Report on Water-Cooled Movable Masks Made of Forged 0.2% Beryllium Copper Alloy

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New water-cooled movable masks made of forged 0.2% beryllium copper alloy have been developed and applied to the front end of the BL-13A undulator beamline at the Photon Factory in Tsukuba, Japan. The masks have a simple structure, are low in cost, and have an extremely low outgassing rate.

1. Introduction

Water-cooled masks and slits are necessary for the front end of synchrotron radiation beamlines to limit acceptance angles of the beam^{1,2)}. For efficient heat exhaustion and to maintain an ultrahigh vacuum, masks and slits are usually made of high-heat-load and low-outgassing materials such as Glidcop^{3,4)}, graphite brazed on oxygen-free copper⁵⁾, tungsten⁶⁾, or molybdenum⁶⁾. Recently, we have developed one-body type water- and air-cooled fixed masks made of one piece of forged 0.2% beryllium copper alloy⁷⁾. The advantages of these masks are the simple structure with no welding, low cost, high durability, and an extremely low outgassing rate of $5.6 \times 10^{-13} \text{ Pa m s}^{-1} (\text{H}_2)^{8-10)}$. The masks have been used in the front end of a new undulator beamline, BL-13A¹¹⁾, at the Photon Factory. In the present paper, we report on the water-cooled movable masks made of forged 0.2% beryllium copper alloy. These masks are useful for small and mid-scale synchrotron radiation facilities.

2. Water-cooled movable masks

Figure 1 shows schematic drawings and a photograph of the water-cooled movable mask system. It consists of two masks (shown in detail in Fig. 1(c)), three bellows nipples, two X stages (SIGMA KOKI, SGSP26-50(X)), two Z stages (SIGMA KOKI, SGSP80-20ZF), a supporting plate, a positioning mechanism, and a frame. The motors of X stages were replaced with high-torque motors (Oriental Motor, PMM33AH-MG20), and the four stages are controlled by a personal computer via two controllers (SIGMA KOKI, SHOT-102). The structure of the water-cooled mask is simple because the flanges, blades, and water pass are made of one piece of forged 0.2% beryllium copper alloy. The water pass, knife edge of the conflat flanges, and air-side surface of the mask are plated with NiP to increase durability¹²⁾. The masks were prebaked in vacuum at 400°C for 72 hours before application. The distance between the light source and first (second) water-cooled mask is 14,216

Fig. 1 (Color online) (a) Schematic drawings and (b) a photograph of the new water-cooled movable masks. (c) Detailed drawings of the forged 0.2% beryllium copper alloy mask. CF70 denotes a conflat flange with a diameter of 70 mm.

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Fig. 2 Schematic layout of a section of front end of BL-13A.
Distances are indicated in mm.

(14,446) mm, and the center of the mask at the coordinate origin is adjusted to coincide with the optical axis of the undulator radiation. The functional purpose of the masks is to limit the vertical and horizontal acceptance angles of undulator radiation through adjustment of the X and Z stages.

The water-cooled masks were installed in July, 2010 between a square duct and the photon position monitor of the front end of BL-13A (**Fig. 2**). Installation and implementation were successful. Typical pressures, monitored with cold cathode gauges, in the front end with and without the undulator beam were $< 5 \times 10^{-8}$ Pa and $< 1 \times 10^{-8}$ Pa, respectively. The temperature rise in the cooling water was negligible. In addition, the masks suffered no damage as a result of the 9.0-magnitude East Japan earthquake on March 11, 2011 (the intensity, in Tsukuba area, on the Japanese seven-stage seismic scale was 6-).

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