Fabrication of KSTAR 5 GHz LHCD launcher coupler

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1. Introduction

In advanced of long pulse operation and experiments, a pulsed 5 GHz LHCD (Lower Hybrid Current Drive) system as an initial stage is under development aiming at first commissioning during 2012 KSTAR plasma campaign. A 5 GHz LHCD system will be used for the long pulse operation and the advanced tokamak experiments in KSTAR in next operation phase [1, 2, 3].

This paper presents the fabrication status and key technology of the front coupler of the LH launcher.

2. Fabrication Process

The KSTAR LHCD coupler consists of 4-way splitter, taper, window channel, and cover plates. Figure 1 shows the 3 dimensional shape of the KSTAR LHCD coupler.

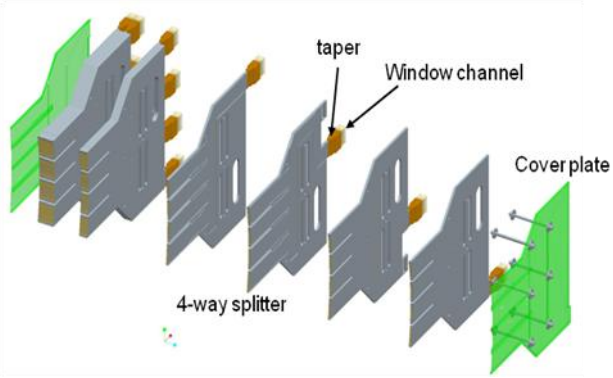

Fig. 1. Configuration of KSTAR LHCD coupler

Table 1 shows the material and quantity of the KSTAR LHCD coupler that is being manufactured at this time.

Table 1. Material of KSTAR LHCD coupler

Components	Material	Quantity
4-way splitter	STS316L	8
Taper	Cu(OFHC)	8
Window channel	Cu(OFHC), ceramic	8
Cover plate	Inconel625	2

2.1 Machining

A stainless steel 316L plate is machined into the 4-way splitting waveguide channel with a weld relief groove for the 4-way splitter body, and 0.8 mm STS316L cover is machined with same shape of the 4-way splitter channel. The manufacturing tolerance is ± 0.02 mm.

The inner surface of splitter body and cover is only copper plated by about 0.04 mm and copper is removed from the weld area. After the welding and brazing process, the basic profile of the coupler is cut off thick plate and the excess thickness is taken off by the final machining.

Figure 2 shows the 4-way splitter that is machined outer shape after the splitter cover welded to the splitter body.

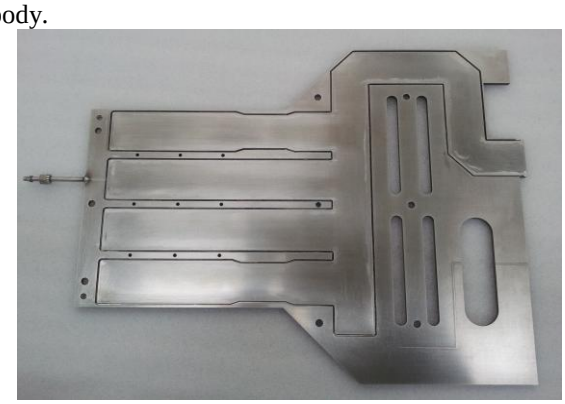

Fig. 2. The 4-way splitter machined outer shape after welded

2.2 Brazing

The ceramic is brazed to the window channel. The filler material for the ceramic brazing is a metal plate type of 0.03 mm thickness and 8 mm width. Its main components are Ag(71 to 73%) and Cu(27 to 29%), and its melting range is 713 to 843 ℃. To estimate the reasonable volume of braze needed for the joint, we calculated the volume of the gap between the ceramic(microwave window) and the window channel, and run several tests to optimize the amount of braze actually needed. It is critical to use an appropriate amount to avoid overflow.

