

# Turn a Ship on the Spot without Using the Rudder!

**Z-Peller, a special turnable ship propulsion unit that can turn its propelling force toward any horizontal direction**

Since we delivered our first unit in 1969, for more than 40 years we have been selling Z-Peller not only in Japan but also overseas. With total production exceeding 3 200 units, this is one of our hit products. This report introduces the Z-Peller and our recent activities.

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External view of Z-Peller



Tugboat operating in international waters

## The product and its history

Tugboats, which help ships dock at and leave ports and harbors within and without Japan, must be able to turn in a small radius and also exert strong tugging or pushing force. The optimal propulsion units for tugboats are 360-degree turnable or azimuth thrusters (ship propulsion units each mainly composed of a pod and a screw propeller shrouded by a nozzle and turnable horizontally 360 degrees). This structure allows the thrust direction of the nozzle-shrouded propeller (screw) to be adjusted in any direction (a full 360 degrees), thereby eliminating the need for an ordinary helm.

In 1950, a German manufacturer developed the first Z-shaped propeller. In 1969, Niigata Power Systems Co., Ltd. (NPS) developed its own Z-shaped propeller under the trade name "Z-Peller," a type ZP-2 with 1 000 PS capacity designed for tugboats used in ports and harbors. When a tugboat is equipped with a pair of Z-Pellers, its steering performance improves drastically (for maneuvering, including forward and backward movements, emergency stops, pivot turns, and skidding). This capability has made Z-Peller indispensable to tugboats. Z-Peller is sold as a set together with a diesel engine, clutch, power transmission shafting, and controller, and the set has received favorable reviews from customers. NPS has continued to improve Z-Peller, releasing several model updates for each type and has sold a total of 3 200 units in a lineup with products ranging from 550 to 3 089 kW.

## Structure of Z-Peller

Z-Peller consists of a power transmission system that drives a propeller and a rotation system that adjusts the propeller direction 360 degrees. Power is efficiently transmitted as a propulsion force to the propeller from the diesel engine located at the center of the hull through the input shaft, vertical shaft, propeller shaft, and the upper and lower bevel gears (which transmit the power to the orthogonal transmission shafts in the same plane). The input shaft, the upper bevel gear, and the vertical shaft are integrated in the upper gear case of Z-Peller, and these two shafts are supported by roller bearings.

The vertical shaft, the lower bevel gear, and the propeller shaft are integrated in the lower gear case. The forward end of the propeller shaft has a built-in thrust roller bearing which supports the reaction load of the propeller thrust. On the outer periphery, the propeller is equipped with a Kort nozzle which serves to increase the propeller thrust.

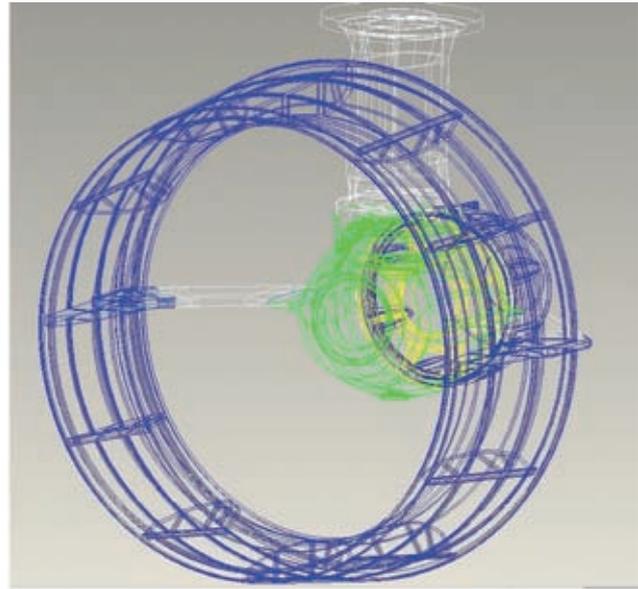
The "Z" shape of the above-mentioned power transmission system is the origin of the Z-Peller name for the propulsion unit. The system is filled with lubricant and the upper gear and bearings are forcibly lubricated by the lubricant pump attached to the upper unit. Special sealing is applied to the rotary parts to prevent the lubricant from leaking into the seawater.



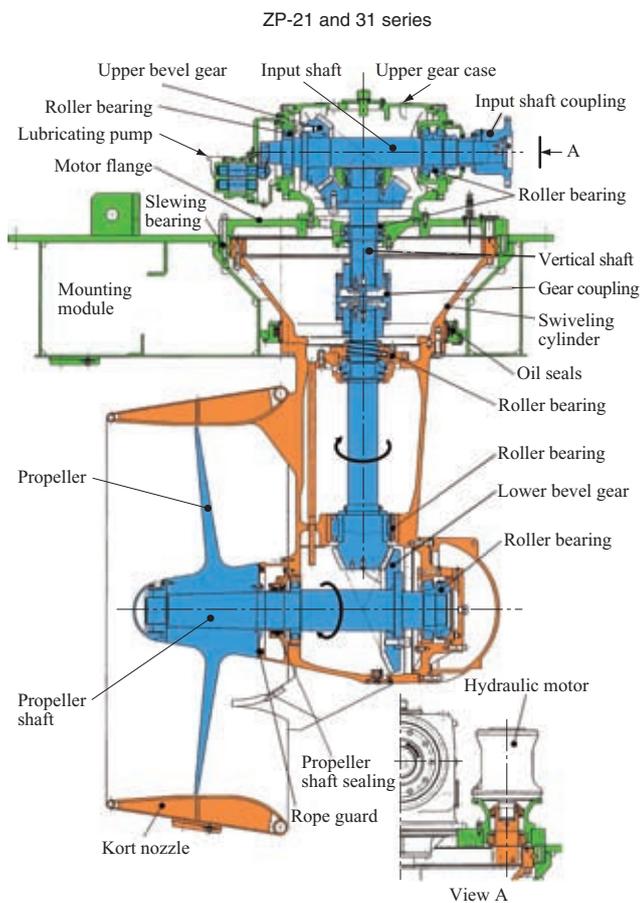
NPS products (for tugboats)

