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Progress in development of the edge Thomson scattering system in ITER
ITER 周辺トムソン散乱計測装置の開発の進展

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Design and development for the edge Thomson scattering system in ITER have been progressed. This paper presents two topics from the recent progress. For the first topic, the prototype YAG laser system has been assembled, and optimization of laser optics and operation parameters has been conducted. For the second topic, initial mechanical design for collection optics and laser beam injection optics has been carried out. From the design, the technical issue which should be solved in the next stage is discussed.

1. Introduction

An edge Thomson scattering system in ITER is a diagnostic system which measures electron temperature (T_e) and density (n_e) at a periphery of the ITER plasma. This system is required to measure T_e and n_e over a relatively narrow spatial area (r/a>0.85), but with a high spatial resolution (5 mm at the midplane). Two topics are reported from the recent progress in development of the system: (1) YAG laser system, (2) mechanical design for collection optics and laser beam injection optics.

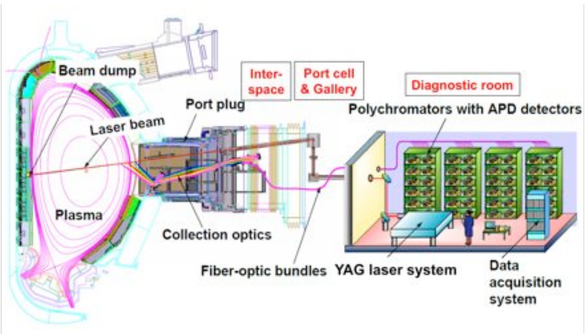

Fig.1. Schematic of the edge Thomson scattering system in ITER

2. YAG laser system

A repetitively-pulsed YAG laser system having output energy of 5 J and a repetition rate of 100 Hz is necessary to meet the measurement requirements for ITER. We have assembled a prototype YAG laser system [1] with two beam lines, and each beam line has four laser amplifiers. In the original design, the laser was designed that each beam line had capabilities of 5 J and 50 Hz, and each beam line was alternatively fired to realize 100 Hz of the repetition rate. However, parasitic oscillation at the high power laser amplification restricted laser output energy. To suppress the parasitic oscillation, the operation parameter has been changed, i.e., pumping energy is reduce to a half, but repetition rate is doubled (100 Hz). Considering the heat load to laser rods, it means that new operation parameter is equivalent to old operation parameter. As an initial result, 2.6 J of output energy at 100 Hz has been obtained from one beam line under this condition. Achievement of target performance (5 J, 100 Hz) is expected by operating two beam lines simultaneously.

3. Mechanical design for collection optics and laser beam injection optics

Mechanical components for the collection optics and the laser beam injection optics have been designed based on their optical design [2,3]. Namely, mirror and lens holders, shutter and their driving mechanism have been designed as shown in Fig.2. Three mirrors for the collection optics and shutter are grouped together in one unit, each components can be individually adjusted from outside of vacuum vessel. A field lens in the port plug is also adjustable from outside.

As an example, a mechanical design for the first mirror of collection optics is described. This component is installed near the plasma, and it is in comparatively severe environment. The mirror holder has been designed with two rotation axes and one linear motion axis as shown in Fig.3.

When substrate of mirror is used as copper, electromagnetic force due to the disruption has been analyzed by the equivalent circuit method. The electromagnetic force on the surface is calculated as 7.9×10^4 N. In this case, the shear stress of a support shaft is 250 MPa, the shear stress transgresses the

