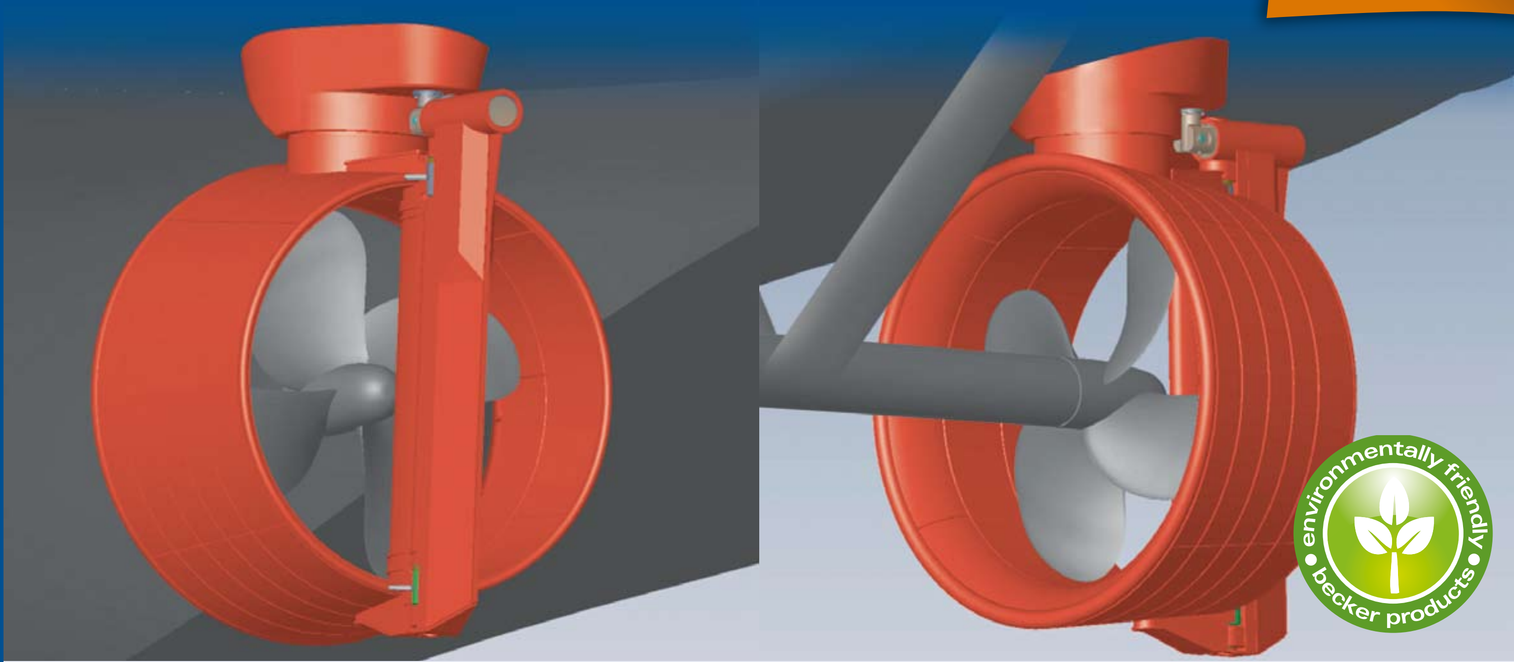
becker marine systems



Becker Nozzle

High-performance and efficient heavy-duty manoeuvring solution

Nozzles: the efficient solution

Nozzles were introduced decades ago to improve propeller efficiency on slow to medium-speed vessels. The most common type is a fixed nozzle in combination with a rudder or flap rudder. This arrangement provides advantages regarding vibrations due to the robust support where the nozzle is connected to the ship's structure and allows a smaller gap between nozzle and propeller, leading to increased efficiency and fewer tip vortices.

The steerable nozzle shows much better manoeuvring performance by generating higher lateral forces. Less space is needed for the whole propulsion arrangement and better efficiency is achieved by placing the propeller further to the rear than the fixed nozzle.

Left: Fixed nozzle and flap rudder
Right: Conventional steerable nozzle with movable flap

The idea: an improved nozzle arrangement

In several discussions with ship designers and operators the idea of a new nozzle arrangement was developed to combine the advantages of the outstanding manoeuvring capability of the steerable nozzle with the efficiency and reliability of the fixed one. The new system should provide following properties:

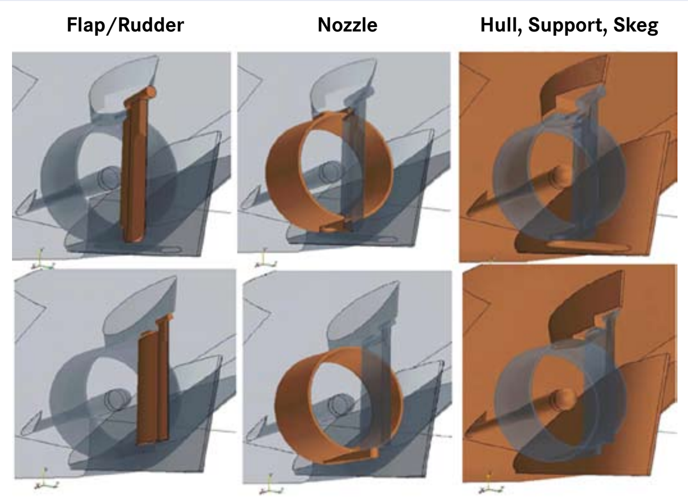
- **New design for space limited vessels (e.g. Offshore, Ro/Ro)**
- **Design without heel pintle and heel wing**
- **Alternative arrangement to a slim forged rudder shaft**
- **Reliable and stable support**
- **Reduced vibrations**
- **Same or better maintainability than conventional systems**
- **Material always available for shorter lead times**
- **Same or lower costs than state-of-the-art solutions**

