Establishment of the Disassembling Technique of the Driver Fuel Assembly Irradiated in JOYO

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Abstract. A disassembling technique for the JOYO driver fuel assembly has been established at the Fuel Monitoring Facility in JAEA. This technique made it possible to remove the fuel pins from the driver fuel assembly without fuel pin sectioning. After disassembling, some selected fuel pins can be reassembled into a new irradiation vehicle for continuous irradiation in JOYO. This technique allows the irradiation data of high burn-up fuel and high neutron dose material to be obtained.

1. INTRODUCTION

In the fast reactor cycle technology development project (FaCT Project), development of fuel corresponding to high burn-up is one of the important issues, and for this it is necessary to obtain the irradiation data of high burn-up fuel and high neutron dose material. To obtain these irradiated data, it is very effective to irradiate the fuel pins irradiated in the experimental fast reactor JOYO again. But re-irradiation is very difficult due to the relationship between the structure of the driver fuel assembly and the conventional disassembling technique. Therefore, a new disassembling technique of the driver fuel assembly was established so that the re-irradiation of the fuel pins irradiated in JOYO might become possible.

2. CONSIDERATION OF DISASSEMBLING TECHNIQUE

2.1. Conventional disassembling technique

Fig. 2.1 shows the fixation method of fuel pins and the conventional disassembling technique used in the Fuel Monitoring Facility (FMF). The JOYO driver fuel assembly is composed of 127 fuel pins, and these fuel pins are arranged in 13 rows. In the fuel pin structure, a piercing hole is opened in the end-plug of the fuel pin, and two knock-bars (upper knock-bar, lower knock-bar) are inserted in the piercing hole to fix each row in place. Both ends of the knock-bars are welded with the B side and F side or the C side and E side of the wrapper tube.

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The conventional disassembling technique procedure used in the FMF is as follows. The six sides of the wrapper tube are cut in an end-mill, and the wrapper tube is pulled out. The row of fuel pins is separately cut by a band-saw. The cut is made 5mm from the upper knock-bar.

