port Authority, Yantian International Container Terminals, and other PRC terminals. ZPMC has new orders for at least 45 DHT40 cranes. We expect other manufacturers will soon supply dual-hoist, tandem lift cranes.

The DHT40 crane has two main hoists in a fixed machinery house on the trolley girders. There are two sets of main falls. The main fall hoist ropes feed through turning sheaves for the combined snag protection and trim, list, and skew system at the landside end of the trolley girders. The ropes then lead through centenary trolleys, to the main trolley, to sheaves on the headblocks, back to the trolley, and finally to dead ends at the waterside end of the boom.

Each hoist system is independent. The ropes for each system run in parallel. Each system is the same as a conventional single-hoist system. The systems run parallel to each other.

ZPMC manufactures two styles of main hoist machinery: One with a single, combined gearbox, and one with two independent gearboxes. See Figure 3. We recommend a design with two independent gearboxes.



Drawing courtesy of ZPMC

Figure 3: DHT40 crane arrangement showing DHT40 machinery house arrangement with twin main hoists and alternative combined gearbox

There are some differences when comparing a DHT40 crane to a conventional single-hoist crane. The most significant differences for the DHT40 crane are:

Operator console is more complex since the operator needs to control two hoist systems

Two main hoist systems in the machinery house

Increased energy consumption

Two sets of reeving systems

Larger trolley, twice as many sheaves, and stowage accommodations for one or two headblocks (with or without spreaders)

Two headblocks and two spreaders

Specialized headblock devices

Ancillary devices to help the operator "see" what is happening

Crane is heavier and wheel loads are large

Detailed Characteristics of and Considerations for a Recommended DHT40 Crane

General Arrangement and Capacity

Rated Capacity—80 LT total on two hoists: the rated landside spreader load is 65 LT, the rated waterside spreader load is 40 LT or 65 LT, and the total combined load on both spreaders is limited to 80 LT. A 120 LT rated load may be considered if the yard operations, including inter-box connector (IBC) removal, can handle tandem, twin-20 lifts.

Rail Gage—30.48 m (100 ft) is the standard. Some new terminals are using 35 m (114.8 ft).

Wharf Loading

Tandem lift cranes are heavier and have greater corner wharf loading compared to conventional single-hoist cranes. Dead loads for a tandem lift, 80 LT crane are approximately 30% greater and operating wheel loads are approximately 40% greater than the corresponding loads for conventional 65 LT cranes with a 30.48 m (100 ft) rail gage. Storm wharf loads are also greater due to the increased surface area.

Speeds

The speeds are the same as for recent single-hoist cranes.

Operation

Single and tandem modes

The DHT40 crane can operate in either a single- or dual-hoist mode. During single-hoist operation, the waterside or landside headblock and spreader are lifted into special guides on the trolley underside and held in place by the hoist ropes. Single-hoist operation is the same as for a conventional single-hoist crane.

Tandem-hoist operations are much more complicated than single-hoist operations. The operator has more controls to manipulate.

When two containers are hanging, they must be latched together so they will not collide during normal operations. The latching system needs to allow for list, trim, relative and absolute skew, differentials in longitudinal and transverse relative positions, and different-height adjacent containers. The latches must also automatically release if one container snags or if for some other reason, moves too far away from the other container.

When hanging headblocks are accidentally or intentionally unlatched, they cannot be moved quickly or they may collide. Headblocks must be latched or unlatched in any one of these four situations:

1. The headblocks are near the upper hoist stops, where load swing is minimal.
2. The spreaders are in the cell guides.

3. One spreader is connected to a container on the ship's deck, and the second spreader is leaning against the same stack.
4. The containers are resting on the wharf.

