Underwater Cutting of Metals with Photons

Chris Nyamayaro

Supervisors: Ali Khan, Andrew Pinkerton, David Cheneler

Background

- Significant numbers of North Sea offshore structures and several onshore nuclear power plants will need to be decommissioned in the next 30 years[1].
- The estimate of decommissioning these North Sea structures and lifetime cost for the UK's legacy nuclear waste is approximately £200 billion and £120 billion, respectively.
- These structures and contaminated components will need to be dismantled using an underwater (UW) cutting process
- Current decommissioning technologies which are abrasive water jet, diamond wire cutting and plasma arch cutting are unable to deliver a **SAFER, CHEAPER & FASTER** process
- Fibre laser technology with remote processing capabilities provides the potential opportunity to satisfy the major drivers and needs for both nuclear and oil and gas decommissioning applications

Experiment setup

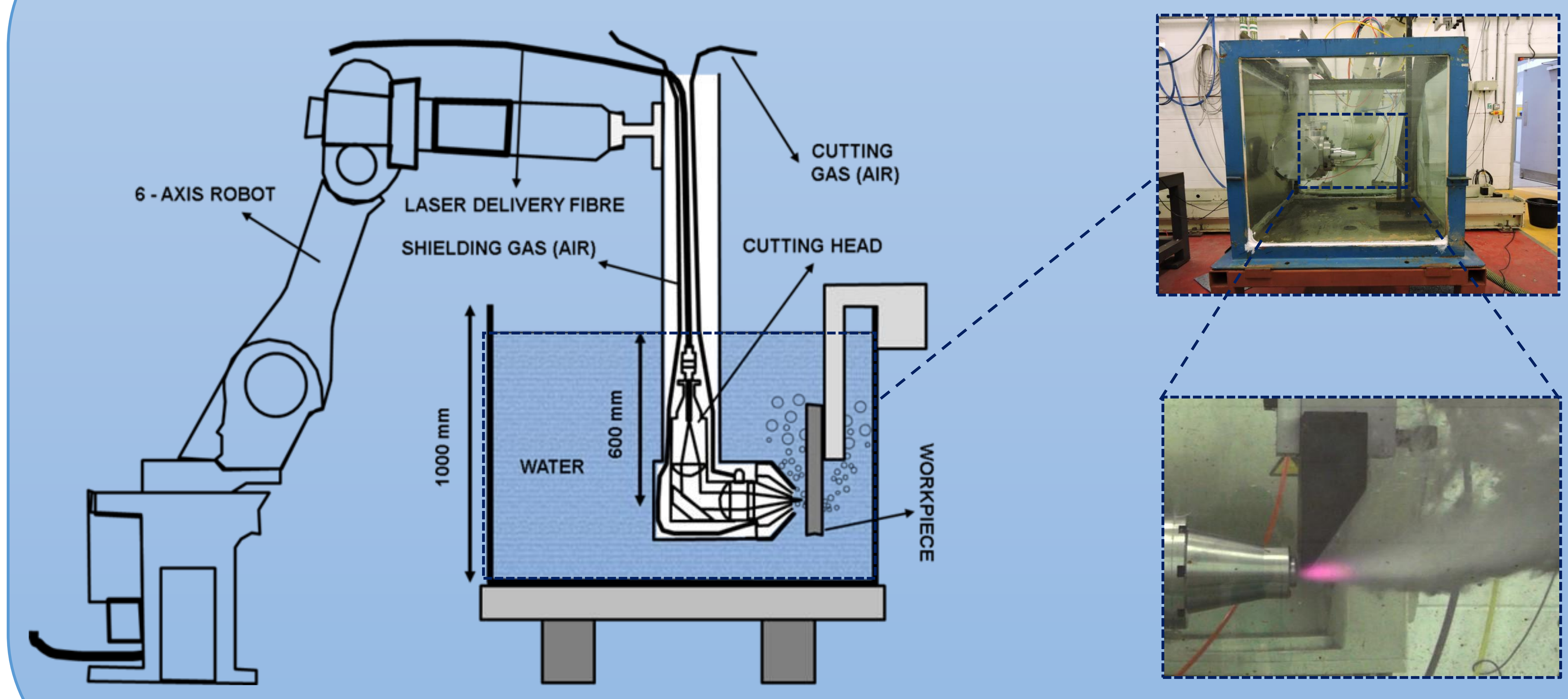


Figure 1: Experiment setup[2]

Aims and Objectives

- ***Scientific***
  - To develop scientific understanding of the underwater laser cutting process and influencing parameters up to hydrostatic pressure of ~20 atmospheres (depth of 200m) on steel structures up to 50mm in thickness.
- ***Technical***
  - To advance the state-of-the–art of an existing underwater laser cutting technology with operational and deployment capabilities up to depths of 200m.
- ***Commercial***
  - To perform dissemination of the project results and exploit developed capabilities.

