3D Printing of Maritime Spare Parts

Results and follow up pilot project

Content originally developed by Jacqueline Schardijn Business developer InnovationQuarter

3D Printing of Maritime Spare Parts

3D Printing for maritime & offshore?

Maritime

Offshore

Opportunities:

- Offshore: High ‘downtime’ costs
- Maritime: long lead time spare parts

Strengths:

- Positive business cases for AM in case of reduced lead times
- Just In Time production by AM

Weaknesses

- Lack of knowlegde by maritime industry about:
  - Different AM technologies
  - Available materials
  - Advantage of redesigns
  - How to redesign for AM
- Technological limitations

3D Printing of Maritime Spare Parts

Initiative

Port of Rotterdam

RDM MAKERSPACE

Innovation Quarter

Service providers (12)

e-Manufacturing Solutions

DMG MORI

SIEMENS

hitech group

oceanz powered by 3D Worknet

NLR

FMI

BUREAU VERITAS

Partners (11)

MARIN

Keppel Verolme

IHC MERWEDE

BROEKMAN LOGISTICS

Fokker

GKN AEROSPACE

RUYSCH SINCE 1935 INTERNATIONAL BV

Huisman

AEGIR Marine

TRANSPETROL

HEEREMA

Support

TU Delft Delft University of Technology

VIRO the performance of technology

Lloyd's Register

NETHERLANDS MARITIME TECHNOLOGY

3Dealise TOUCH YOUR IDEAS

Revamo

Maritime Delta Maritime by Holland.

Focus: printing metal spare parts

Consortium:

- Maritime Industry
- Classification Officers
- 3D Providers
- Software provider
- Logistics (digital warehouse)
- Aerospace Industry (Fokker and NLR)

3D Printing of Maritime Spare Parts

Project structure

WP1	Part selection & (Re)Design	WP4	Testing & Quality
WP2	Material selection & Database	WP5	Cost & return on investment
WP3	Production & Finishing	WP6	Project management

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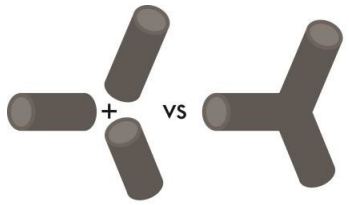
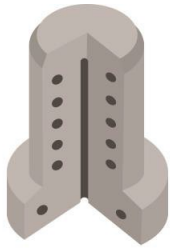
What part has potential?

Product design



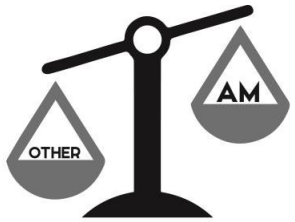
Part consolidation

AM allows production of unified parts, eliminating the need for assembly of multiple parts and it's associated costs.



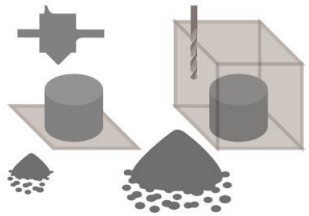
Integrated functionality

AM allows integrated functionality by use of complex geometries and interior structures such as cooling channels.



Weight reduction

AM allows applying internal structures and topology optimization, this efficient design leads to weight reduction.



Less waste

The additive production process opposed to traditional subtractive processes leads to less material being wasted.

Supply Chain

Lead times

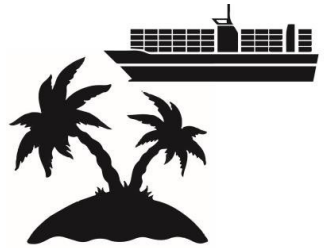
AM requires less steps in the production process, often leading to a decrease in lead time and costs.

Inventory

The local and short production time of AM allows for on-demand production, which decreases need for inventory.

Supplier risk

By qualifying a part for AM, you will no longer be completely reliant on your current supplier.



Location based costs

AM shows potential to overcome transport and import/export related costs by local production possibilities.