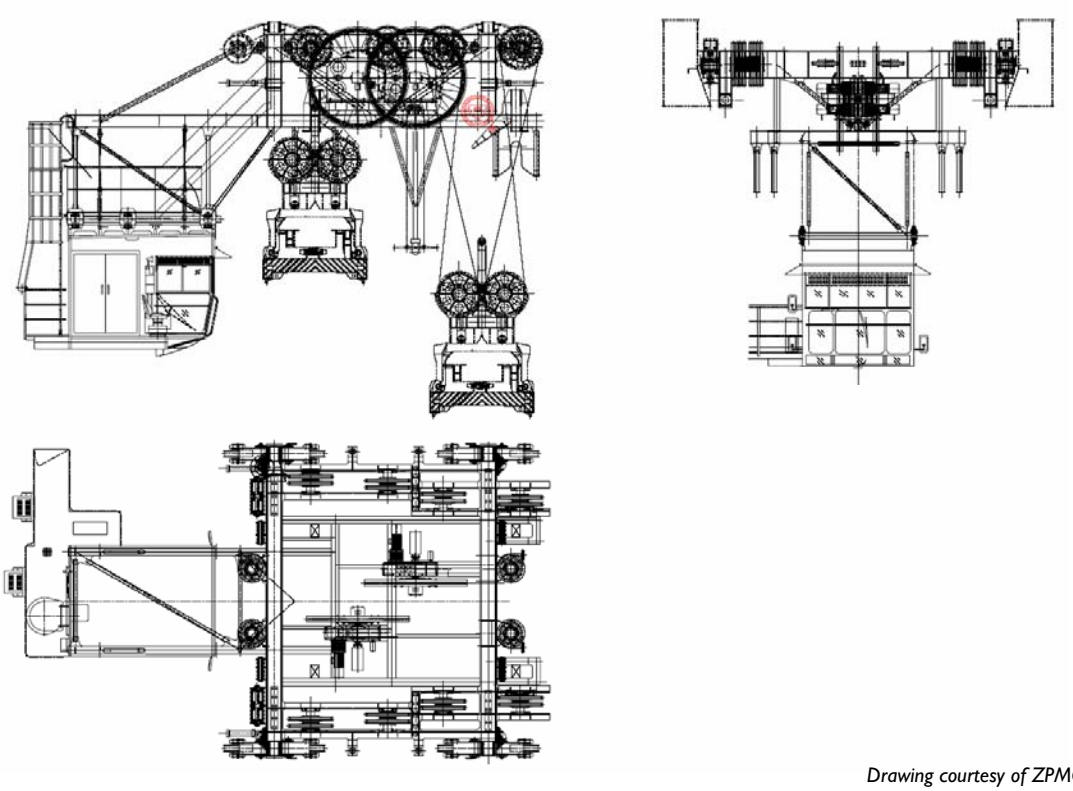
Notice that if the headblocks are unlatched, they cannot be re-latched in the air.

Clear spacing between containers

When containers are set on or picked from the wharf, they need to be separated approximately 1300 mm (51.2 in) for typical chassis operations or 1500 mm (59 in) for straddle carrier operations. When guided into the hold or set on the vessel deck, the distance needs to be reduced to the absolute minimum.

Trolley

The trolley must accommodate two separate sets of main hoist reeving and must provide stowage for unused headblocks and spreaders. Special guides are provided to position and hold the headblock and spreaders securely. The trolley may be operated with one spreader stowed and one loaded. The structure is designed to be safe if it collides with the stops with any combination of lifted or stowed loads. See Figures 4 and 5.



Drawing courtesy of ZPMC

Figure 4: DHT40 trolley arrangement showing the landside hoist stowed (the trolley is designed to stow either or both headblocks)