Analysis of results

- Cut thickness increases with increase in laser power.
- Cut thickness decreases with increase in the cutting speed.
- Cut thickness increases with decrease in standoff distance.
- Cut thickness increases with increasing the assist gas pressure.
- A complete separation of a 50mm thickness C-Mn steel achieved using 10kW laser power, 8 bar compressed air at 4mm standoff distance and cutting speed of 125mm/min.

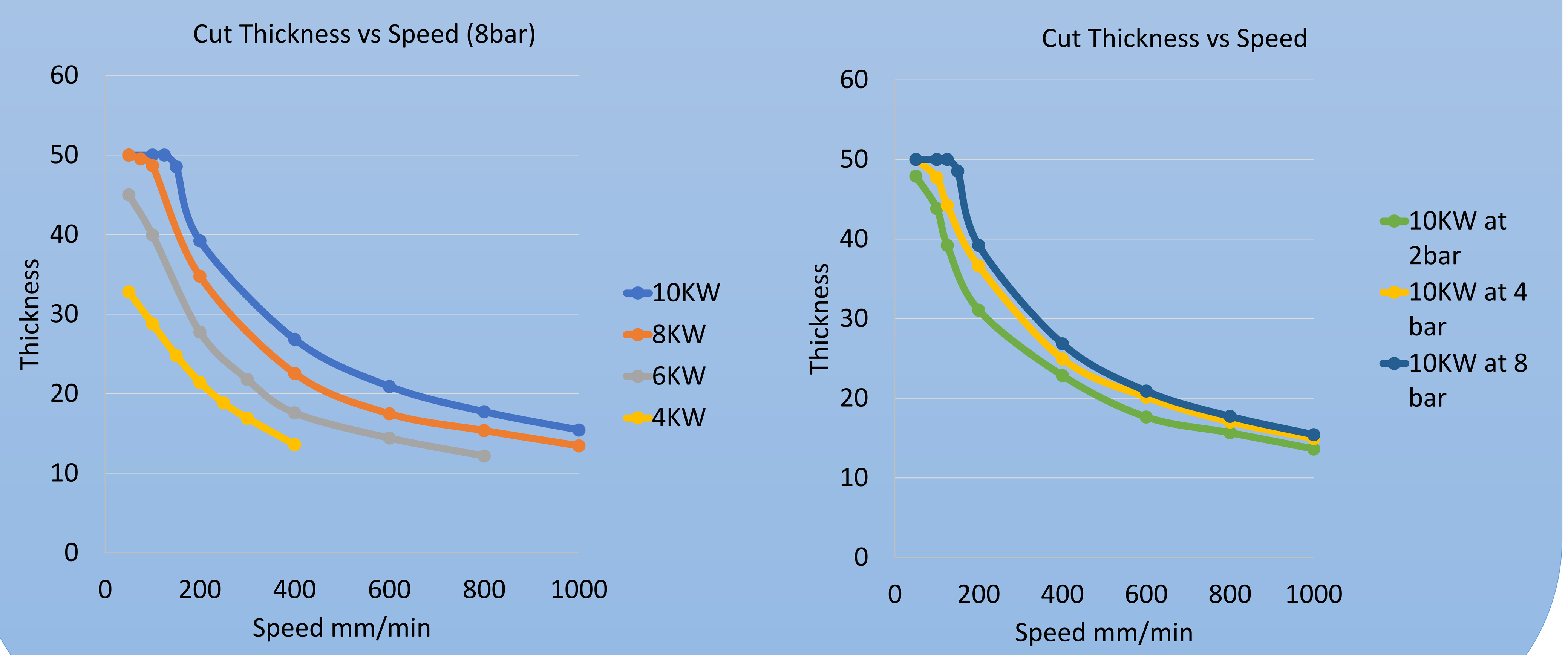
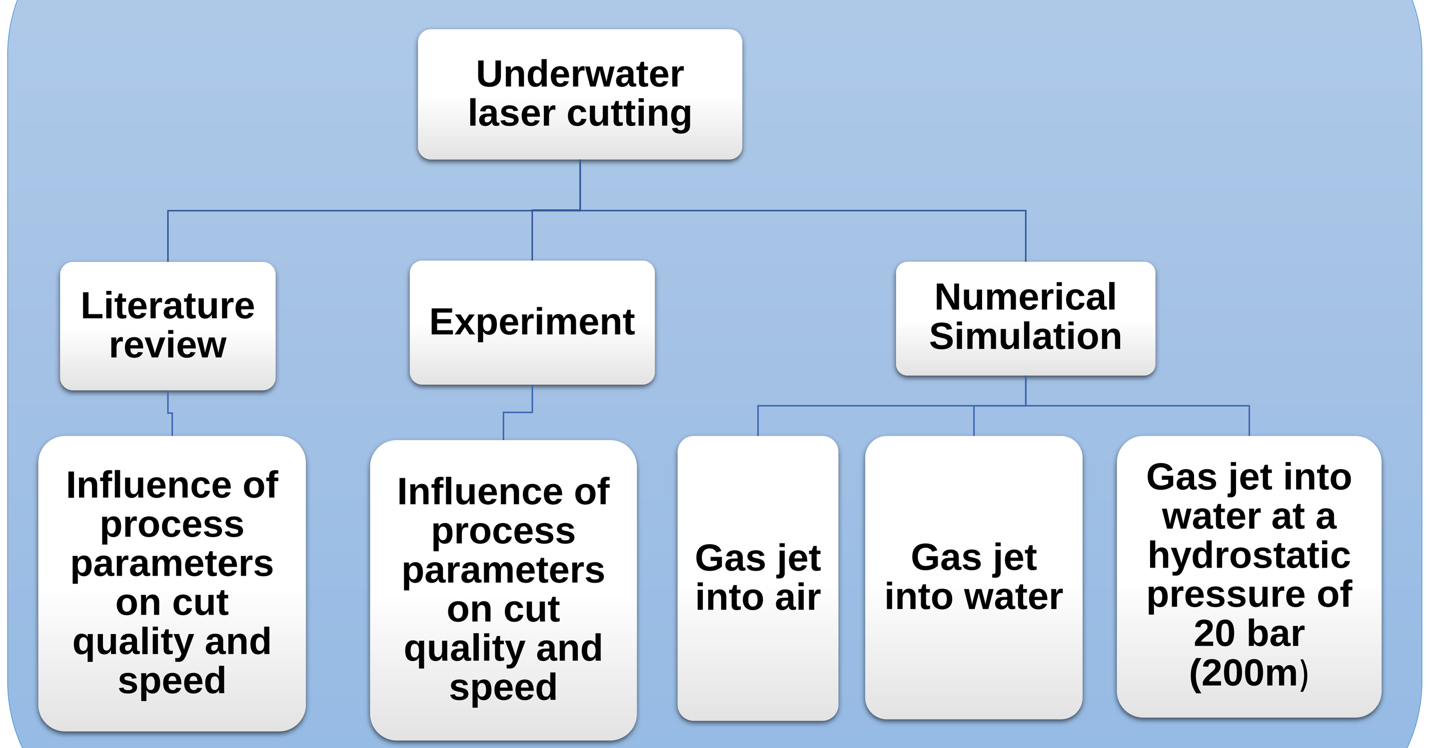


