Development of Fundamental Technologies for Retrieval of Fuel Debris - Remote Controlled laser cutting, simulant characterization, dust and gazes characterization and active trial feasibility study - **COMEX NUCLEAIRE – Final Report Summary**

Outline of the project

COMEX NUCLEAIRE and CEA proposed to apply to Fuel debris retrieval the LASER technology which is being used for decommissioning of nuclear facilities and whose encouraging performances were demonstrated in the tests using simulating fuel debris.

In this project, LASER cutting tests in-air for emerging and non-emerging configurations will be tested. The same LASER cutting configurations are proposed under water for different level of water (up to 5m depth). During LASER cutting sequences, the parameters of the release of cutting (gas composition, chemical composition of dust and water, typical geometry of the particles with the participation of IRSN) will be carefully analyzed. Moreover, a collection loop system for the "big" particles (Ø>10µm) will be implemented as prototype.

Non-emerging LASER cutting under-water

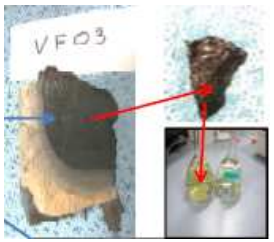
Project outline and outcome obtained

LASER cutting in air and under water:

Performance assessment of LASER cutting in air emerging and non-emerging configurations and improvement of LASER emerging cutting test under-water. Feasibility of non-emerging cut under water

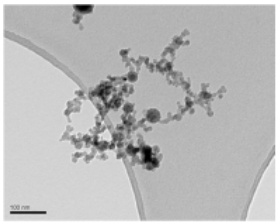
Outcome obtained:

- Emerging LASER cutting in air (ELC-A) : 100mm cut achieved for Zirconia and 160mm for In-vessel fuel debris Simulant
- Emerging LASER cutting under water (ELC-W) : 100mm cut achieved under 17cm of water and 50mm under 5m of water (Zirconia)
- Non-Emerging LASER cutting in air (NELC-A): 50mm cut achieved for Zirconia and 40mm for Ex-vessel fuel debris simulant
- Non- emerging LASER cutting under water (NELC-W): Feasibility has been confirmed with 4 to 7mm cut achieved, to be continued further with new parameters to achieve greater cutting performance



Characterization of the samples of water and aerosol after the cutting

Outcome obtained: Main aerosol released are non radioactive elements (Steel and Zircalloy). The main radioactive elements released have been found to be St, Bs, Ba and Ce (surrogate Pu in the fuel debris simulant). The conversion to radioactivity shows radioactivity released is of a few 10^{11}Bq for 1 m of laser cut.



Evaluation of the main chemical and physical characteristics of the gas and aerosol released during LASER cutting

Outcome obtained: H2 is the main contributor of the gas released (0.36% vol. max) but far under the below limit of explosivity (4%). In the size spectrum of the particles emitted during LASER cutting, the main modes measured by IRSN are ~0.2µm for air cutting and ~0.4µm for under-water cutting. The aerosol mass concentration and the released quantity during cutting are highly dependent of cut the fuel debris simulant (Ex-vessel or In-Vessel) and the environment (air or water).

Collection of the "big" particles (Ø>10µm)

Thanks to a nozzle erected close to the cutting area and connected to a collection loop, assessment of the performance of this loop to recover aerosol and gas during LASER cutting operation.

Outcome obtained: Feasibility has been confirmed, to be continued further to achieve greater collection performance

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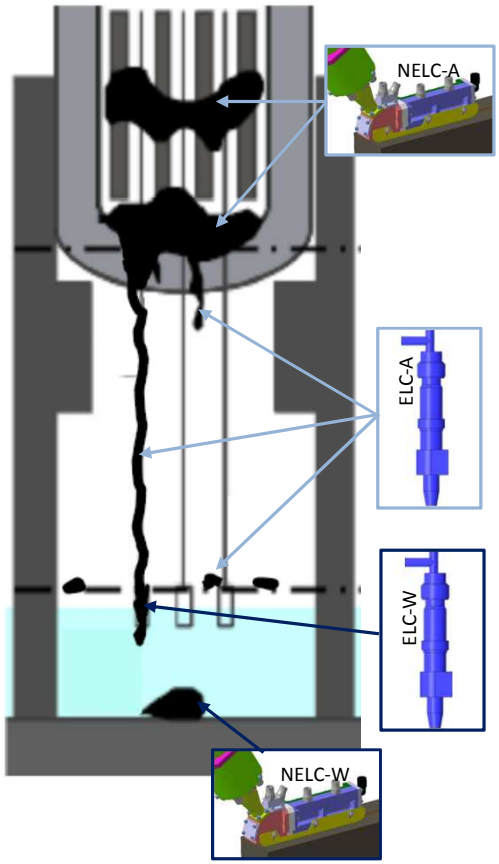
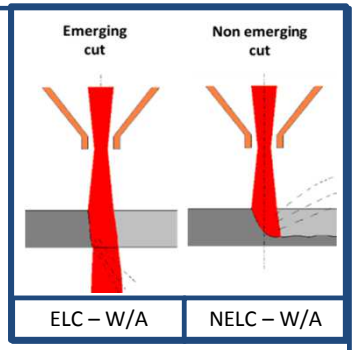
Laser Cutting Summary

ELC-A on Simulant

ELC-W on Zirconia





ELC – W/A | NELC – W/A

2 Technologies :

- Emerging Laser Cutting (ELC)
- Non-Emerging Laser Cutting (NELC)

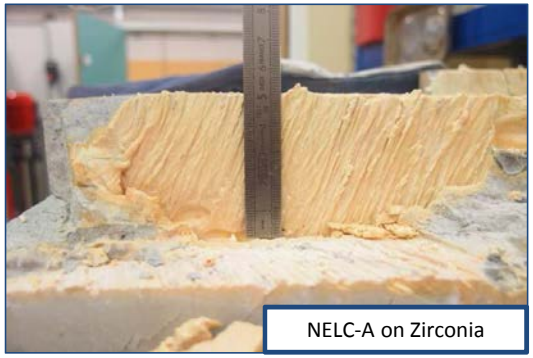
2 Environments :

- In air (A)
- Underwater (W): shallow depth or deep water

✓ ELC-A performance up to 160mm
✓ ELC-W performance up to 100mm under 17cm of water and 50mm under 5m
✓ NELC performance up to 50mm in air

Cutting Technologies

Facility for deep water cutting



NELC-A on Zirconia

Deep water cutting configuration

ELC-W (5m) on Simulant