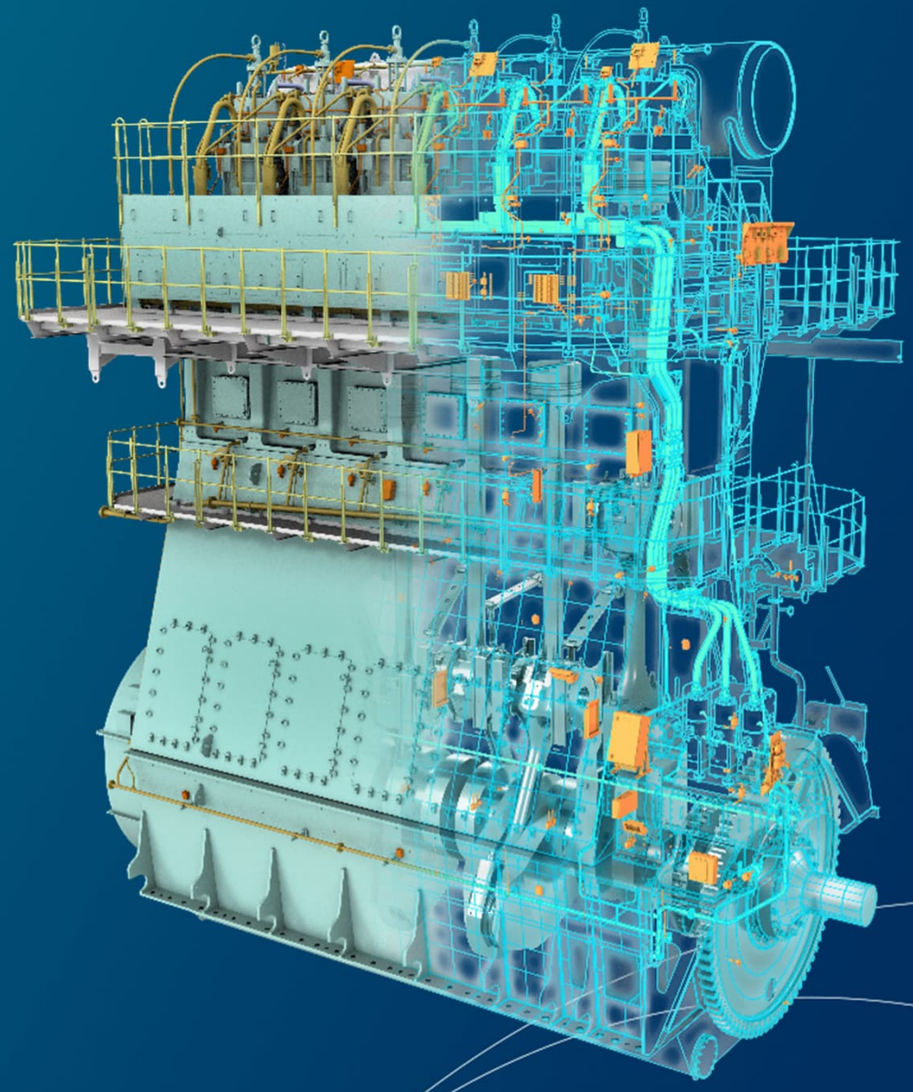
# 3D - Printed Fuel Nozzle

QSmetalAM 2023, 29th of June 2023

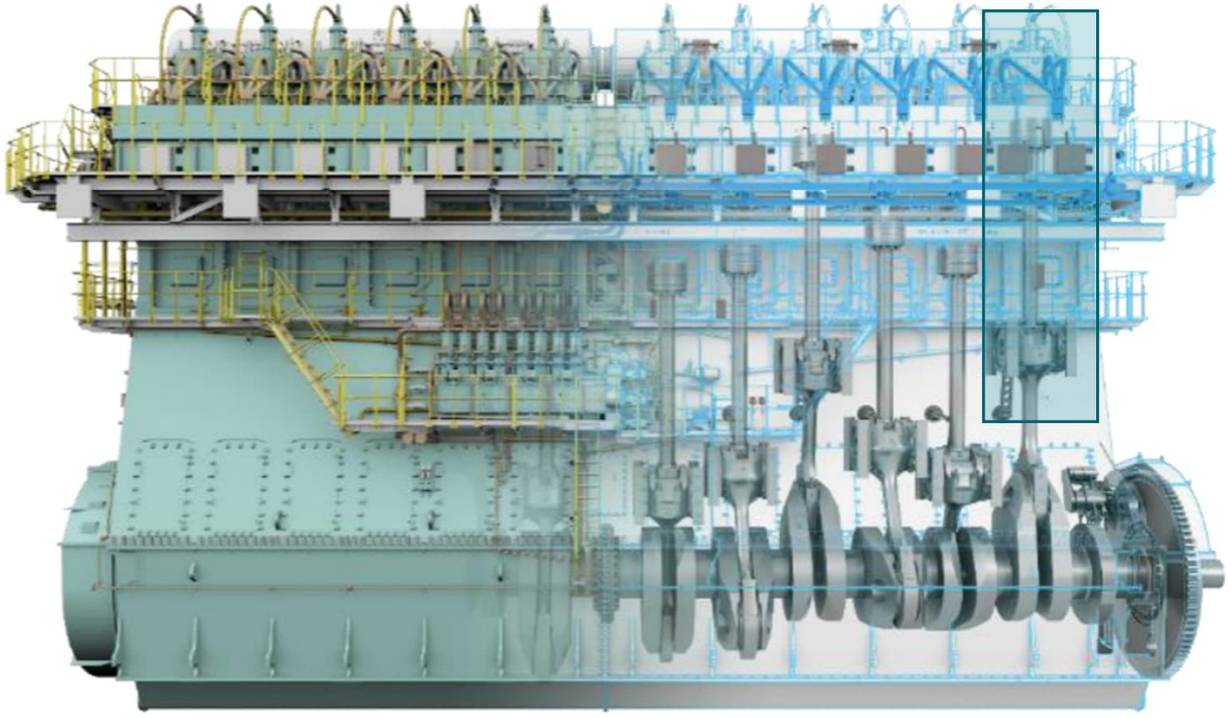
Antti Virta & Dr. Andreas Schmid



WIN GD

# WinGD

## Powering the marine merchant sector




2015 → WIN GD

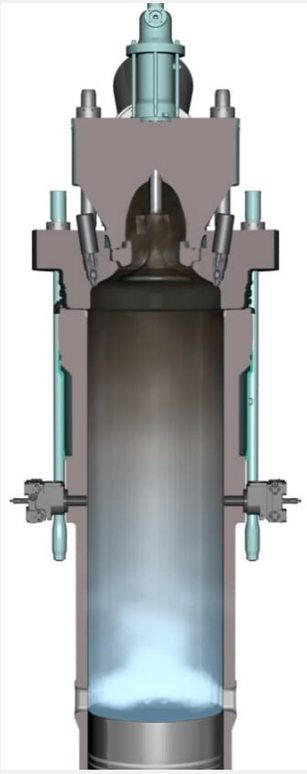
1997 → WÄRTSILÄ