The external molybdenum restraint limits the expansion of the copper during the brazing process. Figure 3 shows the setup of the molybdenum restraint and the window channel before the brazing. Alumina shims inserted between the molybdenum restraint and the window channel to maintain proper clearance during the brazing. The alumina shims and molybdenum restraint compensate the window channel machining

tolerance and the different thermal expansion coefficient between the ceramic and window channel. The clearance of the molybdenum restraint at each side is 0.22 mm and the clearance at each end is 0.1 mm.

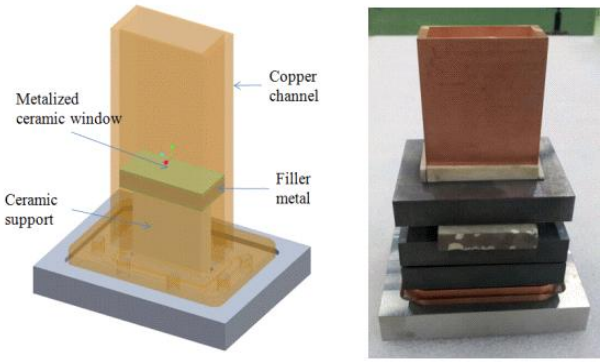

Fig. 3. Configuration of window channel & molybdenum restraint

2.3 Electron Beam welding

The electron beam (EB) weld the cover to the splitter body and the taper and the window channel to the welded splitter.

The splitter body has the weld relief groove to reduce the welding stress and deformation. It is 2.5 mm depth and 2 mm width as figure 4. This concept worked and was carried through to the 4-way splitter several times.

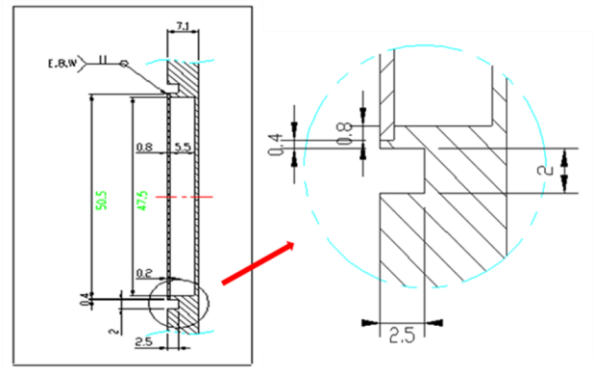

Fig. 4. Section view of 4-way splitter & detail of weld relief groove

The close fit-up between the splitter body and cover is very important for good welding. After EB welded the splitter cover to the body, the back of the splitter body is weakly EB-welded once more to correct the welding deformation. Table 2 shows the welding current of each part.

Table 2. Welding current of each part

Part		Welding current [mA]	Welding material
Splitter cover to body	forward	5	STS to STS
	backward	3~3.5	
Taper to splitter		26	Cu to STS
Window channel to taper		30	Cu to Cu

The taper was butt welded to the 4-way splitter using the spacer to align the inside edges between the taper and the splitter. The spacer consists of 2 stainless steel plates of 0.8 mm thickness and 1 teflon plate of 3.9 mm thickness. The special butt welding fixture as figure 5 was used for good butt welding as well.

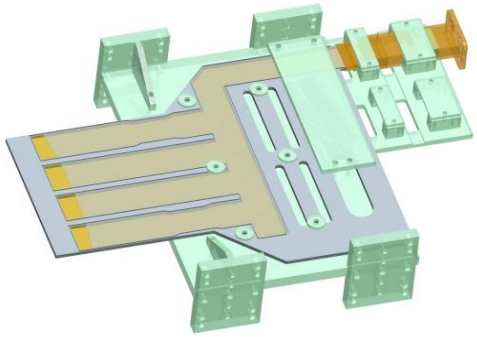

Fig. 5. Butt welding fixture for taper & window channel

3. Conclusions

Since the KSTAR 5 GHz LHCD launcher coupler should be commissioned in 2012 KSTAR campaign. The coupler fabrication will be finished by the end of April and assembled in the KSTAR vacuum vessel with the input standard rectangular waveguides by the middle of July.

REFERENCES

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