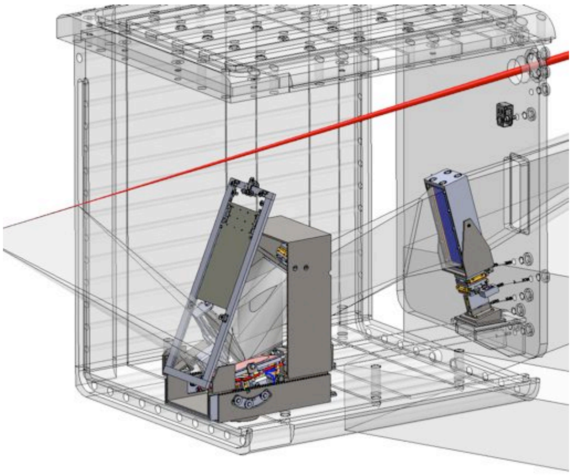

Fig.2. Collection optics in the port plug

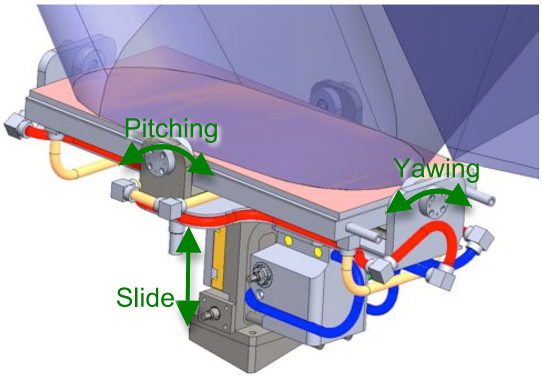

Fig.3. External view of the first mirror.

tensile strength of stainless (240 MPa). When the molybdenum substrate is employed, the stress decreases to 1/9 of that in the case of copper substrate. It is expected that the mechanical strength of the mirror holder to the electromagnetic force is enough in the case of the molybdenum substrate.

Thermal analysis has been carried out under following assumption as shown in Fig. 4.

- Nuclear heating: 2 MW/m^3
- Radiation heat from plasma: 0.05 MW/m^2

In the case of copper and molybdenum substrates, surface temperature is below 300 °C. However, deformation amounts on the mirror surface are 1 mm and 1.8 mm, respectively. This deformation is a very large quantity considering as an optical system. In order to realize it as the optical system, the design which makes smaller deformation is required.

4. Conclusion

Recent progress in development of the edge Thomson scattering system is reported. Regarding the YAG laser system, a prototype YAG laser system has been developed, and optimization of adjustment is carried out. The adjustment work enters in the final stage, we will achieve the target performance (5 J, 100 Hz) soon. As for the mechanical

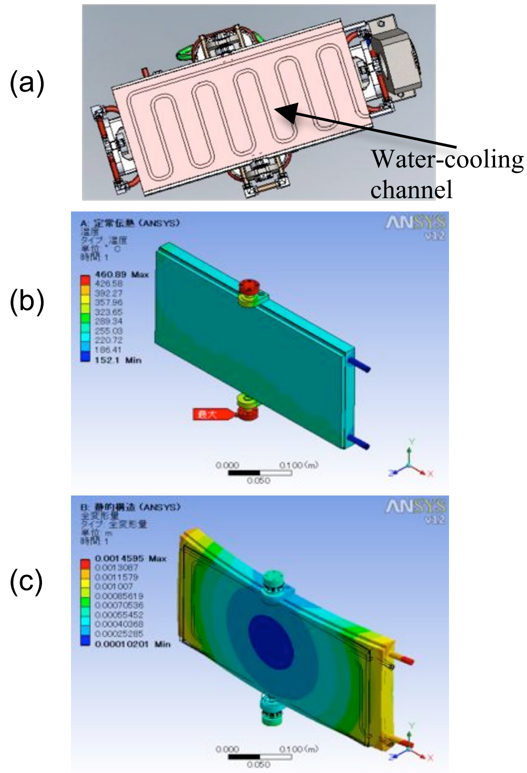

Fig.4. Results of thermal analysis in the case of copper substrate. (a) cooling water channel, (b) temperature profile, (c) deformation profile

design for collection optics and laser beam injection optics, initial design has been conducted. From results, we found that there are some technical issues considering electromagnetic force, cooling design and adjustment of the optical system, especially for the first mirror. Only one kind of simple water-cooling channel was tried in the cooling design. Based on the result, the more effective cooling methods such as a fin structure in the water channel are under examination to reduce the thermal deformation.

Acknowledgments

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