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T-connector

HEEREMA

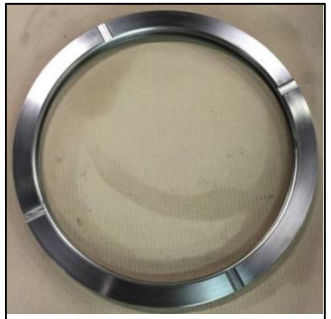
Cooled valve

RUYSCH SINCE 1935 INTERNATIONAL BV

Hinge

Fokker

GKN AEROSPACE



Spacer ring

Huisman

Propeller

MARIN

Jig

AEGIR Marine

Manifold

Huisman

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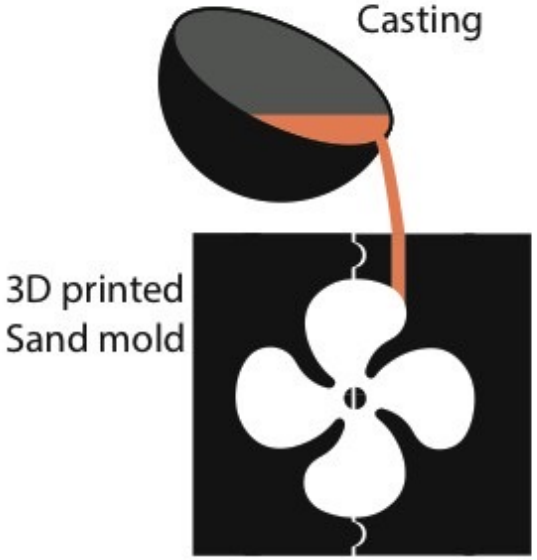
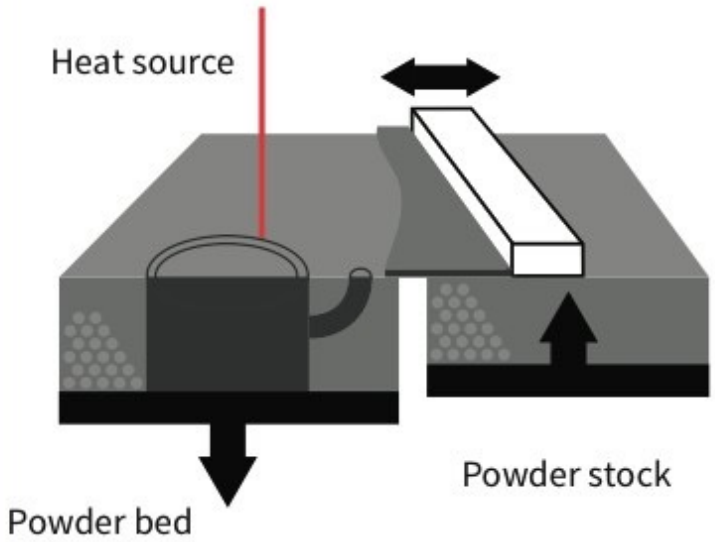
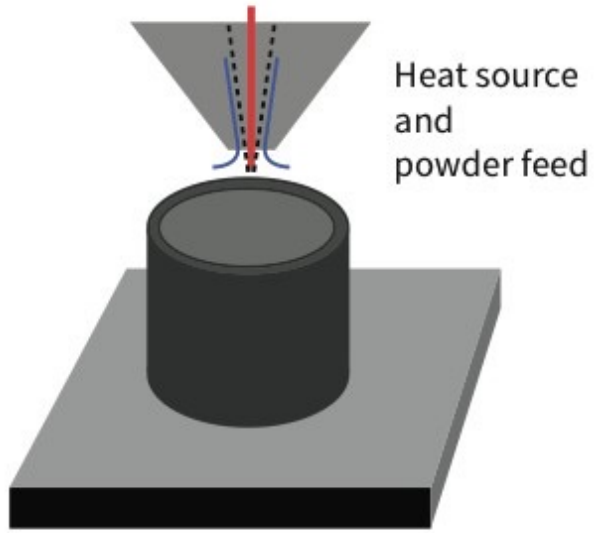
Which 3D printing production process?