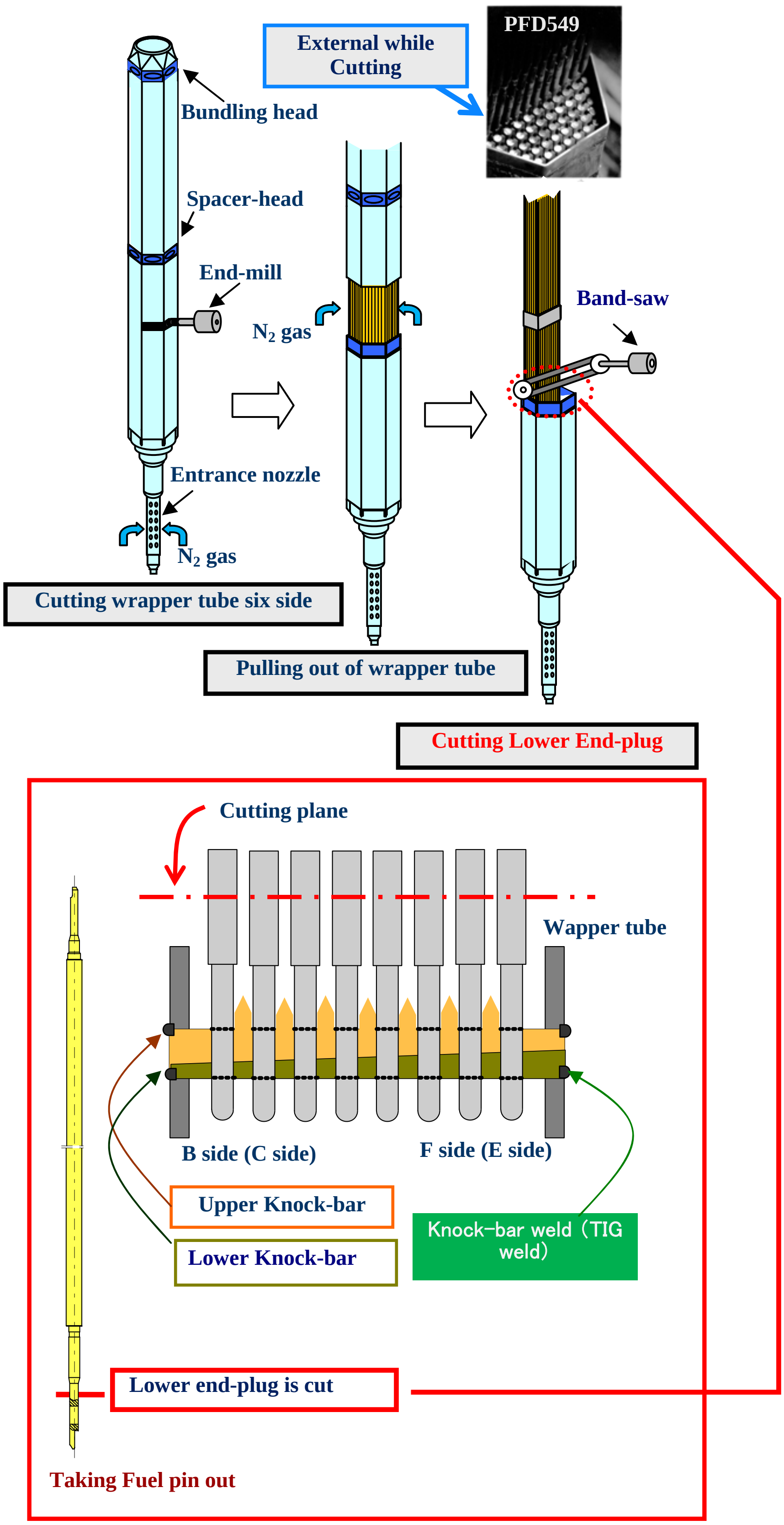

FIG. 2.1. Conventional disassembling technique.

2.2. Irradiation vehicle

There are several kinds of irradiation vehicles in JOYO and the choice is made by considering the irradiation conditions and purpose, etc. The irradiation vehicle used for re-irradiation will be a capsule type, the uninstrumented fuel irradiation subassembly type-B (UNIS-B). The use of the capsule type UNIS-B is considered as a countermeasure for possible fuel failure during irradiation.

Fig. 2.2 shows the method of loading the fuel pins to the UNIS-B. The fuel pins are put in a three-part container consisting of a shroud tube, a capsule, and a compartment, and the container is loaded into the UNIS-B. When the fuel pin is loaded into the shroud tube, the fuel pin is fixed by the support spring through the piecing hole of the lower end-plug. Threfore, it is necessary to leave the lower end-plug of fuel pin in place when disassembling the driver fuel assembly if the irradiated fuel pin is to be irradiated again.