1990 → New Sulzer Diesel

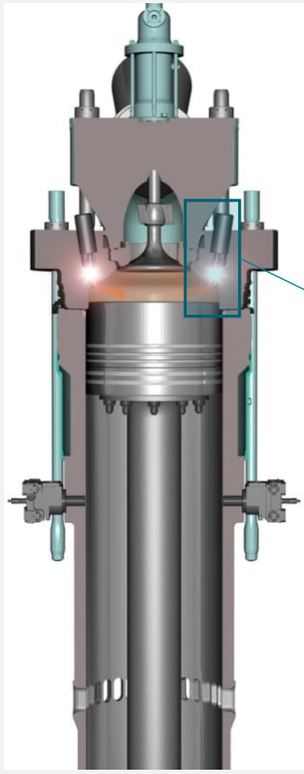
1898 → 1st Sulzer Diesel Engine

1834 → SULZER

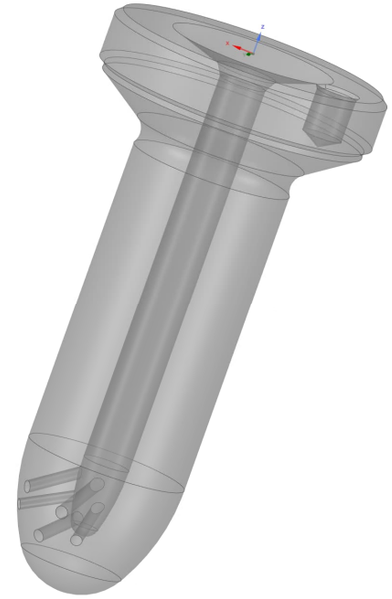
# Combustion Chamber

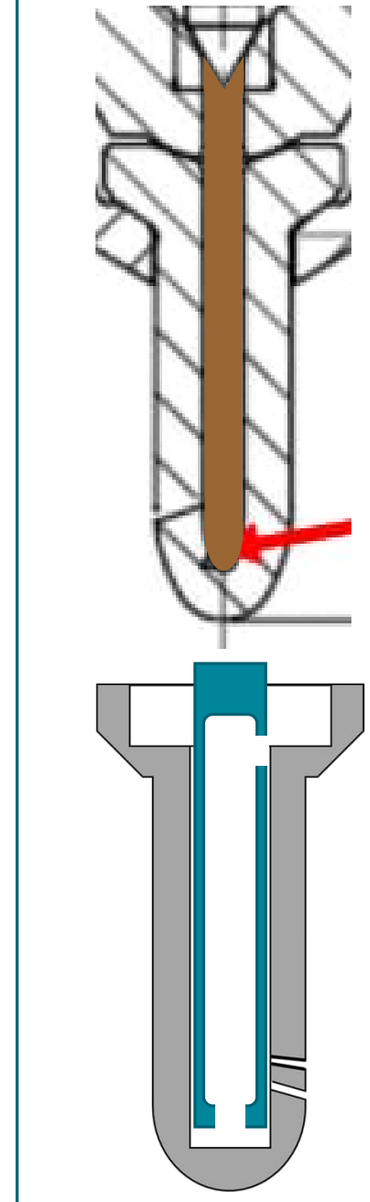


Scavenging



Ignition → expansion

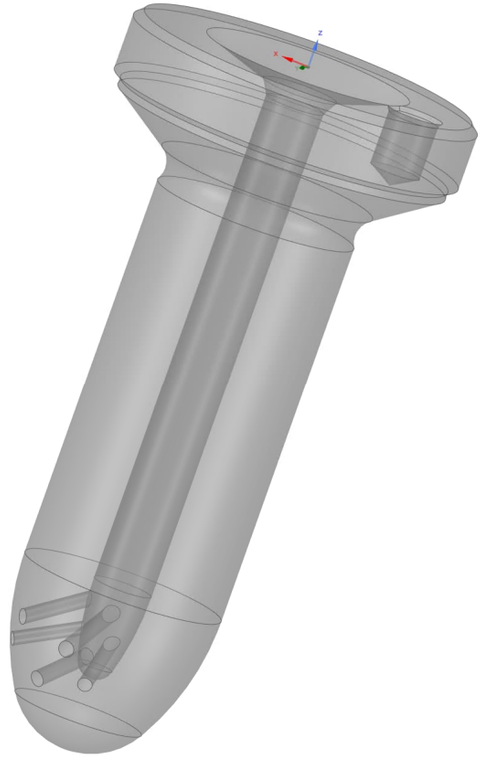