Sand Casting



Powder Bed Fusion

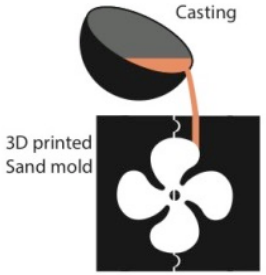


Directed Energy Deposition

3D Printing of Maritime Spare Parts

T-connector

HEEREMA

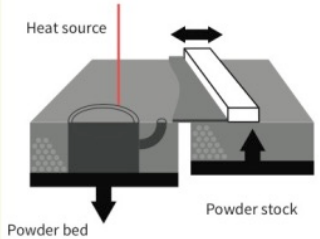


Sand Casting

3Dealise
TOUCH YOUR IDEAS

Cooled valve

RUYSCH
SINCE 1935 INTERNATIONAL BV



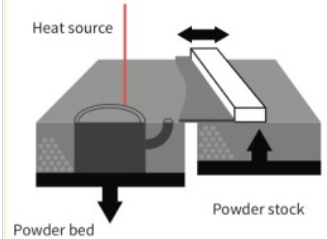
Powder Bed Fusion

eos
e-Manufacturing Solutions

Hinge

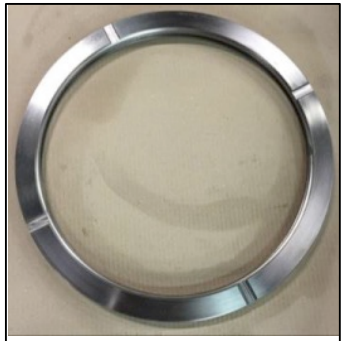
Fokker

GKN AEROSPACE



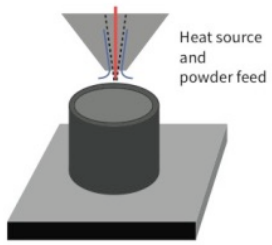
Powder Bed Fusion

eos
e-Manufacturing Solutions



Spacer ring

Huisman

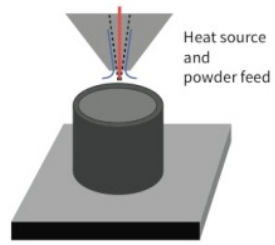


Directed Energy Deposition

Revamo

Propeller

MARIN



Directed Energy Deposition

DMG MORI

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Innovation Quarter
Port of Rotterdam
RDM MAKERSPACE

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Which material to use?

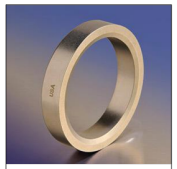
Theory: Powder bed and powder fed machines can process a wide range of powders than those offered by the machine manufacturers.

Practice: Materials selection based on alloys already being offered by machine manufacturers

EOS materials	*DMG materials*	*Casting materials*
316L, 1.452 (GP1), 1.4540 (PH1) 1.2709 (MS1) AlSi10Mg DirectMetal 20 IN625, IN718, HX (UNS NO6002) Ti64, Ti64ELI High Alloys Concrete Plastics	316L, 316L+Si, 304 1.2344 Cu8Al IN625, IN718, Tungsten Stellite 21,6 High Alloys Concrete Plastics	Stainless steels Iron Aluminium High Alloys Concrete Plastics

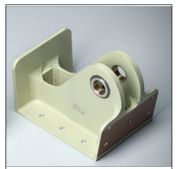
T-connector

DUPLEX



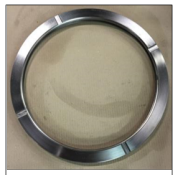
Cooled valve

PH1



Hinge

TI-6AL-4V



Spacer ring

316L + Metco 42C

Propeller

316L

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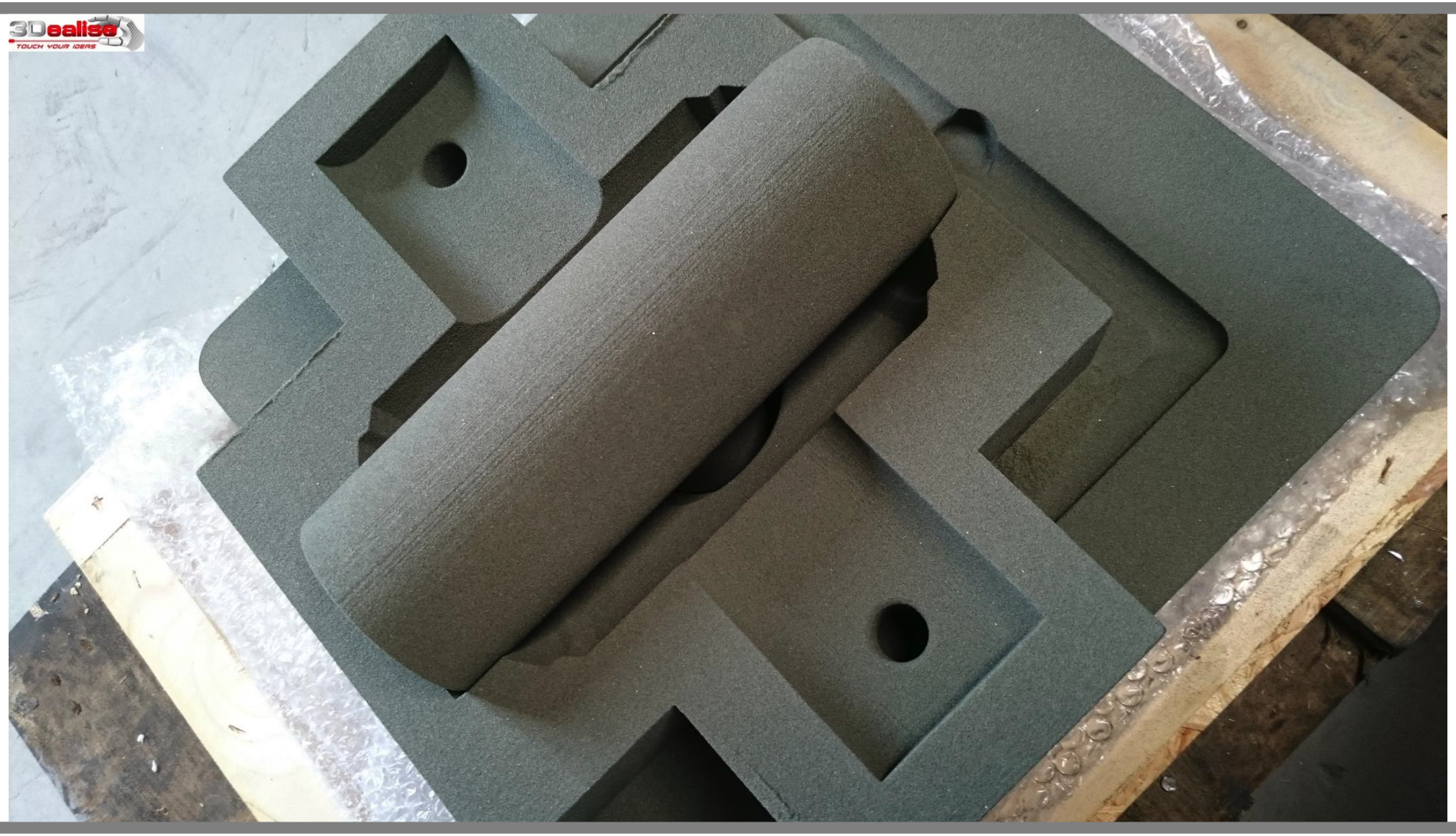

