천수심에서 어선 정박을 위한 자동도선시스템에 관한 연구

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A Study on the Development of Auto Pilot Device at Shallow Water for the Docking of Fishing Boat

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Abstract

Generally a ship in a port or canal is guided by tugboat(s), while the ship engine(s) and steering mechanism idle. The shortcomings of this method are insufficient in course keeping ability, danger of collision with waterside structures, time-consuming preparation for tugging, as well as the need to maintain tugboats. A new technology for ship guiding, based on the physical principle of interaction of a solid body with aerated liquids has been developed [1]. Model tests were carried out for the verification of system at slow speed by engine operating conditions and with an idle steering. The developed device has been proved to keep the ship on course safely.

Key words : guiding ships(도선), narrow channels(협수로), auto pilot system(자동유도시스템), hydrodynamic pressure(유체압력)

INTRODUCTION

When air is discharged into water through a perforated pipe, a zone of aerated liquid is created. Because of bubble buoyancy, the air bubbles, discharged into the water through a perforated pipe, aspire to the surface forming a ridge as shown in Fig. 1.

On the surface the air bubbles burst into the atmosphere, while entrained water is moving away from aerated zone. The bottom layer of water, and so-me of the upper layer of water, move into the aerated zone to replenish the entrained water. In the process two eddy rollers are formed, and makes pressure deviation.
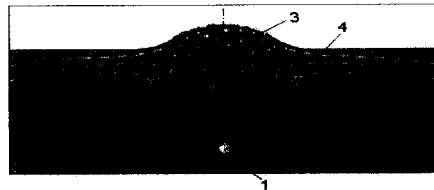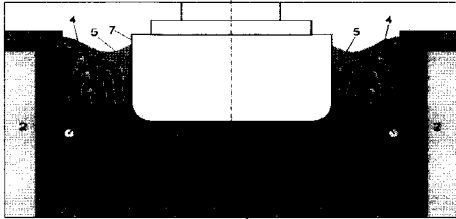

1-seabed, 2-perforated pipe, 3-aerated zone, 4-free surface of the water, 5-eddy motion of the water

Fig. 1. Mechanism of interaction of aerated zone with a layer of liquid.

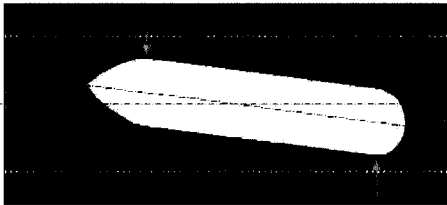† Corresponding author : kjalee@chosun.ac.kr

PRINCIPLES OF THE SHIP GUIDING TECHNOLOGY

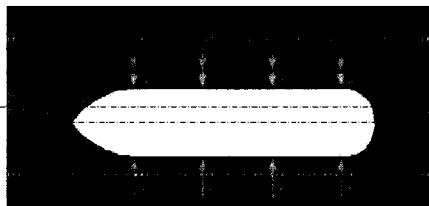Between the two perforated pipes two symmetrical eddy rollers are formed.

1-seabed, 2-wall, 3-perforated pipe, 4-aerated zone, 5-free surface of water, 6-eddy motion of water, 7-ship hull.

Fig. 2. Hydrodynamic Pressure on a ship's hull when it moves between two eddy rollers.

(a)

(b)

1-perforated pipe, 2-axis of the ship guiding system, 3-ship hull, 4-horizontal components of the resultant pressure on the ship boards, 5-horizotal component of the resultant wind pressure on the right board

Fig. 3. Explanation of course keeping.

The kinetic energy of water movement transforms into (potential energy of) hydrodynamic pressure on the ship's hull when it moves between the two eddy rollers, as shown in Fig. 2.

If the ship stays on course, the pressure on both sides is balanced. But the ship deviates from its course as shown in Fig. 3, the pressure on the side closer to the eddy roller rises, while it decreases on the opposite side.

In order for the ship not to deviate, the speed of ship must not be greater than the acceleration of gravity on the curvilinear course.

If the air is discharged in front of the water side structure, it protects the ship from bumping as shown in Fig. 4.
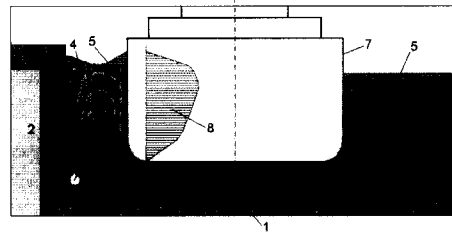
1-seabed, 2-wall, 3-perforated pipe, 4-aerated zone, 5-free surface of the water, 6-eddy motion of the water, 7-ship hull, 8-diagram of horizontal component of hydrodynamic pressure. The wall providedes better influence of aerated zone on ship than in the open water.