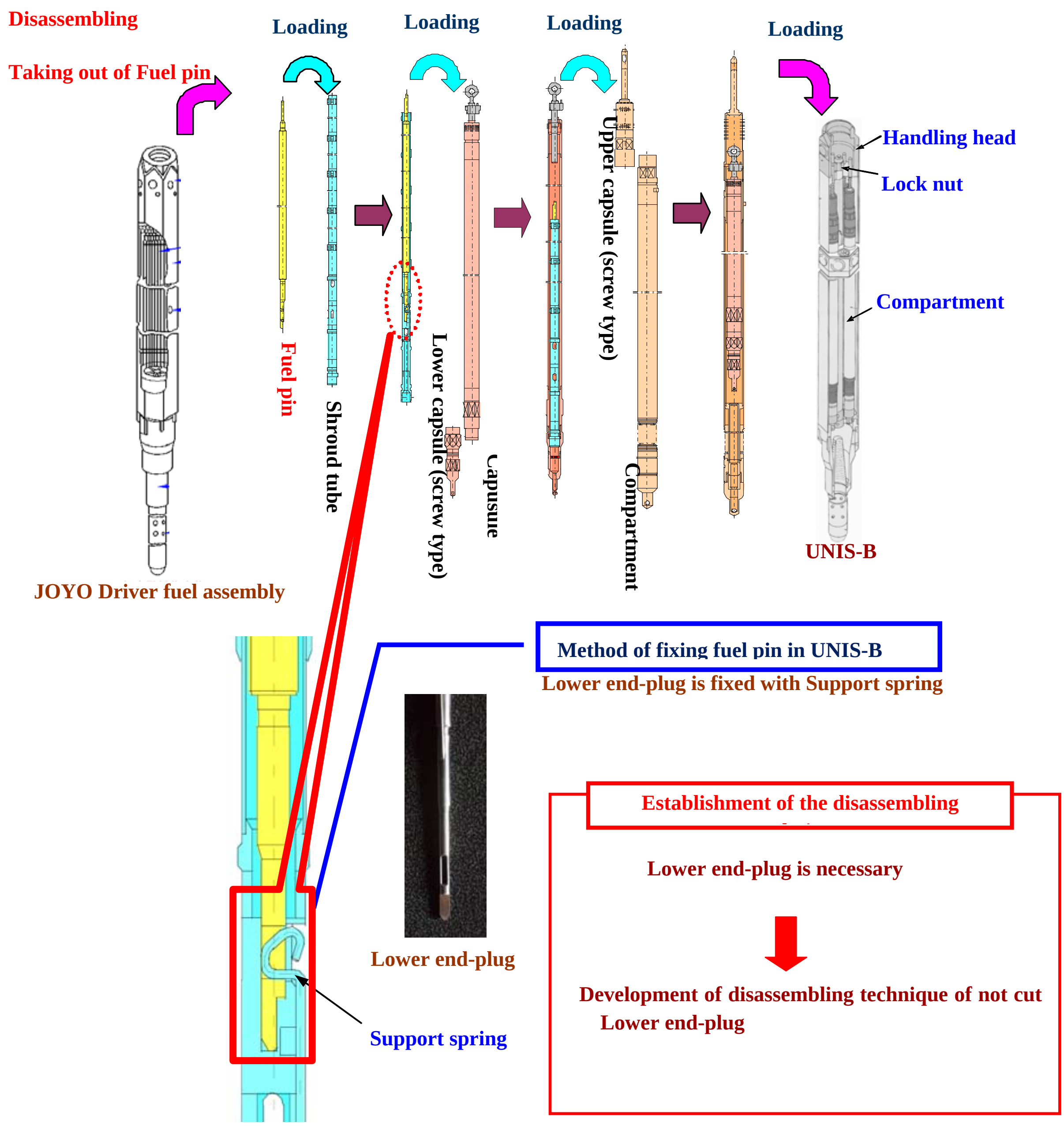

FIG. 2.2. Method for loading UNIS-B.

2.3. Establishment of the disassembling technique

The newly designed disassembling technique is shown in Fig. 2.3. The work consists of cutting knock-bar weld and taking out the knock-bar. The weld of the wrapper tube and the knock-bar to the fuel pin is cut by the end-mill separately. The knock-bar is taken out with a newly developed extrusion tool. This method does not cut the lower end-plugs of the fuel pins. Moreover, the shape etc. of the extrusion tool was devised to allow for remote operability in all work.