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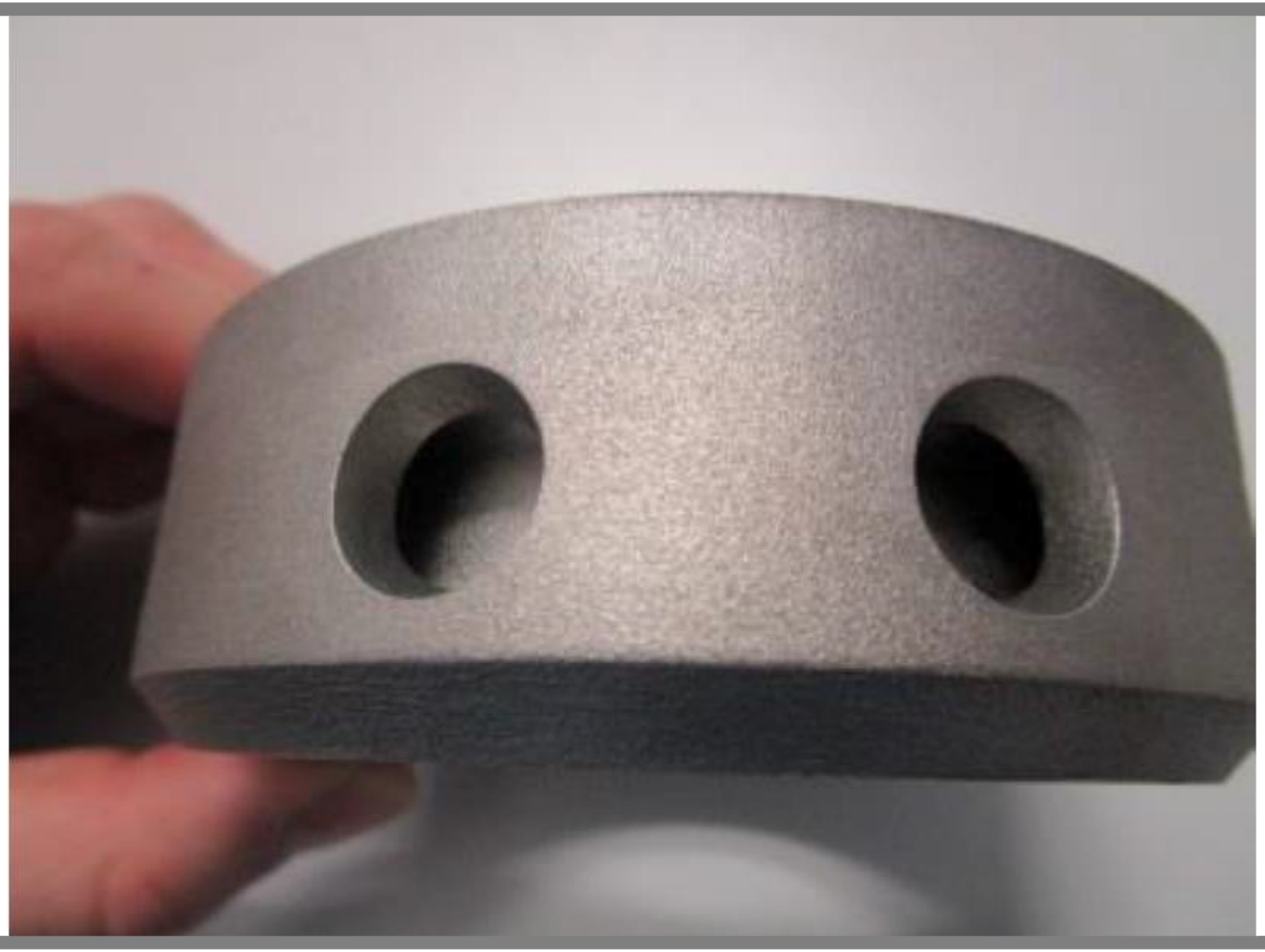

