Feasibility Study of Fuel Debris Cutting and Dust Collection Technology for Innovative Approach <IHI Corporation>

Purpose and Goal

【Objectives】

Feasibility on Laser cutting which has high cutting performance and NitroJet® cutting (*1) which is high safety is studied to diversify the debris cutting technique.

(*1) Ultra-Highly Pressurized Liquid Nitrogen Decontaminating and Cutting Technology

【Targets of this F/S】

- **Extracting issues etc. to realize cutting Debris, through developing system and setting detailed specification**
- **Compatible between safety for Zirconium cutting and imitation debris cutting by Laser, checking cutting availability for hard materials by NitroJet®**

Overview and Feature

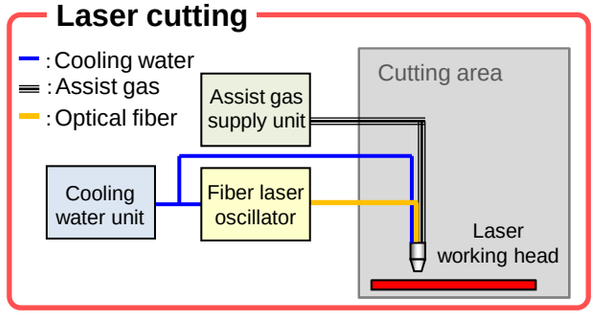
【Item】

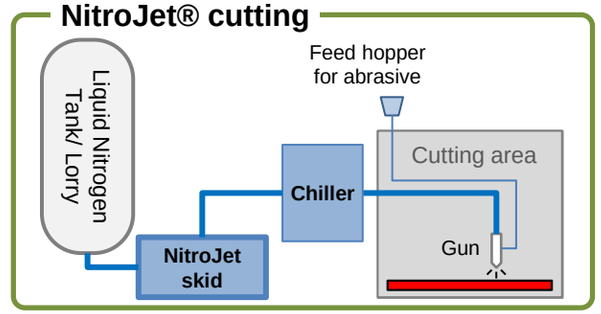
① Basic plan for realization of the proposed technology
- Developing system for cut & dust collection
- Setting Detailed specifications of the equipment
- Study for cutting debris

② Application to the site
- Extracting issues and Planning prospective solutions to realize cutting Debris

③ Process, Organization structure and Cost for realization of the proposed technology
- Study of Process, Organization structure and cost in the period from developing cutting system to applying to the site

【Cutting technologies for this F/S】





【Focus point in this F/S and our Strength】

- ✓ To realize diversification of cutting techniques for Debris (Challenge for faster, safer cutting technology)
- ✓ By means of executing actual cutting test, more feasible cutting techniques to the site can be verified. (on the assumption that debris is cut in unknown material situation)
- ✓ Capability based on practical experiences of “Remote open air Laser cutting technology” as a dismantling system in high dose rate circumstance.

Outcome obtained

(1) Cutting system

System configurations and main specifications of main components which compose Laser cutting & NitroJet® cutting system were set.

(2) Dust collection system

Simplified dust collection system, improvement of workability for cutting debris and decreasing of expanding contamination could be realized by unifying local dust collector and ventilation system. Also system configuration of the ventilation system and necessary treatment method to treat fume etc. generated by Laser cutting were set.

(3) Study of remote operation

Taking two alternative method for fuel debris retrieval (top and side access), Remote operationality study of Laser Cutting system was carried out. (Fig.1 & 2)

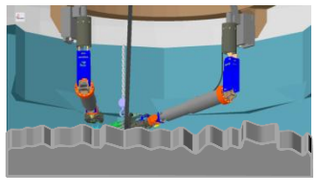


Fig. 1 Image of Laser cutting in top access

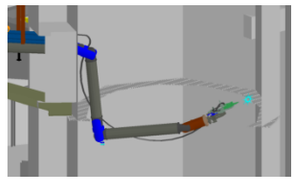


Fig.2 Image of Laser cutting in side access

(4) Cutting test

from viewpoint of vickers hardness and melting point, several cut materials were selected as material of cutting test piece. (Table 1)

