2P-43

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 375-376
6-8 December, 2010

Observation of the internal change of grains in metals caused by cavitation impact

キャビテーションの衝撃力によって生じる金属中の結晶粒の内部変化の観察

Shinobu Sugasawa[1†], Susumu Uematsu[1] and Shigeru Akiyama[1] ([1]National Maritime Research Institute)
菅澤　忍[1‡]，植松　進[1]，秋山　繁[1] ([1]海上技術安全研究所)

1. Introduction

Cavitation erosion is a serious problem for using turbo machinery like ship propeller. Though cavitation damage of ship propellers have been reduced by the improvement of design techniques, this problem is not solved completely. On the other hand, it is thought that the reduction of cavitation by the design has been almost arrived at the limit. For this reason, the improvement of material willl be expected to avoid cavitation erosion. Therefore, we need investgate erosion mechanism of materials to improve anti-erosion properties. Since materials are composed of grains, erosion mechanism will be make clear if we understand the effect of cavitation impact against the grains. To this end, the shape or profile of the surface or cross-section, hardness, residual stress and so on of damaged material have been investgated, but the internal changes of grains from an crystallographical point of view has not been observed. If these changes are evaluated, we can expect to make clear erosion mechanism in detail. Electron back scattering difraction (EBSD) technique can be used to observe these changes. In this paper , we report the results of the observation of those change generated by cavitation impact using scanning micro electroscope eqipped with EBSD device.

2. Experimental method

Cavitation was generated by a vibratory instrument based on ASTM G32; the conditions of generation of cavitation were as follows: frequency of vibration was 19.5 kHz, amplitude of vibration 50 μm p-p, and the diameter of specimens 15.9 mm. Experiment was done in a 3L beaker filled with deionized water of which temperature was 25±1℃. Specimens were made of aluminum casting (19 Hv0.1), tough-pitch copper (105 Hv0.5), mild steel SS400 (136 Hv0.5), and nickel aluminum bronze CAC703 (177 Hv0.5), respectively. These except aluminum were screwed into the vibratory horn of the instrument and the surfaces were sunk 10 mm depth under the water surface of the beaker. Aluminum was placed to opposite direction of the surface of the horn and the interval between the surfaces was 1 mm.

After the experiments, a specimen was cut perpendicular to the surface eroded by cavitation impact. Their cross-section was made smooth and the grinding damage layer of the cross-section was removed by argon ion milling technique, because the roughness and damage layer of the cross-sections disturb the diffraction of back scattering electron. From the cross-sections, the profile of eroded surface and the compositional image were observed by reflected electron, and the crystallographical information was obtained by EBSD technique.

3. Result and Discussion

The exposure time of cavitation of aluminum casting, tough-pitch copper, mild steel and nickel aluminum bronze were 60 s, 60 min, 120 min and 480 min, respectively. After the experiment, the cross-section and its EBSD image of the specimens exposed to cavitation impact were observed. The results are shown in **Fig. 1, 2, 3 and 4**, which correspond to aluminum casting, tough-pitch copper, mild steel and nickel aluminum bronze, respectively. The lower part of the images is the eroded side. The color of a grain expresses to the crystal orientation of the grain.

The original grain size of the specimen made of aluminum casting was of 1 mm order. On the other hand, it is seen from **Fig. 1** that smaller grains of 10 μm order appear near the eroded surface. These grains were not considered as ones created by grinding damage when preparing specimens for SEM observation, because the grinding damage layer had been removed by argon ion milling. As a result, we can say that these smaller grains are generated by cavitation impact. Similarly, we can also observe from other specimens that grains smaller than original grains generate. Consequently, it can be said from the observation of these EBSD

sugas@nmri.go.jp

images that cavitation impact causes grain refining under the region of damaged surface.

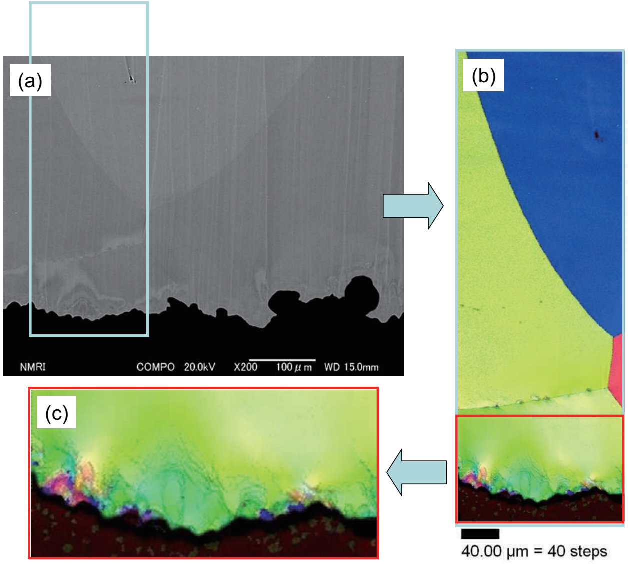

Fig. 1 EBSD image of aluminum casting, except (a), which is compositional image.

