GREENING PROCESSES
ON CONTAINER TERMINALS

New Generation Integrated Container Terminals
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CONTENT

1. PREFACE

Improving the current processes on container terminals is a vital issue regarding the greater volumes, expanding port capacity, speeding up deliveries, increasing reliability and bringing down costs. Optimization of processes is an important goal but it is only one side of the story. Making terminals more eco-friendly should be the other side. Reduction of CO_2 emissions and energy consumption, and reducing the use of raw materials fits in this picture. Generation of local produced green electricity and regeneration of own energy are the challenges in the next decade. All these objectives are in line with each other and reinforce each other in several aspects.

2. ENERGY AND ENVIRONMENT

On one hand optimization of logistic processes on container terminals will have its influence on energy consumption in particular by the number and size of the movements to be performed.
On the other hand modernization of the equipment and where possible a rigorous switch to another form of logistics operations could play an even greater role. In case of new to be built terminals, the most favourable solution can be chosen immediately, but in case of reconstruction of existing container terminals it is more complicated and a phased implementation is more likely.

3. THE IMPACT OF EQUIPMENT

Mainly in the consideration of the environmental impact is the quantity of energy consumption by the equipment even when as much green energy as possible is used. Although the energy consumption of rolling equipment is of course dependent on many factors such as shape, dimensions, speed, rolling resistance of wheels etc., we limit ourselves here to the own weight which is the most normative factor in de comparisons. Considering the transport of containers from ship-to-shore cranes to the stack area (and vs) we distinguish: Straddle Carrier (SC), Shuttle Carrier (SHC), Automated Guided Vehicle (AGV) and Lift AGV.

Considering the transport of containers inside the stack area we distinguish Straddle Carrier (SC), Rail Mounted Gantry crane (RMG), Rubber Tired Gantry crane (RTG) and Overhead Bridge Crane (OHBC). Although the maximum weight of a container is about 40 tons, the average weight of a container that must be transported on the terminal we assume 12 tons which leads to the next table.

	Equipment	Assumption own weight in ton	Ratio to container of 12 ton	Remarks about spreader	Operational area
m	SC 1 over 2	62	5,2 : 1	incl. single spreader	STS + stack
m	SC 1 over 3	68	5,7 : 1	incl. single spreader	STS + stack
m	SC 1 over 2	71	5,9 : 1	incl. twin spreader	STS + stack
m/a	SHC 1 over 2	52	4,3 : 1	incl. single spreader	STS
a	AGV	25	2,1 : 1	not applicable	STS
a	Lift AGV	34	2,8 : 1	not applicable	STS
a	RMG / ASC (10 wide)	300	25 : 1	incl. spreader	stack
a/m	RTG (10 wide)	260	21,6 : 1	incl. spreader	stack
a	OHBC (span ± 30,50 m)	30	2,5 : 1	incl. spreader	stack
a = automated operation m = manned operation					

It is interesting to see in the STS area the difference between the own weight of the SHC 1 over 1 and the own weight of AGV / Lift AGV. However they execute the same function, the AGV has to travel a longer distance which reduces the advantage in energy consumption a little. In the stack area the own weight of RMG and RTG depends of the span and will therefore vary between 260 tons and 300 tons for a span of 10 containers wide. The ratio compared to the OHBC which has a comparable stack density is roughly a factor 10.

4. GREENING THE STACKING PROCESS

Energy saving and reduction of emissions these days is getting the attention it deserves. After all, as long as we continue to use equipment whose own weight is almost twenty times greater than the average weight of the container to be moved, a lot can be won for that matter. And when at the same time the number of moves in the stacking process can also drastically reduced, we can make great strides in greening the stacking processing. For example, let us look at a container terminal with a quay length of 1.000 meter and a yearly throughput of 2.000.000 TEU. We consider the usual moves by the stacking cranes starting with picking up the container at the seaside of the stack lane and drop of that container on the truck at the landside of the stack lane. Further we assume a stack lane length of approximately 250 meter, a stacking height of 5 layers, a 20 tons weight of the container which has to be moved and the same driving- and lifting speed for both RMG / ASC and the OHBC.
For the own weight of the RMG / ASC we assume 250 tons.
For the own weight of the OHBC we assume 30 tons.

Globally speaking the resulting energy consumption of the RMG / ASC configuration is more than twice as much as that of the OHBC configuration for equal stacking performance. In case of longer stack lanes this difference will grow. This greening effect results at the same time in a great financial advantage as well.