## Performance

To change the traveling direction of a ship equipped with an ordinary propeller (FPP or CPP) and an ordinary rudder, the rudder is turned in such a way that it receives water current and generates a counterforce which is used to turn the ship. To change the traveling direction of a ship equipped with Z-Peller, the propeller thrust itself can be changed to any direction (a full 360 degrees). When an ordinary rudder is turned to its maximum rudder angle (usually 35 degrees), only a part of the thrust generated by the propeller is used to turn the ship. By contrast, when Z-Peller is used, the entire propeller thrust works effectively in the desired direction. Therefore, a Z-Peller ship can turn in a much smaller radius while sailing than ships with ordinary rudders, and can even turn when the speed of the ship is zero (Ships with ordinary rudders cannot be steered below a certain speed.). As described above, Z-Peller provides the ship with high steerability at speeds from zero to full speed. It can also provide high performance under adverse conditions, such as when tugboats and various kinds of emergency ships as well as work boats need to change their positions quickly and finely in narrow



Kort nozzle analysis model



Z-Peller structure

stretches of sea or when in close vicinity to other ships or when current positions need to be maintained (for example, when emergency ships must remain in the same position while receiving the force generated by spraying seawater for firefighting).

In addition, a Z-Peller ship can reverse the direction of the entire propulsion unit (the thrust direction), allowing the ship to stop quickly by reversing thrust direction with only a minimal decrease in propeller efficiency. Z-Peller ships can switch between forward and backward movement faster than ordinary ships. This gives Z-Peller ships high performance with respect to sudden stops as well as quick forward and backward movements.



Application to a large work boat

## Markets other than tugboats

Z-Peller is well-known as a propeller for tugboats, but recently it has been increasingly adopted for supply boats, dredgers, cruise ships, ferries, and other types of boats and ships. In most cases, these ships have high-precision control systems, such as Dynamic Positioning Systems (DPS). We are working to improve Z-Peller to realize compatibility with these control techniques.

## Pursuit of higher performance

To increase the propulsion force, which is a performance requirement for the tugboats described above, we proactively worked to develop a new nozzle and propeller, conducted studies to increase the propulsion force using tank tests, and added special parts to the propeller. As a result of all these efforts, we finally succeeded in developing a propeller with increased propulsion force. The resulting high-thrust Z-Peller was launched in 2008 and has enjoyed strong sales, including sales of units still in production.

In 2006, we developed the environmentally-friendly type ZP-41RP, which features motor-driven contra-rotating rudder propeller that is mounted on a foreign seine netter. This new type of propulsion unit has a conventional main-engine-driven controllable pitch propeller and a motor-driven rudder propeller in the rear to realize the contra-rotating propeller effect in order to reduce the environmental burden and save energy. The ship achieves approximately 15% energy savings as a total system compared to conventional types and also has less underwater noise radiation and improved performance, thus realizing high economic efficiency and labor savings.

## Future directions

To address recent global environmental problems, drastic changes are being made not only to automobiles and electrical home appliances but also to construction machines and other industrial equipment.

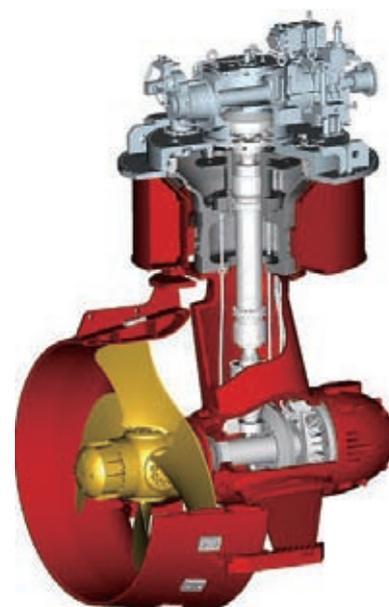
We are making efforts to develop electric motor-driven, hybrid, and other motor-driven products. We have already commercialized some of these as Z-Peller-related products. Also, as part of these efforts, we have developed an electric turning system (a Z-Peller turning system that uses no hydraulic pressure), and delivered our first unit in 2011.

We continue to make steady efforts to further improve the performance of our excellent duct propeller system by conducting tank tests (for example, testing miniature propellers in a special water tank).

We will continue to strive to develop our unique technologies and produce both hardware and software on our own to contribute to the domestic and foreign ship-building industry.



Tandem contra-rotating propeller, rudder propeller (ZP-41RP)



Large-sized Z-Peller (ZP-51CP)

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