Manoeuvring and safety aspects:

- **Improved manoeuvrability**
- **Improved generation of lateral force**
- **Same or better bollard pull conditions**
- **Reduced rudder action for DP and course keeping: energy saving, less maintenance**
- **Quicker manoeuvring response than azimuth thrusters**
- **Much better lateral force at astern conditions**

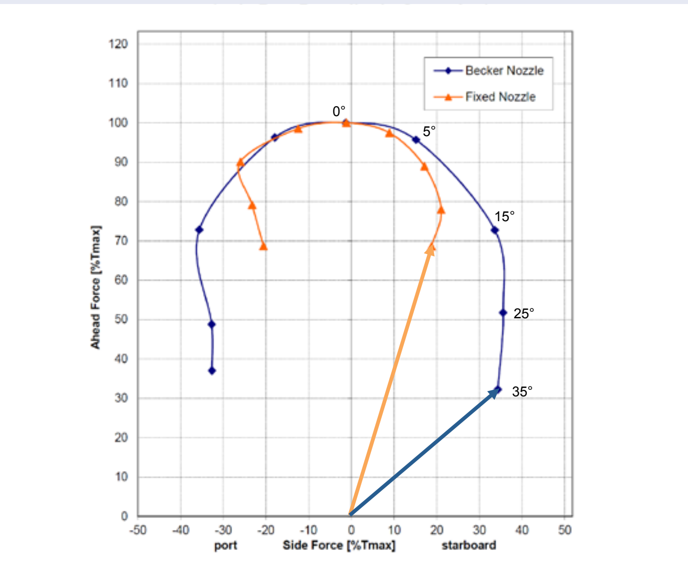
Performance comparison

For comparison three design cases were defined: two representing the standard cases of fixed and steerable nozzles and a new steerable nozzle without heel support, but much stronger bearing arrangement at the top. The study was divided into the system components of the hull (including heel support, if applied), nozzle and rudder/flap.



Components of the study

The CFD studies validated the expected slightly higher bollard pull performance of fixed nozzle at 0° rudder/nozzle angle. Notable is the much higher lateral thrust generation of steerable nozzle and better ahead thrust elimination on high angles. Both effects in combination result in an overall manoeuvring thrust vector in angle three times greater than the fixed nozzle/rudder arrangement (see diagram below). In cruise condition the study shows large savings on removing the heel support, whose drag eliminates up to 50 % of the thrust generated by the nozzle.



Thrust vector diagram (only port propeller in operation)

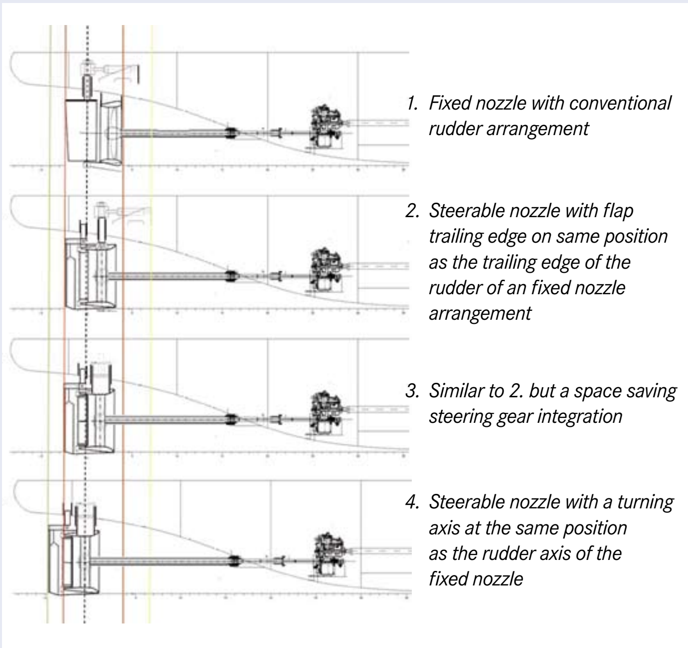
Nozzle design

The targets of a heel support free design on a steerable nozzle places special requirements on the upper support and bearing design. The experience from bearing solutions of high-loaded rudder systems enables Becker to develop a robust and maintainable solution for a steerable nozzle meeting the requirements of heavy-duty offshore operations. Besides the challenge of reliable resistance against operational loads, the following requirements were met:

- **Disassembly by removing only two blades of a CPP**
- **Comparable resistance to a fixed nozzle head box**
- **Nozzle position shifted as far back as possible due to design and operational restrictions**
- **Providing enough space for steering gear arrangements**

Positioning gains

To achieve a less disturbed inflow on the nozzle it is useful to place it as far away as possible from wake field influence. Of course, there are some structural restrictions limiting this approach. To balance these requirements four general cases were developed:



Compared to a fixed nozzle plus rudder, the steerable nozzle arrangements in cases 2 and 3 have a potential shift back distance of about 25 % to 50 % of the propeller diameter, depending on the rudder size used for the fixed nozzle arrangement. Case 4, with no restrictions regarding chain or cable handling, allows a shift back to at least 50 % to 65 % of the propeller diameter without taking into account additional shift back opportunities from future integrated space-saving designs and increased propeller diameters.