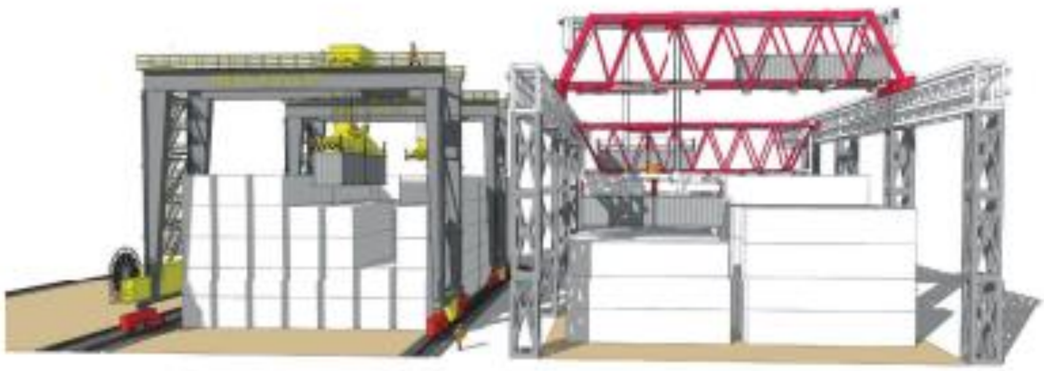
5. PERFORMANCE STACKING PROCESS

The current need for cleaner and energy saving processes will only be a sufficient reason to make a radical change in stack operations if it will actually lead to higher performance at the same time. Up till now a limitation or a reduction of the own weight of the rolling stacking equipment came never in the first place. And now, just greener processing even without performance degradation will not be enough. Greener processing will only be acceptable if it is accompanied by a significant better performance an a significant cost reduction compared to the current practise. In view of the large difference in own weight between the RMG/ASC, and the OHBC it is necessary to go Into both processes in more detail. Although it must be mentioned that as far as the use of raw materials is concerned, the much lower own weight of the OHBC is largely offset by the weight of the support structure. But the support structure consumes no energy during the operation process and retains a residual value for reuse.

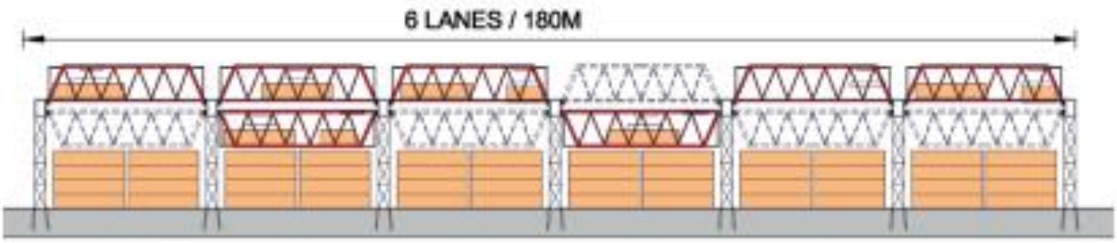
The level of automation of the RMG / ASC process on one hand and the OHBC system on the other hand is the same.

6. EXPLANATION OF THE OHBC STACK OPERATIONS (SEE FIGURE 1)

Part of the NGICT (New Generation Integrated Container Terminals) concept is that the stack operations are executed by means of special overhead cranes (OHBCs). The OHBCs are able to pass each other in one and the same stack lane which makes it easier to follow production changes between waterside and landside demands. And even more important is the significant reduction of moves and consequently the saving of energy. These special OHBCs are made in two models, one with a so called ‘under frame work’ and one with an ‘upper frame work’. The rails for the ‘upper OHBC’ and for the ‘under OHBC’ are connected to one common girder (see figure 1) supported by common columns. The height of the columns can be attuned to the number of stacking layers of containers. One of the many advantages of the special OHBCs compared to the traditional overhead cranes is a significant lower own weight and therefore a lower energy consumption and a considerable reduction on the material quantities for the support structure. The columns of the support structure can be designed in steel as well in concrete. The girders of the support structure can be designed in reinforced concrete, in prestresses concrete or in steel. And even combinations of these structural materials are possible, and these will usual be tailored to the local and economical and maintenance dependent conditions. For more information about the OHBC system please refer to the website www.ngict.eu.



RMGs STACK DENSITY 1500 TEU / HECTARE
STACK 1 OVER 4. CONTAINER PERPENDICULAR TO THE QUAY



OHBCs STACK DENSITY 1900 TEU / HECTARE
STACK 1 OVER 4. CONTAINER PARALLEL TO THE QUAY

Figure 1

7. MULTIPLE COMPARISON BETWEEN OHBC, RMG AND SC IN STACK OPERATIONS

For a multiple comparison between OHBC, RMG and SC we refer to the study report doc.no. 100-025-G02-R-026 revision B dd. 24.11.2020 that can be downloaded from the website https://ngict.eu/wp-content/uploads/2021/04/R-026-Multiple-comparison_Revision-B.pdf. This study is based on a quay length of 1.000 meter, and worked our for a series of 6 terminals with only truck handling at the landside and another series of 6 terminals with both truck- and train handling at the landside. With regard to the financial figures mentioned in this report, we would like to point out that at that time there was no war in Ukraine and no Corona pandemic. But the resulting increase in costs is not expected to detract from the equation.