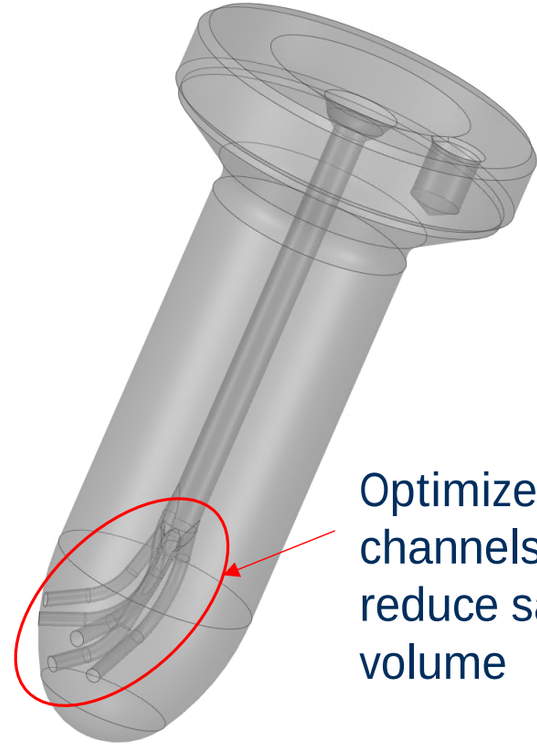
# 3D-Printed Fuel Nozzle

## First investigations with nozzles from EcoParts

Old Nozzle Tip



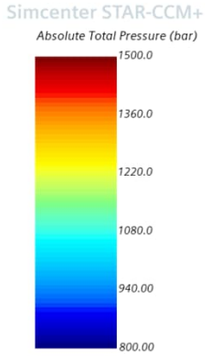
3D-Printed Nozzle Tip

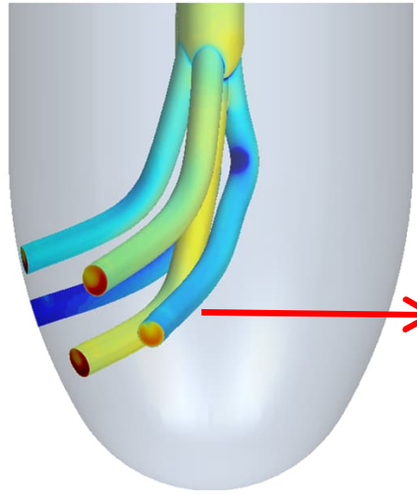


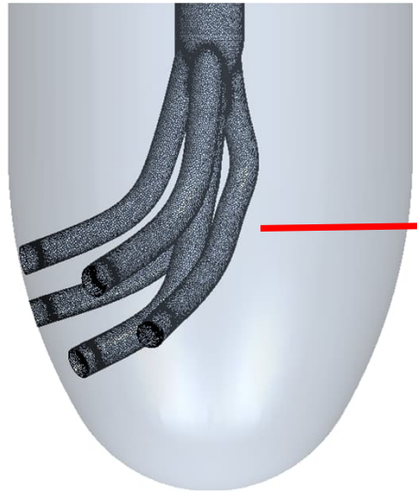
Optimized spray channels to reduce sac volume

