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# Optimization of unconventional bulk and tank ship hulls

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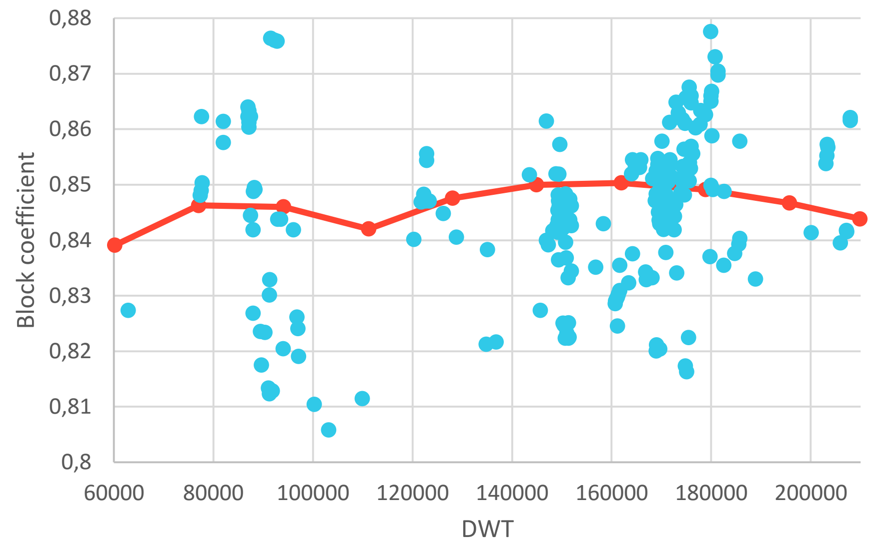
## Conclusion

Using numerical calculations methods the optimum block coefficients of a Capesize bulk carrier wrt. to brake power is found to be in the range of 0,73-0,78, when disregarding traditional dimensional limitations. This is in unlike the results found using empirical methods, which show reduced brake power for reduced block coefficient. Compared to todays fleet new builds should have an increased breadth to reduce the block coefficients and required brake power.




*A regression analysis of the world Capesize bulk carrier fleet show a block coefficient significantly above the optimal found in this thesis of 0,73-0,78.*

## Introduction

International shipping represent 80% of world trade and 2,8% of world green house gasses. By 2025, all new ships will have to be 30% more energy efficient than those built in 2014. Traditionally bulk carriers have been built to minimize construction cost and maximize cargo-carrying capacity, within traditional dimensional limitations. This has lead to designs with high block coefficients and poor hydrodynamic capabilities.

## Aim of thesis

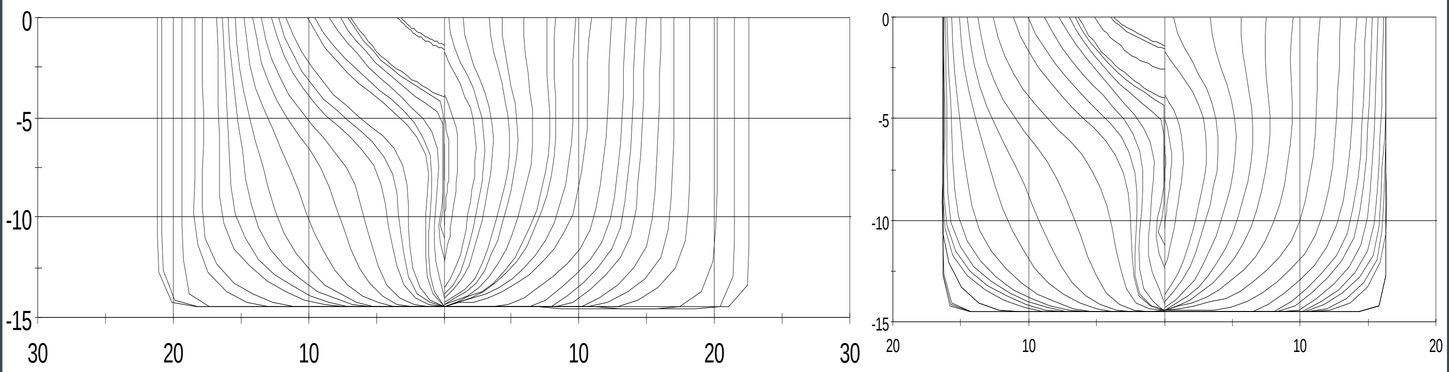
Lindstad (2013) uses an empirical method to investigate the effect of reduced block coefficient on brake power for bulk carriers. Empirical methods have a weakness when applied on unconventional hull designs deviating from the hulls they are based on. This thesis aims to investigate the same effect using numerical methods, finding an optimal block coefficient of Capesize bulk carriers (dwt>85 000t) wrt. brake power.

## Method

Two ship series was designed based on the vessels Toucan Arrow and KVLCC2. For each series the length, draft and displacement was kept constant while the block coefficient was varied with the breadth. The designs disregard traditional dimensional limitations e.g. canals.

| Series | Lenght | Draft | Cb | Breadth | Δ |
|---|---|---|---|---|---|
| Toucan Arrow | 224 m | 14,5 m | 0,64-0,87 | 32,2-45,1 m | 96 300t |
| KVLCC2 | 246 m | 14,5 m | 0,59-0,80 | 32,6-45,2 m | 93 000t |

The calm water resistance of each hull was calculated at 13 knots using panel method. The required brake power in waves was calculated using ShipX with wave conditions for the North-Atlantic and applying the method presented by Gerritsma and Beukelman (1971). This was compared to the empirical results predicted with Lindstad (2013) and Holtrop and Mennen (1984) using the main dimensions of the hulls.

