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Analyses results of the EHF FW Panel with welded fingers

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HIGHLIGHTS

- The design of FW panel with welded fingers has been developed.
- The FW panel with welded fingers has been analyzed.
- The pressure drop in FW panel coolant path do not exceed allowable one.
- The mass flow rate distribution between finger pairs are on acceptable level.
- Temperatures in FW components do not exceed allowable one.

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ABSTRACT

According to Procurement Arrangement (PA) Russian Federation will procure 40% of enhanced heat flux first wall (FW) panels. The signing of PA is scheduled on November 2013. In framework of PA preparation the RF specialists perform EHF FW design optimization in order to provide the ability to operation of EHF FW panel under ITER conditions.

This article contains the design description of EHF FW 14 developed by RF and following analysis have been performed:

- Hydraulic analysis;
- Transient thermal analysis;
- Structural analysis.

Analyses results show that new design of FW panel with two straight welds for finger fixation on FW beam developed by RF specialists can be used as a reference design for ITER blanket EHF FW panel loaded by 5 MW/m^2 peak heat flux.

1. Introduction

The inner surface of vacuum vessel is covered by 440 blanket modules. Each blanket module consists of two main subassemblies: Shield block (SB) and FW. The main FW functions are as follows:

- to provide a plasma-facing surface that is compatible with the plasma performance requirements and a limiting surface that defines the plasma boundary during limiter operation and plasma start-up/ramp-down;
- to absorb radiation and particle heat fluxes from the plasma and neutral beam shine through;
- to provide the protection of in-vessel components and vacuum vessel from plasma touching and run away electrons;
- to provide the first replaceable barrier protecting the in-vessel components from radiation damage.

Each FW includes the following elements:

- FW bearing structure (FW beam);
- FW plasma-facing components (FW fingers);
- FW central slot insert (CSI);
- FW to SB mechanical attachment system.

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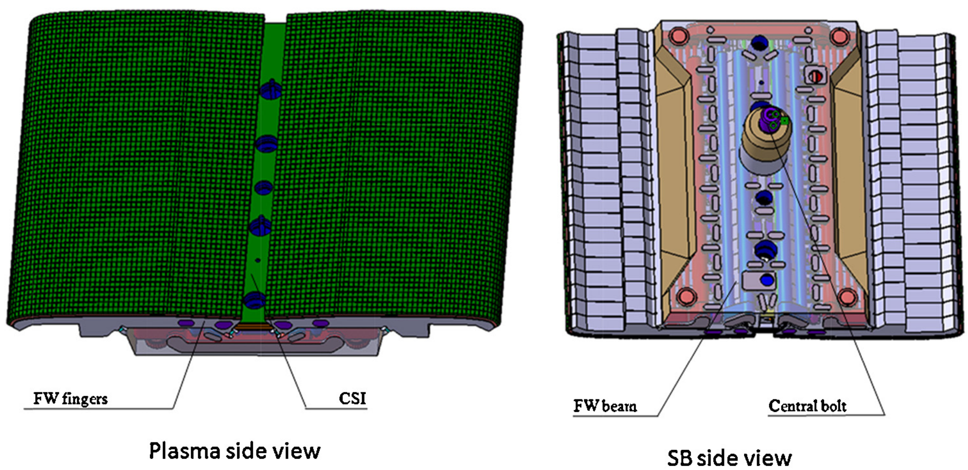

Fig. 1. FW panel 14 design.

The overview of EHF FW is presented in Fig. 1. The dimensions of FW in radial, poloidal and toroidal direction are 170 mm, 1010 mm and 1260 mm respectively.

2. Design description

FW beam is metal structure with profiled external surfaces. It has X-shape configuration with inclined surfaces at flat ends. These inclined surfaces are used to withstand the radial and poloidal torque acting on the FW panel during plasma disruptions.

The main feature of new FW design is welded joint between FW fingers and FW beam. There are two 15 mm FW beam/FW finger welded joints located in the middle and lateral part of FW beam. The using of FW beam/finger welded joints allows to increase the radial FW beam thickness up to 107 mm and to arrange 15 mm diameter coolant channels in the near welded joints zone (see Fig. 2). This design allows to remove heat more effectively from most thermal loaded zones.

The rectangular slot (60 mm × 60 mm) is performed in the front middle part of FW in order to provide the access for welding equipment. In this case the CSI is used for protection of the FW central slot from plasma radiation. The CSI design is presented in Fig. 3. The CSI is 30 mm thickness three-layer structure:

- 6 mm Beryllium protection armor;
- 19 mm CuCrZr bronze die;
- 5 mm steel plate;
- Ø 13 mm × 1.5 mm steel pipe arranged into CuCrZr bronze die.

The Hot Isostatic Pressing (HIP) technology will be used for CSI manufacturing. At the same time the HIPed joint will not be a vacuum boundary due to the using of steel pipe and this pipe will be a vacuum boundary. The hydraulic connection between CSI and FW beam is provided by steel pipe, while mechanical connection is provided by three ring welds. The 5 mm steel plate is added into the CSI structure in order to avoid the welding of different materials.

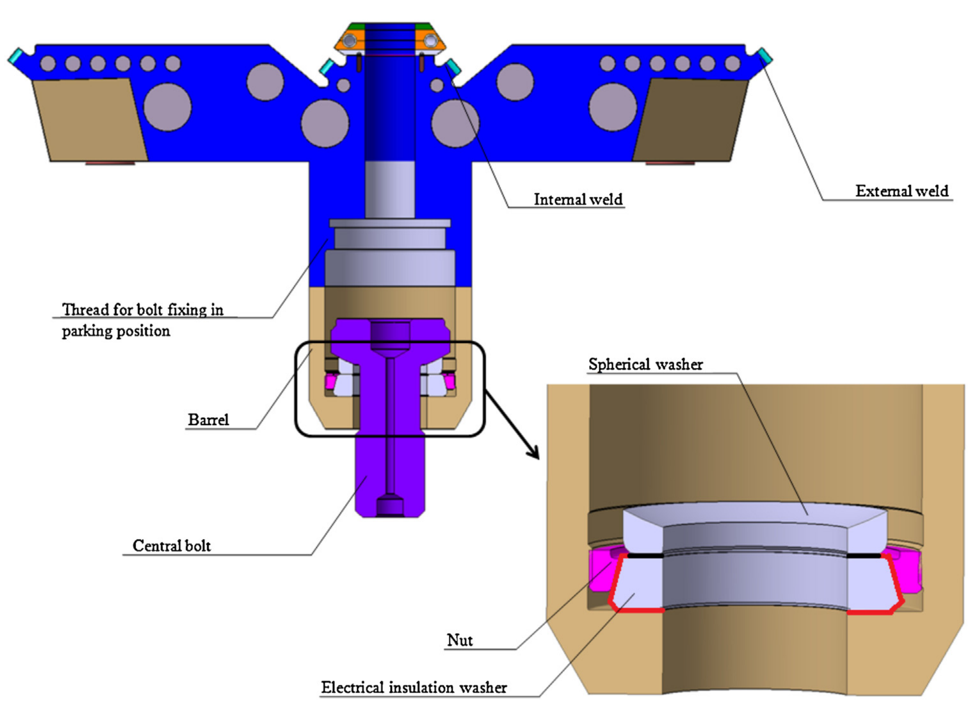

Fig. 2. FW panel toroidal cross-section (fingers are suppressed).