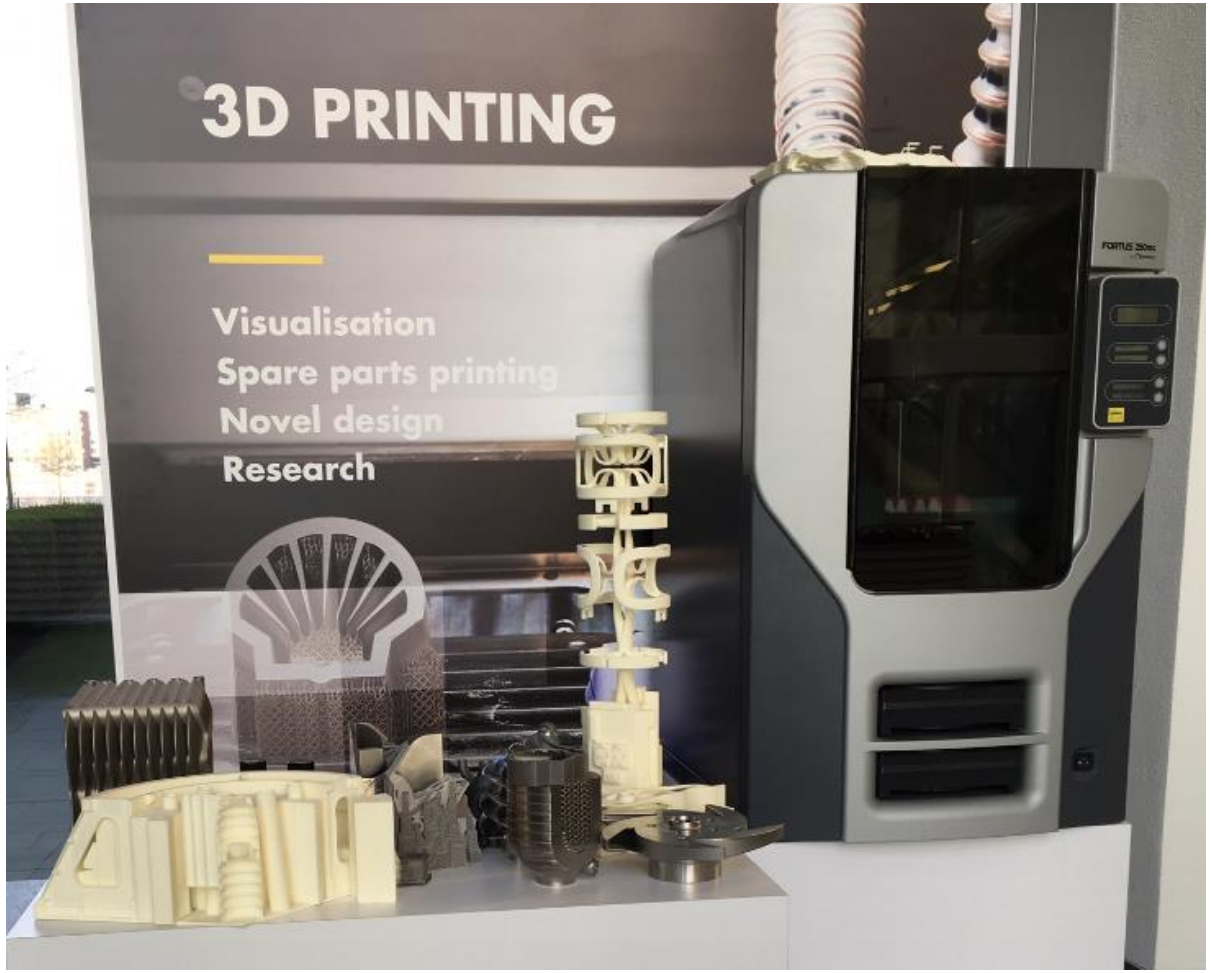
3D Printing – Pump Impellers

ETN AM Workgroup Meeting @ TOTAL
Pau (France) – 28 March 2019
Distribution: for ETN Members only