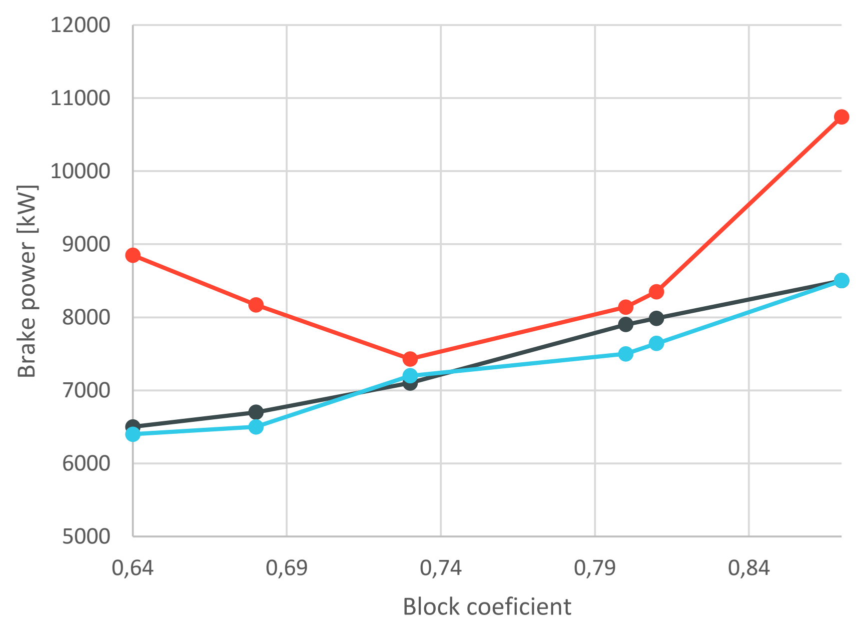


*The widest (Cb=0,59) and narrowest (Cb=0,8) design of the KVLCC2 series*

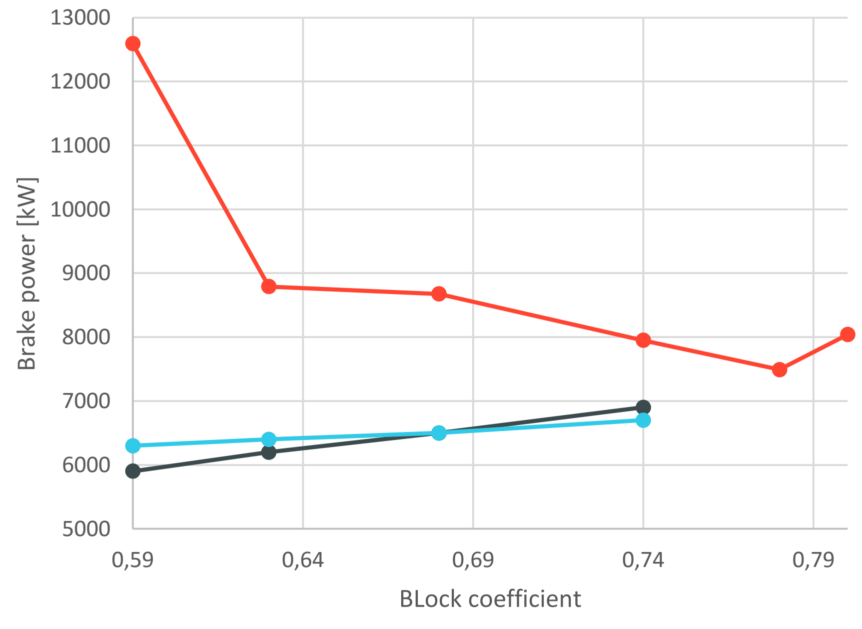
## Results

The empirical results based on Lindstad (2013) and Holtrop and Mennen (1984) show a declining trend for reduced block coefficients for both series. Decreasing the block coefficient by increasing the breadth will at some L/B-ratio increase the wave resistance due to sharp shoulders causing pronounced shoulder waves and vortex separation. This resistance increase is not seen in the empirical results.

The numerical results from the two design series show a equal or higher brake power than predicted by the empirical methods at 13 knots. The key the trends and how the brake power requirement develops as a function of block coefficient for the two design series.




*The Toucan Arrow series numerical calculations show a clear optimum at Cb=0,73 compared to the declining Lindstad and Holtrop results*




*For the KVLCC2 series the numerical calculations optimum is shifted to Cb=0,78 unlike the declining results of Lindstad and Holtrop.*

## References

**Gerritsma, J., & Beukelman, W. (1971)**. *Analysis of the resistance increase in waves of a fast cargo ship* (Vol. 334). Delft: Laboratorium voor Scheepsbouwkunde.
**Holtrop, J., & Mennen, F. (1984)**. A statistical re-analysis of resistance and propulsion data. *ISP, 31*(363).
**Lindstad, H., Jullumstrø, E., & Sandaas, I. (2013)**. Reductions in cost and greenhouse gas emissions with new bulk ship designs enabled by the Panama Canal expansion. *Energy Policy, 59*, 341.