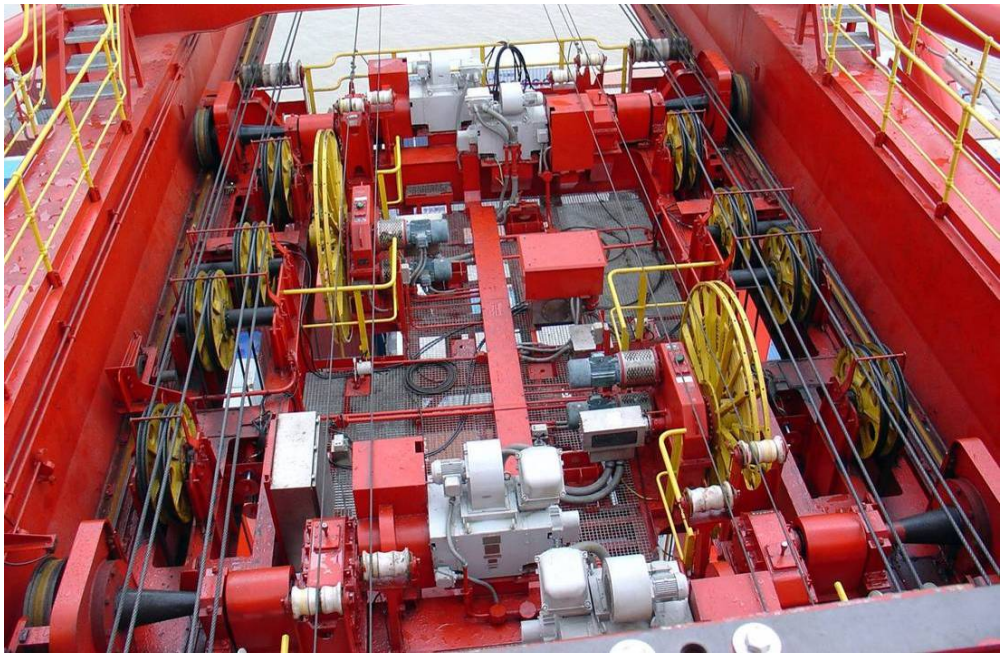


Figure 5: DHT40 trolley (looking from landside to waterside)

Headblock

The headblocks are complicated. See Figures 6.

Clamping mechanisms latch and unlatch the headblocks to and from each other. These mechanisms control the relative positions of the containers. They must release automatically if a snag occurs or if there is excess relative movement between the containers.

Electronic level sensors on both headblocks sense and report trim and list angles. These have not been very reliable on existing cranes and have not been very useful due to load swing. This problem is secondary only and does not interfere with the dual-hoist operations when the sensors are not working.

Encoders measure and report the positions of the separating cylinders and support cylinders that control the clamping mechanism. The encoders have been reliable.

The waterside and landside headblocks each have their own hydraulic systems.

Figure 6: DHT40 headblocks (latched and unlatched)

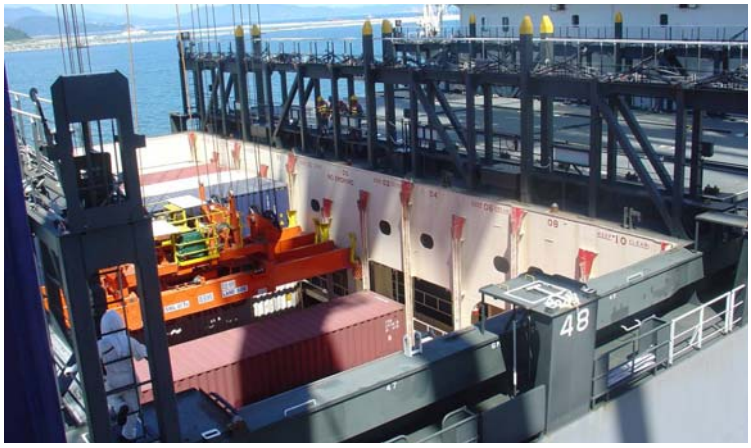


Figure 7: Dual-hoist operations within a ship's cells

Latch mechanism

The latch system includes control cylinders and a clamping mechanism. The clamp can open rapidly, allowing disengagement if the movement between containers is excessive.

During normal operation the latch is engaged whenever the containers are suspended above the wharf, vessel deck, or cell guides. Once the containers are engaged by the cell guides, the latch may disengage, allowing for additional clearance below deck level. On many vessels, there are no obstructions between the below deck cells, and the latches would not need to be disengaged. See Figure 7.

If the latch is disengaged in the cells, the operator would need to reengage before the containers are free from the cells. This takes some time.

Separation and deferential positioning

Hydraulic mechanisms control the latch arms. These mechanisms must provide enough movement to allow the spreader to pick adjacent containers with a 500 mm (19.7 in) difference in height at the full container separation. They also accommodate a difference in longitudinal positioning of 200 mm and a relative skew between containers.

List trim skew

Individual headblock list, trim, and skew is controlled by the system on the landside end of the trolley girder. The latch cylinder must be able to allow for increased cylinders motions due to these movements.

Spreader

Conventional spreaders are attached to the headblocks.

Operator's cab

Since the dual-hoist operation is more complicated, the operator's controls are more complicated. The existing controls are difficult to use and seriously reduce production. New cab and control arrangements are being developed to solve this problem.

Special sensing and visual devices

Some devices will be required on the trolley and possibly the headblock, to allow the operator to "see" behind the waterside (and perhaps landside) containers when the containers are being positioned. Cameras and other devices have been successfully used on headblocks. The required devices are expected to perform satisfactorily on the DHT40 crane.