Jan de Roos
Sr Rotating Equipment Engineer
Focal Point 3DP of RE in Shell

3D Printing in Shell

- Visualisation
- Spare Parts
- Novel Design
- Research



Steps involved in 3DP

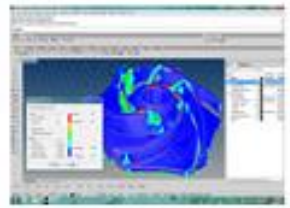
Stage 1
Engineering

Design from "scratch"

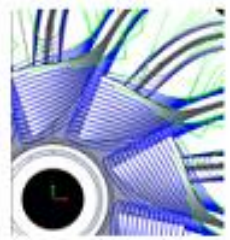
Reverse engineering
& 3D scanning

Stage 2
Design Verification

Mesh Review



Slicer Utility



Stage 3
Printing

Direct printing

Stage Casting

Stage 4
Post-Processing

Surface Milling

Heat Treatment

Stage 5
Part testing

Specification testing

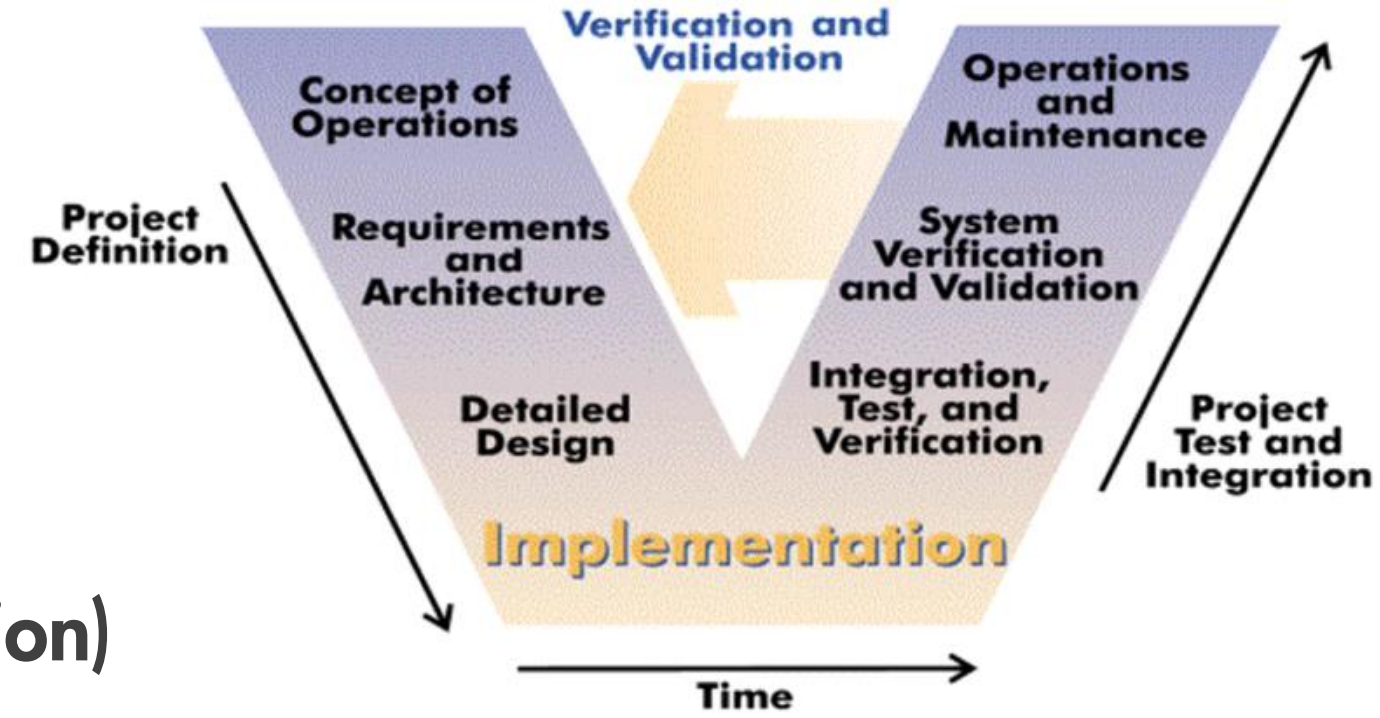
scanning electron
microscope

Failure and Stress
testing

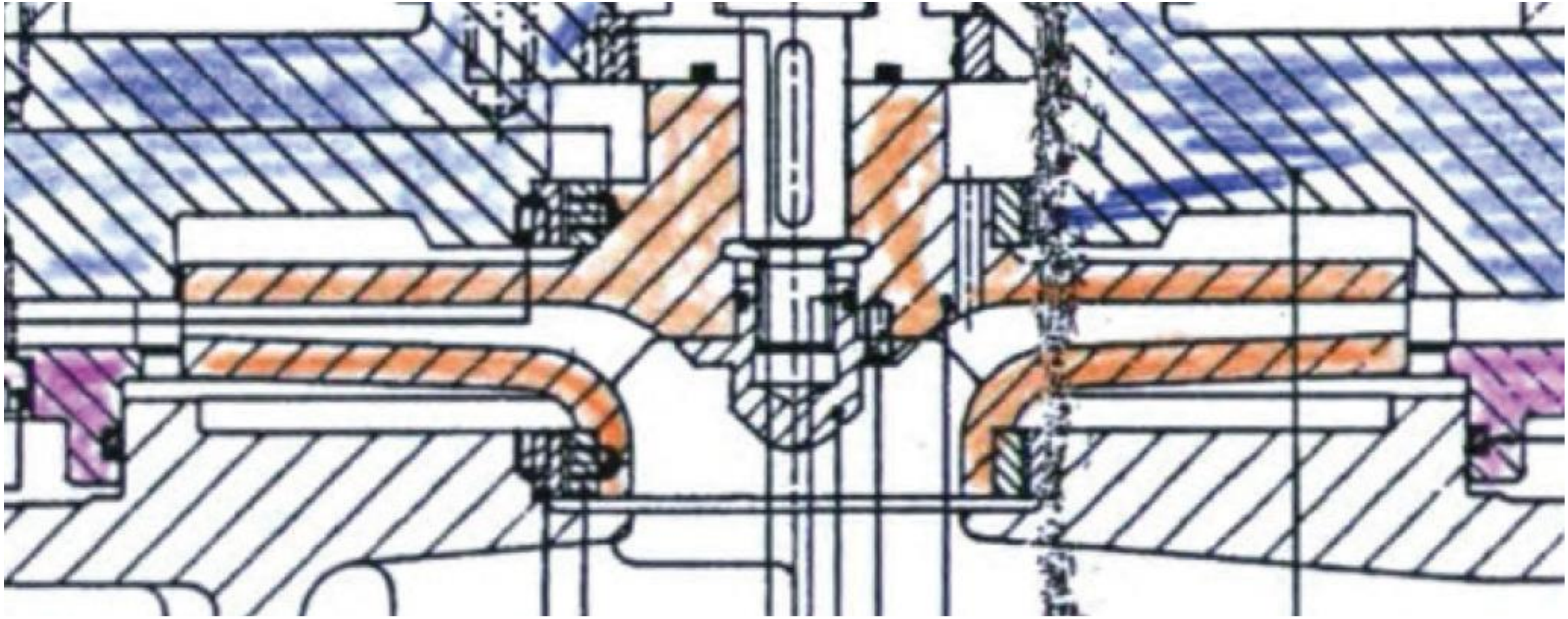
3D Printing – Use of Systems Engineering Principles

- Architecture

  (System Breakdown)
- Requirements
- Integration (Interfaces)
- Test (Verification & Validation)



PoC – P6510 Impeller | Reverse Engineering



Functional Requirement – Performance

#	Performance	Requirement	Tests	Code/Standard & Criteria
	Geometry – Hydraulic	Geometry – „wet surface" to be within specified tolerance	As-built scan for verification	0.2 mm
	Surface condition – friction loss and fouling	Roughness to be within spec. Measure roughness existing impeller	Surface Roughness Test on critical locations	Equal or better than existing impeller
	More…			

Functional Requirement – HSSE, Reliability & Availability

#	HSSE, Reliability & Availability	Requirement	Tests	Code/Standard & Criteria
	Surface condition at Static O-ring locations	Surface sufficiently smooth to ensure sealing	Surface Roughness	API610 6.3.12: for static O-rings max surface roughness average Ra of 1.6 micron
	Mechanical Properties - Strength – Tensile	Maximum operational stress levels well below yield stress	Spin test (130% of speed) Crack Test Ultrasonic of Rontgen Test	No internal and external indications of cracks after spin test
	More …			