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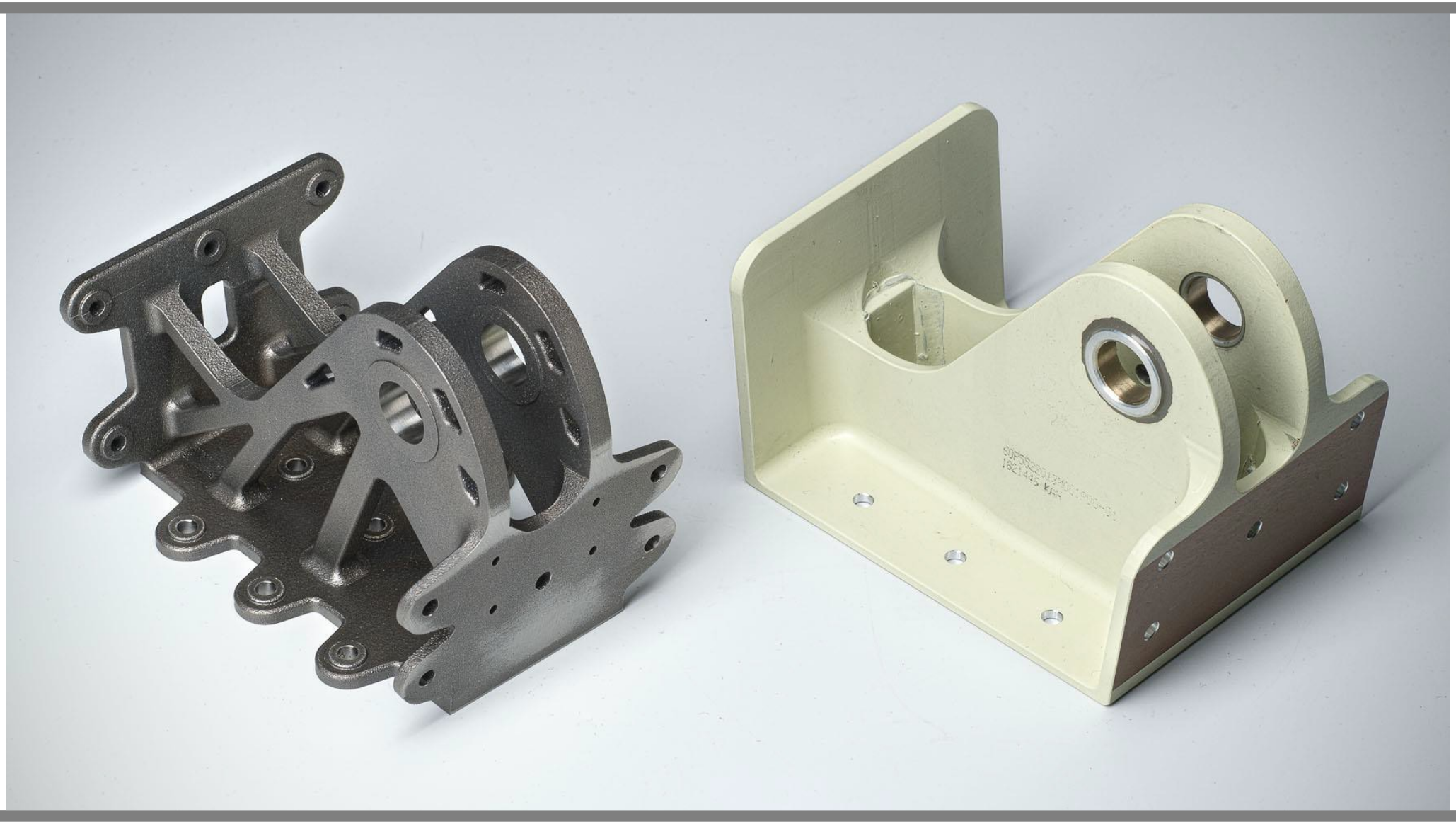