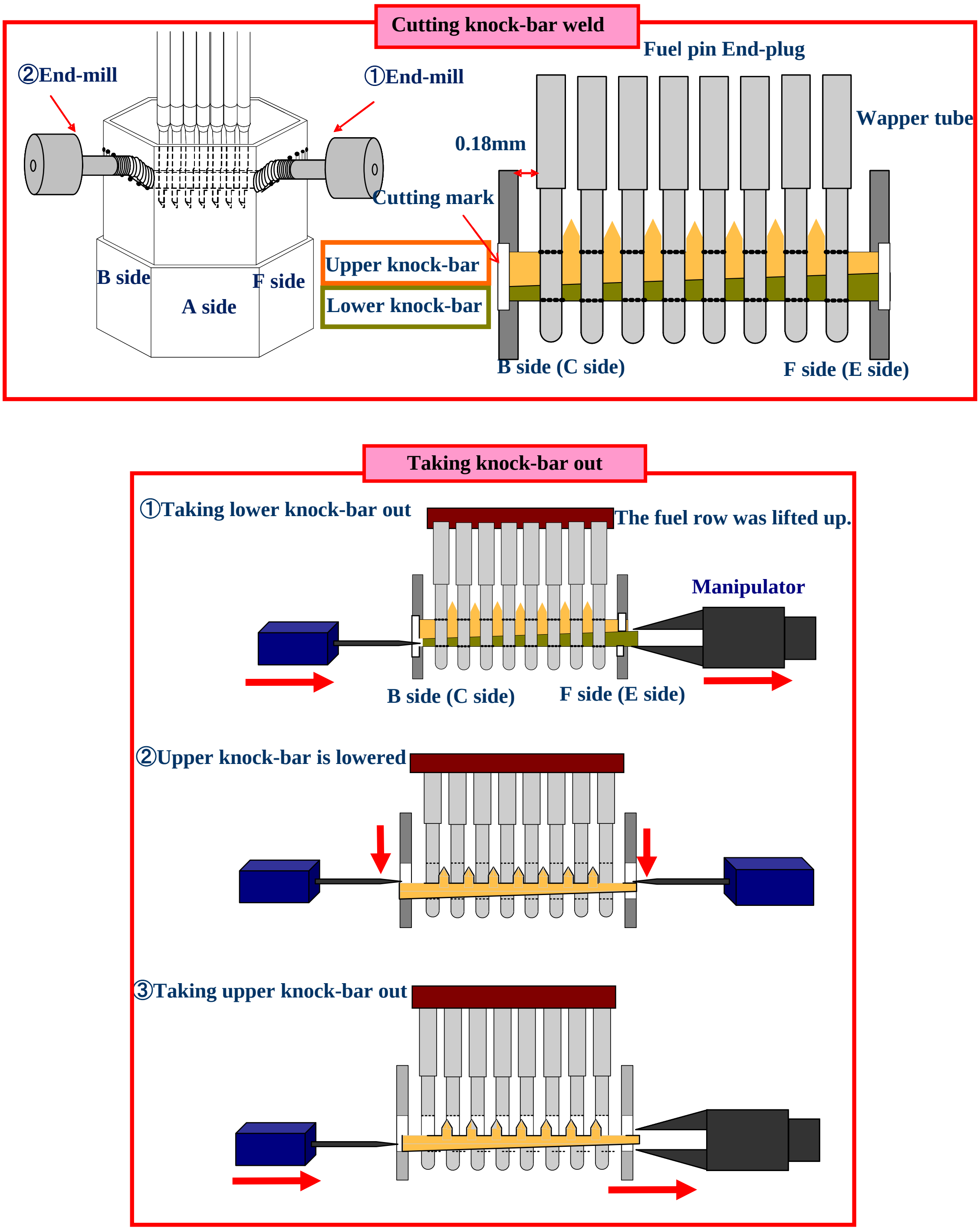

FIG. 2.3. Caption correction work procedure.

3. APPLICATION TO JOYO DRIVER FUEL ASSEMBLY

3.1. Outline of the JOYO driver fuel assembly

This disassembling technique was applied to the JOYO MK-Ⅱ driver fuel assembly. The irradiation conditions of this driver fuel assembly were as follows:

- Burn-up: average 6.09×10^4 MW·d·t^{-1},
    - Max 9.49×10^4 MW·d·t^{-1}.
- Fluence: 8.83×10^{22} n·cm^{-2} (E>0.1 MeV).