# Topology Optimisation

## Goal: Reduction of pressure loss without increasing the volume





CAD base geometry

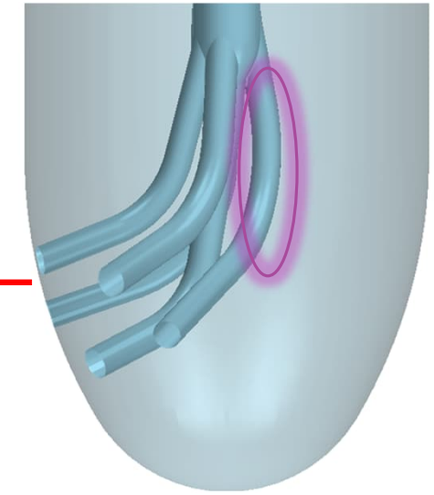
3D CFD simulation

spline points moved

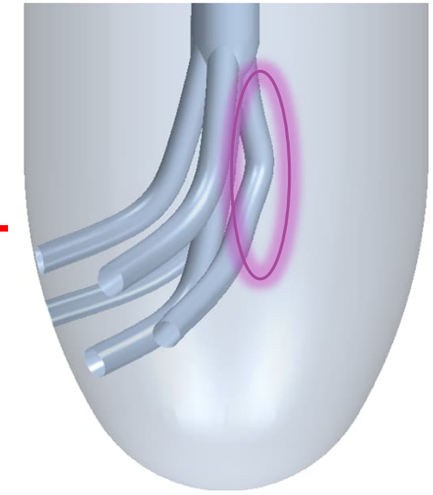
3D CFD automated mesh

new CAD geometry

Base design
Human, intuition

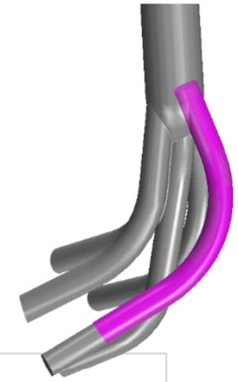


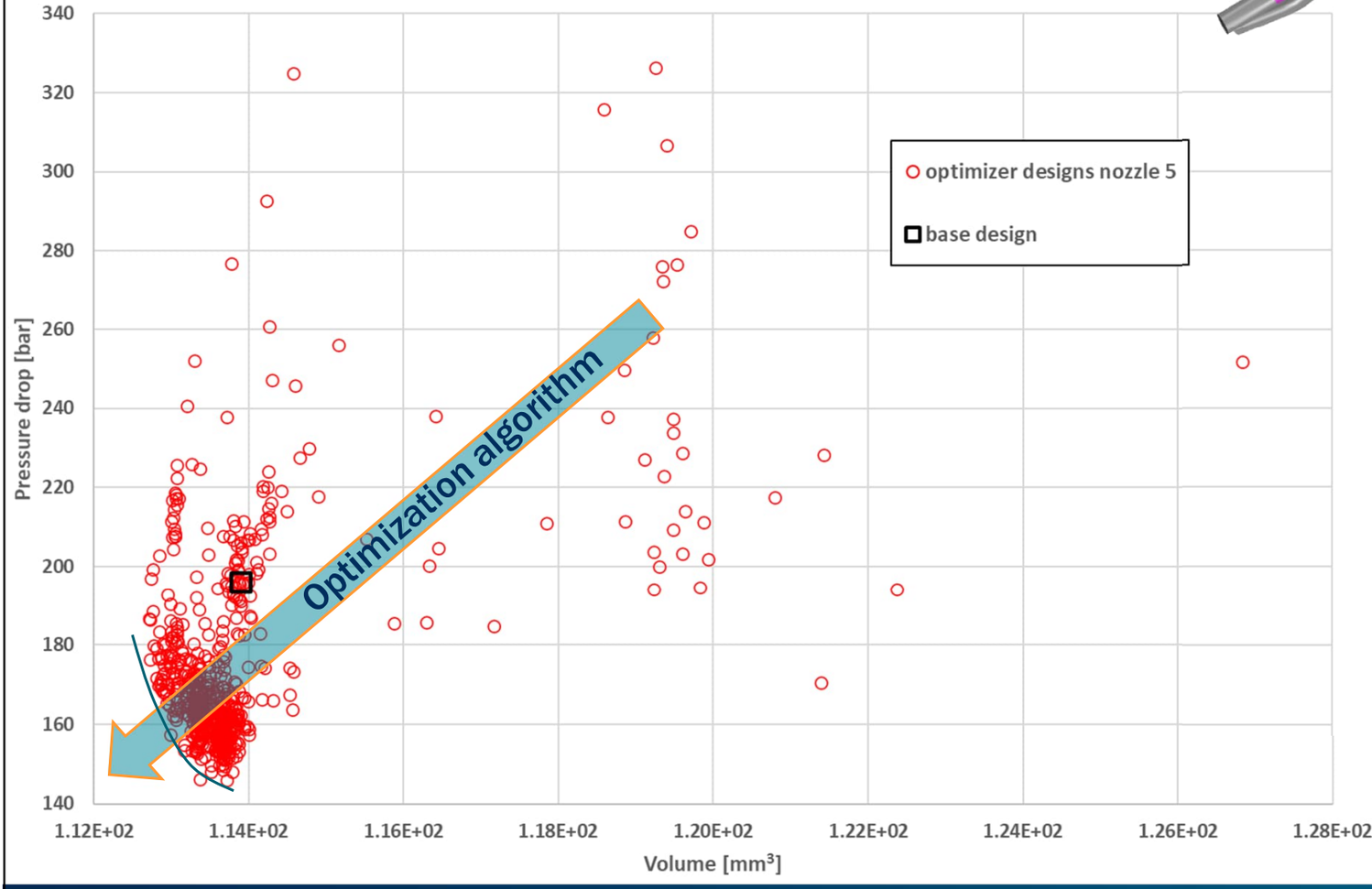
Random design
Code

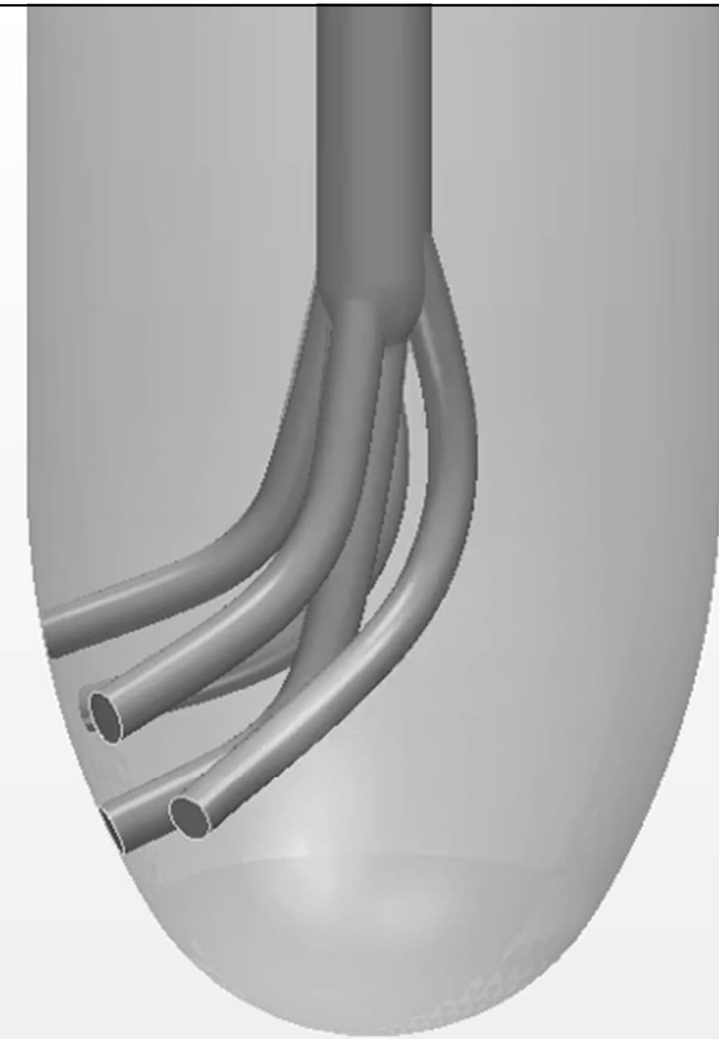