In tough-pitch copper (**Fig.2**), not only grain refining but plastic deformation is remarkable. Grains of sub-micron order are also observed.

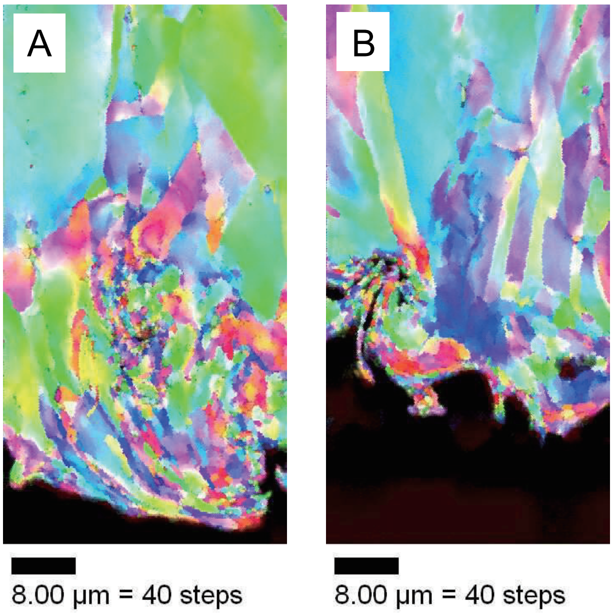

Fig. 2 EBSD image of tough-pitch copper.

In mild steel, it is seen from **Fig. 3** that some grain boundaries generated by cavitation impact do not end in other grain boundaries but disappear in the grain. It seems that these new boundaries are subboundaries. This phenomenon is considered as the first stage of grain refining.

The effect of grain refining will bring the increase of yield stress by Hall-petch law. This

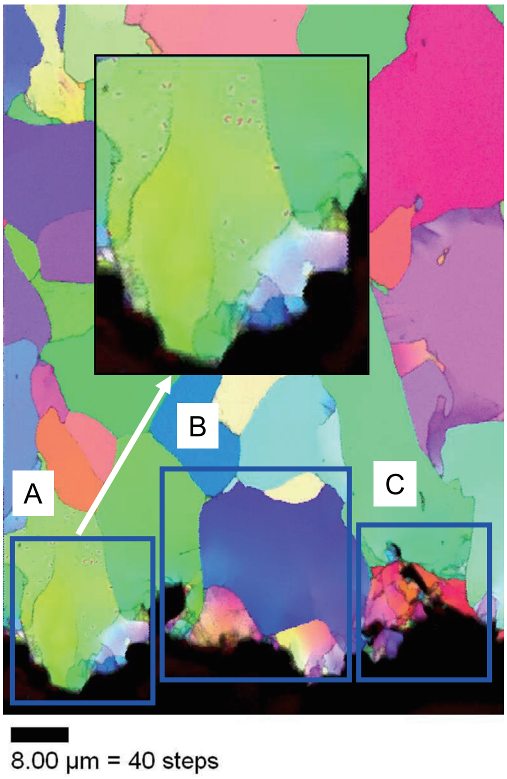

Fig. 3 EBSD image of mild steel.

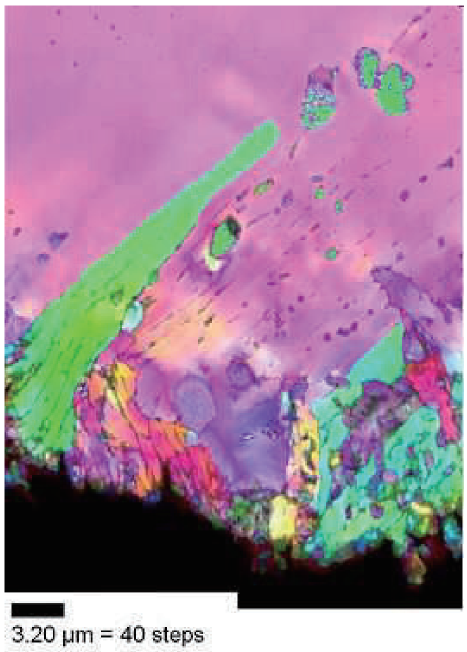

Fig. 4 EBSD image of nickel aluminum bronze.

increase will harden material by Tabor formula. Actually, it is known that cavitation impact hardens the surface of metals.[1] Therefore, grain refining by cavitation impact is considered as one of the cause of this hardening.

References

1. N. Kitajima: J.Japan Inst.Metals. **29** (1965) 948.