Moreover, this driver fuel assembly had been kept in water for about 17 years after irradiation. After disassembling, part of the fuel pins taken will be provided for the re-irradiation test and part for the post irradiation examination (PIE).

3.2. X-ray computer tomography observation

As for the structure of the driver fuel assembly, the space between the wrapper tube and the lower end-plug is very narrow. Therefore, it is necessary to know the internal situation. Then, the driver fuel assembly was observed by X-ray computer tomography (CT) before disassembling. Figs 3.1–3.2 show the CT image of the driver fuel assembly. As a result, it was confirmed that neither the fuel pin lower end-plug nor the knock-bar were changed by the irradiation. Moreover, it was confirmed that there was a space (0.18 mm) between the wrapper tube and the fuel pin lower end-plug. It was judged to be possible to apply this disassembling technique to the driver fuel assembly.

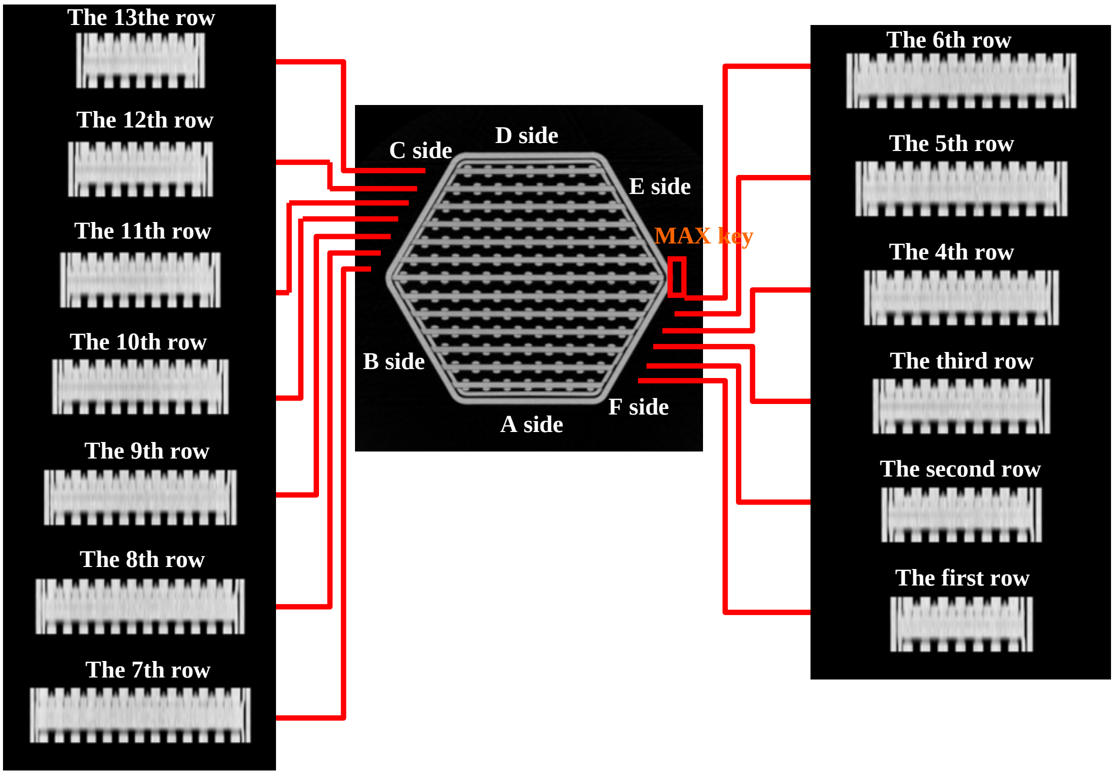

FIG. 3.1. Cross-section observation (range of taking picture: 1249.6–1267.6㎜ from bottom of assembly).