Figure 3: Experiment results - process performance

Process benefits

- Higher cutting speed – *FASTER*
- Light weight and small cutting head with flexibility offered by optical fibre beam delivery making remote deployment less difficult and costly – *CHEAPER*
- Minimal secondary wastes which reduces risk to operator and lower emissions on the environment – *SAFER*
- Ability to cuts complex structural geometries with minimal reaction force on the part being cut – *FASTER*
- High degree of remote automation and large standoff distance control – *FASTER*
- Low deployment input and maintenance, providing significant cost savings – *CHEAPER*
- Laser systems are a high value asset that can be reused many times on multiple projects – *CHEAPER*[2]

Structure



Numerical Simulation

- 2D CFD simulations of a gas jet propagating into air were done using ANSY FLUENT with the aim of looking at the following aspects:
  - a) Influence of different inlet pressures
  - b) Jet potential length
- In water(multiphase simulation still in progress)
  - c) Jet potential length
  - d) Volume fraction and mixing of water and air
  - e) Influence of variations of inlet pressure

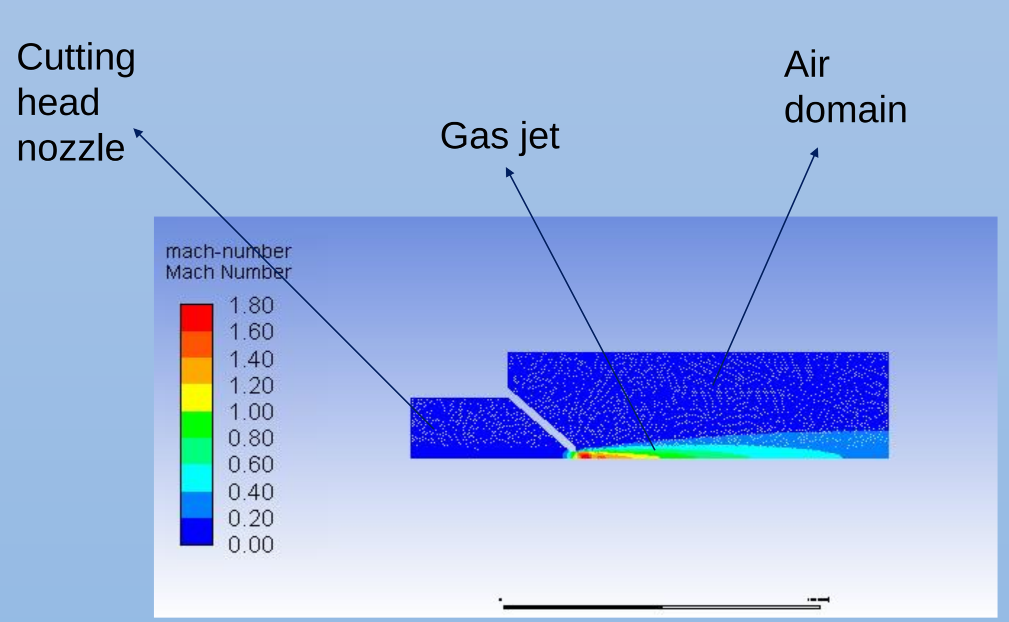


Figure 4: Gas jet into air

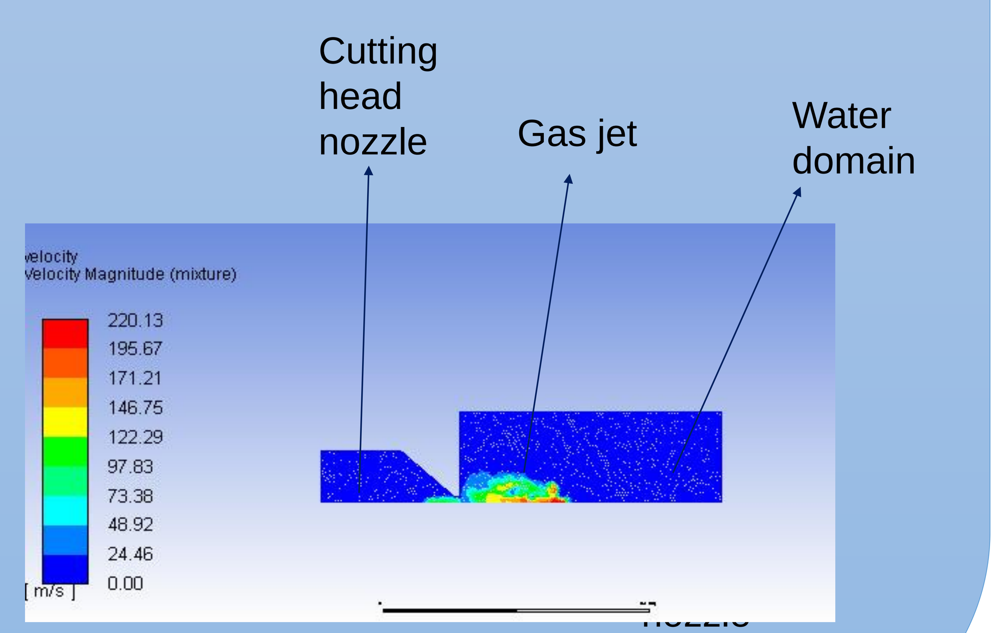


Figure 5: Gas jet into water

Experiment

- Underwater laser cutting trials carried out in a 1m^3 tank at TWI, addressing the influence of laser power, cutting speed, assist gas pressure and standoff distance on the maximum cut thickness and corresponding dross height, kerf width.

Summary and Outlook

- **Initial literature review (phase 1) - completed**
- **1 atmosphere underwater laser cutting trials - completed**
- **Simulation of a gas jet expansion into air - completed**
- **Literature review (phase 1) reporting - in progress**
- **Multiphase flow of a supersonic gas jet simulation - in progress**
- **Multiphase flow simulation in extreme environmental conditions - expected to start in November 2018**
- **High pressure underwater laser cutting trials in a 20bar hydrostatic pressure (200m depth) environment - expected to start in November 2018**

References

1. Legislation.gov.uk. Energy Act 2008: Crown copyright; 2008
2. Ali Khan & Paul Hilton. New opportunities for laser cutting in decommissioning - both in air and underwater: TWI; 2014

Contact

chris.nyamayaro@affiliate.twi.co.uk
c.nyamayaro@lancaster.ac.uk