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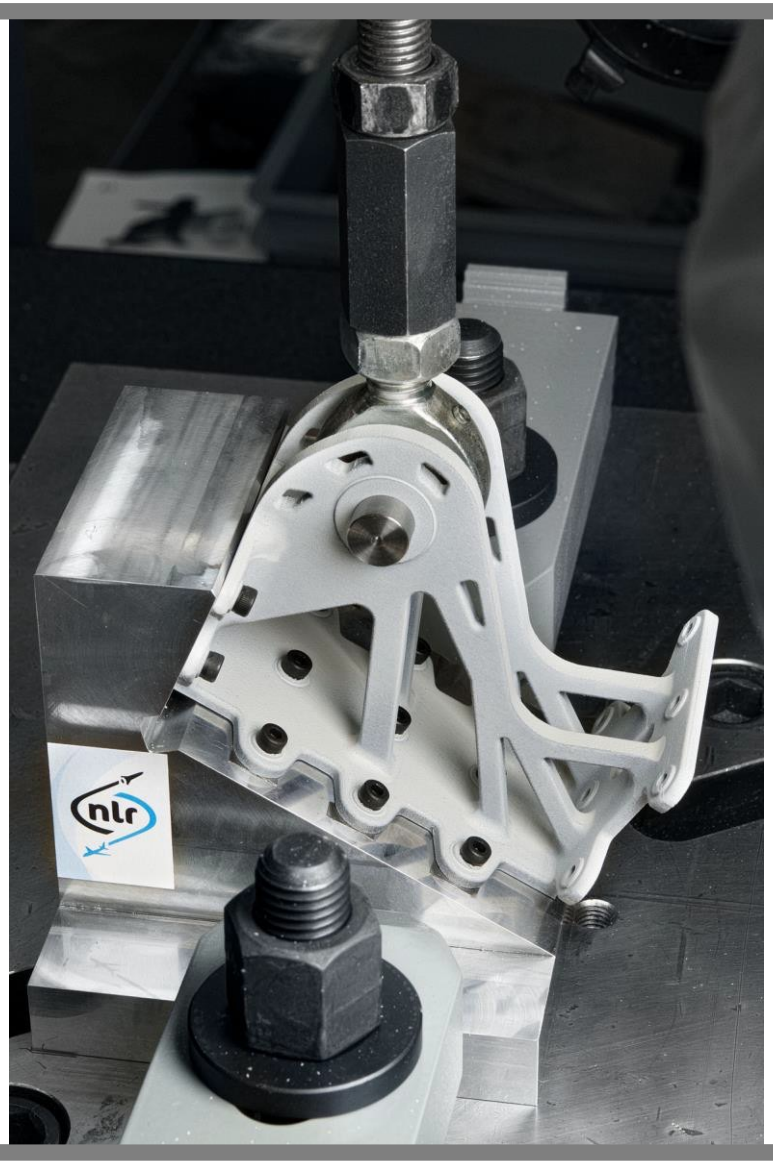