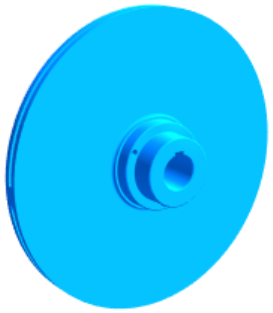
Functional Requirement – Assembly and Maintainability

#	Assembly and Maintainability	Requirement	Test	Code/Standard & Criteria
	Assembly and disassembly of tight fits	Geometry to be within tolerance (hub, key way, impeller nut, shaft axial face)	As-built scan Measurements	Fit key and key way 0.0 - +0.01 mm Fit shaft Impeller bore +0.01 - +0.02 mm
	Repair – Machinability (and Threading)	Material Specification, Metallurgic Structure	Hardness test	See above for MR0103:2016 requirements.
	More …			

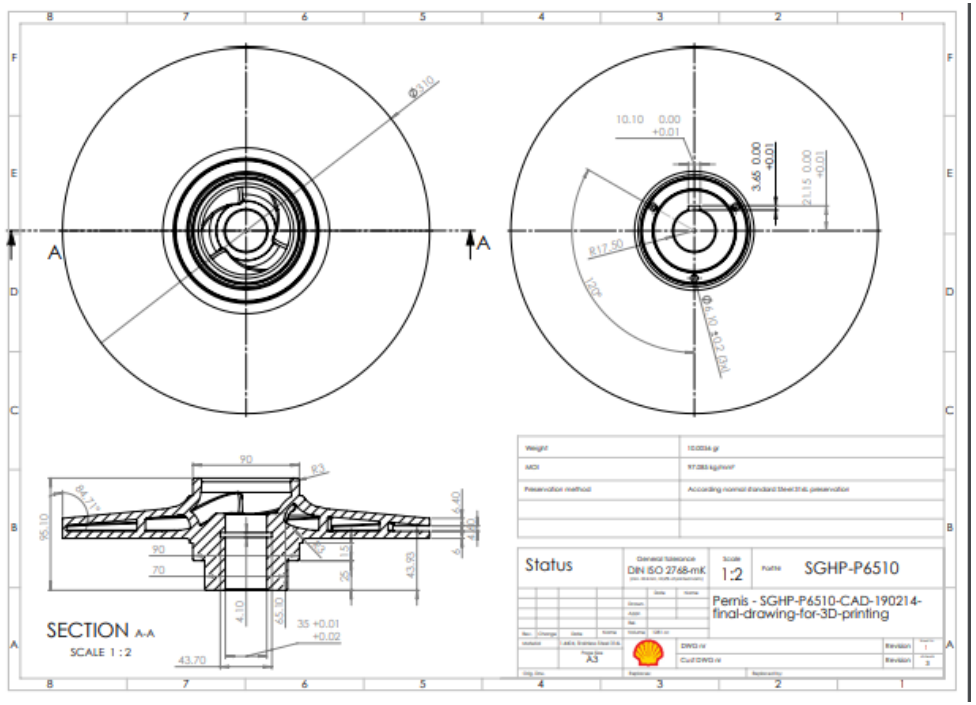
PoC - P6510 Pump Impeller | Design Verification complete -> Ready for Printing

SGHP-P6510	Pernis - SGHP-P6510	1.4404, Stainless Steel 316L (Heraeus)	0	0	No data	34	Dimanex	PROGRESS - AM 3D FILE APPROVED	7	

MODEL



PROPERTIES METADATA



WORKFLOW HISTORY

Chris van Malkenhorst *assigned the case to* **Dimanex** 5 hours ago

Chris van Malkenhorst *changed the status:* 6 hours ago

PROGRESS - AM 3D FILE APPROVED

Chris van Malkenhorst *added a comment:* 6 hours ago

Final version of '3D Printing Pernis Pilot Pump SGHP-P6510 - Specification and Acceptance Criteria 190214 Version at end of Design Verification.docx' uploaded.

Jan de Roos *added a comment:* 2 days ago

Chris, STL file I changed to "set to official". Joost, thanks for your help in reviewing and approving the 3D model and

DiManEx

PEARL – Qatar | 1st 3D Printed Impeller in Operation

Questions?