8. SUMMARY OF COMPARISONS SHOWED IN REPORT R-026

8.1 Comparisons terminal T1 to T6 with only truck handling at the landside

Comparison of the normative factors; only vessel to truck	OHBC	ARMG	SC
Subject	Average (T1 + T2)	Average (T3 + T4)	Average (T5 + T6)
Land occupation (hectare)	35,25 = 100%	42,85 = 122%	53,70 = 152%
Stack density Stack area + transfer area (TEU per hectare)	1.753 = 100%	1.302 = 74%	825 = 47%
Yearly throughput per hectare land occupation (TEU)	61.628 = 100%	48.036 = 78%	35.341 = 57%
Peak capacity yard handling on water side * (container moves per hour)	775 = 100%	468 = 60%	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	620 = 100%	312 = 50%	259 = 42%
Total investment costs (Euro) (x 1.000.000)	174 = 100%	216 = 124%	151 = 87%
Investment costs per TEU stack capacity (Euro)	3.750 = 100%	4.495 = 131%	3.718 = 99%
Investment costs per TEU thoughput per year (Euro)	80,36 = 100%	105,80 = 132%	82,96 = 103%
Operational costs per TEU throughput per year (Euro) (maximal performance)	11,67 = 100%	17,29 = 148%	31,65 = 271%

* If 2 containers at the same time inside the OHBC would be transported the handling capacity could be about 900 cmph.

8.2 Comparison terminal T7 to T12 with both truck- and train handling at the landside

Comparison of the normative factors; vessel to truck + train Subject	OHBC Average (T7 + T8)	ARMG Average (T9 + T10)	SC Average (T11 + T12)
Land occupation (hectare)	39,85 = 100%	51,0 = 128%	65,25 = 163%
Stack density Stack area + transfer area (TEU per hectare)	1.545 = 100%	1.070 = 69%	672 = 44%
Yearly throughput per hectare land occupation (TEU)	54.494 = 100%	40.368 = 74%	29.015 = 53%
Peak capacity yard handling on water side * (container moves per hour)	775 = 100%	468 = 60%	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	620 = 100%	312 = 50%	150 = 39%
Total investment costs (Euro) (x 1.000.000)	198 = 100%	249 = 126%	178 = 90%
Investment costs per TEU stack capacity (Euro)	4.260 = 100%	5.713 = 134%	4.418 = 104%
Investment costs per TEU thoughput per year (Euro)	91,04 = 100%	123 = 134%	95,03 = 104%
Operational costs per TEU throughput per year (Euro) (maximal performance)	13,78 = 100%	22,20 = 161%	34,26 = 248%

* If 2 containers at the same time inside the OHBC would be transported the handling capacity could be about 900 cmph.

9. CONCLUSION

Under pressure from the world wide requirements to reduce CO_2 emissions, reduction of energy consumption and reducing the use of raw materials, the container terminal operators and crane manufacturers will have to consider efforts to make the terminal processes greener. If we exclude fossil fuel powered vehicles like straddle carriers in this article, it is interesting to compare the differences in electricity powered means of container transport. In this comparison we zoom in on the efficient use of energy in general, regardless wether it is generated sustainably. After all, one does not have to generate nor distribute energy that one does not need. Although the extent to which energy can be saved depends on may factors, we calculated that generally speaking replacing RMG / ASC with OHBC could save about 60% on the total energy consumption in the stack operations. Whether or not this will be enough to speed up implementation is difficult to predict.

In case of new to build terminals it looks logically that apart from this reduction of operational costs by energy saving, all other advantages as mentioned in table 8.1 and 8.2 will be reason of investigation in the design phase of a project. Implementation of the OHBC system within the stackoperations of an existing RMG terminal will be a bigger challenge which will mainly depend on the age of the terminal.

In case of expansion of an existing RMG / ASC terminal, the choice for an additional OHBC stack area could be investigated.

In case of an existing Straddle Carrier terminal a phased implementation of OHBC stack lanes would immediately save a lot of space and greatly reduce the operating costs.

Note
For previous publications on the NGICT-OHBC concept see “A NEW CONCEPT IN HANDLING MEGA-SHIPS, Part 1, 2 and 3 in 2014-2016 in PTI.

About the author
Frans Koch, founder of the Koch Consultancy Group (1994), forms together with his son Mathé, the general manager of the team of engineers and architects in the Netherlands who constitute Koch Consultancy Group. Both Frans and Mathé are registered designers and hold a PMSE in structural engineering.

About the organization
Koch Consultancy Group consists of Raadgevend Ingenieursburo F. Koch B.V., Allant Architecten B.V. and Koch Projectmanagement, a local multidisciplinary organization of consultants, architects and engineers. Its portfolio concentrates on projects in favour of industry, harbour and marine structures, civil works, buildings, energy production plants and wind turbines.

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