Fig. 4. Air bubble protects the ship from bumping into water side structures.

MODEL TEST

For verification of this new technology model tests were performed in the experimental facilities of the Chosun university. This test was configured to simulate the control of ships motion in an actual harbor area. Following simulations were performed with an idle steering and under windy conditions.

1. To keep a straight course.
2. To keep a curvilinear course.
3. To pass a narrow harbor area.
4. Mooring.

This test was performed in an experimental tank(Length×Beam×Depth=7.5m×3m× 0.35m) at Chosun University, which can simulate a narrow and crowded harbor. A model ship (Length×Beam=0.88m×0.2m) with a motor, propeller, remote control system, and power supply was used.

Fig. 5 shows a typical section of the perforated pipe used. The pipe is 1" diameter with 1.6mm holes apart 30mm set.
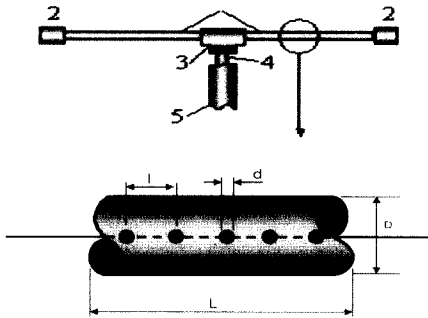

Fig. 5. Typical section of perforated pipe.

1 - Plastic pipe with inner diameter 1"
2 - End cap
3 - T-joint
4 - Socket of hose
5 - Hose with inner diameter 1"

The diameter of the hole, d, the distance between holes, l and the total length of the pipe, L were considered using the following formula.

$$(l+d)n = L \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

Where l is the 30 mm, d is the 1.6mm.

The number of perforated holes of the pipe n was determined as follows.

By equation(1), the number of perforated holes, n, was

$$n = \frac{L}{l+d} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2)$$

The following expression (3) for a perforated pipe must be satisfied.

$$\frac{\pi}{4} D^2 \geq n \frac{\pi}{4} d^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (3)$$

where D is , 25m/m

Equation(3) shows that the cross-section area of pipe must be greater than total area of perforated holes.

Then, the minimum distance between holes was as shown below.

$$\frac{L}{l+d} d^2 \langle D^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (4)$$
$$Ld^2 \langle D^2(l+d)$$
$$Ld^2 - D^2 d \langle D^2 l$$
$$L\frac{d^2}{D^2} - d \langle l$$
$$l \rangle d(\frac{Ld}{D^2} - 1) \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (5)$$

Total air discharge from the holes, G was determined by equation(6).

$$G = \rho_a V_a \frac{\pi}{4} D^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots (6)$$

Where ρ_a is 10−3 g/cm3 .

The estimated total pressure from the water column above the pipe can be presented by a well known formular as below[2].

$$\therefore P_g = \rho_w gh \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (7)$$

Where ρ_w is 1 g/cm^3, g is the 0.98×10^{-2} cm/s^2, and h is 35cm. As the water depth was 35 cm in the tank, $P_g = 3.43 \times 10^{-5}$ P$_a$.

Therefore, it shows that the pressure drop by the water column above the pipes does not effect the air discharge because of 1.96×10^{-3} $\rangle$ P$_a$ $\rangle$ 1.47×10^{-3} P$_a$ and P$_a \gg$P$_g \doteqdot 3.43 \times 10^{-5}$ P$_a$.

The water velocity distribution of the surface current generated by the air flow (P$_a$=1.96×10^{-3} P$_a$) through the perforated pipes are presented in Fig. 6 and Fig. 7.
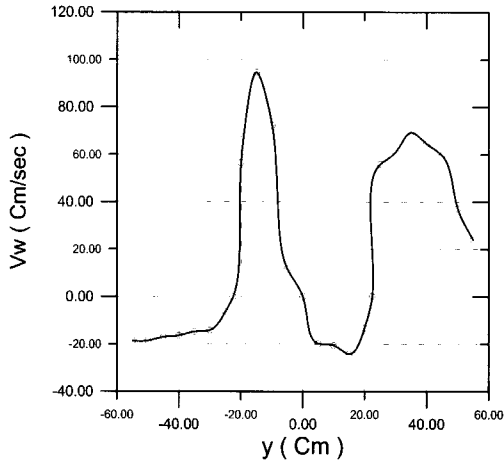
Fig. 6. Water velocity distribution at 1m
distance from center line of tank.

