Cavitation Erosion and Corrosion Behaviors of Various Metallic Coatings Prepared by Arc Spraying

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ABSTRACT
Investigation to find a suitable coating material for a rudder application has been carried out in the present study. Ten different coatings were prepared by arc spraying with Al-, Zn-, Cu- and Fe-based wire feedstock. Both the cavitation erosion and marine corrosion behavior of the arc-sprayed coatings were evaluated, and compared with the conventional anti-corrosion paint.

KEY WORDS: Protective coating; cavitation erosion; marine corrosion; thermal spray; rudder

INTRODUCTION
A Rudder is counted as one of the essential ship components for navigation and safety, and services in the complex conditions of cavitation erosion and marine corrosion. Since recent improvement in shipbuilding engineering increases the cruising speed, the cavitation erosion of rudders becomes much aggravated as to shorten the service life of the rudder to less than one year, as shown in Fig. 1.

Cavitation is defined as the repeated nucleation, growth and violent collapse of cavities, or bubbles in a liquid. Cavitation erosion is the mechanical degradation of materials caused by cavitation in liquids. Two mechanisms have been proposed (Hansson et al., 1992; Marques et al., 2003) to explain the damage occurrence to solid surfaces due to the cavitation erosion. The first is based on the generation of shock waves by the implosion of the bubbles, whose pressure has been estimated to be around $7\times10^9$ Pa. The other considers the generation of micro jets when the bubble collapses in an asymmetric field of pressures. In both cases, the mechanical loads are much localized and can be extremely severe, resulting in deformation of the surface. The repeated loading eventually leads to removal of materials from the surface; viz., erosion.

As the cavitation erosion is more closely related to surface properties, various surface engineering techniques have been studied to enhance the cavitation erosion resistance of hydraulic machinery. Thermal spraying has been recognized as the most effective and practical solution because of its variety of coating material choices without any limits in the shape and size of parts to be applied. Tungsten carbide based coatings prepared by HVOF (High velocity oxy-fuel) spraying have been successfully applied to several parts of hydraulic systems such blades of hydraulic turbines.

In case of the ship rudder, however, there remain several issues to be solved for thermal spraying to be practically applied. One of the issues is the complexity of the service conditions. In the rudder case, marine corrosion and fouling can seriously affect the performance of protective coatings. Cost should also be considered since the sizes of the rudders are much larger than the general parts of hydraulic machinery. The rudder sizes of high-speed carriers and tankers are usually about 6–9m in width and 10–15m in height. Among the various thermal spray techniques, so-called high performance techniques such as HVOF and plasma spraying may not be practically applicable to the rudder application due to their shortage of cost-effectiveness and in-field productivity.

In the present study, therefore, only arc spraying is chosen for coating deposition while the previous studies have been mainly utilized HVOF and/or plasma spraying. Arc spraying, which uses metallic wire as the feedstock, is generally accepted as the most cheap process in thermal spraying, and has proved its high productivity in various large-sized applications such as infra and off-shore structures.