Table 1 Material of Test Piece

Assumed area	Material of T/P	Hardness (GPa)	Melting point (℃)
Inner Structure (Cutting resistant materials)	Inconel（NCF600）	1.8	1,370～1,410
Fuel Debris (Hard materials)	Steatite	5.8	1,300～
	ZrO_2	10.7	2,720
	Al_2O_3 White	12.3	2,050
	Al_2O_3 Ivory	17.2	2,050
Fuel Cladding	Zr	0.9	1,850

＜Test Results＞（Table 2）

・Safety for cutting Zirconium

Cutting conditions without continuous H_2O-Zr reaction and excess detonation limit of hydrogen density in the RPV was checked when zirconium was cut by Laser. (Fig. 3 & 4)

Fig. 3 Test appearance for H_2 density measurement

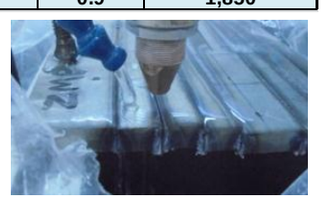


Fig.4 Feeding water situation in Zr cutting

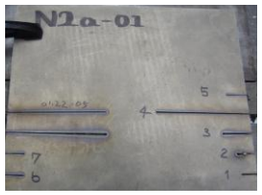
・Laser cutting

Laser could cut all test pieces

(within the conditions for Zr safe cutting)

・NitroJet® cutting

NitroJet® could cut all test pieces



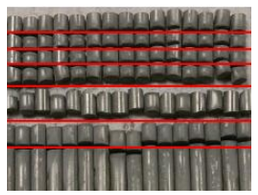


Fig.5 Example of cutting test results

（Left）Laser cutting (NCF600)，（Right）NitroJet® cutting（Zr）

Table 2 Results of cutting test

Technique	Material	Target	Results
Laser	①Zr	Checking that continuous H_2O-Zr reaction isn't happened and the density of hydrogen gas is under detonation limit.	○（Checked）
	②NCF600	Checking compatibility between ① and Inconel cutting	○（Checked）
	③Al_2O_3 white･ivory	Checking compatibility between ① and Alumina cutting	○（Checked）
	④ZrO_2, Steatite	Checking of Laser cutting availability	○（Available）
NitroJet®	⑤NCF600	Checking cutting performance	○（Available）
	⑥Zr	Checking compatibility between ⑤ and Zirconium cutting	○（Checked）
	⑦ZrO_2, Al_2O_3 white･ivory, Steatite	Checking of NitroJet cutting availability	○（Available）

Challenges and Issues in the future

Issues and prospect solutions are shown from the viewpoint of applicability to the site and realization of proposed technologies

Table 3 Issues from field visit

No.	Issues from field visit
1	Space distribution should be coordinated between cutting system and totalizing system in the refueling floor and 1st floor.
2	Cable routing should be investigated between the system and cutting equipment on the another floor.
3	Pedestal is narrow and PCV opening size will be small, so that installing method of optical fiber etc. should be considered.

Table 4 Issues to realize proposed technology

No.	Technical issues	Prospect solutions
1	Validation of radiation tolerance for optical fiver	Irradiation test up to 2MGy will be executed
2	Laser cutting test on the assumption open air and underwater	Open air / Underwater Laser cutting test will be executed to demonstrate followings ・Debris cut-out from thick plate ・Application of higher power and pulse Laser ・Cutting technique up to reach fuel debris ・Tracing of Laser torch head for surface ・Application of compact Laser torch head
3	NitroJet® cutting test.	NitroJet® cutting test will be executed to confirm followings ・Influential to the cutting performance when extending whip tube ・Acceptability of stand-off variation
4	Validation of remote setup, operation and maintenance method	Various remote operations will be verified in cold mock-up test before installation of those equipment to the site.