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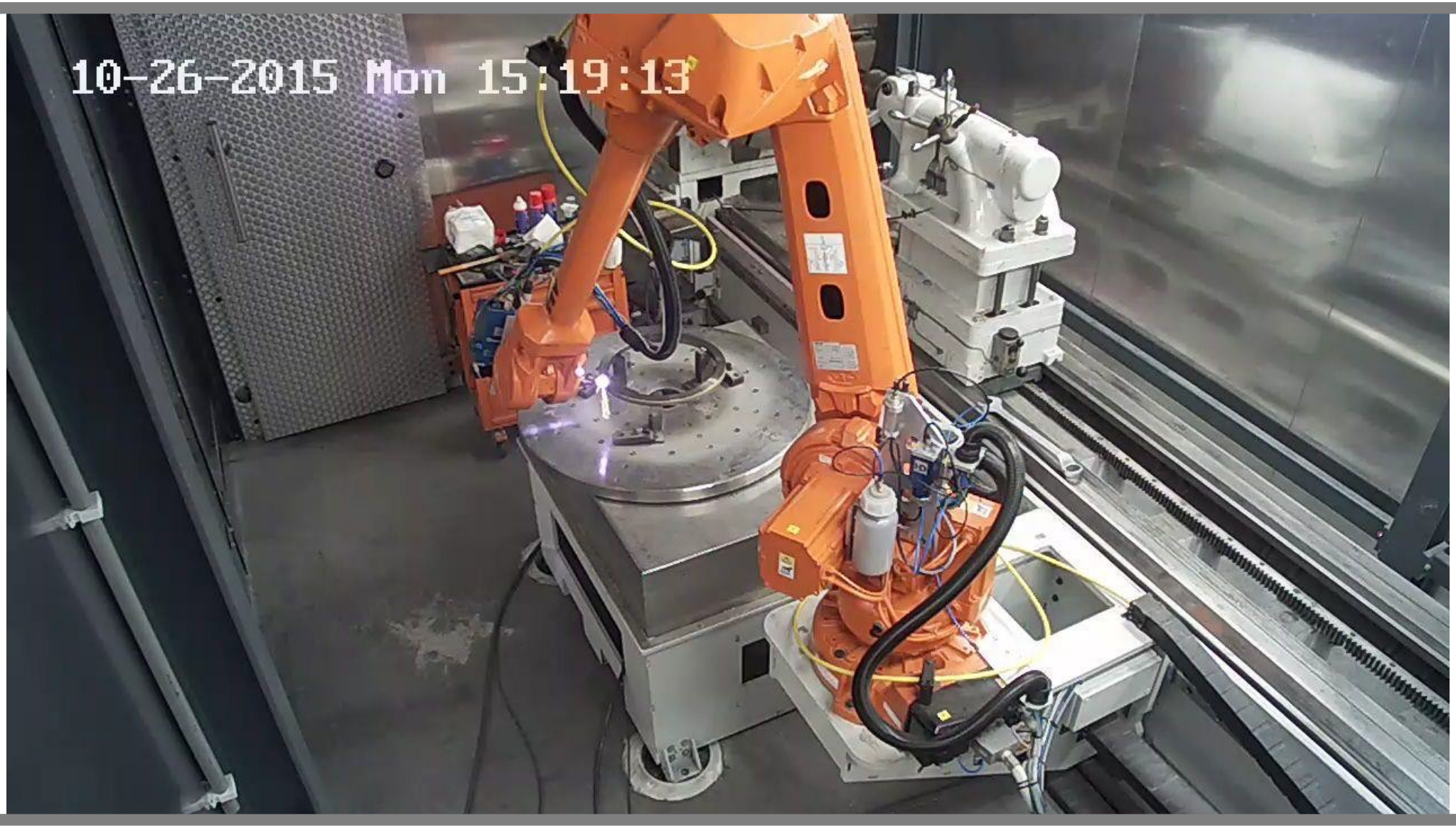