# Topology Optimisation

## Extraction of a Pareto Front





combustion and flow solutions GmbH

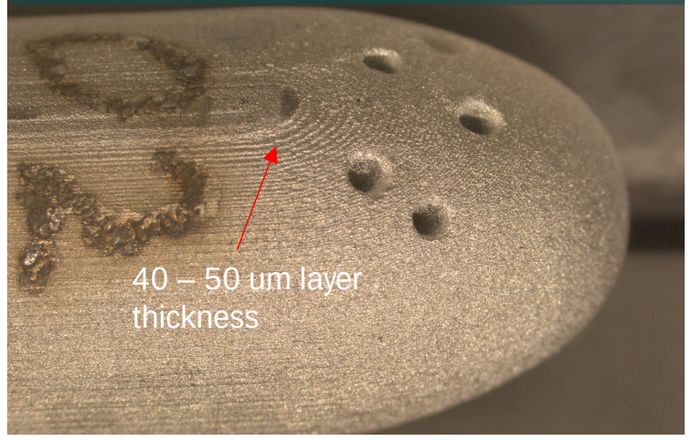


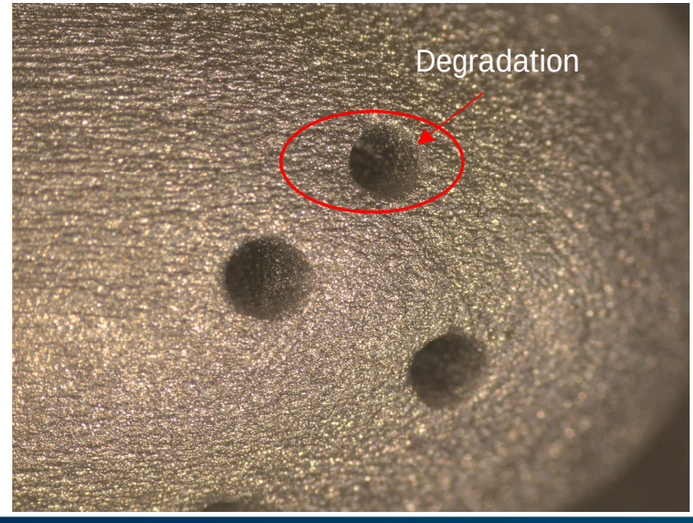

WIN GD

# 3D-Printed Fuel Nozzle – Manufacturing

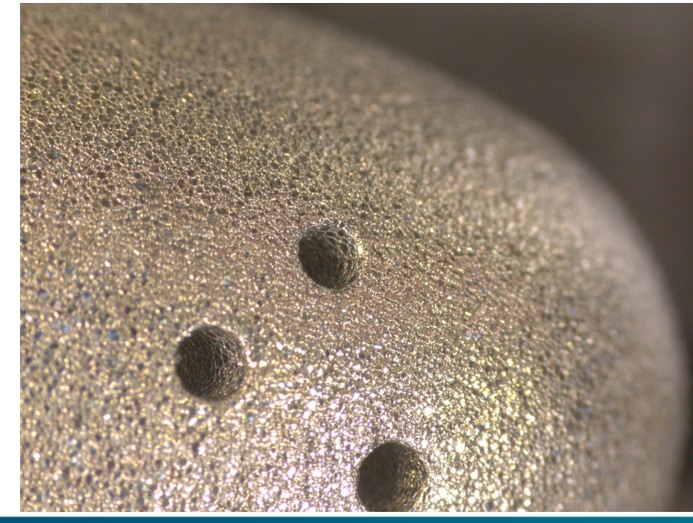
## Prototype components

### Supplier 1 – 17-4 PH



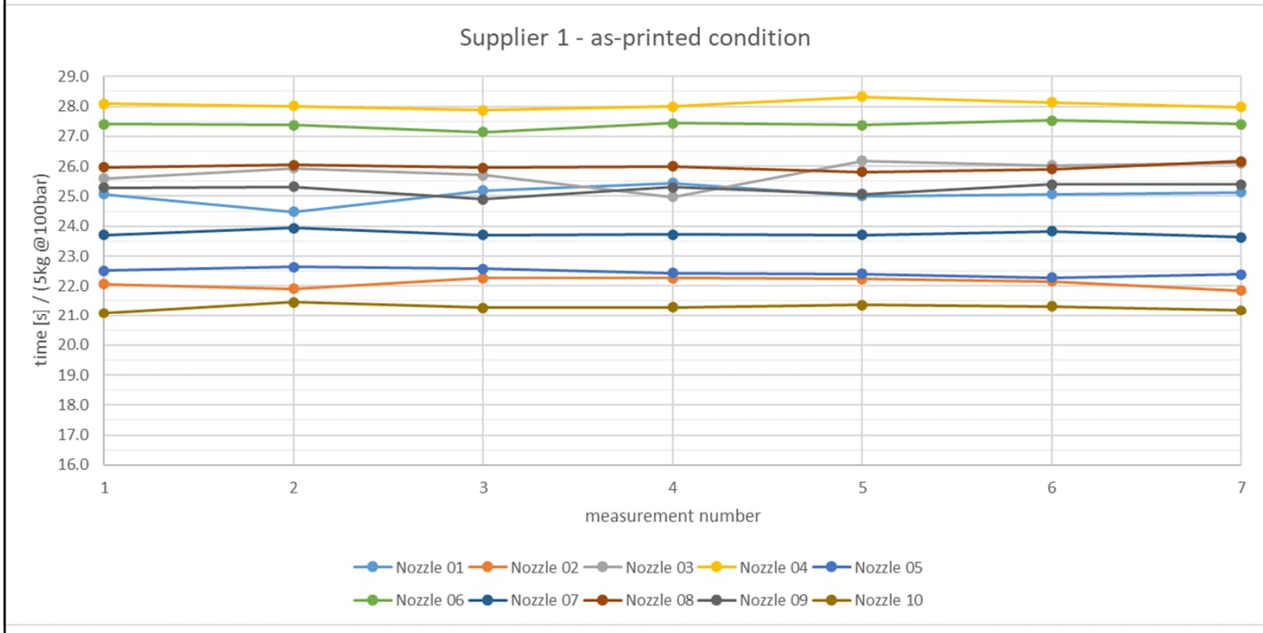



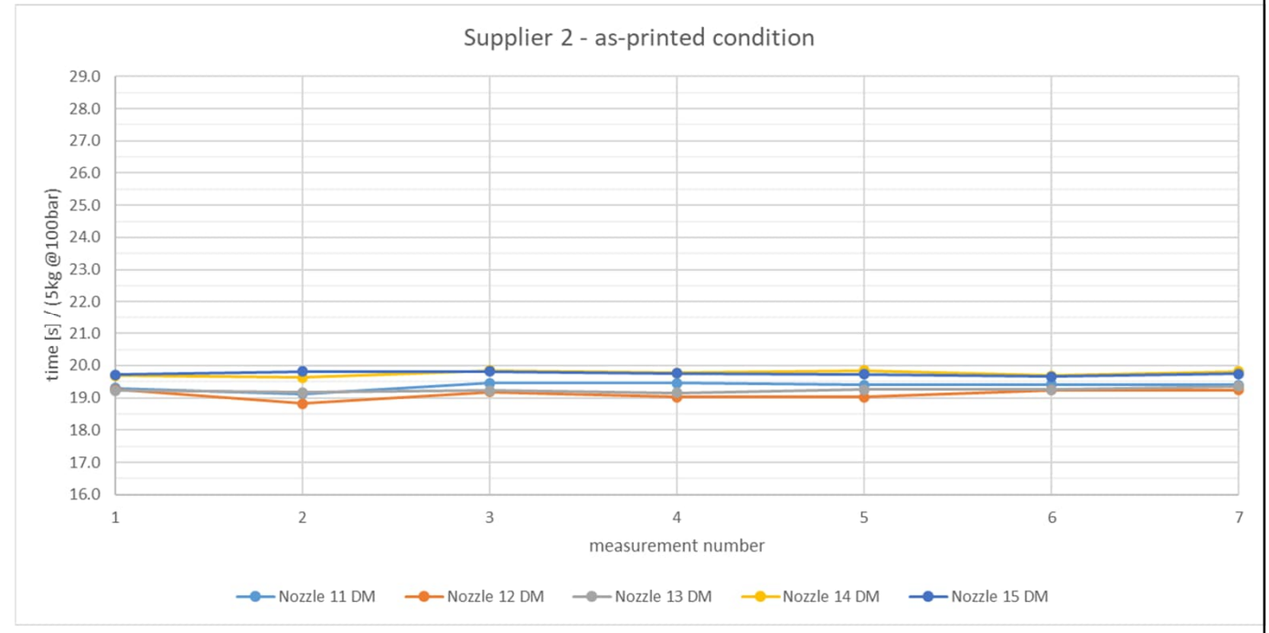

### Supplier 2 – Inconel 718



# 3D-Printed Fuel Nozzle – Manufacturing

## Flowbench test results



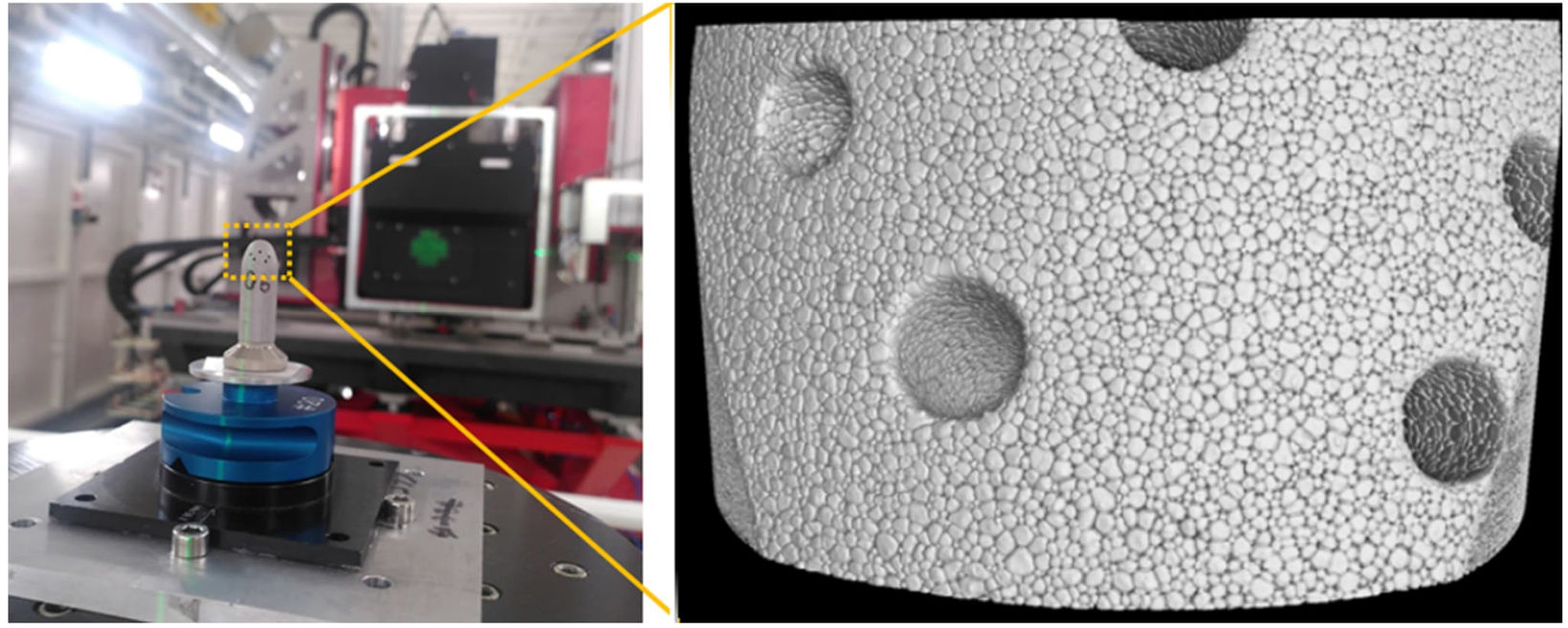