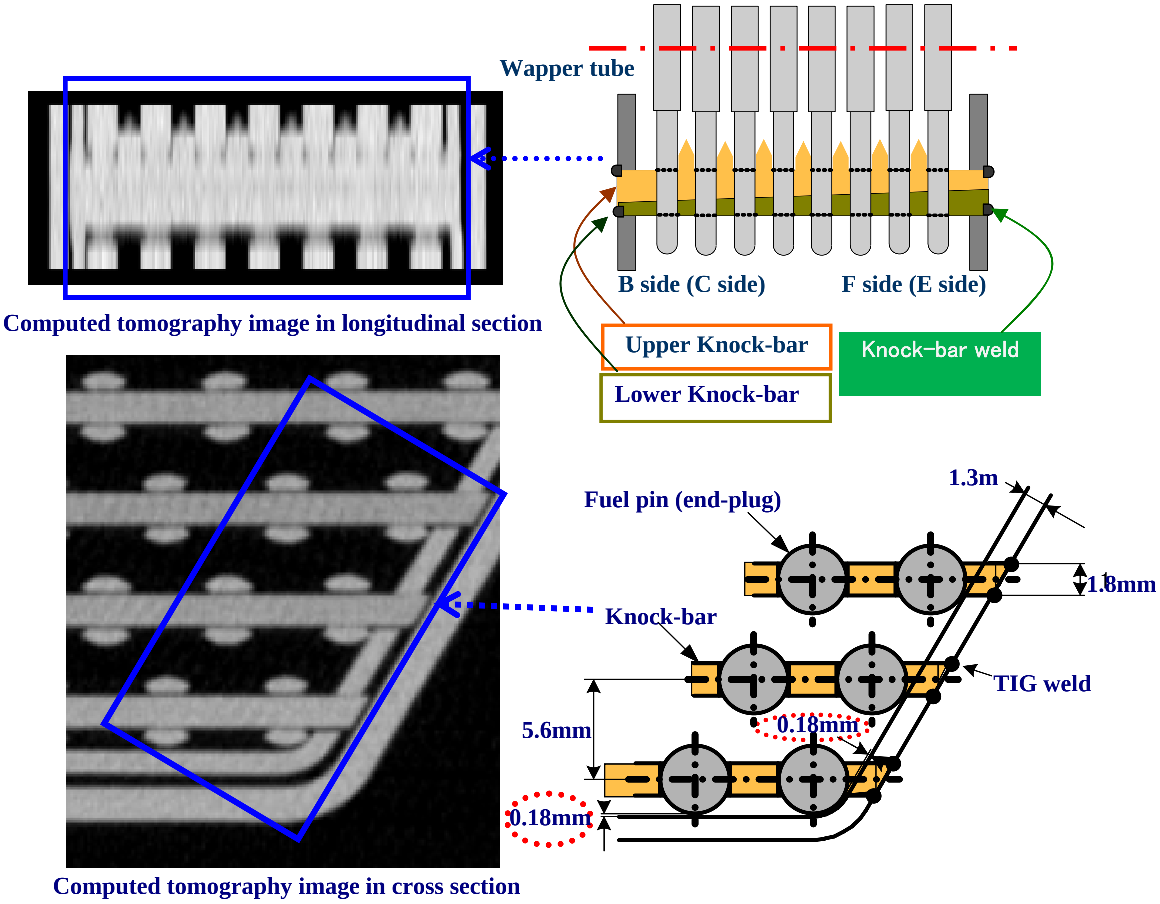

FIG. 3.2. State of the driver fuel assembly.

3.3. Cutting knock-bar weld

Fig. 3.3 shows cutting of the knock-bar weld. The knock-bar weld on the wrapper tube (thickness: 1.3 mm) was cut by the end-mill. The cutting conditions of the end-mill were as follows. Max amount of cutting was 0.3 mm per one time, sending speed was 3 mm·s^{-1}, and cutting position was 1.2567 mm from the bottom of the driver fuel assembly. A row of fuel pin was cut separately for each row in order to take out the knock-bar out. Cutting the knock-bar was in the order of the F side and B side then the E side and C side. To avoid touching the fuel pin lower end-plug by the end-mill, the amount of cutting in the end-mill was controlled in detail.

