DEVELOPMENT OF REFRACTIVE HEAD-UP DISPLAY FOR AIRCRAFT

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ABSTRACT: Because people found that pilots using head-up display (HUD) could operate aircraft more accurately than traditional dashboard, the development of the first HUD was employed on a commercial aircraft in 1970s. The function of the aviation HUD is to project the flight information to the human eye as a virtual image, so the screen information can be superimposed on the external scene. In this way the pilot can obtain the screen information without looking down at the dashboard, which can effectively improve the flight safety.
The HUD optical specifications in this study are described as follows:
(1) The virtual image distance (VID) is infinite, so the light beam entering the human eye is parallel light.
(2) The size of the eyebox is 130 mm, and the pilot can see the complete image when moving and rotating the head within the entire eyebox. If the pilot's eye exceeds the eyebox, the pilot can only see part of the image or cannot see the image. In addition, the average interpupillary distance (IPD) of the human eye is around 65 mm, and the eyebox is typically designed to double the IPD to avoid missing images.
(3) The working wavelength is green light, because the human eye is most sensitive to it. In addition, the design of monochromatic light does not need to eliminate chromatic aberration, so the number of lenses can be reduced effectively. Furthermore, it contributes to cost reduction and size reduction.
(4) The design specification of the total field of view (TFOV) is 20°. The TFOV is larger, the pilot's view for flight information is wider. The large TFOV is beneficial for driving assistance and flight information display.
(5) Instantaneous field of view (IFOV) is a field of view that can be seen by both eyes when the head does not rotate or move in the center of the eye box. The horizontal IFOV is 20°, and the vertical IFOV is 13.7°.
(6) The liquid crystal display (LCD) is used instead of the cathode ray tube (CRT) for the picture generation unit (PGU), which has advantages such as small size, light weight, cost effectiveness, high resolution and high-brightness backlight design.
The optical structure of the HUD is composed of a collimator module and a single combiner to magnify the high-brightness image of the PGU to the eyebox. The combiner is designed in a flat style and coated with a beam splitter, so that the virtual image can be superimposed on the front scene. The collimator module is composed of several large-diameter glass lenses and a flat folding mirror, and the folded structure is used to match the configuration of the cockpit space. In this study, the optical design, image quality analysis, instantaneous field of view and binocular parallax analysis of the HUD have been completed, and the results can meet the optical specifications of the typical aviation HUD.