| | |
|---|---|
| Avg | 24.71 |
| Stdev | 2.15 |
| Δ max–min | 7.23 |

| | |
|---|---|
| Avg | 19.44 |
| Stdev | 0.28 |
| Δ max–min | 1.03 |

# 3D-Printed Fuel Nozzle

## ANAXAM, Synchrotron X-ray tomography

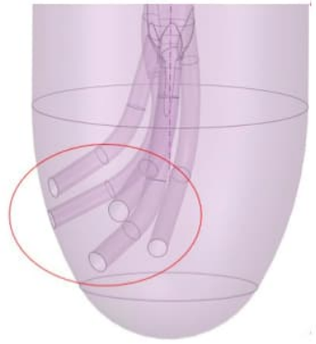


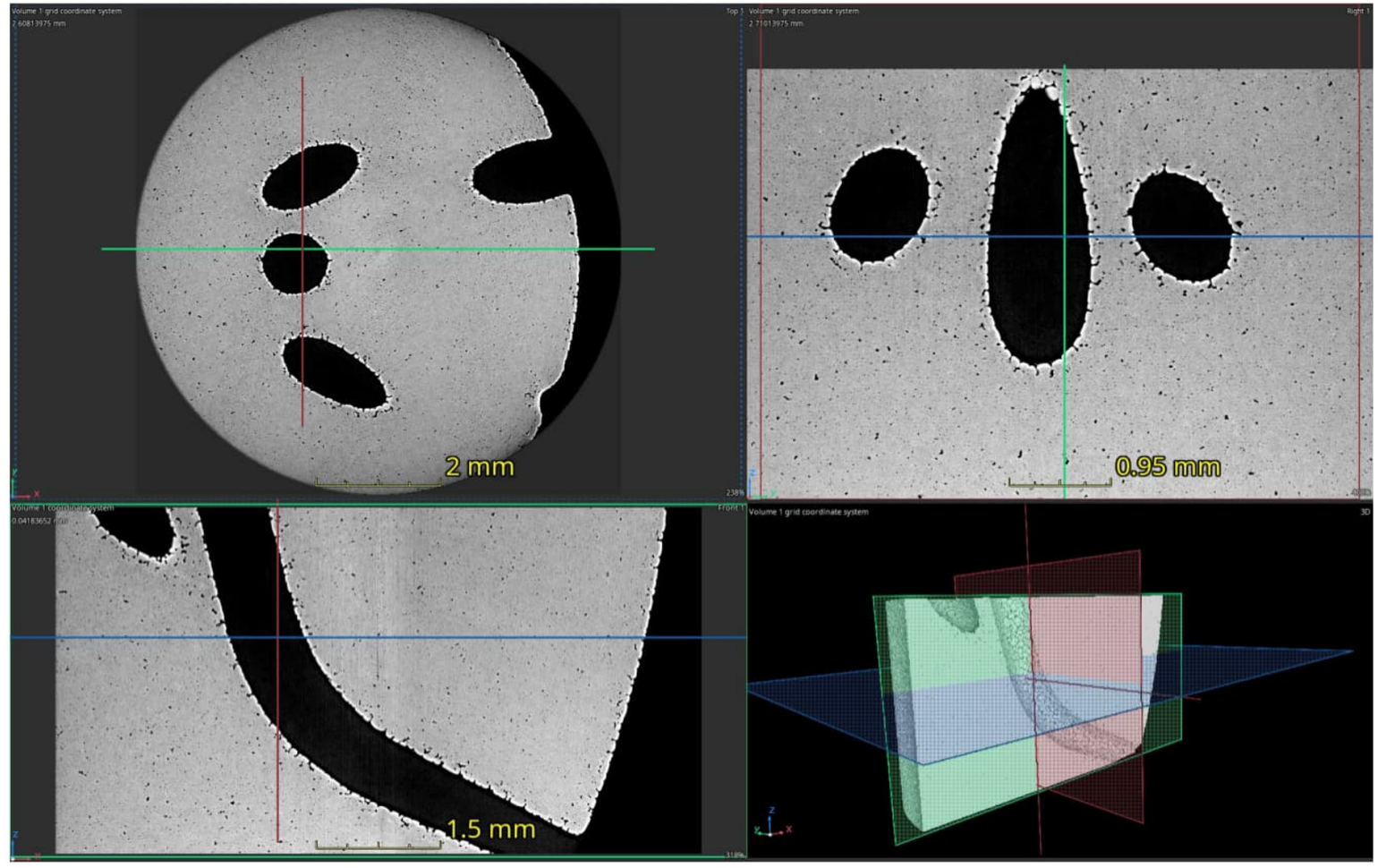
Tomographic imaging reveals the structure of the additively manufactured nozzles non-destructively and with spatial resolution as small as 5 μm

