Improvement Plate for Semibalanced Rudder

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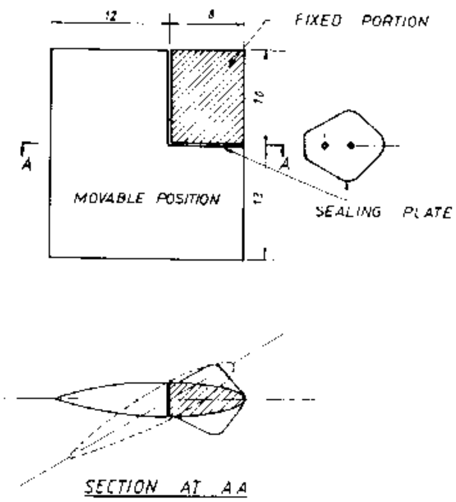

Fig. 1 The model (all dimensions in cm).

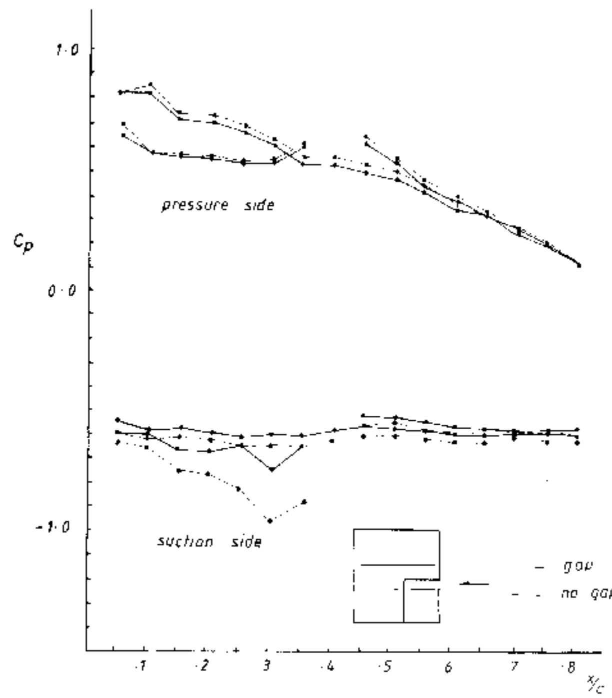

Fig. 2 Distribution of pressure coefficient for 35°.

THERE are several types of rudders commonly used to achieve a desired course-keeping and course-changing ability for a surface ship. The semibalanced rudder has the fixed portion in the upper part of the leading edge, as shown in Fig. 1. This rudder incorporates balance area without introducing a vertical gap when the rudder is laid over. However, it necessarily incorporates a horizontal break between the top of the balance area and the lower edge of the fixed portion; this has an undesirable influence on its characteristics. Mandel[1] performed an experiment comparing the tactical diameters of a model alternately equipped with all-movable, semibalanced, and balanced rudders with similar geometric configurations. He found that the all-movable rudder produces the smallest tactical diameter, whereas tactical diameters produced by semibalanced and balanced rudders have almost the same value.

Close comparision of the configurations of the above-mentioned three rudders shows that the all-movable rudder has no fixed structure ahead of the movable portion, whereas the balanced rudder has a complete fixed structure ahead of the leading edge of the movable portion, and the semibalanced rudder has a fixed portion only ahead of the upper part of the movable portion. Thus the tactical diameter curve of the semibalanced rudder should lie between the values of the other two types. But this is not the case. This is due to the presence of a horizontal gap between the fixed and movable portions of the rudder.

An experiment has been carried out using a small plate to seal off the horizontal gap, as shown in Fig. 1. The section shape of the rudder is NACA 0015. The test has been carried out in a low-speed wind tunnel with a test section of 30×30 cm. The freestream velocity and ambient temperature are 25.7 m/sec and 300 K, respectively. Surface pressures on the rudder for various degrees of deflection angle were measured. We

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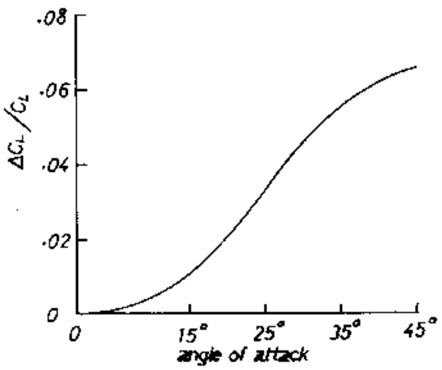

Fig. 3 Graph of increase of lift coefficient.

found that, due to the presence of horizontal gap, the pressure on the pressure side of the rudder is reduced, whereas the pressure on the suction side is increased. A typical pressure distribution for a deflection angle of 35° is shown in Fig. 2. The pressure distribution with gap condition means that the small sealing plate is not installed, whereas no gap condition means that the horizontal gap is sealed off by the plate. Equal values of clearance have been adjusted for the two cases during the measurements. The normal forces for various degrees of the deflection angle were calculated, as shown in Fig. 3. At a large deflection angle, the improvement in normal force by sealing off the horizontal gap is approximately 6%.

Flow visualization also has been accomplished for the two cases. We found that the streamline pattern is improved after the horizontal gap is sealed off. Before the sealing plate is installed, the streamlines near the gap on the leading edge of the pressure side of the movable portion of the rudder are deflected upward, whereas the streamlines near the fixed portion are deflected downward. After the small sealing plate is installed, the streamlines on both portions of the rudder became more or less horizontal.

In addition to the improvement of the normal force produced by the small sealing plate, the large variation of the center of pressure of the semibalanced rudder may also be reduced.

Reference

[1] Mandel, P., "Ship Maneuvering and Control," in *Principle of Naval Architecture*, edited by J.P. Comstock, SNAME publication, 1967, Chap. 8.