Special operations on the wharf

Separation

Clearance is necessary for separating the containers on the wharf for chassis or straddle carrier operations. See *Separation and deferential positioning*, above.

IBCs

During normal operations of conventional cranes with single containers, one worker is typically stationed on the wharf at each end of one container. Each worker removes one IBC, tosses it into a cage, and then removes the other IBC. The crane operator can then move the load while the workers put the second set of IBCs into the bucket.

During DHT40 operations, the worker will need to remove three IBCs, tossing each into the bucket, and then remove the forth IBC before the crane operator moves the load. This will take more than twice as long as for conventional operations. If four, instead of two, workers remove IBCs, the time should not be increased.

Depending on labor restrictions, IBCs may not be able to be removed from tandem, twin-20s, since the worker would need to get between the containers at mid-length. This could be a problem. The operation may not support handling twin and tandem arrangements simultaneously.

Machinery house

The machinery house is larger than that of a conventional single-hoist crane to accommodate the extra main hoist machinery.

Training operating instructions and logic

Proper training and operating instructions should be required. DHT40 specifications need to be drafted so the Owner or Owner's consultants can assist the crane manufacturer with this, if needed.

Performance

A well planned yard is essential to realize the full potential of the DHT40 cranes.

Liftech's CraneSim application has been used to predict production for previous projects. Productivity simulations depend on accurate dwell times and other data, which vary from terminal to terminal. However, some reasonable, generic predictions can be made:

Possible production could be 45 to 50 container moves per hour, about 50% above current production. A conservative expected increase is 30%. To accomplish this, the operator will need to be properly skilled and the yard will need to remove and deliver containers from and to the crane when the crane is ready.

Expected production is reasonably at least 40 container moves an hour provided the yard can keep up.

Costs

Initial

This is the cost of the purchase and related expenses. We expect the initial crane costs to be 1 to 2 million US dollars in addition to the cost of a conventional single-hoist crane.

Lifetime

This is cost of operation, energy, and maintenance.

One operator controls the crane, so the operator cost per hour will be the same as for a conventional crane. If two workers handle IBCs, this cost per hour will be the same but production will suffer to a minor degree since twice as many IBCs need to be handled. If four workers handle the IBCs, the hourly cost will double but production will increase.

Power will be more, but not twice as much as a conventional crane.

Maintenance will be more since there are two hoists, two hoist systems, two complicated headblocks, two spreaders, and a more complicated trolley. We are unaware of problems with the headblock hydraulic systems so far, but DHT40 cranes have not been in operation long enough to properly track the systems, and there may be usage-related problems in the future.

A port's operating and maintenance staff can help estimate these costs.

Options

Owners facing some uncertainty about the DHT40 cranes may consider some options. Using 65 LT hoists for the waterside and landside systems provides the option to switch to a single-hoist, 65 LT capacity crane and use the unused hoist components as spare parts. Alternatively, a DHT40-ready, single hoist crane can be purchased and the second hoist can be added later. Purchasing all dual-hoist cranes, but initially leaving the waterside hoist unreeved on all but one of the cranes is also an option; the other cranes can then be reeved later, once any problems associated with tandem-lift operations are worked out (as may be the case if the yard operations are initially unable to keep up with the tandem-lift operations).

The options above reduce the economic risk if the DHT40 cranes are not a viable solution at some time. The best option would depend on the purchase cost, cost of converting, and the affect of the down time.

Labor issues

We recommend the purchaser engage the labor in the DHT40 crane procurement decision making process. Acceptance of new technology by labor is difficult to predict. Although the production can be much higher, the working team will need to cooperate to make the new system work.

SUMMARY AND RECOMMENDATIONS

We have presented a number of salient issues based on our experience with hundreds of conventional cranes and a relatively small number of DHT40 cranes built by ZPMC.

The DHT40 cranes present a challenge and opportunity. The problems with the prototypes will eventually be solved. New DHT40 crane owners will be able to benefit from the lessons learned by others. We believe that DHT40 cranes will significantly increase production, but this depends on an equally productive yard operation.

We recommend the Owner carefully investigate initial and lifetime costs, applied vs. allowable wharf loading, and yard operations prior to procuring DHT40 cranes.