# 3D-Printed Fuel Nozzle

## ANAXAM, Synchrotron X-ray tomography

- Pixel size 2 μm; FOV 8.0 x 8.0 x 4.0 $mm^3$






21.11.2022

# 3D-Printed Fuel Nozzle

## Take away

1. We can make **better** components (more efficient, less complex)

2. AM offers **huge potential** in and around hydraulics where fluid dynamics are involved
   => AI

3. There are still **challenges**:
   - Manufacturing quality is method and even machine specific
   - Dimensional tolerances are still high for precision components
   - Standardisation needs to have a more important role

# Thank you

## Propelling shipping towards a greener future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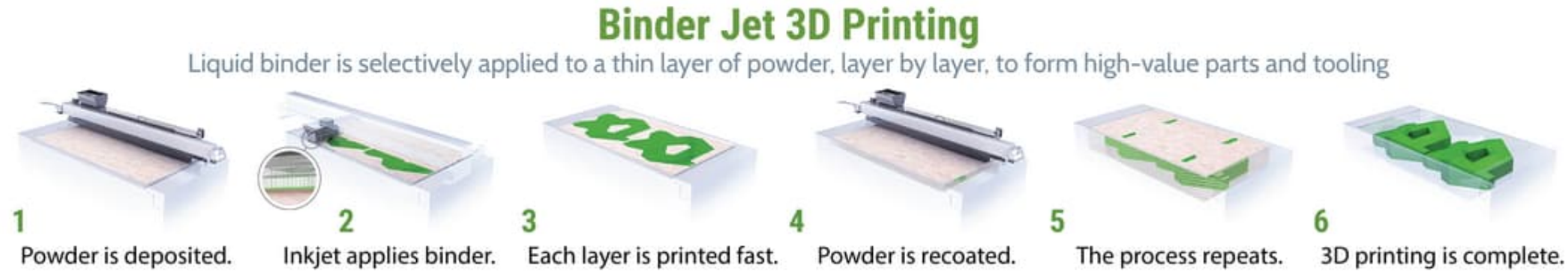
# 3D-Printed Fuel Nozzle

## Binder Jetting




Source: ExOne website, www.exone.com

- Requires post-processing
  - Thermal debinding and sintering
  - 10 – 15% shrinkage after sintering
  - Prone to warping
- High surface and detail quality
- High productivity
- Suitable for batch production
- Low cost