A method for predicting of cavitation erosion-corrosion damage in seawater

Akihiro Yabuki (Graduate School of Engineering, Hiroshima University)
Masanobu Matsumura (Graduate School of Engineering, Hiroshima University)

Summary

Cavitation erosion is a phenomenon, in which materials are mechanically damaged by an impulsive pressure, which is generated by the collapse of cavities that occur in flowing fluids. As fluids, such as sea water, are corrosive, metallic materials undergo damage by electrochemical corrosion in addition of erosion damage. In a severe environment, erosion and corrosion damage may be accelerated with one another, and the damage to the materials can be larger than the sum of the individual contributions. This is referred to as cavitation erosion-corrosion. A feature of cavitation erosion of metallic materials is the removal of materials after an incubation period during which the material is not removed from the surface, but is deformed. In this study, the surface deformation and corrosion behavior of metallic materials during the incubation period of cavitation erosion-corrosion were investigated in seawater. A method for predicting the length of the incubation period and the corrosion rate during the period was developed.

Cavitation erosion-corrosion tests were carried out in 3%NaCl solution at 40°C using a vibratory unit with a stationary specimen. Deionized water was used for the pure erosion tests. Three types of metallic materials, copper, brass and austenitic stainless steel, were used as test materials. The incubation period of each material was determined from the damage depth obtained with a surface roughness meter. In order to evaluate the deformation behavior of the material surface during the incubation period, the increment of surface area was calculated from surface profile data. In addition, a polarization curve of each material was obtaind with a potentiostat.

The following results were obtained. The increment of surface area during the incubation period showed the same shape for each material as well as the intensity of the cavitation attack. This confirms that the parameter is a reliable index for evaluating cavitation erosion-corrosion development. It was expected that a corrosive environment would accelerate erosion damage. However, the use of 3%NaCl environment inhibited the erosion damage of copper. Polarization behavior during the incubation period of cavitation erosion was also investigated. The corrosion rate under cavitation attack was the highest compared to these in static and flowing solutions and, as a result, corrosion damage was accelerated by cavitation. In the case of stainless steel, cavitation inhibited pitting corrosion. The length of the incubation period of cavitation erosion-corrosion for a material in an actual machine can be determined by measurement of the increment of the surface area of the component material in the machine, based on the development of the increment of surface area of the material obtained from an accelerated test. The corrosion rate was predicted from polarization curve measurement under conditions of cavitation. These results can be applied to the rapid prediction of the service life of a material.