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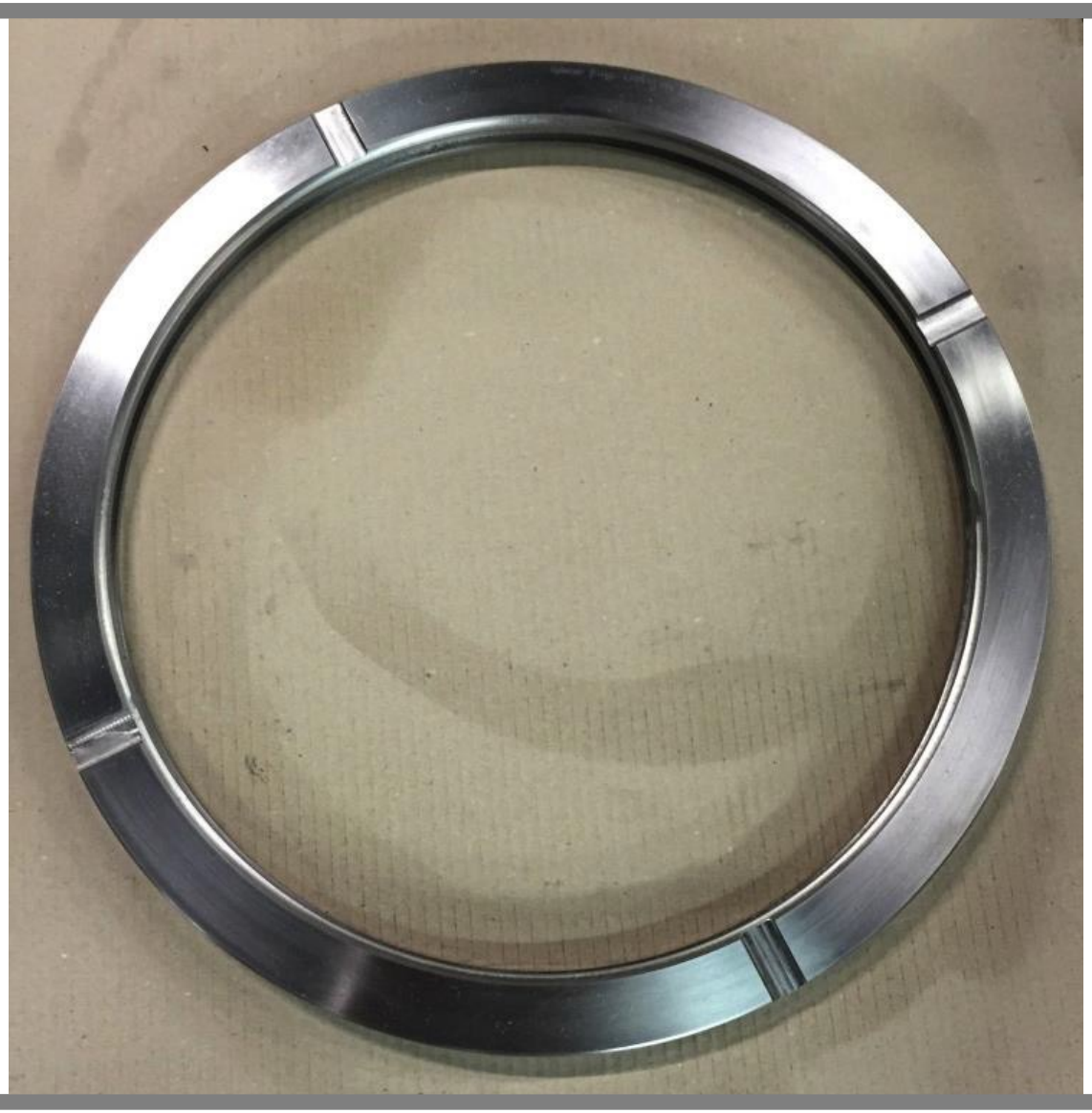

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3D Printing of Maritime Spare Parts

T-connector

HEEREMA

+ Reduced lead time
+ Form freedom

-Traditional is cheaper > 5 pieces
-Quality of forging vs. casting

Cooled valve

RUYSCH SINCE 1935 INTERNATIONAL BV

+ Reduced lead time

- Traditional part cheaper (minimum batch of 80 pieces)

Hinge

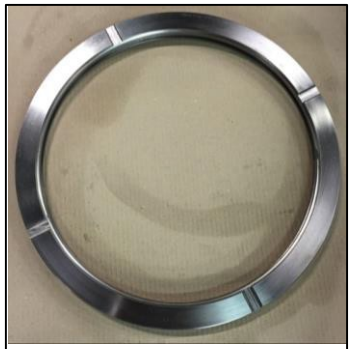
Fokker

GKN AEROSPACE

+ Weight reduction

+ Lead time reduction

- Room for optimization



Spacer ring

Huisman

+ Reduced inventory risk

- Traditional part cheaper at the moment

Propeller

MARIN

+ Part consolidation

+ Reduced lead time

- Lasertec still in research phase

3D Printing of Maritime Spare Parts

Conclusions

From an economic perspective currently only applicable for:

- Nominally “unmanufacturable” components
- High added value, long lead time items
- Adding features to low yield castings and forgings
- Repair applications

Also…

- Costs of AM are going down exponentially
- Total cost of operation should be taken into consideration for fair comparison

3D Printing of Maritime Spare Parts

Downtime costs

A standard northwestern European jack oil rig has average daily rates of $150.000. * “For estimation purposes, a reasonable value (operating costs) can be had by simply taking the rig's day rate, and doubling it for transportation services, rentals, communication services, drilling services, support services, security services, shore-based support etc. [2]”.

So an oil rig in the North Sea could have a downtime cost of ($150.000 *2 / 24 =) **$12.500 per hour of not being operational.**

*https://www.ihs.com/products/oil-gas-drilling-rigs-offshore-day-rates.html

3D Printing of Maritime Spare Parts

Rise to the Challenge

- **Design**: Designers must be taught the performance and economics of 3D printing
- **Quality control**: standards are needed to assure that every part meets requirements
- 3D printing processes must be much more productive
- **Supply Chains:** (maintenance) companies need help to commercialize new 3D printing technologies
- Threshold to start innovating with 3D printing is high due to high initial investments … but this is changing rapidly

3D Printing of Maritime Spare Parts

Full report available at

https://www.portofrotterdam.com/sites/default/files/report-3d-printing-marine-spares.pdf