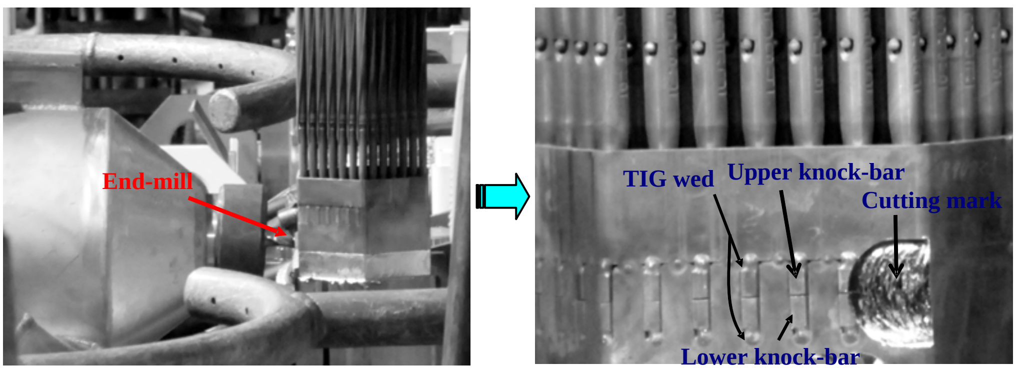

FIG. 3.3. Cutting knock-bar weld.

3.4. Taking the knock-bar out

Fig. 3.4 shows taking the knock-bar out. The knock-bar is pushed out of the B side or C side by the extrusion tool, and taken out of the F side or E side by a manipulator. The knock-bar was taken out in the order of lower knock-bar then upper knock-bar. The upper knock-bar was pushed up by the lower knock-bar in a fuel pin row. Therefore, after the low knock-bar had been taken out, the upper knock-bar was lowered to the position of the piercing hole by using the extrusion tool.

Fig. 3.5 shows the disassembling procedure of the first row. All fuel pins could be taken out without cutting the lower end-plugs. Some of these fuel pins will be loaded to UNIS-B and re-irradiated in JOYO.

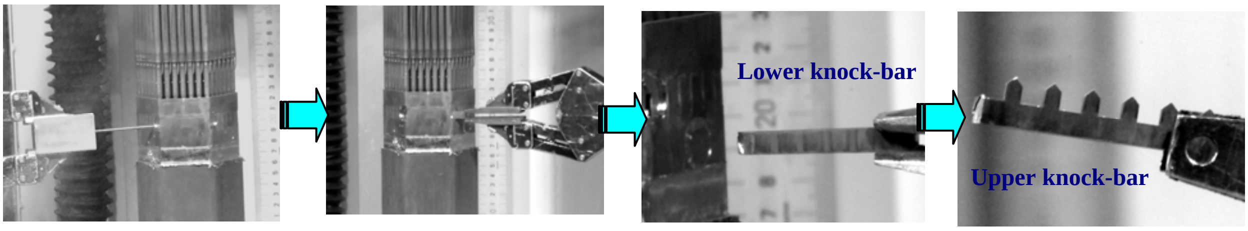

FIG. 3.4. Taking knock-bar out.