Fig. 6 and 7 show that the water velocity is
0 on the wall, and at the points of y values
are −22.5, 0 and +22.5cm. Where y is width
from the center of the course to the wall.

It also shows that if the ship model in the
track is located between −22.5 and +22.5cm
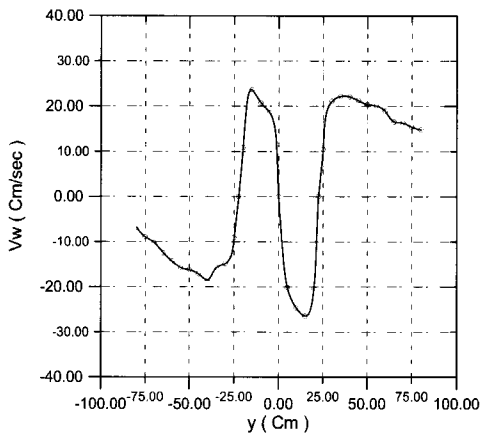of perforated pipes, it moves with safe motion.

Fig. 7. Water velocity distribution at 2m
distance from center line of tank.

Fig. 8 shows an experimental setup for the
test. It simulates curvilinear courses of about
7m distance for the ship model by a track of
perforated pipe. It also simulate the narrow

harbor, waterside structures and pier.

The unit includes a flow meter with air
consumption of about G=30−50 l/s, a pressure
gauge for up to 2.94×10^{-3} Pa and valves
regulating airflow in each position. And the
speed of model in straight course is 0.5㎧, and
0.3㎧ in curved course.

The 9.8×10^{-3} Pa air compressor accumulated
air in the gas−holder keeping an average
pressure of $1.96 \times 10^{-3} > P_a > 1.47 \times 10^{-3}$ Pa.
Air from the gas−holder came into the
perforated pipes through the hoses and
generates aerated flow accompanied by eddy
structures, which keep the ship models in the
track. The airflow is controlled by valves.

On the test, after opening the gas holder, air
discharge from the pipe and air bubbles burst
on the water surface making two eddy rollers.
Model ship was safely and smoothly
maneuvered with good course keeping between
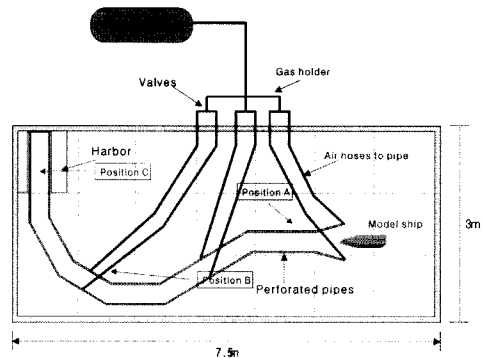two eddy rollers as shown in Fig. 9, 10, 11.
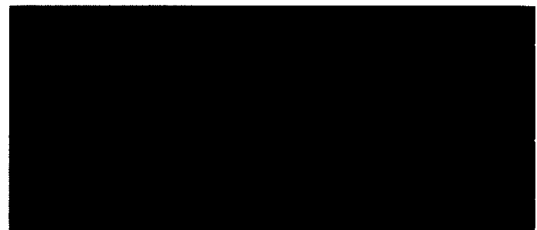

Fig. 8. Plan of water tank for the test.

Fig. 9. Model ship smoothly guiding bet-
ween two eddy rollers. (PositionA).

Fig. 10. Model ship smoothly guiding bet-
ween two eddy rollers (Position B).

Fig. 11. Model ship smoothly guiding bet-
ween two eddy rollers (Position C).

CONCLUSIONS

The results and discussions can be concluded as follows :

(1) On the dry docks in shipyards, marine and maritime police bases, this system would guide the ship safely and quickly to the dock.

(2) If it is adopted in the serious foggy areas, specially between close islands, safety of operation even under bad the weather conditions will be increased.

요 약

해저에 설치된 파이프에서 분출되는 기포에 의해 형성된 강한 수평압력분포를 이용하여 선박을 신속하고 정밀하게 유도, 정박시키는 도선시스템으로 항구, 협수로, 해협 등과 같이 복잡한 수상, 수중 장애물 지역에서 선박을 신속하고 정밀하게 유도함과 동시에 협소한 부두에 안전하게 선박을 정박시키기 위하여 본 도선 시스템을 고안하였다.

REFERENCE

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