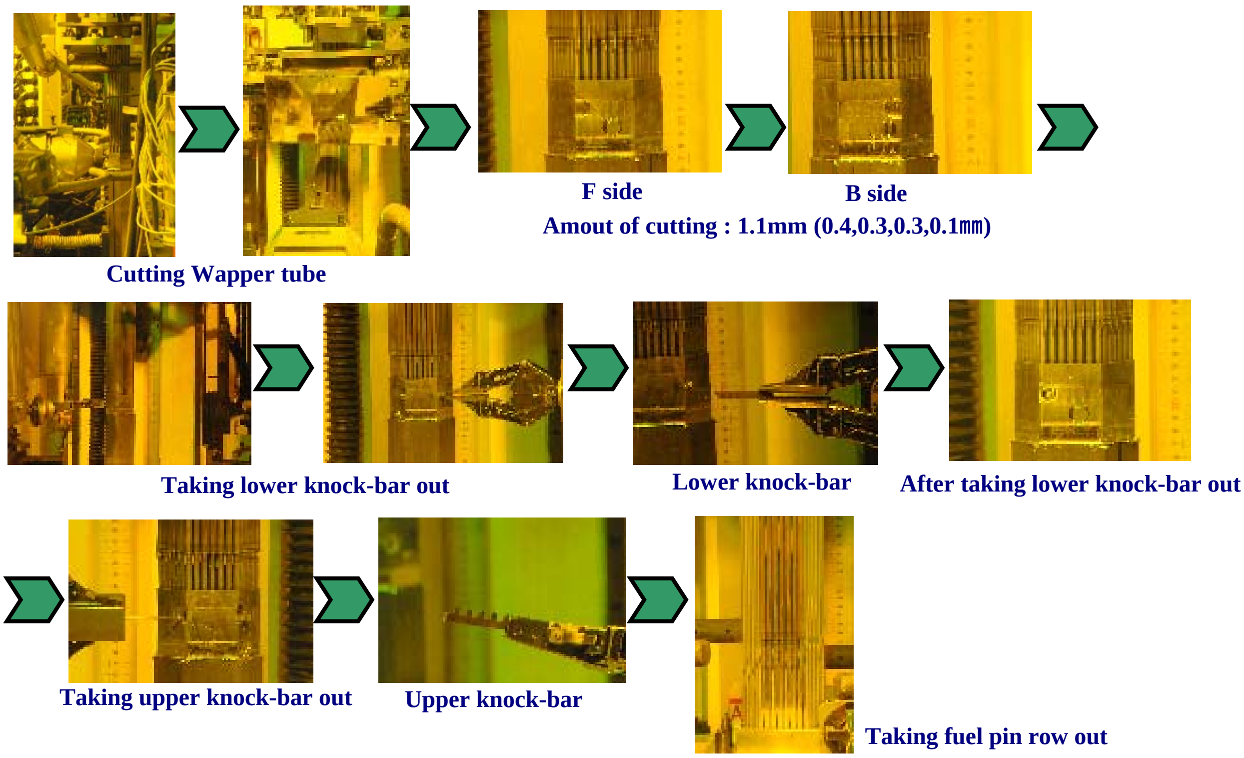

FIG. 3.5. Disassembling procedure of the first row.

4. APPLICATION OF THE DISASSEMBLING TECHNIQUE

This disassembling technique can also be applied to disassembling the uninstrumented fuel irradiation subassembly type-C (UNIS-C). UNIS-C is an irradiation vehicle similar to UNIS-B, and the method of fixing fuel pins in UNIS-C is the same “knock-bar fixation type” as the JOYO driver fuel assembly. UNIS-C is a double wrapper tube structure, and continuous irradiation of the fuel pins is possible by exchange of the outside wrapper tubes. A further continuous irradiation using UNIS-B becomes possible by applying this disassembling technique after the continuous irradiation of UNIS-C ends.

5. CONCLUSION

The re-irradiation of the fuel pin of the driver fuel assembly (knock-bar fixation type) irradiated in JOYO has become possible. As a result, it will be possible to obtain high burn-up fuel for the FaCT Project and to reuse irradiated fuel in JOYO. This disassembling technique can get many fuel pins for the continuous irradiation from the same driver fuel assembly. It will be possible to carry out important irradiation examinations such as the power-to-melt (PTM) examination using the previously irradiated pins.

REFERENCE

[1] JAPAN ATOMIC ENERGY AGENCY, Irradiation Center User Guide, Japan Nuclear Cycle Development Institute (2000).